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Ability of bottle cap color to facilitate accurate glaucoma patient-physician communication regarding medication identity

Pujan Dave, BA¹, Guadalupe Villarreal Jr., MD¹, David S. Friedman, MD, PhD¹, Malik Y. Kahook, MD², and Pradeep Y. Ramulu, MD, PhD¹

¹Wilmer Eye Institute, Johns Hopkins University, Baltimore, Maryland ²Department of Ophthalmology, University of Colorado School of Medicine, Aurora, Colorado

Abstract

Objective—To determine the accuracy of patient-physician communication regarding topical ophthalmic medication use based on bottle cap color, particularly amongst individuals who may have acquired color vision deficiency from glaucoma.

Design—Cross-sectional, clinical study.

Participants—Patients 18 years old with primary open-angle, primary angle-closure, pseudoexfoliation, or pigment dispersion glaucoma, bilateral visual acuity of 20/400 or better, and no concurrent conditions that may affect color vision.

Methods—One hundred patients provided color descriptions of 11 distinct medication bottle caps. Patient-produced color descriptors were then presented to three physicians. Each physician matched each color descriptor to the medication they thought the descriptor was describing.

Main Outcome Measures—Frequency of patient-physician agreement, occurring when all three physicians accurately matched the patient-produced color descriptor to the correct medication. Multivariate regression models evaluated whether patient-physician agreement decreased with degree of better-eye visual field (VF) damage, color descriptor heterogeneity, and/or color vision deficiency, as determined by Hardy-Rand-Rittler (HRR) score and the Lanthony D15 testing index (D15 CCI).

Address for Reprints: Pradeep Y. Ramulu, MD, MHS, PhD, 600 North Wolfe Wolfe Street, Maumenee B110, Johns Hopkins Hospital, Baltimore, MD 21287, Fax: 410-955-2542, pramulu1@jhmi.edu.

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Pujan Dave and Guadalupe Villarreal Jr. have no conflicting relationships. David Friedman serves as a consultant for Alcon and Allergan. Malik Kahook serves as a consultant for Aerie Pharma and receives grant support from Alcon and Allergan. Pradeep Ramulu receives grant support from the National Eye Institute and from Research to Prevent Blindness and personal fees from Tissue Banks International and Carl Zeiss Meditec. There are no conflicting relationships for any author regarding the work under consideration.

Results—Subjects had a mean age of 69 (± 11) years, with mean VF mean deviation of -4.7 (± 6.0) and -10.9 (± 8.4) dB in the better- and worse-seeing eyes, respectively. Patients produced 102 unique color descriptors to describe the colors of the 11 tested bottle caps. Among individual patients, the mean number of medications demonstrating patient-physician agreement was 6.1/11 (55.5%). Agreement was less than 15% for 4 medications (prednisolone acetate [generic], betaxolol HCl [Betoptic], brinzolamide/brimonidine [Simbrinza], and latanoprost [Xalatan]). Lower HRR scores and higher D15 CCI (both indicating worse color vision) were associated with greater VF damage ($p < 0.001$). Extent of color vision deficiency and color descriptor heterogeneity were the only significant predictors of patient-physician agreement in multivariate models (odds of agreement = 0.90 per 1 point decrement in HRR score, $p < 0.001$; odds of agreement = 0.30 for medications exhibiting high heterogeneity [11 descriptors], $p = 0.007$).

Conclusions—Physician understanding of patient medication usage based solely on bottle cap color is frequently incorrect, particularly in glaucoma patients who may have color vision deficiency. Errors based on communication using bottle cap color alone may be common and could lead to confusion and harm.

Introduction

Reduction of intraocular pressure (IOP) using topical ophthalmic medications remains the primary method of treating glaucoma.^{1,2} Since 1983, topical ophthalmic medications of the same class have generally been manufactured with uniformly colored bottle caps (e.g. all miotic medications are green-topped). Patients on multiple eye drops can use these differences in cap color to distinguish their eye drop medications.³ Additionally, patients and physicians can use these colors to identify which medications are being used and guide how they are to be used (frequency, which eye, etc.), particularly when medication bottles are not available in the office and medication names are unknown. Patient knowledge of medication names ranges from 10.9% to 85%, varying significantly with factors such as level of education.^{4–6}

It is largely unknown whether the present color-coding system allows for accurate medication recognition and patient-physician communication. There are many potential reasons why the system may not work well. For instance, patients with glaucoma can develop acquired color vision deficiency, and a considerable proportion of male patients may have inherited color vision deficiency. Either deficiency could create confusion about differently colored bottle caps.^{7–10} Additionally, color naming may be imprecise, and the impact of this imprecision is likely to grow as the number of differently colored bottle caps continues to increase. It is therefore possible that patients may not properly understand color names stated by physicians, and/or that physicians may not properly understand color names provided by patients. Either circumstance fosters ambiguity and allows for patient-physician miscommunication.

In this study, we determined how often physicians were able to accurately identify the medication/medication class to which a patient was referring based on the patient's color description of the medication's bottle cap. Additionally, we asked whether physician-patient agreement was lower for bottle caps of specific colors and amongst glaucoma patients with

impaired vision. These data will help define how well the current bottle cap color system works, and elucidate possible avenues for improvement to reduce patient-physician confusion regarding medication usage.

Methods

Study Participants

The study protocol was approved by The Johns Hopkins Medicine Institutions' Review Board and adhered to the Declaration of Helsinki. Study subjects were recruited from all study-eligible patients receiving care at the Wilmer Eye Institute Glaucoma Service at Johns Hopkins. All participants signed written informed consent forms before all study procedures. Subjects were recruited between June and August 2014.

Participants' medical charts were prescreened for eligibility. Glaucoma subjects had to be at least 18 years of age and have a confirmed chart diagnosis of primary open-angle glaucoma, primary angle-closure glaucoma, pseudoexfoliation glaucoma, or pigment dispersion glaucoma. Visual acuity (VA) was required to be at least 20/400 or better in both eyes. Participants were required to have visual field (VF) testing within 6 months of study participation. Subjects with (1) neovascular glaucoma, (2) glaucoma/increased IOP secondary to other ocular conditions (e.g. uveitis, corneal surgery, etc.), (3) surgery in the two months prior to study participation, or (4) concurrent conditions that affect contrast sensitivity or color vision (e.g. significant cataract, age-related macular degeneration, other optic nerve disease, etc.) were excluded. Eligible and agreeable subjects had to pass the Mini-Cog dementia screening test.¹¹ Participant demographic information, including date of birth, gender, race, and level of education, was collected by self-report.

Evaluation of Vision

Snellen VA was recorded as the presenting VA on the day of their most recent clinic visit and was converted to the logMAR scale.¹² Presenting VA was chosen to reflect real-life function of the patient, and because uncorrected refractive error has been shown to affect color vision only at extreme levels.¹³ Severity of VF loss was quantified according to the mean deviation (MD) in the better-seeing eye (i.e. the eye with a higher [less negative] MD on SITA standard 24-2 visual field testing), given prior research demonstrating that integrated VF MD and better-eye MD infrequently differ and do not predict visual disability differently across a wide range of functional metrics.¹⁴

Color vision was tested using the Richmond Hardy-Rand-Rittler (HRR) pseudoisochromatic plate test and the Lanthony D15 Hue Desaturated Panel Test. Color vision testing was performed binocularly using participants' usual (presenting) correction and under standard full spectrum lighting (OttLite Technology, Tampa, FL).

For HRR testing, plates were held approximately 25 inches from the subject and subjects were asked to trace the shapes present on each plate. Scoring of results was performed as described in prior papers using HRR testing to quantify acquired dyschromatopsia.¹⁵ Subjects received either 0 points (incorrect) or 1 point (fully correct) for screening plates, 0 points (incorrect) or 1 point (correct) for plates with one symbol, and 0 points (incorrect),

0.5 points (1 of 2 symbols correct), or 1 point (both symbols correct) for plates with two symbols. Under this scoring system, an error-free performance on the HRR test yields a maximum score of 20 points, and a lower score is associated with worse color vision.

Methods for using the Lanthony D15 test to quantify acquired color vision deficiency have been previously described and were employed here.¹⁶ The D15 testing board was positioned approximately 20 inches from the subject and subjects were given as much time as needed to reorganize the 15 discs into the chromatic sequence that they felt best minimized hue differences between adjacent caps. The degree of color vision loss as measured by the D15 test was then scored using the Color Confusion Index (D15 CCI).¹⁷ An error-free D15 test, occurring when all 15 caps are perfectly arranged in the correct sequence, is given a D15 CCI of 1.0. The D15 CCI increases in proportion to the number and severity of mistakes.¹⁸

Bottle Cap Description and Physician Survey

Subjects were asked to describe the color of 11 distinct medication bottle caps using their own color descriptor. Each bottle cap was held in front of the patient at a distance of 25 inches under the illumination described above. The following 11 medication bottle caps were used: betaxolol HCl (Betoptic), dorzolamide (Trusopt), prednisolone acetate (generic, white-capped), brimonidine (Alphagan), brinzolamide/brimonidine (Simbrinza), cyclopentolate HCl (Cyclogyl), levobunolol (Betagan), latanoprost (Xalatan), pilocarpine (Salagen), moxifloxacin (Vigamox), and brimonidine/timolol (Combigan). Bottles were presented in one of two pre-determined sequences (sequence 1: in the order named above; sequence 2: latanoprost, dorzolamide, brimonidine, brinzolamide/brimonidine, brimonidine/timolol, prednisolone acetate, pilocarpine, levobunolol, cyclopentolate HCl, moxifloxacin, betaxolol HCl). These patient-produced color descriptors were then presented to three male physicians with normal color vision (as determined by perfect HRR and Lanthony D15 scores). Physicians included two glaucoma faculty members at different institutions and one ophthalmology resident. Each physician was asked to match each color descriptor to the medication they thought the color descriptor was being used to describe. Physicians were given the name of the 11 medications whose caps patients had described. In primary analyses, patient-physician agreement was defined as present for a given medication when the medication name given by all three physicians was the same as the medication whose bottle cap color was described by the patient. Additional analyses were performed in which patient-physician agreement was said to be present when 2 of 3 physicians provided a medication name corresponding to the medication whose bottle cap color was described by the patient. Physicians also rated the confidence of their choice as low, medium, or high.

Statistical Analysis

Word clouds were generated at www.wordle.net to depict the variety of color descriptors used to describe individual medications. In these word clouds, the size of the words shown corresponds with the number of times patients provided that color descriptor. Factors affecting patient-physician agreement were also analyzed using univariate and multivariate logistic regression models in which each patient-medication combination was considered to be a separate observation and generalized estimating equations (GEE) were used to account for within-patient correlations. Outcomes were expressed as an odds ratio and 95%

confidence interval. Statistical analyses were performed using STATA 13 (STATA, College Station, Tx, USA).

Results

One hundred glaucoma subjects were enrolled in the study and completed the study protocol. Mean participant visual acuity (logMAR) and better-eye visual field MD were 0.11 (SD = 0.13) and -4.7 dB (SD = 6.0 dB), respectively. Participant demographics and vision characteristics are summarized in Table 1.

Color Vision Testing

Twenty-five patients (25%) made no errors on D15 testing, resulting in a D15 CCI of 1.00. Mean D15 CCI was 1.46 ± 0.48 (range, 1.00 – 3.45). Forty-four patients received an error-free score of 20 points on the HRR test and mean HRR score was 17.6 ± 3.7 (range, 2 – 20). Lower HRR scores and higher D15 CCI (both indicating worse color vision) were both found at greater degrees of visual field damage (Figures 1A and 1B), with D15 CCI scores increasing 0.21 points (95% CI=0.14 to 0.29, $p<0.001$) and HRR scores decreasing 2.24 points (95% CI=-2.97 to -1.51, $p<0.001$) per 5 dB decrement in the better-eye VF MD.

Bottle Color Naming

A total of 102 unique color descriptors were used to describe the colors of the 11 tested medication bottle caps. The number of color descriptors used to describe individual medication bottle caps ranged from 2 to 19. The minimum number of color descriptors for the 11 medication bottle caps tested was 2, with all patients describing white-capped prednisolone acetate as either white or off-white. The median number of descriptors was 12 (for latanoprost) and the maximum number was 19 (for cyclopentolate). The color descriptors used to describe the bottle cap colors of latanoprost and cyclopentolate are expressed as word clouds in figures 2A and 2B. In many cases, color descriptors were used to describe many distinct medication bottle caps (illustrated for medication bottle caps along the blue-green spectrum in Figure 3).

Physician Bottle Cap Survey

Three physicians spanning 2 institutions and varying levels of training (one resident physician, 2 glaucoma specialists) completed the physician bottle cap survey, matching the 102 color descriptors provided by glaucoma subjects to the 11 different medications and rating their confidence of their choice. Overall, physicians rated their confidence as low for 108/306 assignments (35.3%), medium for 92/306 assignments (30.1%), and high for 106/306 assignments (34.6%).

Patient-physician agreement was determined in a two-step process. First, patients observed a topical ophthalmic medication bottle and described the color of its bottle cap. Next, three physicians surmised to which medication a patient was referring based on the cap color provided. If the medication name provided by all three physicians matched the medication whose bottle cap was initially described by the patient, then patient-physician agreement was defined as present.

For individual patients, the mean number of medications with patient-physician agreement was 6.1/11 (55.5%; SD = 1.09 medicines [9.9%]) (Figure 4). Amongst the medications studied, the degree of patient-physician agreement was lowest for betaxolol, prednisolone acetate, and brinzolamide/brimonidine, and highest for brimonidine/timolol, dorzolamide, and pilocarpine (Table 2). When the definition of agreement was loosened such that patients and physicians were in agreement if the medication bottle cap color provided by patients was deemed to be referring to the same medication by at least 2 of the 3 queried physicians, the mean number of medications demonstrating patient-physician agreement increased to 9.27/11 (84.3%; SD = 1.3 medicines [11.8%]). Under this new definition, the degree of patient-physician agreement was lowest for betaxolol, brinzolamide/brimonidine, and cyclopentolate, while highest for pilocarpine, brimonidine, and prednisolone acetate. The sequence with which the medications were presented to patients did not alter patient-physician agreement. When patients were required to agree with each of the 3 possible physician pairs, mean agreement was 57.1%, 62.3% and 75%.

Factors predicting the likelihood of poor patient-physician agreement in univariate analyses included severity of better-eye visual field loss, extent of color vision loss (reflected by a lower HRR score or a higher D15 CCI), and level of heterogeneity of color descriptors (i.e. number of color descriptors provided per bottle) (Table 3). In multivariate analysis, lower HRR score (OR = 0.90; 95% CI = 0.86 to 0.95; $p < 0.001$) and high heterogeneity of patient-produced color descriptors (11 descriptors) (OR = 0.30; 95% CI = 0.12 to 0.71; $p = 0.007$) were the only significant predictors of patient-physician agreement.

Discussion

Color descriptors used to describe ophthalmic bottle caps are heterogeneous and numerous, and physician understanding of patient medication usage based solely on bottle cap color is frequently incorrect. The likelihood of misinterpreting a medication class based on cap color alone varied significantly across the spectrum of medications we evaluated. Greater disease severity (as defined by the extent of VF loss or color vision loss) and greater heterogeneity of color descriptors used to describe a bottle cap color were associated with an increased likelihood of misinterpretation. These findings provide strong evidence that clinicians, particularly those treating patients with more advanced glaucoma, should not rely exclusively on cap color descriptions when communicating with patients and assessing their medication usage.

The focus of this study was to define the accuracy of patient-physician communication based solely on medication bottle cap color. Overall patient-physician agreement was poor (agreement among all three physicians on 56% of tested medications for the average patient), and was particularly poor (<15%) for four medications: betaxolol, prednisolone, brinzolamide/brimonidine, and latanoprost. Three of these four medications' cap colors lie along the blue-green spectrum, where overlapping color descriptors were frequent (Figure 3). High heterogeneity of color descriptors (11 or more color descriptors for a given medication) also significantly decreased patient-physician agreement. Indeed, in our study, patients produced nearly ten times as many unique color descriptors as the total number of medications. Medications that exhibited high heterogeneity included (number of color

descriptors provided in parentheses): latanoprost (12), levobunolol (13), betaxolol (14), brinzolamide/brimonidine (15), moxifloxacin (18), and cyclopentolate (19).

We hypothesized that communication based solely on cap color information may be worse in patients with more advanced glaucoma as a result of acquired color vision deficiencies. As a first step towards testing this hypothesis, we investigated whether greater glaucoma severity was associated with worse color vision. Our work corroborated prior studies that found that color vision deficiencies worsen with increasing glaucoma severity.^{19–23} A challenge inherent to this research is that acquired color deficiencies can be mild and of a different pattern compared to inherited deficiencies, and thus require specialized methods for evaluation using standard tests (e.g. the D15 CCI and an HRR scoring metric used here), especially given that these standard tests were originally designed to detect inherited defects.^{15,16,24–27} A majority of glaucoma patients in this cohort showed at least some evidence of color vision changes based on HRR score and D15 CCI, though some errors in color vision testing will be observed even in patients with no ocular disease (mean D15 CCI=1.04 in prior reports, as compared to 1.46 here).²⁸ Moreover, a greater degree of color vision loss correlated with increased VF damage, suggesting that glaucoma was responsible for the observed color changes. In multivariate models, only color vision deficiency (defined by lower HRR score) increased the likelihood of poor patient-physician agreement. Severity of VF loss did predict poor patient-physician agreement in univariate models, and may be a useful tool to gauge the ability to describe bottle cap color given that color vision is not routinely tested amongst glaucoma patients.

Our findings strongly reinforce that patients should be asked to bring their medications with them to appointments, particularly when there is a possibility of confusion (i.e. multiple medications, bottle cap colors consistent with multiple types of medications, etc.). Additionally, these findings also support the practice of encouraging patients to know the names of their medications, checking medication bottle labels before using the medications, and opening one medication bottle at a time to reduce the likelihood of accidentally switching the bottle caps of different medications. Moreover, given that color vision loss was associated with increased glaucoma damage, another option is for physicians to test the color vision of glaucoma patients or to discuss proper medication usage with the aid of sheets containing colored images associating medications with the color of their caps.

While these clinical changes may help reduce some miscommunication, systemic changes are likely needed to reduce confusion and maximize patient safety. Systemic changes may include instituting more unique or differentiated bottle cap colors (particularly along the blue-green spectrum), altering bottle shape or feel, creating multicolored medication bottles and caps, or employing other changes that may help further delineate medications. In particular, it may be important to introduce cap colors that would elicit fewer descriptors, as color descriptor heterogeneity (greater number of descriptors per bottle cap) predicted reduced patient-physician agreement on both univariate and multivariate analyses.

Is systemic change feasible? The current color-coding system was created in 1983 by the American Academy of Ophthalmology (AAO) out of concern for patient safety and is a purely voluntary system without formally published guidelines. The colors employed today

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were selected from the Pantone Matching System as they were thought to be sufficiently distinguishable by patients (though no work validated this process). Although the system is not enforced, both brand name and generic manufacturers have generally adhered to this system. Notable challenges to change exist, however, despite the low level of regulation. For instance, the dyes/resins used to achieve cap colors can potentially leach into the product, and are relevant in the stability experiments that precede medication release. As a result, manufacturers must be told the color of a medication class years in advance of release, and changing medication bottles/caps in any way may necessitate additional multi-year stability experiments. The required stability testing is costly, and changes may result in additional costs (e.g. re-marketing) that are ultimately borne by patients using the drops. Thus, desirable or necessary system-wide modifications may be difficult to achieve, and must balance safety/quality considerations with cost considerations.²⁹

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One limitation of our study was that physicians were forced to choose a medication based purely on bottle cap color. Other potentially identifying clinically relevant metrics that may be present during regular patient-physician interactions, such as dosing or size/shape of the bottle, were not available to the physicians. Similarly, physician clinical judgment (i.e. probability weighting of medications most likely to be used by patients) could not be incorporated. In practice, physicians may integrate their knowledge of which medications are commonly used to correctly identify medications (e.g. since light blue-capped betaxolol is rarely used, it is less likely a patient is referencing it). On the other hand, our study did not include medications with the same bottle cap colors (e.g. dorzolamide/timolol [Cosopt] and brimonidine/timolol), which must also be distinguished in practice, and are bound to result in disagreement not captured here. Although medical records may contain medication information of return patients, miscommunication may still occur when modifying treatment regimens just as it may when communicating with a new patient whose history is unknown. Future studies are needed to investigate direct, inperson patient-physician interactions to capture communication in a more clinically applicable context.

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In summary, there is a substantial need for a practical better system by which glaucoma patients can discern their many medications and accurately communicate their medication usage with physicians. Individuals with color vision deficiency have been noted to have difficulty recognizing a variety of colored objects (e.g. signal colors, wires, systemic medications), and our work demonstrates that topical ophthalmic medication bottle cap recognition may also be impaired.^{30–33} Miscommunication between patients and providers may foster confusion, resulting in inaccurate and potentially harmful changes in treatment regimens, and ultimately worsen health outcomes. Given the poor accuracy, reliability, and specificity of the current system, it is vital that changes are considered and introduced, though significant barriers exist that may hinder systemic change. An improved system would integrate dosing and entail the addition of more identifiable features to supplement bottle cap color, and may also benefit from being enforceable. Most importantly, ophthalmologists and other healthcare providers must be cognizant of potential errors in communication that is based on bottle cap color alone (particularly for medications with bottle cap colors along the blue-green spectrum) to protect patients from both confusion and harm.

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Abbreviations/Acronyms

AAO	American Academy of Ophthalmology
D15 CCI	Lanthony D15 color confusion index
dB	decibels
GEE	generalized estimating equations
HRR	Hardy-Rand-Rittler
IOP	intraocular pressure
logMAR	logarithm of the minimum angle of resolution
MD	mean deviation
VA	visual acuity
VF	visual field

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FIGURE 1.

Relationship between severity of better-eye visual field loss and color vision deficiency
HRR = Hardy-Rand-Rittler, MD = mean deviation, D15 CCI = Lanthony D15 color confusion index

FIGURE 2.

Distribution of words used to describe representative medication bottle caps. Representations are shown as word clouds for the medication bottles caps with the (A) median number of color descriptors (latanoprost, n=12) and the (B) highest number of color descriptors (cyclopentolate, n=19). The size of each word in the word cloud is proportional to the frequency with which it was used to describe the medication cap color. The color of each word is depicted via a typical representation of the color as found on <http://rgb.to>.

FIGURE 3.

Distribution of medications being referenced by commonly used patient color descriptors along the blue-green spectrum

This figure shows how glaucoma patients attributed five common colors to distinct medications whose bottle cap colors lie in the spectrum between blue and green, highlighting potential areas of confusion and ambiguity.

(A) “Blue” and “green” contain only patient responses “blue” and “green”, respectively (i.e. deep blue, kelly green, etc. are not included). (B) “Light blue” includes patient responses “light blue”, “baby blue”, “pale blue”, and “sky blue”. (C) “Blue-green” includes patient responses “blue-green”, “teal”, “aqua”, “turquoise”, “dark teal”, and “aquamarine”. (D) “Light green” includes patient responses “light green” and “pale green”.

*One patient attributed the color “green” to describe the bottle cap color of moxifloxacin.

FIGURE 4.

Distribution of patient-physician agreement per patient

Per-patient patient-physician agreement is defined as the percentage of the 11 patient-produced color descriptors that is accurately matched to the correct medicine by all 3 physicians.

TABLE 1

Demographic and visual characteristics of study participants

Variable	n = 100
Demographics	
Age, years	68.9 (10.5)
African-American Race, %	23
Female Gender, %	46
Education, years	15.4 (2.1)
Vision	
Better-eye Acuity, logMAR	0.11 (.13)
Visual Field MD, better eye	−4.7 (6.0)
Visual Field MD, worse eye	−10.9 (8.4)
HRR Score	17.6 (3.7)
D15 CCI	1.46 (0.48)

Values shown for continuous variables reflect means with standard deviations shown in parentheses.

logMAR = logarithm of the minimum angle of resolution; MD = mean deviation; HRR = Hardy-Rand-Rittler; CCI = color confusion index

TABLE 2

Degree of patient-physician agreement by medication

Medication	% Patient-Physician Agreement (3/3 physicians) (n = 100)	% Patient-Physician Agreement (2/3 physicians) (n = 100)
Betaxolol	0	42
Prednisolone acetate	0	100
Brinzolamide/Brimonidine	3	64
Latanoprost	13	77
Cyclopentolate	66	75
Levobunolol	76	91
Moxifloxacin	78	87
Brimonidine	83	100
Brimonidine/Timolol	92	94
Dorzolamide	97	98
Pilocarpine	98	99

Patient-physician agreement was defined as present if all three physicians correctly matched a bottle cap color provided by a patient to the proper medication whose bottle cap the patient had described.

In column 2, this definition was loosened such that patient-physician agreement was present if at least two out of the three physicians made the accurate identification, as described above.

TABLE 3

Factors affecting likelihood that all three physicians match a color descriptor to the correct medicine

		Univariate	
Variable	Interval	OR (95% CI)	P-value
Demographic			
Age	10 years older	0.93 (0.83 – 1.05)	0.24
Male	vs. Female	0.98 (0.77 – 1.25)	0.88
African American	vs. Not African-American	1.15 (0.87 – 1.53)	0.34
Education	4 years less	1.02 (0.82 – 1.29)	0.84
Vision			
VA, better eye	0.1 logMAR worse	1.08 (0.98 – 1.18)	0.13
VF MD, better eye	5 dB worse	0.90 (0.81 – 0.99)	0.03
HRR Score	1 point lower	0.96 (0.93 – 0.99)	0.01
D15 CCI	.1 points lower	1.03 (1.00 – 1.05)	0.04
Color Descriptors			
High Heterogeneity*	vs. Low Heterogeneity	0.23 (0.18 – 0.29)	<0.001

* High heterogeneity is defined as 11 color descriptors for a presented bottle cap color.

VA = visual acuity; logMAR = logarithm of the minimum angle or resolution; VF = Visual field; MD = mean deviation; dB = decibels; HRR = Hardy-Rand-Rittler; CCI = color confusion index