MEDUCATION: A RANDOMIZED CONTROLLED TRIAL OF AN ONLINE EDUCATIONAL VIDEO INTERVENTION TO IMPROVE GLAUCOMA EYE DROP TECHNIQUE AND ADHERENCE

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A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Division of Pharmaceutical Outcomes and Policy in the UNC Eshelman School of Pharmacy.

Chapel Hill
2018

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ABSTRACT

Scott A. Davis: Meducation: A Randomized Controlled Trial of an Online Educational Video Intervention to Improve Glaucoma Eye Drop Technique and Adherence
(Under the direction of Betsy Sleath)

Glaucoma is the second-leading cause of blindness in the United States. Progression of glaucoma can be prevented by reducing intraocular pressure using eye drop medications, but patients tend to have difficulty instilling eye drops correctly. Short educational videos may be helpful to instruct patients on correct eye drop instillation, but only one small study testing an educational video for glaucoma eye drop technique has been performed to date. Therefore, the objective of this dissertation was to determine the effectiveness of an online video intervention in improving self-efficacy, technique, and adherence to eye drops in glaucoma patients.

Ninety-two patients with glaucoma, who self-administered their own eye drops and had less than perfect technique, were enrolled in this pilot randomized controlled trial. They were randomized to watch the Meducation® eye drop technique video in the intervention group, or a nutrition video in the control group. Five eye drop technique steps were assessed using objective video recordings at baseline, immediately after the video, and 1 month later. The secondary outcomes were eye drop technique self-efficacy and medication adherence. Linear regression models were used to determine whether the intervention group had better self-efficacy, technique, and adherence than the control group after adjusting for important covariates.

Adjusted for baseline self-efficacy, intervention patients had better eye drop technique self-efficacy than controls immediately after the video ($p=0.024$) and at 1 month ($p=0.015$). Adjusted for baseline technique and other covariates, eye drop technique averaged 0.75 steps better in intervention patients than controls immediately after the video ($p=0.002$) and 0.63 steps better at 1 month ($p=0.011$). The intervention did not significantly improve adherence. Participants' mean rating of usefulness of the video was 3.40 on a 4-point scale. Patients' most preferred method for having access to the intervention was in the doctor's office exam room, but also desired online options for watching the video.

We concluded that a short educational video can significantly improve glaucoma patients' self-efficacy and eye drop technique. The video should be disseminated in multiple ways: in the exam room when drops are prescribed as well as online.

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AAO	American Academy of Ophthalmology
AD	Atopic dermatitis
ART	Antiretroviral therapy
BG	Blood glucose
BP	Blood pressure
CABG	Coronary artery bypass graft
CFS	Chronic fatigue syndrome
CI	Confidence interval
CPAP	Continuous positive airway pressure
DWM	Days without medication
EHR	Electronic health record
EMR	Electronic medical record
ER	Emergency room
ESRD	End-stage renal disease
FMD	Frequency of Missed Dose
GTCAT	Glaucoma Treatment Compliance Assessment Tool
HBM	Health Belief Model
HD	Hemodialysis
HIV	Human immunodeficiency virus
HRQOL	Health-related quality of life
IMB	Information-Motivation-Behavioral Skills
IOP	Intraocular pressure

IRB	Institutional Review Board
LOCF	Last observation carried forward
MAR	Missing at random
MCAR	Missing completely at random
MDI	Metered dose inhaler
MEMS	Medication Event Monitoring System
MI	Motivational interviewing
MMAS	Morisky Medication Adherence Scale
MPR	Medication possession ratio
NA	Not applicable
NS	Not significant
OAG	Open-angle glaucoma
OAT	Oral anticoagulant treatment
OR	Odds ratio
OSA	Obstructive sleep apnea
PACG	Primary angle-closure glaucoma
PDC	Percentage of days covered
PEF	Peak expiratory flow
PHR	Personalized health record
POAG	Primary open-angle glaucoma
POEM	Patient-oriented eczema measure
QOL	Quality of life
RA	Research assistant

RCT	Randomized controlled trial
REALM	Rapid Estimate of Adult Literacy in Medicine
RNFL	Retinal nerve fiber layer
RR	Relative risk
SCT	Social cognitive theory
SD	Standard deviation
SF-12 MCS	Short Form-12 Mental Components Scale
SF-12 PCS	Short Form-12 Physical Components Scale
TDA	Travatan Dosing Aid
UNC	University of North Carolina
VAS	Visual analog scale
VF-14	14-item Visual Function Questionnaire

Chapter 1: Introduction

1.1 Overview

Glaucoma affects over 2 million Americans, and about one-sixth of cases eventually result in blindness.[1,2] Eye drops are the first-line treatment for patients with glaucoma, aiming to decrease intraocular pressure (IOP).[3] Proper eye drop technique involves multiple steps to instill the medication into the eye for maximum effectiveness without contamination. However, in today's rushed and overburdened clinical settings, many patients are prescribed eye drops with little or no instruction on proper self-administration technique.[4,5] When patients do not instill eye drops correctly, their clinical outcomes can be negatively affected.[5] Glaucoma that is not effectively treated with eye drops can lead to blindness or the need for eye surgery. Therefore, improving technique and adherence to eye drop therapy is a major unmet need that can likely be addressed by novel educational interventions.

Short instructional videos that can be watched on a website, tablet, or smartphone, offer the potential to instruct patients either during or after clinic visits, with little or no time burden to the provider. Animated videos can be provided in multiple languages. The Meducation® system (Polyglot Systems, Morrisville, NC) has shown success with improving inhaler technique in asthma[6] and adherence to daily medication for cardiovascular conditions.[7] Although many eye drop technique videos exist on YouTube and other websites, no peer-reviewed literature has

evaluated any of these videos to determine whether they actually improve eye drop technique in glaucoma patients. Existing YouTube videos do not cover all the important steps in correct eye drop technique, and often use language that is too difficult for low literate patients, who tend to have the greatest need for education to improve their technique and adherence.[8] The new Meducation eye drop technique video is designed to explain all the major technique steps in more accessible language. This dissertation evaluated the impact of the Meducation eye drop technique video on technique and adherence in a randomized controlled trial of glaucoma patients, making this the first study to evaluate the effectiveness of an eye drop technique online video intervention.

1.2 Specific Aims

A major reason that glaucoma patients do not achieve proper control of intraocular pressure, which can potentially lead to blindness, is patients' improper eye drop instillation technique. In a recent study, 60% of patients contaminated their eye drop bottle by touching the eye or face with the bottle tip, 10% missed the eye, and 49% wasted drops by not squeezing the bottle to produce exactly one drop.[9] Just 18.5% of patients reported that their physicians had explained correct technique to them.[5] Indeed, physicians usually lack adequate time to instruct patients on the proper use of eye drops,[9] so there is an ***urgent need*** for effective methods to communicate proper technique to patients with minimal time burden to providers.

Educational videos are a promising method for patient education on self-management of chronic diseases, but only one small study, and no randomized controlled trials, have specifically used video instruction to improve patients' eye drop technique.[10] In that study (n=34), Feng et al. used a video plus educational handout and observed an improvement in average technique score

from 2.53 out of 15 points at baseline, to 6.15 points immediately after the intervention ($p=0.008$).[10] The only other intervention studies addressing eye drop technique focused on either a mechanical dosing aid, live provider education, or printed instructions to educate patients.[11,12] Given the gap in knowledge of interventions to improve eye drop technique in glaucoma, and the research gap in evaluating the effectiveness of eye drop technique videos, an effective video intervention offers considerable potential to teach patients proper technique and improve their outcomes, while saving the healthcare system the costs of improperly instilled eye drops. Social Cognitive Theory states that improving patients' self-efficacy to perform a health behavior correctly is the key to enabling continued regular performance of the behavior.[13] This study tested the Meducation® eye drop technique video developed by Polyglot Systems, a company that makes educational materials for low literate patients, to see how well it can improve eye drop technique. The video instructs patients on all the critical steps of proper eye drop technique and has not yet been tested in a real-world population. The video can be made accessible on mobile devices and at home so that patients can watch it anytime, at their convenience. Our *overall objective* was to determine how well a video works to improve patients' eye drop technique self-efficacy, technique, and adherence to treatment. Our *central hypothesis* was that glaucoma patients who watch the Meducation video would have improved self-efficacy, technique, and adherence compared to patients who receive standard care.

Therefore, we conducted a randomized controlled trial in which 92 glaucoma patients either watched the Meducation video or received standard care. Those in the experimental group watched the Meducation video, and those in the control group watched a 3-minute nutrition video on cooking with whole grains. To be enrolled, patients had to self-administer their eye drops and perform at least one eye drop instillation step incorrectly. Patients were recruited at an

academic ophthalmology clinic in suburban North Carolina and a private practice in urban Maryland. Eye drop technique was objectively assessed by video recording at three time points: before watching the video, immediately after watching the video, and at 1-month follow-up. This trial was expected to achieve the following specific aims:

Aim 1: To determine whether glaucoma patients' eye drop self-efficacy and technique are improved <u>immediately after</u> watching a video instructing them on proper technique.

The primary comparison was the number of steps performed correctly immediately after watching the Meducation or nutrition video by members of the intervention group compared to members of the control group.

Aim 2: To determine whether intervention patients have better self-efficacy, eye drop technique, and medication adherence than control patients at <u>1 month</u> after study enrollment.

The primary comparison was the number of steps performed correctly at 1 month by members of the intervention group compared to members of the control group.

Aim 3: To describe patient perspectives on how to improve the video and how to disseminate it to other glaucoma patients.

Patients completed interview questions at the end of the study on improving the video and disseminating it to other patients.

Completion of these aims is expected to fill a significant gap in our understanding of how providers can use videos to educate patients about correct eye drop technique at a very low cost with minimal time burden. The video intervention also has the potential to be disseminated nationwide with minimal resources. Patients who have improved technique will likely avoid loss

of vision, and will be less likely to incur unnecessary costs by wasting medication. If the video is effective, providers may benefit from being able to improve patient satisfaction and reach patients with evidence-based instruction that is easily understood, even by low literate patients.

1.3 Significance

Glaucoma is a chronic eye disease that is one of the leading causes of blindness in the United States, especially in African Americans.[1,2,14] Eye drops are the usual treatment to prevent progression of glaucoma,[3] but are difficult to use properly.[15] Studies show that more than half of patients contaminate the tip of the eye drop bottle by touching their eye or face.[5,9] Patients also frequently miss the eye or waste drops by not squeezing the bottle correctly. These problems with technique can prevent patients from reaping the full benefit of the medications, can give rise to unanticipated eye infections, and may cause patients to become frustrated and discontinue the regimen altogether.[16] Health disparities also exist in eye drop technique and adherence; African American race and lower educational level tend to be associated with worse technique and adherence.[4,9,17]

Studies show that healthcare providers usually lack time during clinical visits to educate patients adequately on correct eye drop technique.[9,18] Thus, interventions that can be delivered outside the clinical setting are needed to promote correct eye drop technique.[19] Yet few such interventions have been developed and evaluated. The only study using a video was a pre-post study of 34 participants by Feng et al., which showed an improvement from an average score of 2.53 out of 15 possible points before the video, to 6.15 points after ($p=0.008$).[10] Another study by McVeigh and Vakros investigated an educational intervention, which consisted of a printed eye drop chart with detailed instructions. This intervention increased performance of hand washing

from 64% to 92%, shaking the bottle from 40% to 84%, and punctal occlusion from 44% to 72%.[11] However, technique was assessed by self-report; thus, patients may have overestimated their improvement. The design also lacked a control group, and patients failed to show improvement in instilling exactly one drop and avoiding contamination of the bottle tip. In addition, although not directly addressing technique, Okeke et al. showed that a multifaceted intervention consisting of an educational video, reminders, and a review of barriers with a study coordinator significantly improved adherence to glaucoma eye drops.[19] However, there were no data on the effect of the video alone, and the intervention appeared less effective in African American patients.

Educational interventions using short videos have shown success in other diseases, catering to many patients' preferences for visual learning, and allowing repetition as many times as necessary to learn complex skills.[6,7] The Meducation® system developed by Polyglot Systems consists of customizable printed materials and videos in 21 languages that can be accessed online or on smartphones. The new Meducation video on eye drop technique explains each of the 5 critical steps in plain language, very much like a clinician would demonstrate the procedure to patients. The present pilot randomized controlled trial assessed patients' technique self-efficacy, eye drop instillation technique, and medication adherence immediately and 1 month after watching the Meducation video. In addition to the specific features of the Meducation video and the fact that it can be accessed online, this study was expected to be an advance over prior studies because it used a randomized controlled design, included a 1-month return visit to measure intervention effect over a period of time, was well powered (n=92, providing 80% power to detect a difference in technique between intervention and control groups), and also assessed the relationship between technique and medication adherence. Intervention group

patients viewed the 4-minute Medication video in the clinic and had online access to view it again at home by computer or smartphone, while control group patients viewed a 3-minute nutrition video called "How to Cook with Budget Friendly Whole Grains". *We anticipated that the study results would be significant because patients who successfully learn better eye drop technique can have a greatly improved chance of performing the crucial skill of eye drop instillation correctly, without added burden to overworked clinicians.*

This study was also innovative because it assesses eye drop technique objectively by video recording and used a masked observer to score each patient's technique. Some studies, such as the previous intervention study by McVeigh and Vakros, used a self-report questionnaire, which is too reliant on patients' ability to assess and report their own performance accurately.[11] Feng et al. video-recorded each patient's technique, but the recordings were scored by an unmasked researcher.[10] Another intervention study by Lazcano-Gomez et al. used video recording and showed significant improvements in technique, but required a great deal of physician time to educate the patients.[12] Observational studies have also found video recording of eye drop technique to be highly reliable and effective.[9] The present study combined the best available method of technique assessment – video recording of the patient's technique – with a practical intervention that takes essentially no clinician time to deliver.

If successful, the Medication video can be disseminated to millions of patients on clinic websites, in waiting rooms, or via YouTube. By enabling more patients to successfully manage their glaucoma by using eye drops correctly, costs to both the healthcare system and society may be reduced. Patients who avoid vision loss may preserve their ability to stay in the workforce or

perform more tasks of daily living independently, avoiding expensive long-term care costs. Future studies will assess the impact of the Meducation video on clinical outcomes and long-term effects of avoiding vision loss.

Chapter 2: Literature Review

2.1 Glaucoma: Importance and Disease Burden

2.1.1 Disease characteristics

Primary open-angle glaucoma (POAG) is a common, chronic, progressive eye disease.[20,21] Glaucoma is characterized by elevated intraocular pressure (IOP), which gradually leads to several adverse consequences to different parts of the eye.[20] In POAG, increased resistance to aqueous humor drainage through the trabecular meshwork keeps IOP elevated, whereas in primary angle-closure glaucoma (PACG), the drainage pathways tend to be obstructed by the iris.[20] The result of the increasing IOP is stress and strain on the posterior part of the eye, especially the lamina cribrosa. As glaucoma progresses, the retinal ganglion cells and their axons gradually suffer degeneration, which leads to a gradual narrowing of the range of vision until complete blindness may result.[22]

Despite a strong correlation between IOP and glaucoma symptoms, there is not a certain level of IOP that is necessarily associated with glaucoma.[21,22] Some patients with relatively normal IOP can have damage from glaucoma, while some patients with elevated IOP may not ever develop glaucoma. Therefore, glaucoma must be diagnosed by inspecting the optic nerve head and retinal nerve fiber layer using an ophthalmoscope, examining optic nerve head photographs, or any of several more advanced methods.[20] Glaucoma is asymptomatic in its early

stages, so patients often do not realize that they have it until they start to lose vision. Therefore, it is important to screen for glaucoma every 1-2 years in patients ages 65 or older, and also consider regular screening in younger patients who are African American or have a family history of glaucoma.[20-22]

PACG usually must be treated with surgery, unlike POAG, which can be treated with topical medications to lower IOP (see section 2.2 below).[20] The pathophysiology of PACG is substantially different, and since PACG is usually not susceptible to management with medications, the present study focused on POAG. PACG is more common in Asian populations, particularly in China and India, and relatively less common in populations of African or European descent.[21] It is estimated that 80% of cases of glaucoma in the United States are POAG.[20] Our clinics treat many more patients with POAG than PACG, so the availability of study subjects was anticipated to be adequate if we focused only on POAG.

2.1.2 Prevalence

Glaucoma is estimated to affect 70 million people worldwide[20] with the number expected to rise to 79.6 million by 2020.[23] Worldwide, prevalence of open-angle glaucoma (OAG) is estimated to be greatest in African-descent populations, somewhat elevated in Latin American and Chinese populations, and lower in European, Indian, and Japanese populations.[23] Seventy-four percent of glaucoma sufferers worldwide in 2010 are estimated to have OAG, including 89% in European populations and 96% in African populations, while angle-closure glaucoma accounts for nearly half the cases in China.[23]

In the United States, 2.71 million people were estimated to have POAG in 2011.[24] The onset of glaucoma typically occurs after the age of 60.[21] Glaucoma prevalence increases with

age, although leveling off in the oldest age groups; POAG affects 5.1% of the population aged 70 to 79 and 4.0% aged 80 or older.[24] Women account for slightly more of the cases than men, but after adjusting for the age distribution, both sexes have equal prevalence.[24] Prevalence of POAG is much higher in African Americans (1.6%) and Latinos (1.4%) than in non-Hispanic Whites (0.6%).[24,25] After adjustment for age, POAG prevalence may be as much as four to five times higher in African Americans than in Whites, starting at a younger age and ultimately reaching over 10% in African Americans age 80 or older.[26] By 2050, an estimated 50% of POAG cases in the US may be in Latinos, as the Latino population continues to increase and Latino life expectancy also increases, especially for Latino men.[24] Overall, the number of Americans with POAG is expected to almost triple to 7.32 million by 2050.

2.1.3 Health impact

Glaucoma is generally asymptomatic in its early stages, but then leads to a gradual constriction of the visual field in its advanced stages, ultimately resulting in total blindness for some patients.[20] Due to the lack of symptoms in early glaucoma, only about 10-50% of people who have glaucoma are aware of their condition.[20] However, as the disease progresses, the impact can rapidly become more severe, and an estimated 10% of glaucoma sufferers worldwide are blind in both eyes.[23] Glaucoma is the second leading cause of blindness globally, and, in the US and other developed countries, only age-related macular degeneration causes more blindness.[27] In a chart review by Peters et al., one-sixth of open-angle glaucoma patients eventually became bilaterally blind.[2]

POAG has a particularly profound effect on health-related quality of life in African Americans, both due to increased genetic susceptibility and less successful treatment compared

to White patients.[22] Age-adjusted POAG prevalence is four to five times higher in African Americans,[26] and African Americans were found to be 45% less likely to receive surgery than one would expect given the prevalence, strongly suggesting undertreatment in this population.[14] As a result, rates of blindness from glaucoma in African American patients were six to eight times higher than in White patients.[26,28] To improve outcomes in African Americans with glaucoma, more frequent screening has been emphasized in the hope of detecting glaucoma earlier.[3,22] Better medication treatment, including earlier initiation of eye drops and greater attention to ensuring correct usage of eye drops, is also a key to reducing the persistent racial disparity in glaucoma outcomes, as will be discussed in sections 2.3 and 2.4.

2.1.4 Economic, quality-of-life, and societal impact

Due to the frequent vision loss and eventual blindness that often results from glaucoma, uncontrolled glaucoma is associated with substantial economic impact. Rein et al. estimated the economic burden from glaucoma at $2.9 billion direct costs in 2006.[29] However, Varma et al. estimate that the burden could be twice as large if all patients were treated.[30] For patients who become blind, indirect costs become the main reason for high costs.[30] Data from a US setting are sparse, but a study in Europe estimated that the total costs associated with glaucoma-related blindness rise from 429-523 euros per patient to 11,578-19,111 euros once indirect costs, such as assistance provided by families or professional caregivers, are considered.[31] Thus, preventing blindness with more attention to glaucoma treatment is probably cost-effective, despite the high cost of glaucoma medications.[30,32,33] To the extent that there is debate about cost-effectiveness of IOP-lowering treatment, it concerns whether to treat people who have ocular hypertension but

have not yet been diagnosed with glaucoma.[32] There is agreement that glaucoma, once diagnosed, must be treated.

Even relatively early-stage glaucoma can affect patient health-related quality of life (HRQOL).[34] Negative HRQOL impact is associated in an approximately linear fashion with the extent of vision loss. Societal burden from glaucoma can include burden on caregivers when patients lose the ability to live independently due to loss of vision. Even for patients with less severe impairment, vision loss can hinder them from walking, reading, or driving, creating a significant impact on activities of daily living and causing them to require additional help from others to perform basic tasks.[30,34,35] In addition, vision loss can start a downward spiral in quality of life if it impairs patients from being able to instill eye drops accurately into the eye, causing diminished medication effectiveness. This issue will be addressed in section 2.3.

2.2 Treatments for Glaucoma: The Role of Eye Drops

2.2.1 Overview of glaucoma treatments

Both medical and surgical options exist for treating POAG.[36] All these options are directed at lowering IOP to prevent glaucoma progression and minimize the adverse consequences of POAG; lowering IOP receives a strong recommendation in the American Academy of Ophthalmology (AAO) Preferred Practice Pattern® Guidelines.[36] In addition to managing the IOP in a target range, the goals of treatment also include maintaining a stable optic nerve and retinal nerve fiber layer (RNFL) status, and stable visual fields. The target IOP should be set at a value that is expected to maintain a patient's vision and result in minimal quality-of-life impact for the rest of the patient's lifetime.[36] There is good evidence that reducing IOP by 25% substantially slows progression of glaucoma.[36] However, a greater target reduction may be

desirable if a patient is already suffering rapid progression or major damage from glaucoma, or in the presence of additional risk factors such as a family history of poor outcomes from glaucoma.[20,36] Meanwhile, a smaller target reduction may be chosen if a patient is particularly intolerant to treatment or has only a short life expectancy remaining.[35,36]

The main treatment options to lower patient IOP are medications, laser trabeculoplasty, and incisional glaucoma surgery.[36] Medications are considered the first-line treatment for most patients, with multiple medications often being used when response to the first medication is suboptimal. Laser trabeculoplasty can be considered a first-line option for patients who are especially unable to adhere to a medication regimen or have intolerance to medications. For example, patients who are physically unable to instill eye drops and cannot obtain assistance from a caregiver may not be appropriate candidates for medication therapy.[35] Incisional glaucoma surgery, such as trabeculectomy, is often associated with more complications, but can be considered first-line therapy in rare cases.[20,36] Both laser trabeculoplasty and incisional glaucoma surgery can also be considered as second-line options when IOP is not effectively controlled by medications.[20,36] However, most POAG patients will initially be prescribed medications, so there is a significant opportunity to improve glaucoma outcomes by addressing medication technique and adherence (see sections 2.3 and 2.4).

2.2.2 Eye drops in glaucoma treatment

Guidelines suggest initiating medication therapy for POAG with topical medications, specifically eye drops.[36] Prostaglandin analogs are the most common eye drops prescribed and generally considered the first-line therapy,[20] but there are also several other categories of eye drops such as beta-blockers, alpha$_2$-adrenergic agonists, parasympathomimetics, and carbonic

anhydrase inhibitors.[36] Prostaglandin analogs are normally dosed once daily and include bimatoprost, latanoprost, and travoprost.[35] A meta-analysis of 114 RCTs suggested that the prostaglandin analogs were the most effective, with bimatoprost showing the greatest mean IOP reduction, followed by latanoprost and travoprost.[37] All the classes of drugs that were studied showed significant efficacy compared to placebo; however, the meta-analysis suggests that prostaglandin analogs may offer the best chance to achieve the recommended 25% IOP reduction.[37] Latanoprost was the most commonly prescribed glaucoma medication in the United States in a study using 2006-2009 data.[38] Both latanoprost and travoprost are now available as generics.[39,40] Using the Clinformatics DataMart database, Stein et al. reported that adherence increased when patients switched from brand-name bimatoprost, latanoprost, or travoprost to generic latanoprost.[39] Guidelines do not currently specify that any single prostaglandin analog should be preferred over the others.[36] However, prescribing generics would help to alleviate cost-related barriers.[41]

Barriers to successful real-world use of eye drops include difficulty instilling the eye drops correctly, as well as poor adherence for a variety of reasons, including cost, side effects, forgetfulness, complex regimens, running out of medication early, and beliefs that the medication will not help. These barriers will be discussed in detail in the next two sections.

2.3 Eye Drop Technique

2.3.1 Importance

Correct eye drop technique is critically important to reaping the full benefit of eye drops in preventing progression of glaucoma. This section will explain how poor eye drop technique is

widespread and results in patients not controlling their IOP, causing faster progression to blindness.

Correct eye drop technique requires a number of steps that are essential to get the medication into the conjunctival sac (or pocket) of the eye where it can confer the greatest benefit, while avoiding contamination of the bottle that can result in unwanted side effects. The steps that are addressed in the Meducation video are shown in Table 2.1. Polyglot Systems referenced the same resources reviewed in this dissertation, such as practice guidelines and evidence-based online instructional materials derived from the guidelines, when developing the video.[42-49]

Table 2.1: Steps in eye drop technique[11]
• Washing hands before instillation*
• Mixing the medication by turning the bottle over*
• Squeezing the bottle to instill a single drop
• Holding open the lid with the finger
• Getting the drop accurately into the eye
• Not touching the bottle tip to the eye or face
• Closing the eye after instillation
• Punctal occlusion*
• Removing excess fluid*

*Cannot be measured in this study

First, patients must wash their hands to keep the bottle sterile when they touch it. Second, they should mix the medication by turning the bottle over several times. Shaking the bottle introduces unwanted air bubbles, but turning the bottle over mixes the medication without creating air bubbles. Third, patients must squeeze the bottle firmly for just long enough to squeeze out one drop, not several drops or a stream of drops. The eye can only hold one drop, so squeezing out multiple drops, even if they are aimed accurately, tends to cause liquid to spill out of the eye and down the face. Fourth, patients must hold open the lower eyelid with the finger of

the non-dominant hand to expose the conjunctival sac. Fifth, patients must get the drop accurately into the eye. Sixth, they must not touch the eye or face with the bottle tip at any time, due to risk of contaminating the bottle with the facial microbiota. Seventh, they must close the eye after instillation. Eighth, they should perform punctal occlusion by placing the finger on the inside of the closed eye and exerting gentle pressure to prevent the medication from traveling through the tear duct into the nose. Finally, they should remove excess fluid from the face with a tissue. As described below in section 2.3.2, not touching the eye or face with the bottle is the most frequently missed step in the existing literature, followed by squeezing out more than one drop and getting the drop accurately into the eye.[5,9,50,51] The other steps may also be problematic, but have rarely been assessed in studies.

The present study did not assess 4 of the steps included in Table 2.1: hand washing, mixing the medication, punctal occlusion, and removing excess fluid. Although the 4 excluded steps are also among the steps covered in the Meducation video, objective video recording of technique is intended to make this study more rigorous, and the excluded steps cannot be directly observed. Mixing the medication is necessary only for some suspensions such as brinzolamide, while most glaucoma medications are solutions.[52] Punctal occlusion is also not necessarily recommended by all ophthalmologists for all patients; gently closing the eye for one minute is considered an equivalent alternative.[42] Many studies have assessed only three steps: squeezing the bottle to instill a single drop, getting the drop accurately into the eye, and not touching the bottle tip to the eye or face.[5,9,53] At the opposite extreme, Feng et al. used a 15-point checklist, deducting points for making multiple attempts in each eye, and also including tilting the head back, looking up, replacing the bottle cap without touching the tip, and two separate items related to contaminating the bottle.[10] McVeigh and Vakros (using self-report) assessed 12 steps,

including waiting 5 minutes between instilling multiple eye drops, using drops before using ointments, and discarding the bottle after 28 days of use.[11] The first two of these are only applicable to patients who use multiple eye drops or ointments in addition to eye drops, and discarding the bottle after 28 days cannot be objectively assessed.

The consequences of incorrect technique can be severe in terms of both effectiveness and safety. In addition to low medication effectiveness from not getting the medication correctly into the eye, poor eye drop technique can include contamination of the bottle and consequent eye infection with the microorganisms that grow on the contaminated bottle (infectious keratoconjunctivitis).[12,54] Eye infection can be painful and can itself endanger vision.

In addition, patients who routinely squeeze the bottle incorrectly, producing multiple drops or a stream of drops, are likely to run out of drops more quickly than intended. They may not be able to obtain a new supply of drops until the next date they are allowed to get a refill. Even if they are allowed to get a refill sooner, eye drops are expensive at approximately $62 out-of-pocket for a 5 mL bottle,[55] and patients may not be able to afford the cost. By needing extra refills, patients who waste drops also incur unnecessary costs to the broader healthcare system, including Medicare, Medicaid, and private payers. Wong et al. performed a cost-consequence analysis of bimatoprost 0.01% versus bimatoprost 0.03% and estimated that $3433 could be saved over each patient's lifetime by using bimatoprost 0.01% instead of bimatoprost 0.03%, due to savings in medical resource use from the better average adherence to bimatoprost 0.01%.[55] These results did not take into account imperfect technique, and therefore the more adherent bimatoprost 0.01% patients were assumed to incur $466 more in drug costs over their lifetime, which was outweighed by a $3900 savings in non-drug costs such as medical visits, skilled

nursing facility care, and home healthcare. Therefore, the results may be even more dramatic if poor technique is taken into account.

2.3.2 Observational studies on eye drop technique

Patients report receiving little education from their providers on eye drop technique.[5,56] Just 18.5% of patients in the study by Gupta et al. in India reported receiving instruction from their physician on correct technique.[5] Similarly, in a study of 738 patients by Cohen Castel et al. in Israel, 16% of patients reported being explained eye drop technique by their family physician.[56] In a US context, in a large observational study where the medical visit was videotaped, analysis of the videotapes revealed that only 40 of 255 patients (16%) received instruction about eye drop administration.[9] Patients who did not have questions about eye drop administration had 4.8 times the odds of instilling exactly one drop as those who had at least one question, indicating that it is important to elicit questions from patients who may not have good understanding, and provide additional instruction if needed.[9] Having received instruction on eye drop instillation has been associated with better technique.[16]

Using the PubMed search terms "eye drop AND technique AND glaucoma", 17 observational studies were found that collected data on eye drop technique (Table 2.2a). Most studies were in agreement that not getting the medication into the eye, touching the tip of the bottle to the eye or face, and wasting drops were a problem for a significant number of patients. Five studies found that more than half the patients touched the bottle tip to the eye or contaminated the bottle.[5,9,12,50,57]

Table 2.2a. Observational studies assessing eye drop instillation technique

Author, Year	Design	Outcome Measure	Results
Hennessy 2010[54]	Single-group observational, n=204	Successful instillation of a drop onto the ocular surface from video recording of technique	71% able to get any drops onto the ocular surface; 52% able to get exactly 1 drop onto the ocular surface; 39% able to get exactly 1 drop onto the ocular surface w/o touching ocular surface
Hennessy 2011[58]	Prospective observational of pts w/visual impairment, n=205	Correct instillation measured by video recorded observation	33% touched the eye with bottle tip; 29% could not get a drop into the eye
Sleath 2011[53]; Sleath 2012[59]	Longitudinal observational, n=102	Video recording of technique	38% had perfect technique; 80% got a drop in the eye on the first attempt; 70% instilled only 1 drop; 34% touched eye or eyelash with bottle tip; 52% touched face
Tatham 2013[16]	Cross-sectional observational, n=85	Video recording of technique	54.1% had poor technique; 11.8% missed eye, 15.3% touched tip of bottle to eye, 27.1% touched tip of bottle to eyelid or lashes
Strungaru 2014[60]	Observational cross-sectional, n=30	Video recording of technique	After implementing a mirror-hat drop delivery aid, 13% contaminated the bottle (p=0.02); 86.7% could see the drop with the device (p=0.0005)
Sayner 2016[9]; Carpenter 2015[61]	Longitudinal observational, n=279	Video recording of technique	51% instilled exactly 1 drop; 90% got the drop in the eye on the first attempt; 60% touched the eye or face with the bottle tip; Provider education about adherence and provider inclusion of patient input into treatment plan predicted decrease in IOP; Relationships not mediated by adherence or eye drop technique
Tsai 2007[18]	Single-group observational survey, n=253	Self-reported method of administering eye drops	82.6% self-administered drops; 36.4% administered drops standing, 37.8% sitting, 31.6% lying down; 16.3% used mirror; 36.4% always washed hands before administration; 25.4% always, usually, or sometimes touched their eye w/tip of bottle
Kholdebarin 2008[17]	Observational survey, n=500	Self-reported	6.8% missed eye, 28.8% contaminated bottle when instilling drops
Curtis 2009[62]	Cross-sectional survey, n=100	Self-reported (responses to questionnaire)	23% did not know the names of their eye drops; 13% said they had problems instilling the drops; 49% correctly closed their eyes after instillation; 41% had poor understanding of glaucoma, 49% had partial understanding, 10% had good understanding

Author, Year	Design	Outcome Measure	Results
Kawai-Tsuboi 2015[63]	Single-group cohort, n=67	Self-reported (5-item questionnaire of technique and adherence)	76.1% instilled exactly 1 drop; 62.7% instilled it accurately
Taylor 2002[64]	Focus groups, n=21	NA	Most patients had misconceptions about technique, although they thought they knew the correct technique
Brown 1984[57]	Observational cross-sectional, n=150	Direct observation by examiner	13% failed to instill drops in both eyes after one or more attempts; 80% contaminated the bottle; 82% claimed to have no difficulty using the medications properly; 21% unnecessarily tried to instill >1 drop in one or both eyes
Hosoda 1995[50]	Single-group observational, n=142	Direct observation by examiner	39.4% instilled one drop; 54.9% touched eye with tip of bottle
Konstas 2000[65]	Observational survey, n=100	Direct observation by examiner	53% very capable of instilling medication correctly
Ikeda 2008[66]	Single-group observational, n=27	Direct observation by examiner	20% performed entire technique correctly; 60% did not close eyes, 70% did not compress the nasolacrimal region after application; 63% reported they sometimes forgot to apply eye drops; 41% washed hands before using eye drops; 85% applied exactly one drop
Gupta 2012[5]	Single-group cohort, n=70	Direct observation by examiner	Used 1.8 drops per instillation; 50% squeezed out exactly 1 drop; 68.6% did not misdirect the drop; 75.7% touched the eye with the bottle tip; 8.5% performed all steps correctly
Schwartz 2013[51]	Secondary analysis of RCT data, n=163	Direct observation by examiner	88.6% reported having no difficulty administering eye drops; 18.2% touched eye or adnexa with bottle; 10.3% missed eye; 11.3% administered more than 1 drop

IOP, intraocular pressure; NA, not applicable; RCT, randomized controlled trial

Most studies assessed the eye drop technique steps of instilling exactly one drop, getting the drop accurately into the eye, and avoiding contamination of the bottle; a few also assessed hand washing, closing the eye after instillation, and punctal occlusion (Table 2.2a). Contaminating the bottle by touching the eye or face was the most frequently missed step. Reported rates of contaminating the bottle in eight different studies ranged from 18.2%[51] to 80% (Table 2.2b).[57] Two other studies reported separate estimates for touching multiple sites with the bottle; 34% of patients touched the eye or eyelash and 52% touched the face in the study by Sleath et al.,[59] and 15.3% touched the eye and 27.1% touched the eyelid or lashes in the study by Tatham et al.[16] The three studies with the lowest rates of contaminating the bottle used a self-reported measure of technique[17,18] or used patients already enrolled in an RCT;[51] therefore, it is likely that the higher estimates are more accurate for typical patients.

Table 2.2b. Frequency of missing each eye drop technique step in observational studies

Step (number of studies)	Range of estimates of patients performing step incorrectly	Estimates
Contaminating the bottle (n=10)	18.2 – 80%	18.2%,[51] 25.4%,[18] 28.8%,[17] 33%,[58] 54.9%,[50] 60%,[9] 75.7%,[5] 80%[57], 34% (eye or eyelash) and 52% (face)[59], 15.3% (eye) and 27.1% (eyelid or lashes)[16]
Instilling exactly one drop (n=7)	11.3 – 60.6%	11.3%,[51] 15%,[66] 23.9%,[63] 30%,[53] 49%,[9] 50%,[5] 60.6%[50]
Missing the eye (n=8)	6.8 – 37.3%	6.8%,[17] 10%,[9] 10.3%,[51] 11.8%,[16] 20%,[53] 29%,[58] 31.4%,[5] 37.3%[63]
Washing hands before instillation (n=1)	59%	59%[66]
Closing eyes after instillation (n=1)	60%	60%[66]
Compressing the nasolacrimal region after instillation (n=1)	70%	70%[66]

Instilling exactly one drop was another frequently missed step. The number of patients missing this step in seven different studies ranged from 11.3%[51] to 60.6%.[50] Missing the eye was not as frequent, but still a significant problem, performed incorrectly by 6.8%[17] to 37.3%.[63] Poorer accuracy had consequences in the sense that it was correlated with more bottles used, which could cause patients to experience more cost-related barriers to adherence.[63] In addition to contaminating the bottle, instilling a single drop, and missing the eye, the study by Ikeda et al. also measured several other steps with direct observation and found that only 41% washed their hands before instillation, 60% did not close their eyes after instillation, and 70% did not compress the nasolacrimal region after instillation.[66]

Four studies stated that older age was associated with poorer technique.[16,17,54,58] Other factors significantly associated with poorer technique included not having received instruction on

eye drop technique,[16] female gender,[9] arthritis,[9] more severe visual field defect,[9] lack of positive reinforcement to take eye drops,[61] lower educational level,[9,17] low self-efficacy,[59,61] and being seen at a clinic rather than a private practice.[57] No effect of race has been observed in relation to technique in most studies, although Sayner et al. found that African Americans were less likely to touch their face with the bottle tip during instillation.[9] However, given the wide racial disparity in glaucoma outcomes with respect to blindness,[14] it is important to assess the potential differences in effect of the video intervention by race, so that health disparities may be minimized.

The next section will turn to interventional studies addressing eye drop technique and their results.

2.3.3 Outcomes of interventions addressing eye drop technique

Only 8 studies included an intervention together with a control group or control phase that provided a basis for comparison (Table 2.2c). Six of these (75%) showed a significant benefit of the intervention on at least one main outcome measure, such as technique, specific steps in technique, or ease of use.[10-12,67-69] Three of the six used a mechanical dosing aid or modification to the bottle to make eye drop instillation easier.[67-69] In a crossover study, Nordmann et al. found that the Xal-Ease delivery device reduced the number of patients who needed help instilling their drops, the number who touched their eye with the bottle tip, and the number who often or always missed their eye with the drop.[67,70] Stack and McKellar found that compared to a standard bottle, 87.5% of patients rated a black-tipped bottle (where the tip was painted black) as easier to use, and 67.5% used extra drops less frequently when using the black-tipped bottle.[68] Dietlein et al. found that patients age 80 or older were more able to open the

container with no help or explanation when a new single-dose bottle was used, compared to the standard bottle.[69] The patients were also more likely to correctly get a drop into the corneo-conjunctival area when they used the new bottle.[69]

Table 2.2c. Intervention studies assessing eye drop instillation technique

Author, Year	Design	Intervention	Outcome Measure	Results in intervention group or phase	Results in control group or non-intervention phase
Stack 2004[68]	Pre-post intervention, n=40	Black colored bottle tips	Ease of use, technique	87.5% said black tipped bottles were easier to use; 67.5% said they instilled extra drops less frequently with black tipped bottles	NA
Salyani 2005[71]	Pre-post intervention, n=93	Eye drop guide	Scale of ease of use of the guide	Mean rating of ease of use with guide: 6.0 of 10	Mean rating of ease of use without guide: 8.0 of 10 ($p<0.01$)
Dietlein 2008[69]	Observational cross-sectional, n=44	New single-dose bottle	Direct observation by examiner	Patients age >80 with new single-dose bottle: 34% opened container w/o help or explanation; 43% placed no drop on corneo-conjunctival area	Patients age 50-65: 73% opened container w/o help or explanation (p=0.002); 5% placed no drop on corneo-conjunctival area (p=0.001); Patients age >80 using standard bottle: 64% opened container w/o help or explanation (p=0.009); 11% placed no drop on corneo-conjunctival area (p=0.003)
Nordmann 2009[67]	Randomized crossover, n=211	Xal-Ease delivery device	Self-reported technique	6.9% would need someone to help with instillation ($p<0.001$); 3.2% touched eye with bottle tip ($p<0.001$); 62.4% rarely or never missed eye with drop (p=0.03)	18.1% would need someone to help with instillation; 35.6% touched eye with bottle tip; 49.9% rarely or never missed eye with drop
McVeigh 2015[11]	Pre-post intervention, n=25	Printed eye drop chart tool	Correct instillation (assessment method unclear)	Hand hygiene: 92% (p=0.029); Shaking bottle before use: 84% (p=0.001); Tear ducts occlusion: 72% (p=0.015)	Hand hygiene: 64%; Shaking bottle before use: 40%; Tear ducts occlusion: 44%
Lazcano-Gomez 2015[12]	Pre-post intervention, n=45	Ophthalmol-ogist education	Video recording of technique	Patients squeezed out mean of 1.2 drops (p=0.011); 28.9% touched the eye or face with the bottle tip (p=0.05)	Patients squeezed out mean of 1.5 drops; 64.4% touched eye or face with bottle tip

Author, Year	Design	Intervention	Outcome Measure	Results in intervention group or phase	Results in control group or non-intervention phase
Al-Busaidi 2016[72]	Observational cross-sectional study, n=55	Small-group glaucoma educational sessions	Video recording of technique	16% of patients who attended a small-group educational session had good technique (p=0.498)	23% of patients who never attended an educational session had good technique
Feng 2016[10]	Pre-post intervention, n=34	Educational video and handout	Video recording of technique	Average eye drop technique score post-intervention: 6.15 of 15 points (p=0.008)	Average eye drop technique score pre-intervention: 2.53 points

NA, not applicable; NS, not significant. All p-values represent between-group comparisons (intervention vs control).

Three studies successfully used educational interventions to improve eye drop technique.[10-12] Feng et al. performed a pre-post study of an educational video and handout, and found that the average technique score improved from 2.53 pre-intervention on a 15-point scale to 6.15 post-intervention (p=0.008).[10] Out of 15 items assessed, four showed statistically significant improvements: holding open the eyelid, squeezing one drop into the pocket (conjunctival sac), closing the eye for 1 minute, and punctal occlusion.[10] In a pre-post study of an eye drop chart explaining proper technique, McVeigh and Vakros found that hand hygiene, shaking the bottle before use, and tear duct occlusion occurred more frequently in the post-intervention phase; nine other steps showed no significant improvement.[11] In the other study, Lazcano-Gomez et al. measured eye drop instillation technique before and after the ophthalmologist provided instruction on technique.[12] The patient's initial technique was videotaped and the patient then watched the video with the ophthalmologist, who pointed out the patient's mistakes and explained how to instill the eye drops correctly. After patients received education, the mean number of drops squeezed out of the bottle decreased from 1.5 to 1.2 (p=0.011) and the percentage of patients who touched the eye or face declined from 64.4% to 28.9% (p=0.05).[12]

There were two exceptions to the generally successful results. Salyani and Birt found that the mean rating of ease of use of eye drops was actually worse after patients started using an eye drop guide – a device designed to direct the bottle accurately toward the eye – than before.[71] Al-Busaidi et al. found that both a group who attended glaucoma educational sessions and a group that did not attend had poor technique at the time of assessment more than 1 year later.[72] Sixteen percent of people who attended the sessions had good technique, compared to 23% of those who did not attend (p=0.498). The majority of patients had attended the sessions at least 3 years

before the study was done, which may have been too long to retain any benefit from attending. Patients may have also received eye drop technique education from sources other than the hospital's educational program, such as their pharmacists.

Since there have been only three intervention studies that used an educational intervention to improve technique, none of which were randomized or had control groups,[10-12] more studies of practical educational interventions are needed. The other studies used a mechanical delivery aid or modification to the bottle, which was helpful, but they have not been widely adopted.[67-69] Even if mechanical delivery aids are used, patients still need to know how to get a single drop into the eye accurately without contaminating the bottle, so there still is a need for effective educational interventions. While the printed material intervention by McVeigh and Vakros showed some success, only three of twelve steps showed significant improvement after the intervention, the design lacked a control group, and a self-report measure of technique was used.[11] Lazcano-Gomez et al. used objective video recording of technique, but the intervention required significant provider effort, and this study also lacked a control group.[12] Feng et al. also showed improvement and used an objective technique measure, but their study was small and lacked a control group.[10] No randomized controlled trials of educational interventions for eye drop technique have been published, and only one of the eye drop technique interventions used a video.[10] Also, none of the existing studies measured the relationship between eye drop technique and adherence (see section 2.4.5 below). Therefore, a randomized study of an easily understandable educational video intervention, which is very practical for routine use and does not take significant time for clinicians to deliver, may be a significant advance in the field.

2.3.4 Measurement of eye drop technique

This section will discuss the ways that eye drop technique has been measured and the benefits and drawbacks of each method. Of the 25 technique studies reviewed – 17 observational studies from Table 2.2a and 8 interventional studies from Table 2.2c – 9 studies measured technique by video recording the patient's technique,[9,10,12,16,53,54,58-61,72] 8 asked patients to self-report their technique (including one qualitative focus group study),[17,18,62-65,70,71] 6 studies involved direct observation by a study team member,[5,50,51,57,66,69] and 2 did not state the technique assessment method clearly.[11,68]

Self-report does not appear to have as much systematic error in relation to eye drop technique as for some other behaviors, such as medication adherence, in which self-report consistently underestimates adherence.[17,18,63,67] Results of studies using self-report and objectively assessed eye drop technique have both found high rates of incorrect use (Table 2.2). Patients seem fairly willing to admit that they incorrectly perform eye drop instillation.[17,18,63,67] However, self-report may still be less reliable than more objective measures.

More objective measures of eye drop technique include direct observation and video recording. In direct observation, an observer watches the patient attempt to instill eye drops and completes a checklist of which steps on a list are correctly performed. Video recording of patients' eye drop technique can be even better since it can allow multiple raters to watch the video, and then interrater reliability can be calculated. Even if multiple raters cannot be used, a masked observer can grade the patient's performance, minimizing bias that might be introduced by an unmasked researcher. The main difficulty is that the video recording needs to be made carefully enough so that the viewer of the video can tell whether the patient performed the steps

correctly or not. In the observational study by Sayner et al., 34.9% of patients were graded as "unclear" on whether they squeezed the bottle to produce a single drop, 30.6% were graded as unclear whether they instilled a single drop, and 21.6% were graded as unclear on whether they touched their eye or face with the bottle tip.[9] These problems often occurred because patients blocked the video camera, or the camera was out of focus.[9]

Video recording of technique was used in the present study because it is the most reliable way to know exactly which steps patients performed correctly, and unlike direct observation, video recording allows a masked assessor to score the patients' technique. Self-reported technique can be biased if patients mistakenly think they have improved their technique but are still not performing some steps correctly. If a self-report measure were used, intervention group patients would probably be especially susceptible to reporting that they have improved their technique when they actually have not; it is not possible for subjects to be blinded to their group assignment. Therefore, it is especially important to measure technique objectively with video recording in this type of study.

2.3.5 Eye drop technique self-efficacy and its measurement

According to Social Cognitive Theory (SCT), self-efficacy, or confidence in one's ability to perform a behavior correctly, is one of the most important determinants of successful performance of health behaviors.[13,73] Higher eye drop technique self-efficacy has been associated with better eye drop technique.[53,59,74] In 2010, Sleath et al. developed a 35-item glaucoma self-efficacy scale with a 21-item medication adherence subscale and a 14-item technique subscale.[74] In 2012, the investigators aimed to validate a shorter version of the technique scale and published a validated 6-item short version called the Eye Drop Technique Self-Efficacy Scale.[59] This study

found that higher technique self-efficacy was associated with both a better ability to instill one drop, and a lower chance of touching the eye, eyelash, or face with the bottle.[59] In another observational study of 102 patients using a 10-item short version of the adherence self-efficacy scale and the 6-item technique self-efficacy scale, subjects who had worse adherence and worse adherence self-efficacy had greater visual field defect severity, while eye drop technique and technique self-efficacy did not predict visual field defect severity.[53]

Sayner et al. used the 6-item Eye Drop Technique Self-Efficacy Scale in a later study of 279 patients and found no association between eye drop technique self-efficacy and correct technique in this population.[9] It is unclear why this study found such a different result from the study that validated the scale. Patients may have been overconfident in their ability to administer their eye drops correctly or unaware of their poor performance.[9] However, no other scales for measuring eye drop technique self-efficacy exist, and given the scale's face validity and strong theoretical justification for the expected association between self-efficacy and eye drop technique, it was reasonable to use the 6-item Eye Drop Technique Self-Efficacy Scale in the present study.

2.4 Eye Drop Adherence

2.4.1 Importance

Medication adherence is defined as the degree to which medication is taken as prescribed by a healthcare provider.[75] A review article shows that the literature is in agreement that good adherence is essential for control of IOP and prevention of glaucoma progression.[35] Poor eye drop adherence has been associated with higher IOP,[70,76] and some studies that have successfully

intervened to improve adherence have shown decreases in IOP.[77,78] In a 36-month observational study by Rossi et al., patients who had stable vision over the course of the study had median electronically monitored adherence of 85%, while patients whose vision worsened had median electronically monitored adherence of 21%.[79] Sleath et al. also found that having less than 80% eye drop adherence was associated with more severe visual field defect.[53]

Poor glaucoma medication adherence also has a broader societal impact. As noted above in section 2.3.1, a cost-consequence analysis showed that patients using bimatoprost 0.01% would be estimated to save $3433 over each patient's lifetime compared to patients using bimatoprost 0.03%.[55] This result was due to better adherence and resulting glaucoma control with bimatoprost 0.01%; in the model, the IOP reduction efficacy of bimatoprost 0.03% was assumed to be slightly greater when other factors were equal, but more patients were assumed to be adherent to bimatoprost 0.01% than 0.03%. The adherence estimates, stated as percentage of days covered (PDC) over a 12-month period, were calculated from real-world Medicare claims data. In both groups, the effectiveness of the drug in reducing IOP was assumed to be 100% of the efficacy observed in the phase III clinical trials for patients with more than 80% PDC, 50% of the efficacy from the trials for patients with 20-80% PDC, and 0% for patients with less than 20% PDC. The difference in economic outcomes resulted from a difference in clinical outcomes. The model predicted that 12.60% of patients in the bimatoprost 0.01% group, and 17.28% of patients in the bimatoprost 0.03% group, would eventually become blind.[55] Based on a prior cost estimation study by Bramley et al.,[80] blind patients incurred greater costs for services such as medical visits, skilled nursing facility care, and home healthcare. The burden to families in supporting their blind family member may be even greater. Therefore, if an intervention could raise the percentage of patients who achieve an 80% PDC significantly above 29.1%, then

potentially much greater benefit in terms of both clinical and economic outcomes could be achieved.

2.4.2 Observational studies of glaucoma eye drop adherence

This section will explain what is known from the existing observational studies of glaucoma eye drop adherence. Of 59 glaucoma studies collecting data on adherence to eye drops, 40 were observational studies with a single group or cohort, 2 were observational studies with multiple groups, and 17 were intervention studies that included multiple study groups or phases that could be compared. The 40 single-group observational studies are shown in Table 2.3a.

Table 2.3a. Adherence results in observational studies with no comparison group or phase

Author, Year	Design	Outcome Measure	Adherence results
Sleath 2011[53]	Longitudinal observational, n=102	MEMS	89% of patients were at least 80% adherent
Boland 2014[81]	Observational cohort, n=491	MEMS	82.8% took medications correctly at least 75% of days
Slota 2015[82]; Sayner 2015[83]; Carpenter 2015[61]	Longitudinal observational, n=279	VAS, MEMS	Mean VAS adherence: 89%; mean MEMS percent adherence: 97.5%; mean MEMS timing adherence: 83.7%; Provider education about adherence and provider inclusion of patient input into treatment plan predicted decrease in IOP; Relationships not mediated by adherence or eye drop technique
Barker 2015[84]	Observational cohort, n=47	MEMS	Mean adherence: 79.7%
Kumar 2016[85]	Observational cohort, n=137	MEMS, MPR, VAS, 2-question self-report survey	Mean MEMS adherence: 84.4%; Mean MPR: 1.49; 76.6% of patients >8 cm on VAS; 81% of patients "very confident" they remember to take their medications
Okeke 2009[86]	Observational cohort, n=196	Travatan Dosing Aid (TDA)	55.6% patients took >75% of expected doses
Rossi 2010[87]	Observational cohort, n=56	TDA	30.3% had more than 90% adherence at every visit
Ajit 2010[88]	Observational cohort, n=37	TDA	23 pts had good adherence (dosed within 4 hours of prescribed time at least 80% of the time), 3 had early discontinuation, 4 had frequent drug holidays, 7 frequently missed doses
Nordmann 2010[70]	Observational cohort, n=113	TDA	Mean adherence: 60.0%
Dreer 2012[89]	Prospective observational, n=116	TDA	64% adherence (proportion of days taking prescribed number of drops within 3 hr of prescribed time)
Mansberger 2013[76]	Cross-sectional with focus groups (n=20) and case series (n=57)	TDA	49.1% adherent (took at least 1 drop within 6 hr of designated time at least 90% of days)

Author, Year	Design	Outcome Measure	Adherence results
Cate 2015[90]	Secondary analysis of Norwich Adherence Glaucoma Study RCT, n=208	TDA, Morisky scale, self-report	54% of pts were adherent by Travalert Dosing Aid, 60% by Morisky scale, and 57% by Frequency of Missed Dose self-report
Norell 1980[91]	Observational cohort, n=82	Medication monitor, fluorescein test to detect medication in eye	Mean dose interval for 3-times-daily pilocarpine: 8.7 hr; 18% of dose intervals >=12 hr; 11% of dose intervals <=4 hr
Hermann 2010[92]	Observational cohort, n=6 glaucoma pts (28 total pts)	Electronic monitor	55% adherence; 1.15 attempts/application
Quigley 2007[93]	Observational cohort from HealthCore claims database, n=13,977, and chart review, n=300	MPR	MPR 68% for chart review, 63% for non-charted patients from database; 72 of 300 charts contained negative physician comments on adherence, while 81 contained mixed or positive comments
Friedman 2008[94]	Observational survey with database and chart reviews, n=300	MPR	Median MPR: 0.48 for doctor-dependent learners, 0.66 for collaborative learners, 0.69 for independent learners ($p<0.05$)
Asefzadeh 2014[95]	Retrospective review of EMR, n=161	MPR	69% mean MPR
Cohen Castel 2014[56]	Cross-sectional survey, n=738	MPR	71% had MPR >=80%
Campbell 2014[96]	Observational cohort from Source Lx Database, n=12,985	12-month PDC	Adherence to bimatoprost: 0.540 ($p<0.001$) versus adherence to travoprost Z: 0.486; 29.1% at least 80% adherent to bimatoprost versus 22.3% for travoprost Z ($p<0.001$)
Stein 2015[39]	Cohort of Clinformatics DataMart database, n=8427	PDC	Adherence increased from 62% to 65% when pts switched from brand-name to generic latanoprost; 47% to 61% when switching from bimatoprost to generic latanoprost; 43% to 54% when switching from travoprost to generic latanoprost
Rotchford 1998[97]	Observational cohort, n=86	Dispensing data on quantity of eye drops dispensed to each patient	24% admitted nonadherence; 51% did not acquire enough medication to medicate as prescribed

Author, Year	Design	Outcome Measure	Adherence results
Patel 1995[98]	Observational survey, n=100	Self-report according to interview	59% admitted not using medication exactly as prescribed
Konstas 2000[65]	Observational survey, n=100	Self-reported adherence	44% not fully adherent
Balkrishnan 2003[99]	Cross-sectional survey, n=358	Self-reported adherence	82% reported "regular" use of eye drops; 14% had difficulty self-administering eye drops and 17% needed assistance to instill eye drops
Stewart 2004[100]	Survey of pts and physicians, n=250 patients and 250 physicians	Self-reported adherence	Most physicians said 0-25% of pts were noncompliant; 34% of patients rated themselves noncompliant
Chawla 2007[101]	Observational cross-sectional, n=83	Self-reported adherence	31% missed >10% of doses
Kholdebarin 2008[17]	Observational survey, n=500	Self-report	27.9% missed at least one dose of eye drops per week or could not accurately describe their regimen
Olthoff 2009[102]	Observational survey, n=166	Self-reported adherence	26.7% nonadherent
Sleath 2010[74]	Observational survey, n=191	Self-reported adherence, 2 self-efficacy scales	30.2% of patients nonadherent by Morisky scale
Rees 2010[103]	Cross-sectional survey, n=131	Reported Adherence to Medication scale	45% reported nonadherence, of which 66.1% reported unintentional, 16.9% reported intentional, and 16.9% reported both
Vanden-broeck 2011[104]	Observational survey, n=663	Self-reported and ophthalmologist-reported adherence	39.2% self-reported nonadherence, 2.1% of patients identified as nonadherent by their ophthalmologist
Park 2013[105]	Observational cross-sectional, n=581	Adherence questionnaire	60.2% had highest possible adherence score; Most common reasons were forgetfulness (50.1%), busy daily schedule (19.1%), patient's indifference (18.4%)
Moore 2014[106]	Observational cohort, n=236	Survey on factors related to early bottle exhaustion	5.1% at least "often" ran out of drops; 25.4% ran out at least once

Author, Year	Design	Outcome Measure	Adherence results
Kawai-Tsuboi 2015[63]	Single-group cohort, n=67	5-item questionnaire of technique and adherence	95.5% adherent by self-report
Tamrat 2015[107]	Cross-sectional observational, n=200	Self-report of missed medications, missed appointments, or physician-reported poor adherence	67.5% of patients were nonadherent
Newman-Casey 2015[108]	Observational survey, n=190	Self-reported adherence and barriers	27% reported poor adherence; 10% cited 1 barrier, 61% cited >=2 barriers
Killeen 2016[109]	Qualitative analysis of interviews to develop intervention, n=21	MMAS-8	57% were adherent; Patients age 75 or older more likely to report difficulty instilling eye drops and more likely to say they did not understand the purpose of their medication
Taylor 2002[64]	Focus groups, n=21	NA	Patients cited forgetfulness, side effects as major reasons for nonadherence
Lacey 2009[15]	Qualitative analysis of focus groups or home-based interviews, n=24	NA	Patients identified as barriers: Poor education, low motivation due to doubts about efficacy, forgetting, difficulty of drop application, practical issues, age/individual differences
Ikeda 2008[66]	Single-group observational, n=27	Measure not stated	Adherence: 100% for twice-daily, 71% for once-daily eye drops

EMR, electronic medical records; MEMS, Medication Event Monitoring System; MMAS-8, 8-item Morisky Medication Adherence Scale; MPR, medication possession ratio; NA, not applicable; PDC, percentage of days covered; RCT, randomized controlled trial; TDA, Travatan Dosing Aid; VAS, visual analog scale

In general, the observational studies in Table 2.3a show that glaucoma eye drop adherence is poor, with estimates generally ranging between 50-65% adherence for the most reliable method, objective electronic monitoring (see 2.4.4 below), in the absence of any intervention.[19,70,86,89] The literature suggests that African American race,[4,19,53,76,81,84,89] lower health literacy,[16] fewer years of education,[17,56,81] shorter length of time using glaucoma medications,[17,81,87] more severe visual field defect,[9,53,107] depression,[81] and being unmarried[84] are

associated with poorer medication adherence (Table 2.3). There have been conflicting results regarding the effect of age; the majority of studies have found that older patients are more adherent,[56,76,81,84,89,94,102,103] but a few studies suggested that older patients are less adherent.[87,107]

African American or nonwhite race has been associated with poorer medication adherence in many glaucoma studies.[4,19,53,76,81,84,89,110] Okeke et al. found that their video intervention for glaucoma medication adherence was less effective in African American patients, which suggests that a video must be carefully designed and implemented with attention to the needs of each subgroup.[19]

There are conflicting data on the effects of age on glaucoma medication adherence.[56,76,81,84,87,89,102,103,107] Older patients might be more adherent because they have more experience using their medications, fewer cost barriers due to Medicare eligibility, or fewer competing demands on their time due to being retired. On the other hand, older age could lead to lower adherence for many of the same reasons that it negatively influences technique: decline in physical and mental functioning, which may also lead to giving up if medication adherence is seen as being too difficult to accomplish. In addition, one study found that patients over age 65 had a lower rate of good understanding of glaucoma than patients under 65, which may exacerbate the problems.[62]

Low health literacy and less education are also risk factors for poor glaucoma medication technique and adherence.[9,17,56,81] Patients with low health literacy and less education may have a harder time understanding instructions or learning to use their medication correctly. They may also have less understanding of the consequences of their disease and the importance of using the medication. Educational materials that use language at a high reading level are not likely to benefit these patients. Since the Meducation video was intended to be easier to understand than

other forms of instruction on eye drop use, health literacy and years of education were considered important covariates that may moderate the effect of the intervention on the primary outcomes. It was hoped that the video will provide more benefit for low literate patients, but if it did not, then tailoring the video more effectively on literacy level would be a focus for future refinement of the intervention.

Length of time using glaucoma medications, glaucoma severity, and presence of comorbidities can also affect glaucoma medication technique and adherence. Patients that have used eye drops for a longer time tend to have somewhat better adherence,[17,81,87] although no difference has been observed in technique. Patients who have more vision loss due to more severe glaucoma have shown poorer technique and adherence,[9,53,107] which is not surprising since patients often perform better if they can see the bottle tip.[68] Arthritis also inhibits patients' ability to get their eye drops into the eye accurately,[9,54] and depression tends to inhibit adherence to all types of medications, because depressed patients often believe that taking medication is futile.[111,112] Patients who have considerable vision loss or significant arthritis may not benefit from the Meducation video intervention, but it is still important to control for those variables. Therefore, arthritis and severity of glaucoma were included as covariates in the model.

Providing patient education is associated with higher knowledge of glaucoma and glaucoma treatment, as well as higher adherence.[78,86] A greater number of glaucoma medications,[82,113] as well as a more frequent dosing regimen (three-times-daily as opposed to twice-daily, or twice-daily rather than once-daily), are usually associated with poorer adherence,[114-116] although one study found that adherence to once-daily medications was worse, which the authors attributed to side effects of the once-daily medications.[66] Despite a lower percent of expected doses taken with a three-times-daily regimen, patients may still take more

total doses with the three-times-daily regimen.[114,115] Switching from multiple separate products that must be instilled separately, to a combination product containing two drugs (e.g. latanoprost/timolol), is associated with better adherence.[117,118] When instilling multiple eye drops, patients must typically wait 5 minutes between drops, which is inconvenient and not surprisingly, reduces adherence.[117,118] A morning dosing regimen also seems to be associated with slightly better adherence than an evening regimen.[119,120]

In addition to many single-group observational studies, there were also two observational studies with multiple groups, shown in Table 2.3b. Robin et al. compared adherence between a group that was prescribed one glaucoma medication and a group that was prescribed two glaucoma medications,[113] while Kahook et al. compared morning dosing and evening dosing.[120] The group using a one-drug regimen had higher adherence than the two-drug group (no p-value reported),[113], and the morning dosing group had slightly better adherence than the evening group.[120]

Table 2.3b. Adherence results in observational studies with multiple groups

Author, Year	Design	Outcome Measure	Results in first group or phase	Results in second group or phase
Robin 2007[113]	Parallel-group observational, n=60	MEMS	One-drug group: 97.5% adherence	Two-drug group: 93.0% adherence to adjunctive drug, 85.6% adherence to entire regimen
Kahook 2007[120]	Retrospective chart review, n=41	TDA	Morning group: Mean adherence 82.7% (p=0.08); Missed entire day of dosing 3.33 times (p<0.001)	Evening group: Mean adherence 79.0%; Missed entire day of dosing 5.87 times

MEMS, Medication Event Monitoring System; TDA, Travatan Dosing Aid

Next, the results of the interventional studies addressing eye drop adherence will be presented.

2.4.3 Outcomes of intervention studies addressing eye drop adherence

Seventeen glaucoma eye drop adherence studies conducted an intervention, and all of them contained multiple study groups or phases that could be compared. Of these, 10 (59%) found a statistically significant difference in at least one major adherence-related outcome measure.[19,77,78,114,117,118,121-124]

Table 2.4. Adherence results in interventional studies

Author, Year	Design	Intervention	Outcome Measure	Results in intervention group or phase	Results in control group or non-intervention phase
Educational:					
Okeke 2009[19]	RCT, n=66	Video, review of barriers with study coordinator, phone call reminders, and audible/visible reminders on device	TDA	73% adherence at 3 months (up from 54% at baseline, p<0.001)	51% adherence at 3 months (up from 46% at baseline, NS)
Glanz 2012[125]	RCT, n=312	Automated, interactive, tailored phone intervention and tailored print materials	Interviews, charts, and pharmacy data	30.2% self-reported adherence at 12 months (p>0.05)	27.0% self-reported adherence at 12 months
Beckers 2013[78]	RCT, n=588	4 arms: 1) use of dosing aid; 2) use of drop guider; 3) dosing aid + patient education; 4) dosing aid + drop guider + patient education	TravAlert	% patients >97% adherent: 55.8% (Arm 1), 56.0% (Arm 2), 58.9% (Arm 3), 62.0% (Arm 4); p=0.0056	NA
Difference in regimen:					
Kumar 2002[116]	Pre-post crossover, n=52	Timolol in gel forming solution once-daily vs standard timolol twice-daily	Self-reported adherence	10 patients had less than perfect adherence over 6 weeks (p>0.05)	3 patients had less than perfect adherence over 6 weeks
Sakai 2005[126]	RCT, n=36	Latanoprost versus separate timolol and dorzolamide	Self-reported adherence	Latanoprost: 2 of 18 patients missed >=1 dose/week (p=0.37)	Timolol and dorzolamide: 5 of 18 patients missed >=1 dose/week
Hermann 2011[115]	Obser-vational cohort, n=37	Open vs masked electronic monitoring	Electronic monitoring device	Masked: 77% adherence with twice-daily dosing, 62% adherence with 3-times-daily dosing	Open: 70% adherence with twice-daily dosing, 65% with 3-times-daily dosing (NS)
Hermann 2011[114]	RCT, n=67	Twice-daily vs 3-times-daily dosing	Electronic monitoring device	Twice-daily dosing: 72% adherence (p=0.04); Dosing frequency 1.4 per day (p<0.001)	3-times-daily dosing: 62% adherence; Dosing frequency: 1.9 per day

Author, Year	Design	Intervention	Outcome Measure	Results in intervention group or phase	Results in control group or non-intervention phase
Inoue 2011[117]	Pre-post intervention, n=162	Combination latanoprost/timolol vs separate products	Adherence question-naire	71% had perfect adherence 1 month after switching to combination therapy (p=0.0115)	59.3% had perfect adherence before the switch
Inoue 2012[118]	Single-group pre-post, n=43	Switch from 2 separate products to combination travoprost/timolol	Self-reported adherence	71.4% had perfect adherence at 1 month after switch (p<0.05)	64.3% had perfect adherence
Ford 2013[119]	Randomized crossover trial, n=30	Morning vs evening dosing	TDA	Morning dosing: 90.9% adherence (p=0.07), 91.4% in males (p=0.039)	Evening dosing: 87.3% adherence; 85.0% in males
Reminder:					
Chang 1991[77]	Pre-post intervention, n=122	Medication cap with memory aid	Number of patients with 100% adherence (self-report)	67% of patients completely adherent (p=0.0001)	41% of patients completely adherent
Laster 1996[121]	Crossover, n=13	Prescript TimeCap electronic medication alarm device	Amount of drug used, self-reported adherence	95.8% mean self-reported adherence (p<0.01)	83.1% mean self-reported adherence
Boland 2014[124]	Cohort, n=491 and RCT, n=70	Automated text or voice messages	MEMS	Adherence increased from 53% pre-intervention to 64% post-intervention (p<0.05)	Adherence 51% pre-randomization, 46% post-randomization (NS)
Mechanical device:					
Lievens 2006[127]	Randomized crossover, n=32	Proview Eye Pressure Monitor	Bottle weight	Average 1.742 ml used (NS)	Average 1.745 ml used
Nordmann 2009[67]	Randomized crossover, n=211	Xal-Ease® delivery device	Self-reported adherence	Adherence: 95.8% in first period, 96.6% in second period (NS time and between-group difference)	Adherence: 96.9% in first period, 97.8% in second period
Junqueira 2015[123]	Randomized self-controlled, n=32	Eyedrop® delivery device	VAS rating of satis-faction with device; pattern of fluorescein in each eye	Mean satisfaction rating 7.6 of 10	Mean satisfaction rating 6.2 of 10 (p<0.01)

Author, Year	Design	Intervention	Outcome Measure	Results in intervention group or phase	Results in control group or non-intervention phase
EHR-based online systems:					
Kashiwagi 2014[122]	RCT, n=171	Internet-based glaucoma support system with Personalized Health Record (PHR)	Change in MPR	MPR 82.3% pre-intervention, 91.1% post-intervention (p=0.03)	MPR 84.0% pre-intervention, 82.9% post-intervention

MEMS, Medication Event Monitoring System; MPR, medication possession ratio; NA, not applicable; NS, not significant; PHR, personalized health record; RCT, randomized controlled trial; TDA, Travatan Dosing Aid; VAS, visual analog scale

The interventions used can be classified as educational (sometimes together with reminders), differences in regimen, reminders alone, mechanical devices, or EHR-based online systems (Table 2.5). Educational interventions are those that strive to educate the patient about the need to use eye drops regularly, using print materials, videos, or face-to-face instruction. Differences in regimen interventions attempt to simplify a regimen so it does not need to be used as often, or requires only one eye drop containing multiple active ingredients, instead of two separate products. Reminder interventions consist of a device on the bottle that alerts the patient when to take a dose, or text or voice message alerts sent to patients. Mechanical device interventions consist of physical objects that can be mounted on the face to direct the eye drop bottle more accurately toward the eye. Examples include the Xal-Ease delivery device which holds the bottle in a position directed straight toward the center of the eye, and has a button that patients can press to administer a single drop, thus avoiding the risk of squeezing out multiple drops.[67] EHR-based online system interventions may allow patients to log on to a secure health record and track how well they are doing in controlling their IOP and preventing glaucoma progression.

Table 2.5 Types of interventions used to improve eye drop adherence and number of studies for each patient outcome

Type of intervention	**Favors intervention ($p<0.05$), n**	**No significant difference, n**	**Favors control, n**
Educational	2[19,78]	1[125]	0
Difference in regimen	3[114,117,118]	3[116,119,126]	0
Reminders alone	3[77,121,124]	0	0
Mechanical devices	1[123]	2[67,127]	0
EHR-based online systems	1[122]	0	0
Total	**10**	**6**	**0**

Note: Hermann's study of open vs masked electronic monitoring was not included in this table since it was not clear which should be considered the intervention group.[115]

2.4.3.1 Educational interventions

Educational interventions showed success in two of three studies.[19,78,125] In a 4-arm RCT, Beckers et al. found that a dosing aid, drop guider, and patient education resulted in 62.0% of patients being at least 97% adherent, while only 55.8% were adherent with the dosing aid alone, 56.0% with the drop guider alone, and 58.9% with the dosing aid and patient education.[78] Okeke et al. found that a multifaceted intervention including educational videos, review of barriers with the study coordinator, phone call reminders, and audible and visible reminder devices produced 73% adherence in the intervention group at 3 months compared to 51% for the control group.[19] The unsuccessful example was the I-SIGHT trial, an RCT of an automated, tailored, interactive phone intervention and tailored print materials by Glanz et al.[125] In this trial, 30.2% of intervention patients and 27.2% of control patients were considered adherent (defined as not having missed any doses in the last month by self-report) after 12 months, versus 10.2% of intervention patients and 13.5% of controls at baseline. The between-group difference at 12 months was too small to be statistically significant even with the large sample size of 312 patients, but both groups did significantly improve their adherence from baseline ($p<0.01$).

2.4.3.2 Difference in regimen interventions

A different regimen or change in regimen showed statistically significant successful results in three of six studies.[114,116-119,126] Hermann et al. found that 72% of doses were taken correctly in patients randomized to twice-daily dosing compared to 62% for three-times-daily.[114] Inoue et al. used a pre-post design to compare adherence to a combination latanoprost/timolol product with the two products separately and found that 71% had perfect adherence 1 month after the switch compared to 59.3% at baseline.[117] In another pre-post study by the same author,

patients were switched from separate products to a combination travoprost/timolol product, and 71.4% had perfect adherence 1 month after the switch compared to 64.3% at baseline.[118] The unsuccessful results came from an RCT by Sakai et al.,[126] and crossover studies by Kumar et al. and Ford et al.[116,119] All of these studies showed trends in the expected direction of better adherence with the simpler regimen but were likely underpowered as they contained between 30 and 60 participants each.[116,119,126] Therefore, the overall evidence in favor of simpler regimens for maximizing adherence remains very strong.

2.4.3.3 Reminder interventions

In addition to education and simplifying regimens, reminder interventions, such as a memory aid, alarm on a medication cap, or automated voice or text message, have improved adherence.[19,77,121,124] Although some patient populations can be averse to reminders, the mostly elderly glaucoma population seems to benefit. Reminders were successful in all three studies that used them alone,[77,121,124] in addition to the previously discussed study by Okeke et al. that used them together with educational interventions. In Chang et al.'s pre-post study of a medication cap with a memory aid, 67% of patients were completely adherent after introducing the intervention compared to 41% before the intervention.[77] Laster et al. performed a crossover study of an electronic medication alarm device and found that mean self-reported adherence was 95.8% in intervention phases compared to 83.1% in control phases.[121] Boland et al. tested automated voice and text messages in an RCT and found that adherence improved from 53% to 64% in the intervention group compared to a nonsignificant decline from 51% to 46% in the control group.[124]

2.4.3.4 Mechanical device interventions

Mechanical device interventions for facilitating eye drop instillation, though effective for improving technique (see 2.3.5 above), were less effective for improving adherence, succeeding in just one of three studies.[67,123,127] The successful cross-over study by Junqueira et al. found that rating of the facility of drop instillation was 7.6 of 10 with a special delivery device and 6.2 without the device.[123] No measure of adherence itself was provided, and the difference between groups in IOP change was not significant. Unsuccessful studies of devices included randomized crossover trials by Nordmann et al. and Lievens et al.[67,127] The Xal-Ease delivery device tested by Nordmann et al. was effective in improving technique, but there may have been a ceiling effect inhibiting detection of a significant effect on adherence, as self-reported adherence was already 95.8% in the intervention group and 96.9% in the control group at baseline.[67]

2.4.3.5 Electronic health record interventions

An Internet-based personalized health record system was also successful in improving medication adherence.[122] Kashiwagi and Tsukahara implemented an Internet-based glaucoma support system with a Personalized Health Record (PHR), and found that intervention group patients' adherence improved from 82.3% before intervention to 91.1%, while control group patients' adherence was 84.0% before and 82.9% after the implementation date.[122] With this system, patients used a secure online connection to view their IOP results and visual field test results from their past visits, their medication history, as well as personalized graphs showing the likelihood of glaucoma progression.

2.4.3.6 Summary of eye drop adherence interventions

The present study tested an educational intervention because educating patients about how to use their medication correctly had shown success,[19,78] but had not yet been adapted to an online video format. An online video allows patients to watch the video as much as they want from anywhere they can access an Internet-connected device. The Meducation video also may be more effective than the general video about glaucoma tested by Okeke et al., which did not focus on technique and therefore may have left patients lacking the skills that they needed to achieve successful clinical outcomes from their eye drops.[19]

2.4.4 Measurement of eye drop adherence

Eye drop adherence can be measured with electronic monitoring, pharmacy refill data, self-report measures, or weight of medication bottle used.[104] In the observational studies of eye drop adherence in Table 2.3, 16 studies used self-report measures,[74,82,85,90,98-109] 8 studies used the Travatan Dosing Aid (TDA),[19,70,76,87-90,120] 6 studies used Medication Event Monitoring System (MEMS®) caps,[4,53,81,84,85,113] 2 studies used some other type of electronic monitor,[91,92] and 8 studies used refill-based measures.[39,56,85,93-97] Meanwhile, in the intervention studies of methods to improve eye drop adherence in Table 2.4, 9 studies used self-report measures,[67,77,116-118,121,123,125,126] 3 studies used the TDA or TravAlert,[19,78,119] 1 study used MEMS caps,[124] 2 studies used some other type of electronic monitor,[114,115] 2 studies used medication weights,[121,127] and 2 studies used refill-based measures.[122,125]

Electronic monitoring, in which the bottle or bottle cap automatically records each time the bottle is opened, is considered the gold standard for measuring adherence, but has some drawbacks, including the expense of the caps (about $100 each) and possible Hawthorne effects

on adherence.[104] Hawthorne effects refer to the way in which subjects change their behavior because they know their performance is being monitored. Subjects who know their adherence is being monitored are likely to make an effort to be more adherent.[128-130] The Hawthorne effect may resemble "white-coat" adherence in which patients are more adherent just before a medical visit, expecting their doctor will notice if they were not adherent in the last few days.[128,130,131]

Pharmacy refill data are also considered an accurate measure and are more practical in large data sets drawn from real-world patients not necessarily enrolled in trials. In glaucoma, pharmacy refills show similar average adherence results when compared to electronic monitoring.[39,93,96] Studies using pharmacy refills typically report adherence rates using Medication Possession Ratio (MPR) or Percentage of Days Covered (PDC). Both measures attempt to determine what percentage of days the patient had medication available to use, based on the number of days' supply that the patient obtained each time a prescription was filled. Although the measures have been operationalized in different ways, they differ mainly in that MPR often includes only the time while the patient was persistent with the medication in cases of discontinuation, whereas PDC includes potential periods of nonpersistence up to a predetermined study endpoint.[132] Thus a patient who fills medications monthly for the first half of the year and then discontinues could have 100% MPR, but only 50% PDC.[132] Advocates of using pharmacy refill measures argue that pharmacy refill data from large retrospective observational studies reflect more accurately how typical patients behave, because clinical trial patients are unrepresentative of the general population, tending to be more conscientious and adherent than patients who do not enroll in trials.[133] However, pharmacy refills do provide somewhat less detailed data than electronic monitoring and are more problematic with topical medications like eye drops, which are less straightforward in terms of dosage amounts than oral medications.[90] If

patients obtain medication but never use it, or if they throw out the bottle before exhausting it – which is recommended if the bottle gets contaminated[11] – pharmacy refills would not capture the fact that the patient did not use the whole bottle. Pharmacy refills could also overestimate adherence for glaucoma patients who inappropriately squeeze out more than one drop, and thus run out of medication quickly. [132] These patients could be incorrectly classified as adherent based on refill data because they used the same amount of medication as adherent patients, but used too many drops on the first few days and then were nonadherent on the days after they had run out.

Self-report measures that have been used include the Visual Analog Scale (VAS),[82] the Morisky Medication Adherence Scale,[90,109] and various other questionnaire measures. The VAS was validated for eye drops by comparing it to 60-day MEMS objective electronic monitoring results in a large observational study of 279 patients.[83] Patients were asked to mark on a 10-cm line their answer to, "All things considered, how much of the time do you use ALL of your glaucoma medications EXACTLY as directed?" with endpoints "None of the time" and "All of the time." The VAS was moderately correlated with MEMS (r=0.32) and when treated as a binary variable classifying patients with at least 80% adherence as "adherent", VAS identified adherent patients with 85% sensitivity and 38% specificity.[83]

Kumar et al. explored adherence in an observational cohort study of glaucoma patients simultaneously monitored with MEMS, pharmacy refill data, and two self-report measures: VAS and a two-question survey.[85] Patients were rated adherent on the two-question survey if they answered "yes" to "How confident are you that you can carry out the following task: always remembering to use your glaucoma medications?" and "no" to "In the past 4 weeks, did you ever forget to take your medicine?" The authors found that the majority of patients with medication possession ratios (MPR) in a low, medium, or high range were at least 80% adherent according

to MEMS. Fifty-nine percent of patients with MPR less than 1.2 (low), 63% of those with MPR of 1.2 to 1.8 (medium), and 88% of those with MPR above 1.8 (high) were at least 80% adherent according to MEMS.[85] These ranges were chosen to correspond to an undersupply of medication, an appropriate supply, and an oversupply, respectively. It may be that an apparent oversupply of medication is actually what patients need, to compensate for wasting drops that are not accurately instilled. Compared to patients with low scores, patients with high scores on each of the two self-report measures were more likely to be at least 80% adherent according to MEMS (OR: 2.78, 95% CI: 1.19-6.52 for the two-question survey; OR: 2.35, 95% CI: 0.96-5.75 for VAS).[85]

The Morisky Medication Adherence Scale (MMAS) is one of the most common self-report adherence measures and was used in glaucoma by Cate et al. in an 8-month RCT of 208 patients that compared three different adherence measures: the 4-item Morisky Scale, the Travalert Dosing Aid (TDA), and Frequency of Missed Dose (FMD) self-report questionnaire.[90] Medication possession ratio (MPR) data were also calculated from pharmacy refills. The percentage of patients who were at least 80% adherent was 60% according to the Morisky scale, 54% by TDA, and 57% by the Frequency of Missed Dose questionnaire. The two self-report measures agreed well with each other (κ=0.632) but both agreed poorly with the TDA electronic monitor (κ=0.117 for the Morisky scale, κ=0.233 for Frequency of Missed Dose). The TDA results also agreed poorly with the refill measure MPR (Spearman's coefficient=0.216). The authors suggested that the results did not lead them to endorse any of the measures strongly since all had significant limitations.[90]

2.4.4.1 Comparison of eye drop adherence measures

As shown in Tables 2.3 and 2.4, studies using electronic monitoring have typically reported around 50-65% adherence for glaucoma eye drops without any intervention, which is lower than the results from self-report measures and similar to those from pharmacy refill data.[19,83] For example, Slota et al. reported mean self-reported adherence of 89% using a Visual Analog Scale (VAS).[82] Other self-report studies have measured medication adherence as the percentage of patients who reported less than perfect adherence, such as whether the patient missed any doses in the last 2 weeks;[104] this measure is difficult to compare to the non-self-report studies that usually considered adherence as a continuous measure. Meanwhile, studies using pharmacy refills gave mean MPR estimates of 68%,[93] 67%,[94] and 69%[95] using chart review and 63%[93] from a claims database. As discussed above, the study by Cate et al. that used two different self-report measures and electronic monitoring suggested that adherence (defined as percentage of patients at least 80% adherent) was about the same using all three measures: 60% were adherent using the Morisky Medication Adherence Scale, 57% using the Frequency of Missed Dose questionnaire, and 54% using the Travatan Dosing Aid (TDA) electronic monitor.[90] However, this was a secondary analysis of an RCT, and the same patients were being monitored by all three different measures. Therefore, the results may not be typical of ordinary patients who are not being electronically monitored.

Since the VAS is validated against MEMS data and is simple and intuitive to use, we used the VAS as the measure of adherence in the present study.[83] Because of the modest correlation between single-item VAS and MEMS results in prior studies, a new 5-item VAS measure asking patients to rate each item by placing a mark on a 10-cm line was developed as part of this study, as explained in section 3.3.3.[83] For a pilot study such as this, MEMS caps were

too expensive (about $100 each), and since they require placing the eye drop bottle in a larger bottle that fits the MEMS cap, they also would have served as a constant reminder of being monitored. Therefore, if MEMS had been used, the results might have reflected Hawthorne effects on adherence that are difficult to replicate outside of the context of a research study. Pharmacy refills are also impractical and would have required a great deal of time to obtain records from every pharmacy that study participants have used. In the study by Kumar et al., pharmacy refills were only collected for the subset of patients who were in the Veterans Affairs system, where all pharmacy records were available in a single electronic system.[85] In addition, pharmacy refills are not ideal for topical medications, where the number of doses in a bottle is not always possible to determine precisely, complicating the computation of adherence.[85] It would have been difficult to know whether a patient who used a large amount of medication was very adherent, or simply wasted a great deal of medication by squeezing out extra drops. Also, the follow-up period of only 1 month would have been too short to obtain good accuracy with pharmacy refills. Therefore, the VAS was used to assess adherence in this study.

2.4.5 Relationship between eye drop technique and glaucoma medication adherence

Although a few studies have assessed both glaucoma eye drop technique and glaucoma medication adherence,[17,53,59,61,63,65,66] the relationship between these two variables is not known. Sleath et al. included eye drop technique self-efficacy as an independent variable in a multiple regression model predicting adherence, but it was not a significant predictor.[59] Similarly, medication adherence self-efficacy was not a significant predictor of eye drop technique. However, the relationship between adherence and technique has not been assessed in any prior glaucoma studies.[59]

In other disease states such as asthma and chronic obstructive pulmonary disease (COPD), an association between better adherence and better technique has been suggested, but not directly shown.[134-138] In a nonrandomized observational study, better self-reported COPD medication adherence was observed for patients using pharmacies that provided enhanced inhaler technique education compared to those using pharmacies that did not provide enhanced inhaler technique education.[136] In another study by the same author, self-reported asthma adherence was significantly better in patients who reported having received more instruction on inhaler technique.[134] One observational study in asthma showed better adherence to metered dose inhalers than dry powder inhalers,[138] which the authors attributed to better technique despite not actually measuring technique. However, another study showed no difference in technique between metered dose inhalers and dry powder inhalers, while adherence was actually better with the dry powder inhalers.[137]

The existing studies in asthma and COPD have either used proxy measures of adherence or technique, such as an easier-to-use inhaler type as a proxy for better technique,[138] or they have not directly analyzed the relationship between adherence and technique. Therefore, the present study was the first to provide insight into the association between medication adherence and objectively measured video-recorded eye drop technique.

The next section will discuss educational video interventions in a more general sense across all types of chronic conditions.

2.5 Educational Video Interventions

This section will review the literature surrounding educational video interventions for improving self-management behavior in chronic conditions. This helps to define where gaps in

the literature exist that may be filled with a particularly innovative online video intervention. This literature also helps inform what an appropriate study design is, what intervention characteristics need to be included, and what outcomes should be included in the present study.

The brief, often rushed visits that characterize modern medicine afford little time for conveying essential information about critical disease self-management skills.[139] Communicating how to perform these essential skills, as well as coaching and motivating patients to keep up their chronic disease self-management over periods of many years, are areas where eHealth, defined as "the use of emerging information and communication technology, especially the Internet, to improve and enable health and health care",[140] may be able to fill the gap by providing education that cannot fit into short provider visits. For example, physicians often do not have time to ensure that their patients know how to perform basic self-management skills ranging from managing their diet to taking various types of medications. That is especially true with medications that are less straightforward than taking a pill, such as eye drops,[141] injected medications,[142] or inhalers.[6] The results of studies assessing medication technique and adherence in these chronic conditions suggest that providers are not engaging in patient education on how to use these medications for maximum benefit.[6,19]

Videos are a simple and intuitive means of communicating health information and are now increasingly being posted online to educate the public about health. Videos may be a preferred format for people with low health literacy, who may find video easier to learn from than text-heavy websites or written materials.[8] Videos can also demonstrate exactly how to perform a task, which would be much more difficult to explain with text or pictures alone. However, it is currently unknown how effective educational health videos are at improving technique and how their effectiveness might be increased further.

2.5.1 Intervention characteristics

Using a PubMed search, 179 studies were found on educational video interventions. Thirty studies were reviewed that were related to patient self-management of a chronic condition and did not meet any of the following exclusion criteria: the intervention was intended as a decision aid, they addressed only the development of the intervention and did not test it, they addressed video games, they addressed videoconferencing or care manager interventions with heavy provider involvement, or they were review articles.

Studies considered several different areas of chronic disease self-management, including adherence to medications or vitamins; control of blood glucose, blood pressure, and cholesterol; asthma inhaler technique; as well as diet, exercise, and avoidance of smoking as part of larger chronic disease self-management programs. The chronic conditions studied included diabetes (5 studies),[143-149] asthma (5 studies),[6,150-153] coronary artery disease (3 studies),[154-156] end stage renal disease (2 studies),[157,158] glaucoma (2 studies),[8,19] HIV (2 studies),[159,160] and 1 study each in atopic dermatitis,[161] amblyopia,[162] obstructive sleep apnea,[163] atrial fibrillation,[164] fragility fracture,[165] post-transplantation risk of skin cancer,[166] chronic fatigue syndrome,[167] physical functioning after hip repair surgery,[168] heart failure,[169] and epilepsy.[170] One study also addressed medication misuse in a variety of conditions.[171]

Only two studies specifically considered an online video intervention.[149,161] Most studies considered videos that were watched during the clinic visit or were given to the patient as a DVD to watch at home.

2.5.2 Designs

Twenty-one of the studies used an RCT design (Table 2.6).[6,8,19,143-148,150-152,154,155,158,159,161-167] Seven studies used a quasi-experimental design;[149,153,157,160,168,169,171] six measured outcomes in the same group of participants before and after watching the video,[149,153,157,160,169,171] and the other study[168] did not state clearly how the intervention and comparison groups were determined. One study used a choice design, where participants could choose between video plus a written handout, or a handout only.[170] One study used a single-group cross-sectional design, measuring outcomes only after all participants watched the video.[156]

Among the 21 RCTs, 16 had two arms, 4 had three arms, and 1 had four arms. Wilson et al.'s four-arm RCT promoting self-management of asthma randomized patients to receive video education, print education, both, or neither.[150] Among 3-arm RCTs, two compared two different videos to usual care. Mahler et al. compared a diet and exercise video using a Mastery frame to a video using a Coping frame to standard care.[155] The Mastery frame was designed to be more optimistic and emphasize recovery as a "steady forward progression", while the Coping frame was designed to prepare patients more intensively for problems that would likely arise.[155] The other study by Nordfeldt et al. compared a video specifically about diabetes self-management to a general diabetes video to usual care.[146,147] Another 3-arm trial by Beaudoin et al. compared video plus print material to print material only to usual care.[165] Finally, a 3-arm RCT by Liu et al. compared face-to-face asthma education to group education to home-based video education,[152] while also recruiting a no-intervention comparison group from a neighboring hospital.

Among two-arm RCTs, 4 compared a video to usual care,[8,143-145,167] 4 compared a multifaceted intervention using video plus other components to usual care,[19,151,162,163] 2 compared a video to printed materials,[161,166] 2 compared a video to live in-person education,[158,159] 2 compared two different videos,[6,148] 1 compared video plus printed materials to printed materials only,[154] and 1 compared video plus printed materials plus live education to printed materials only.[164]

The study reported in this dissertation used a two-arm RCT design comparing the 4-minute Meducation eye drop technique video to a 3-minute nutrition video on cooking with whole grains as the active comparator (see Chapter 3, Methods). Using another video as an active comparator allows better assessment of the value of the video content than a usual care comparator would. Print materials could also be used as an active comparator. However, print materials have only been tested in one small quasi-experimental pilot study of 25 patients with no control group.[11] It is considered preferable to use an active comparator with known efficacy when one exists,[172] but due to the lack of a large, well-controlled study on print materials for glaucoma education, print materials do not currently meet this standard. Thus, the results of a study comparing the Meducation video to print materials might not have been readily interpretable. A three-arm design with two video arms and usual care is also worth considering, but is not feasible considering the limited time and budget for this study. The nutrition video being used as a comparator[173] was not expected to provide appreciable improvement in eye drop technique or medication adherence, so there would probably have been little value in having both a nutrition video arm and a usual care arm.

Table 2.6. Summary of study designs and results for educational video interventions.

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Glasgow 1995, Glasgow 1996, US[144,145]	Self-management of diabetes	RCT: Interactive video vs usual care	SCT, social learning theory, systems approaches, stages of change	Interactive video tailored to stage of change and barriers identified. Videos are on eating away from home, eating at home, or food purchasing	Intervention group showed more improvement in calories per day, % calories from fat, % calories from saturated fat, serum cholesterol (all p<0.01); NS change in HbA1c
Nordfeldt 2005, Nordfeldt 2003, Sweden [146,147]	Prevention of severe hypoglycemia in type 1 diabetes	RCT: Video/brochure about self-management vs Video/brochure with general diabetes info vs usual care	None mentioned	Two videos (17 min and 18 min) on preventing hypoglycemia, symptom recognition, and treatment; General diabetes group received 13-min video containing only general diabetes info	Reduced incidence of hypoglycemia at 24 mo in targeted video arm only (p=0.0241); NS at 12 mo
Gerber 2005, US[148]	Self-management of diabetes	RCT: Supplemental computer multimedia vs control multimedia (diabetes quizzes)	Gagne's theory of learning, component design theory	19 tailored computer-based multimedia lessons that could be done in any order	Video group had higher perceived susceptibility to complication (p=0.009) but other outcomes NS different
Dyson 2010, UK[143]	Type 2 diabetes self-management	RCT: Video vs no intervention	None mentioned	Three 10- to 15-min videos on "Food Choices", "Physical Activity", "Weight Management"	Increased knowledge after intervention in video group (p=0.024); no change in control group
Davis 2016, US[149]	Self-management of type 2 diabetes	Quasi-experimental pre-post study: All patients received online video	IMB model	Nine 2-min video modules tailored to patients' individual barriers	No statistically significant improvement in adherence or self-efficacy; self-efficacy improved more in patients with eighth-grade or lower reading level (p=0.02)

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Cordina 2001, Malta[151]	Asthma self-monitoring and self-management	Cluster RCT: Pharmacies randomized to provide verbal counseling+ video+leaflet+ monitoring with reinforcement, vs routine services	None mentioned	Video educating about asthma and demonstrating inhaler technique	Significant improvement in QOL (p=0.044) and inhaler technique (p=0.021) in intervention group at 12 mo; Intervention group had better PEF at 12 mo than control (p=0.009)
Liu 2001, Australia [152]	Self-management of asthma	RCT: Face-to-face education (individualized or not) vs group education vs home-based video education. In addition a no-intervention control group was recruited at a different hospital	PRECEDE model	2 videos containing the same information delivered in the educational sessions	All intervention groups gained knowledge; however, video group experienced similar asthma severity to controls, and face-to-face education group performed significantly better than other groups
Wilson 2010, US[150]	Self-management of asthma symptoms and triggers	RCT: Video vs print vs both vs no education	Cognitive learning theories	4-min video about triggers/symptoms and 3-min video about inhaler use; print materials with same content	Both interventions worked better than no intervention; NS difference between print and video
Carpenter 2015, US[6]	Asthma inhaler technique	RCT: Inhaler technique video vs nutrition video (functioning like placebo)	SCT	3-min video explaining MDI technique	Intervention group performed more steps correctly (mean difference 1.08 steps, 95% CI: 0.53, 1.63) than control group immediately after video
Carpenter 2016, US[153]	Asthma inhaler technique	Pre-post assessment of technique before video, immediately after, and at 1 month	None mentioned	1-2 min tailored video giving step-by-step feedback on inhaler technique steps performed correctly or incorrectly	Technique steps performed correctly increased from 6.4 before video to 7.6 immediately after (p=0.03) in patients who used a spacer, and 4.5 before video to 7.2 immediately after (p<0.01) in patients who did not use a spacer

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Mahler 1999, US[155]	Adherence to diet and exercise following CABG	RCT: Video with Mastery frame vs Video with Coping frame vs standard care	Self-regulation theory	Instructional video on adherence to diet and exercise after CABG, from either a Mastery or Coping frame	Both video groups had higher dietary self-efficacy immediately after video ($p=0.0055$) and at 1 month ($p<0.01$), lower dietary fat at 1 month ($p<0.05$); Coping video produced best exercise behavior ($p<0.05$ compared to both other conditions)
Klein-Fedyshin 2005, US[156]	Adherence to medications and healthy lifestyle following CABG	Single-group cross-sectional study: All patients watched video	None mentioned	31-min video on recovery from heart surgery	Most patients reported gaining knowledge through the video
Eckman 2012, US[154]	Medication adherence, diet, exercise, and smoking for patients with CAD	RCT: Video+booklet vs booklet only	None mentioned	30-min video with segments on "How Medications Help", "Managing Cholesterol", "Controlling Blood Pressure", "Quitting Smoking", "Managing Exercise and Stress", "What's In It For You", "What's Best For You"	Knowledge improved in both groups ($p=0.07$ for difference between groups); both groups had significant improvements in diet and smoking
Baraz 2010, Iran[158]	Dietary and fluid compliance in patients having HD	RCT: Video education vs oral group education	None mentioned	30-min video on ESRD, dietary and fluid management	Both methods produced improvement in biochemical parameters; NS difference between groups
Baldwin 2013, US[157]	Phosphorus control in ESRD patients on HD	Pre-post assessment of phosphorus levels before and 1-2 wk after watching video	None mentioned	45-min video on factors governing phosphorus levels in the body, symptoms of poor phosphorus control, how to control phosphorus levels	Phosphorus levels lower after viewing video ($p=0.0006$); significant improvements in phosphorus-related knowledge and attitudes

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Okeke 2009, US[19]	Adherence to eye drops for glaucoma	RCT: Video+review of barriers+phone call reminder+visible reminders on device vs no intervention	None mentioned	10-min video on importance of medication adherence and ways to remember to take eye drops	Intervention group more likely (p=0.01) to have improved adherence at 6-mo follow-up
Muir 2012, US[8]	Glaucoma medication adherence	RCT: Video education vs standard care	None mentioned	2-5 min video tailored to health literacy level (at 4th, 7th, or 10th grade level) plus 20-min 1-on-1 session with study coordinator	No overall difference between intervention and control; in lowest literate subgroup, intervention participants had NS fewer DWM (mean of 51 vs 92, p=0.173)
Brock 2007, US[160]	Adherence to HIV medications	Quasi-experimental pre-post study: Assessment before and after watching video	None mentioned	17-min video attempting to maximize self-efficacy to adhere to HIV medications	Improved knowledge of disease and medications after watching video (p<0.05); improved adherence 4-6 wk after watching video (p=0.005)
Sampaio-Sa 2008, Brazil[159]	ART adherence for HIV	RCT: Educational workshop vs video	Information-Motivation-Behavioral Skills Model	Four 8-12 min videos on HIV, its transmission and its treatment. Patients could ask a physician questions after the video	No difference between groups in adherence or viral load after 12 mo
Tappen 2003, US[168]	Restoration of physical functioning after hip repair surgery	Quasi-experimental study: Intervention vs comparison group (details unclear)	None mentioned	Generic video on appropriate activity during recovery, plus individualized video on exercises demonstrated by therapist	Greater improvement in distance and time walked in intervention group (p<0.05)
Alemagno 2004, US[171]	Avoidance of medication misuse in seniors	Single-group pre-post study: All patients received video clips	None mentioned	Multiple 5-7 minute video clips customized based on patient's answers to questions	38% of participants had started using a pill box 2 mo after intervention; 24% reported changing their medication use behaviors

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Smith 2005, US[169]	Self-management of heart failure	Pre-post assessment of knowledge and health status before and after watching video	Triandis model of health behavior, Smith Family Care Theory	4 videotapes on weight management, medication adherence, dietary sodium control, exercise, and other topics	12.5% mean increase in heart failure knowledge score (no p-value given)
Armstrong 2011, US[161]	Self-management of AD	RCT: Online video-based patient education vs pamphlet	None mentioned	Online video about symptoms of AD, environmental triggers, treatments, bathing/hand washing, moisturizers	Online video group had greater improvement in POEM (p=0.0043) and knowledge (p=0.011) than pamphlet group
Bakker 2011, Netherlands [167]	CFS management and prevention of school absence	RCT: Video vs usual care	None mentioned	Video about coping strategies and treatment for CFS	Becoming persistently fatigued with school absence was 3.3 times more common in the intervention group (intervention had a negative effect)
Hua 2011, Germany [164]	Adherence to OAT	Physician-level cluster RCT: Video+brochure+ nurse education vs brochure only	None mentioned	20-min video/brochure on OAT purpose/benefits, nutrition, drug interactions, adherence; 20-30 min nurse education	None available
Lai 2014, Hong Kong[163]	Adherence to CPAP treatment for OSA	RCT: Video+Interview+ Phone follow-up vs usual care	SCT, MI theory	25-min video, 20-min patient-centered interview, 10-min follow-up phone call	Intervention group had better CPAP adherence (p<0.001) and self-efficacy (p=0.012)
Beaudoin 2014, Canada[165]	Adherence to calcium and Vitamin D supplements post-fragility fracture	RCT: Video+written material vs written material only vs usual care	None mentioned	15-min video on osteoporosis diag-nosis and treatment, fragility fracture; written materials on preventive behaviors for osteoporosis, fragility risk, and supplements	Calcium and Vitamin D intake increased more in the video group compared to usual care (p=0.026 for calcium, p=0.012 for vitamin D); difference between video and written material groups NS

Author, Year, Country	Behavior considered	Design	Theory used	Description of intervention(s)	Results
Trinh 2014, US[166]	Adherence to sun-protective behaviors in transplant patients at risk of skin cancer	RCT: Video vs pamphlet	None mentioned	2-min video on skin cancer epidemiology, risks, treatment, complications, prevention; brief pamphlet on same content	Video group had more improvement in knowledge ($p<0.01$) and higher satisfaction
Pradeep 2014, UK[162]	Adherence to patching for amblyopia	RCT: Multifaceted educational/ motivational intervention vs usual care	None mentioned; semi-structured interviews used for needs assessment	Video, cartoon story book, information booklets, sticker charts, session with researcher	Adherence higher in intervention group ($p=0.0027$); no significant difference in visual outcomes
Pascual 2015, US[170]	Epilepsy self-management	Nonrandomized pre-post study: Patients chose video+handout or handout only, ER visits assessed before and after	None mentioned	14.75-min Epilepsy Foundation video on general epilepsy care, medications, avoiding triggers, first aid, when to call 911	No patients in either group had ER visits in 4 mo after study ($p<0.0001$ compared to before); no difference between groups

AD, atopic dermatitis; ART, antiretroviral therapy; BG, blood glucose; BP, blood pressure; CABG, coronary artery bypass graft; CAD, coronary artery disease; CFS, chronic fatigue syndrome; CPAP, continuous positive airway pressure; DWM, days without medication; EMR, electronic medical records; ER, emergency room; ESRD, end-stage renal disease; HD, hemodialysis; HIV, human immunodeficiency virus; IMB, Information-Motivation-Behavioral Skills; MDI, metered dose inhaler; MI, motivational interviewing; NS, not significant; OAT, oral anticoagulant treatment; OSA, obstructive sleep apnea; PEF, peak expiratory flow; POEM, patient-oriented eczema measure; QOL, quality of life; RCT, randomized controlled trial; SCT, social cognitive theory

The next section will turn to the outcomes and overall effectiveness of video interventions tested in the literature.

2.5.3 Outcomes of video interventions

Among 10 RCTs comparing video intervention (with or without other components) to usual care, eight found statistically significant results favoring the video intervention (Table 2.6),[19,143-147,151,155,162,163,174] while Muir et al. found no significant difference between groups of glaucoma patients,[8] and Bakker et al. found that their video intervention had a negative impact.[167] Outcomes that were significantly improved in the successful trials included diet,[144,145,155] exercise,[155] adherence to medications,[19,162,163] knowledge,[143] self-efficacy,[155,163] inhaler technique,[151] quality of life,[151] as well as clinical measures such as hypoglycemic episodes,[146,147] cholesterol,[144,145] and peak expiratory flow (PEF).[151]

Five RCTs compared video to print materials in some form.[150,154,161,165,166] Armstrong et al. found that an online video for improving atopic dermatitis self-management outperformed a pamphlet in improving patient-oriented eczema measure (POEM) scores ($p=0.0043$) and knowledge ($p=0.011$).[161] Trinh et al. reported greater improvement in skin cancer knowledge in a group that watched a 2-min educational video compared to those receiving the same information in a pamphlet.[166] The other three studies found that video produced significant benefits, but not significantly greater than print materials.[150,154,165] The difference in knowledge between video-plus-booklet and booklet-only groups for improving healthy lifestyle in coronary artery disease (CAD) patients was almost statistically significant in Eckman et al.'s study ($p=0.07$).[154]

Four studies used some form of comparison between video and live in-person education; one of these published only the protocol without any results.[164] Baraz et al. found no difference

between video education and oral group education for improving dietary and fluid compliance in patients having hemodialysis.[158] Sampaio-Sa et al. also found no difference in improving antiretroviral therapy (ART) adherence for HIV between an educational workshop and a video format, supplemented with the ability to ask a physician questions after the video.[159] On the other hand, Liu et al. found that face-to-face individual education for asthma self-management performed significantly better than delivery of the same information by group education or home-based video education.[152] Although all three intervention groups gained knowledge, the video group had similar asthma severity to the control group at the end of the study.

Two studies compared a video intervention condition to a similar format with different content.[6,148] Carpenter et al. randomized children with asthma to watch the Meducation video on asthma inhaler technique or a video on nutrition, which functioned like a placebo control since it was not expected to improve the inhaler technique outcome.[6] The intervention group performed more steps correctly after the video than the control group ($p<0.05$). Gerber et al. randomized diabetes patients to 19 tailored computer-based multimedia lessons on diabetes self-management that could be done in any order, or a control multimedia group that received only diabetes quizzes.[148] The video group had higher perceived susceptibility to complications ($p=0.009$), but most outcomes were not significantly different between groups.[148]

In addition, although not an RCT and without a comparison group, a pre-post study of a tailored inhaler technique video also by Carpenter et al. demonstrated that patients performed significantly more steps correctly after the video than before ($p<0.05$ for both subgroups, with and without spacer).[153]

Overall, it appears that video-based education for self-management of chronic conditions is a valuable tool. Video education has almost always outperformed usual care, sometimes

produced better results than printed materials,[161,166] and sometimes performed as well as much more resource-intensive live education.[158,159] Most studies did not use online videos, which may produce better effects than videos watched in the clinic setting only. Unlike videos shown in the clinic, online videos can easily be watched as many times as patients want, including just before they attempt to use the medication in their usual setting.

Since the proposed intervention in this study is a Meducation video, the next section will turn to studies specifically testing Meducation products.

2.5.4 The Meducation system

The Meducation system developed by Polyglot Systems consists of both print and video materials that are designed to provide easy-to-understand, practical instruction on correct medication use.[175] These include tailored patient-specific printable medication instructions with pictograms to visually communicate the proper timing for taking doses, as well as videos on how to take medications correctly. The instructions are presented in the patient's choice of any of 21 languages, at a fifth- to eighth-grade reading level, in large font, and accessible at any time online through a patient portal.[175] All Meducation products are easy to disseminate through health systems that use Polyglot Systems' products.

Meducation has been tested successfully in both a pediatric population with asthma,[6] and an adult population of veterans with cardiovascular disease risk factors.[7] In the asthma study, as discussed above in section 2.5.3, patients who watched the Meducation video on inhaler technique performed significantly more steps correctly after watching the video than a control group that watched a nutrition video.[6] In the cardiovascular disease study, a pre-post design was used to assess antihypertensive medication adherence, weight, and blood pressure before and

after receiving a Meducation calendar.[7] The Meducation calendar prints all the medications the patient must take and lists the quantity to take in the morning, at noon, in the evening, and at bedtime in a handy chart form. After using the Meducation calendar, patients had a medication possession ratio (MPR) that was 3.2 percentage points higher at 6 months compared to baseline (p=0.73), and also had improved scores (p-values not stated) on 6 of 7 items of a modified Morisky self-reported adherence scale. Body weight also decreased by a mean of 3.6 pounds, and systemic and diastolic blood pressure decreased by a mean of 0.5 and 1.5 mmHg, respectively.[7] Given the small sample size of only 23 participants, none of the differences in adherence or clinical measures were statistically significant. Therefore, although the results seem promising, further testing with larger samples is needed. Unlike the cardiovascular disease study, the present study was adequately powered and used a randomized controlled design.

2.5.5 Research gaps

Although many studies have shown success in using videos to improve chronic disease self-management, few online videos have been tested, and no studies in which videos were hosted on social media platforms were found. Simply placing an educational video online to be watched without any provider involvement seems that it would have been straightforward, but only two studies evaluated the effects of this method on medication outcomes.[149,161] Despite the very large number of videos on social media such as YouTube, including many health-related videos from famous academic medical centers and government agencies, none of the studies evaluated the effects of social media videos. According to the RE-AIM criteria (reach, effectiveness, adoption, implementation, and maintenance), which strive to assess the real-world impact of an intervention by emphasizing its potential for wide implementation and

dissemination, social media videos should have an advantage on all criteria except possibly effectiveness.[176] However, perhaps researchers are reluctant to place videos on social media because they want to preserve the integrity of the intervention by preventing control patients from accessing it. There might also be a concern about harming patients by posting public online videos that turn out to be ineffective or even harmful.

Not only were health videos rarely online, but in many cases the patients only had the ability to view the video once.[150] For example, Wilson et al. compared a video that was watched once in the clinic to print materials that patients could take home; one study arm also received both.[150] This type of design may seem to give an unfair advantage to print material interventions. Investigators should strive to compare similar delivery methods for videos and print materials by giving patients a DVD copy of the video if online video access is impossible or unsuitable due to the limited technological savvy of the patient population. For educating patients on complex behaviors such as use of inhalers or eye drops, it is essential that patients be able to view videos multiple times, including at home if that is where they usually take their medications. Home access also helps to ensure that essential caregivers can watch the videos as well, which may increase social support for patients to take their medications.

Few studies explicitly mentioned tailoring or making their video accessible to patients with low health literacy. Patients with low health literacy are one of the most vulnerable populations, and may be the most in need of a video format to compensate for their limited ability to comprehend either printed material or text-heavy websites.[177] Sadly, one of the studies that did give special attention to health literacy, the glaucoma adherence study by Muir et al., did not find that the video on the anatomy of the eye and process of vision loss, tailored to patients at a fourth-grade, seventh-grade, or tenth-grade level, outperformed usual care.[8] However, patients

in the lowest literate subgroup did experience a mean of 51 days without medication (DWM) in the intervention group, compared to 92 days for the lowest literate subgroup of control patients (p=0.173). It should be noted that with only 13 low-literate subjects in each group, the power to detect a statistically significant difference in this subgroup analysis was very low; the authors noted that 97 low-literate subjects per group would have been needed to have 80% power to detect a statistically significant difference given the observed effect size. In addition, it was encouraging that the mean of 51 DWM for low-literate intervention patients was better than the means of 85 DWM for marginal-literate and 74 DWM for adequate-literate intervention patients.[8] These results suggest that perhaps more video education studies need to focus on the lowest literate group that may initially have the poorest understanding of how and why to carry out the prescribed health behavior.

Although the present study was not limited to low literate patients, the Meducation eye drop technique video was well suited to low literate patients, since Meducation videos are written at a fifth- to eighth-grade reading level, and appeal to visual learners with their animations of correct eye drop technique.[175] The Meducation video avoids complex medical terminology, such as "systemic absorption", that is present in other eye drop technique videos.[48] Therefore, the present study was expected to fill a gap in the literature by providing an effective, easily accessible intervention that meets the needs of patients at all literacy levels.

2.6 Conceptual Model

This section will begin by describing the theoretical frameworks used in the literature surrounding both 1) eye drop technique and adherence, and 2) educational video approaches to improve performance of chronic disease self-management behaviors. Then the rationale for

grounding the present study in Social Cognitive Theory (SCT) will be discussed, and the specific model to be used in the study will be presented and justified. The individual constructs included in the model will also be defined and the reasons for the expected relationships among variables will be described.

2.6.1 Theoretical frameworks used in prior literature

Of the studies on glaucoma eye drop technique and adherence reviewed in sections 2.3 and 2.4, six studies, all of which were observational studies, described being rooted in a specific theoretical framework. One study conceptualized eye drop use with Street's model of communication,[61] three studies used the Health Belief Model (HBM),[76,84,108] and two used Social Cognitive Theory.[4,82] None of the intervention studies focused on improving eye drop technique or adherence mentioned being rooted in a theoretical framework.[11,12,19]

Street's model of communication was used in an observational study by Carpenter et al. to conceptualize the impact of communication on glaucoma patients' IOP, a relationship theorized to be mediated by eye drop technique and adherence.[61] More education about adherence and inclusion of patient input into the treatment plan were associated with improvement in IOP, but technique and adherence did not mediate these associations. The present study is not focused on patient-provider communication, but instead tests a video designed to be watched outside of the patient's time with the provider. Therefore, Street's model would not have been appropriate for the present study.

The Health Belief Model emphasizes the role of beliefs about perceived barriers, perceived benefits, perceived susceptibility, and perceived severity in influencing performance of health behaviors.[178] The Health Belief Model was used by Mansberger et al. and Barker et al. in

the development of a measure called the Glaucoma Treatment Compliance Assessment Tool (GTCAT).[76,84] In the first study, Mansberger et al. conducted 5 focus groups with a total of 20 participants, and classified 826 of the 931 adherence-related statements that participants made into one of the constructs of the Health Belief Model.[76] The statements included 30.9% that were about barriers, 14.1% about cues to action, 12.5% about susceptibility, 12.4% about benefits, 9.8% about severity, 9.1% about self-efficacy, and 11.3% about other reasons. Principal components analysis revealed that items loaded on seven factors: two related to severity, one related to susceptibility, two related to different aspects of barriers (difficulty of use and side effects), one related to knowledge, and one factor that was unidentified. Fifty-eight patients were then enrolled into an observational case series to test construct validity, test-retest reliability, and predictive validity using the automated monitoring Travatan Dosing Aid as a gold-standard measure of adherence. Glaucoma medication adherence was best predicted by 3 specific questionnaire items: personal knowledge of risk factors for glaucoma, agreement that "I am likely to use the drop every night," and self-reported side effects of eye drops.

In the second study using the Health Belief Model results from the Glaucoma Treatment Compliance Assessment Tool were compared to results from objective electronic monitoring with MEMS caps for the same 201 participants in a large multicenter trial.[84] Principal components analysis showed that the 47 items loaded on six components, which were classified as knowledge, forgetting due to lack of cues to action, susceptibility, self-efficacy, severity, and barrier/medication side effects. The best predictors of higher glaucoma medication adherence were 4 items from the Health Belief Model, white ethnicity, older age, and being married. The 4 Health Belief Model items were categorized as one severity construct ("If I lost the same amount of vision over the next five years as I have over the past five, it would have no effect on my

quality of life"), one forgetting due to lack of cues-to-action construct ("Over the last month I have not missed taking my drops"), one barriers construct ("Sometimes I am out of drops"), and one self-efficacy construct ("There are things I can do to control my glaucoma"). No item relating to benefits turned out to be among the useful predictors. The researchers also attributed the effect of being married to the lack of cues to action for unmarried patients, and the effect of age to potential cost-related barriers in the younger population, which would not generally have Medicare.

Newman-Casey et al. aimed to identify barriers to optimal use of eye drops in a cross-sectional survey study.[108] Six of 11 barriers tested were significantly more prevalent in patients classified as nonadherent by the Morisky Adherence Scale, compared to adherent patients: low self-efficacy, difficulty administering drops, forgetfulness, side effects, life stress, and difficult medication schedules. The authors were surprised that beliefs about glaucoma and beliefs about medication, such as skepticism that glaucoma will cause vision loss or that eye drops will prevent vision loss, were not significantly different between adherent and nonadherent patients.

Based on these studies, the Health Belief Model has a number of weaknesses for studying eye drop technique and adherence. None of the studies using the Health Belief Model assessed eye drop technique, which is more of a skills-based behavior. The Health Belief Model might be more helpful in studying behaviors where lack of motivation may be more central to the nonadherent behavior. In addition, two of the studies did not find that beliefs about glaucoma or beliefs about medication were associated with better adherence.[84,108] Instead, the barriers that were identified, such as low self-efficacy and difficulty administering drops, may be better addressed within the context of Social Cognitive Theory, which emphasizes building self-efficacy to maximize the chance to acquire a skill. Self-efficacy was not originally a part of the

Health Belief Model, but was later inserted after its importance was recognized by other theorists. Since the key outcome of technique in the current study has not been studied using the Health Belief Model, and appears to be linked more to self-efficacy and lack of skills than to health beliefs, Social Cognitive Theory is likely a better theoretical framework for the current study.

The studies on educational videos reviewed in section 2.5 also support using Social Cognitive Theory for the present study. Of these studies, eleven studies mentioned a theoretical framework that was used. There was little consensus on theoretical frameworks. The only theoretical frameworks that were used in more than one study were Social Cognitive Theory, which was used in three studies,[6,144,145,163] and the Information-Motivation-Behavioral Skills (IMB) model, which was used in two studies.[149,159] Since I used Social Cognitive Theory, I will discuss the findings using Social Cognitive Theory. Lai et al. used Social Cognitive Theory to study adherence to continuous positive airway pressure (CPAP) treatment for obstructive sleep apnea (OSA),[163] Carpenter et al. used it to study asthma inhaler technique,[6] and Glasgow et al. used it to study self-management of diabetes.[144,145] All three studies emphasized the central Social Cognitive Theory concept of self-efficacy as a key to producing the desired healthy behavior. Lai et al. found that self-efficacy was significantly higher in the intervention group ($p=0.012$) at 3 months,[163] while Carpenter et al. found that the difference just barely failed to be statistically significant ($p=0.052$).[6] Glasgow et al. did not report self-efficacy results, but did determine correlations between several other psychosocial constructs and the primary outcome measures (dietary self-care and attributes of diet). Specifically, in a diabetic population, higher scores on barriers significantly predicted less improvement in terms of calories from fat, calories from saturated fat, and cholesterol, while the constructs of seriousness and importance together

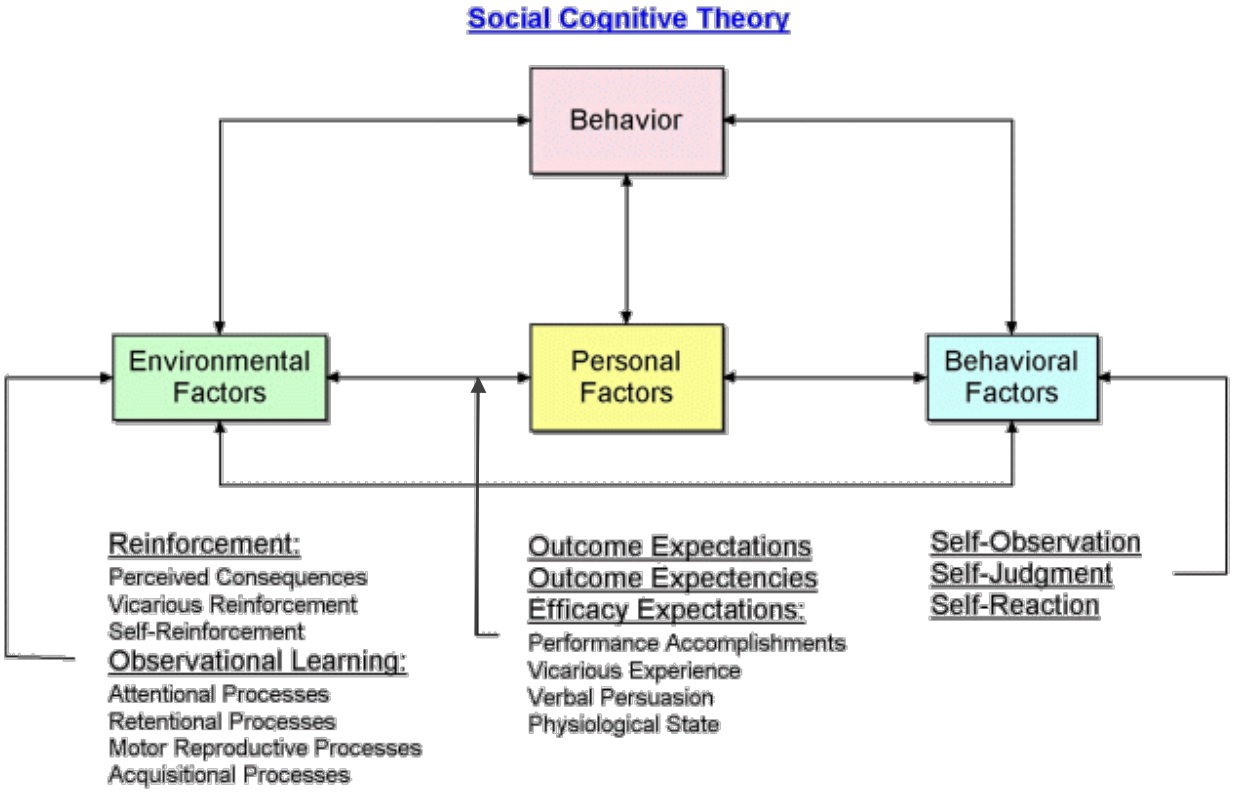
predicted better food habits and less improvement in cholesterol.[145] Therefore, the successful results of past studies using Social Cognitive Theory to develop educational videos supported the use of Social Cognitive Theory in the present study.

2.6.2 Social Cognitive Theory

Social Cognitive Theory, developed by Albert Bandura in the 1970s,[179,180] is well suited to studying educational interventions because it emphasizes the influence of self-efficacy on behavioral outcomes. Social Cognitive Theory emphasizes that even when individuals have knowledge about the need to engage in healthy behaviors, they are unlikely to expend effort on performing a behavior unless they have a belief in their personal efficacy to succeed.[73] Goals mediate the relationship between self-efficacy and behavior, since people with greater self-efficacy set more ambitious goals and are more likely to display the persistence needed to reach those goals when setbacks occur.[13] People's self-efficacy can be improved through mastery experiences, vicarious experiences provided by social models, social persuasion, and changing their interpretations of physical and emotional states.[73] Self-efficacy can affect health both by its effect on biological processes – such as patients experiencing activation of the endocrine system because they believe they lack the ability to cope with a challenge – as well as more indirectly through its effect on performance of healthy behaviors.[73] Besides self-efficacy and collective efficacy (a group's belief in its ability to perform together), other concepts influencing the performance of health behaviors in Social Cognitive Theory include outcome expectations, observational learning, incentive motivation, facilitation, self-regulation, and moral disengagement.[178] Reciprocal determinism refers to the way that the environment influences people and groups, but people and groups can also change their environment to improve their

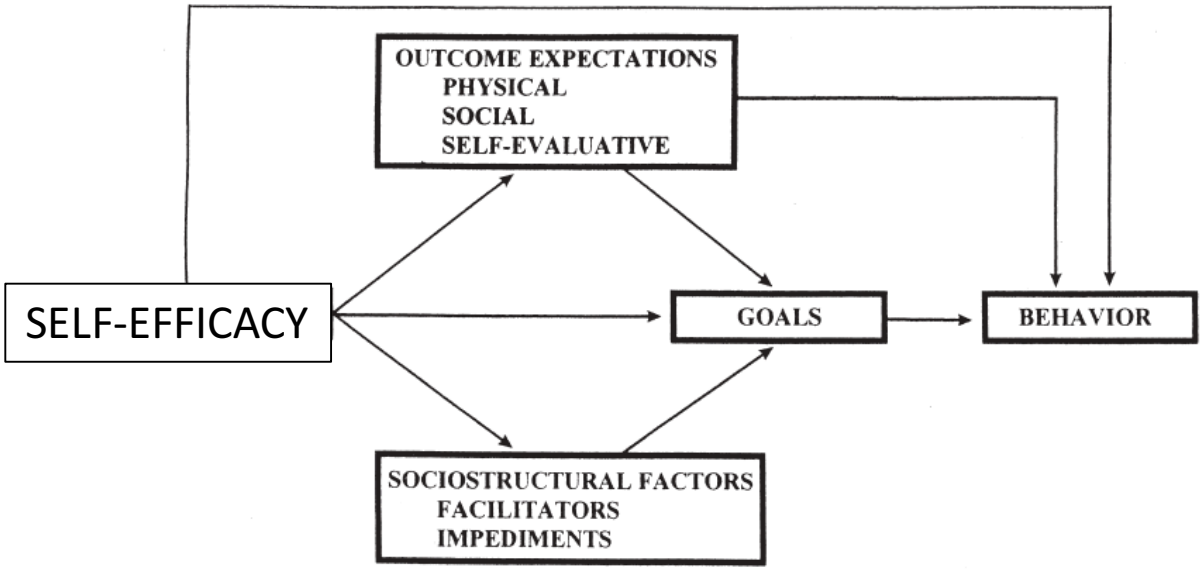
chances of performing desired behaviors.[178] The determinants fit into three broad categories (Figure 2.1): (a) environmental factors such as observational learning, incentive motivation, and facilitation; (b) personal factors such as self-efficacy, collective efficacy, and outcome expectations; and (c) behavioral factors such as self-regulation and moral disengagement.[179]

Figure 2.1 Reciprocal Determinism in Social Cognitive Theory[179]



Outcome expectations and sociostructural factors (facilitators and impediments) are important mediators of the relationship between self-efficacy and goals, because people are more likely to set more ambitious goals, be more persistent in striving toward the goals, and then achieve those goals if they have higher outcome expectations, many facilitators, and few impediments (Figure 2.2).[13]

Figure 2.2 Social Cognitive Theory[13]



As described in section 2.6.1, Social Cognitive Theory has been previously used in a major observational study of factors influencing glaucoma patients' eye drop technique and adherence,[4,82] as well as other studies of video education for self-management behaviors in asthma,[61] obstructive sleep apnea,[163] and diabetes.[145] In general, higher self-efficacy in using medications has been associated with higher medication adherence in a wide range of studies across multiple diseases,[181,182] including glaucoma.[74,108,183] Higher eye drop technique self-efficacy has also been associated with better eye drop technique.[53,59,74]

Particularly relevant is the fact that Social Cognitive Theory has been used to assess determinants of eye drop adherence with a focus on patient-provider communication.[4,82] In a study by Sleath et al., ophthalmologist visits were video-recorded to assess the content and quality of patient-provider communication.[4] Among Social Cognitive Theory constructs, adherence self-efficacy and outcome expectations were hypothesized to be particularly important determinants of adherence.[4] Adherence self-efficacy was measured with a general 21-item glaucoma self-efficacy questionnaire, outcome expectations were measured with a 4-item self-

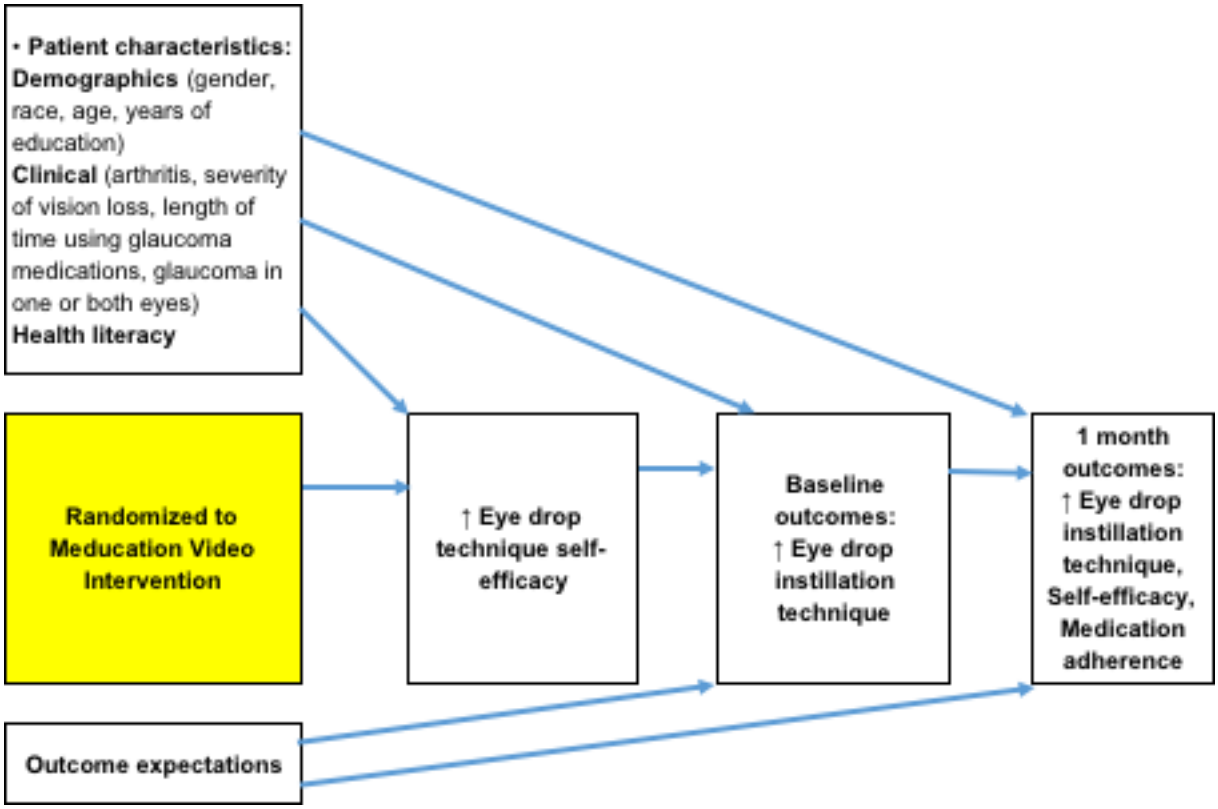
report measure, and adherence was measured objectively with MEMS caps.[4] The results supported the hypothesis that adherence self-efficacy and outcome expectations were significantly associated with adherence. The positive effect of outcome expectations in this study contrasts with the Health Belief Model studies by Barker et al. and Newman-Casey et al., who asked patients about whether they believed eye drops would help prevent vision loss and found that beliefs about medication benefits had no effect on adherence.[84,108]

In another publication from Sleath's study, Slota et al. focused on problems using medications and self-reported difficulty with proper instillation of drops.[82] Transcripts of visits were coded to determine whether patients mentioned problems with using medications, side effects, or nonadherence to glaucoma medication. Patients who had lower than an eighth-grade reading level were less likely than other patients to mention a problem with administering eye drops.[82] Patients were more likely to express a problem with nonadherence if they also had problems with eye drop administration or problems with side effects. Although the Social Cognitive Theory constructs of self-efficacy and outcome expectations were not explicitly included in this analysis, the results support the idea that self-efficacy and side effects – which are one type of negative outcome expectation – influence patient adherence.

The proposed conceptual model for this study based on Social Cognitive Theory is shown in Figure 2.3. As suggested by the results of the observational study by Sayner et al., patient demographics affect eye drop technique self-efficacy and likely also have an independent effect on eye drop technique.[9] Vision loss and arthritis are associated with lower self-efficacy to instill eye drops as well as poorer technique.[9,59] Low health literacy is also a risk factor for poor technique and self-efficacy.[16] Improving self-efficacy and technique with an eye drop technique intervention is expected to result in better adherence, since patients are likely to notice more benefit from the

medication if they know how to instill their eye drops correctly and are getting drops in their eyes.[6,83,108] Outcome expectations are also a key component of Social Cognitive Theory; patients who believe that performing correct eye drop instillation is more clinically beneficial are likely to be more persistent at learning to instill eye drops, and thus adhere to their regimen better.

Figure 2.3. Conceptual model based on Social Cognitive Theory



Sections 2.6.3-2.6.8 will now present the different components of the theoretical framework.

2.6.3 Intervention

The 4-minute Medication eye drop technique video was used in the intervention group to instruct patients on the critical steps in proper eye drop instillation. The video demonstrates how to wash one's hands correctly prior to eye drop use; remove the cap from the bottle and set it down on its side to avoid contamination; tilt the head back and direct the bottle toward the eye; hold open the lower eyelid; aim the bottle toward the eye and squeeze the bottle to produce a single drop; close the eye and occlude the tear duct; and remove excess medicine with a tissue. Similar to other Social Cognitive Theory-based educational videos that have shown success in past studies,[6,144,163] the Medication video applies Social Cognitive Theory by demonstrating the process of eye drop instillation in simple language, drawing on the Social Cognitive Theory concepts of observational learning, facilitation, and self-efficacy. The previous studies using videos have generally seen improvements in self-efficacy[6,163] which were linked to improvement in final outcomes of medication technique, medication adherence, or diet change, as discussed above in section 2.6.1.[6,144,145,163] The Medication eye drop technique video is compatible with any platform, allowing it to be viewed on computers, tablets, or mobile phones. The video is available in 21 languages, using the same graphics, which are displayed for different lengths of time to fit together with narration in the patient's preferred language. However, since interviewers fluent in other languages were not available for this pilot study, only the English version was tested in this study.

The video intervention was expected to influence eye drop technique self-efficacy and eye drop technique. Social Cognitive Theory predicts that observing a model performing the desired behavior of correct eye drop technique should improve self-efficacy to perform that behavior.[179] The intervention was expected to improve eye drop technique, an effect that may be

mediated by eye drop technique self-efficacy. However, there could also have been an independent effect of the intervention on eye drop technique that was not mediated by eye drop technique self-efficacy. As shown in the model, the video was not expected to directly influence medication adherence because the video is focused on technique.

The control group viewed a 3-minute nutrition video called "How to Cook with Budget Friendly Whole Grains" produced by the US Department of Agriculture Food and Nutrition Service as part of the Choose MyPlate campaign.[173] This video is available free on YouTube and explains how to use whole grains to prepare healthy dishes such as rice bowls, pasta salad, and breakfast burritos. It also emphasizes the health benefits of eating whole grains high in fiber. This video does not discuss medication use and therefore was not expected to have any effect on eye drop technique, technique self-efficacy, or medication adherence. While changes in diet may have a minor effect on blood pressure, reducing blood pressure does not improve IOP; in fact, lower blood pressure is likely to increase IOP.[21,184] Even if the nutrition video had affected IOP, IOP is not an outcome in this study due to the difficulty of measuring it outside of the clinic setting. Therefore, no placebo effect on the major outcomes of this study was anticipated.

2.6.4 Patient characteristics

Patient characteristics that may influence eye drop instillation technique and adherence include gender, race, age, health literacy, years of education, length of time using glaucoma medications, severity of glaucoma or vision loss, and comorbidities such as arthritis.[9,17,53,56,76,81,84,87,89,102,103,107,185] The literature suggests that female gender, older age, lower health literacy, more severe glaucoma, and having arthritis are associated with poorer medication technique.[9,16,17,54,58] The literature also suggests that African American race,[16,18,48,66,71,73-75] lower

health literacy,[16] fewer years of education,[17,56,81] shorter length of time using glaucoma medications,[17,81,87] more severe visual field defect,[9,53,107] depression,[81] and being unmarried[84] are associated with poorer medication adherence. Though not a patient characteristic, strictly speaking, more frequent dosing (e.g. three times a day vs twice or once daily) and greater number of glaucoma medications have also been associated with poorer adherence,[82,115] although one study found better adherence with twice-daily than once-daily dosing.[66]

Patient characteristics may also influence eye drop technique self-efficacy. In a study of 102 glaucoma patients by Sleath et al., age, gender, race, and years of education were not associated with eye drop technique self-efficacy, but a longer time taking glaucoma medications was associated with better eye drop technique self-efficacy.[59] The relationship of health literacy to eye drop technique self-efficacy is not known. It may be that low literate patients are overconfident in their ability to use eye drops, and therefore do not experience a decrement in self-efficacy. The idea that patients may be overconfident is supported by the study by Al-Busaidi et al., where 91% of patients stated that they had no trouble instilling drops, but only 20% actually had good technique.[72] Similarly, Dietlein et al. found that all patients in their study judged themselves sufficiently capable of instilling their own drops, but 55% contaminated the bottle and only 39% instilled just one drop.[69]

2.6.5 Outcome expectations

Outcome expectations are an important component of Social Cognitive Theory, which theorizes that patients who anticipate a greater likelihood of a certain behavioral outcome (e.g. avoiding vision loss or blindness), and a greater value from that outcome, will strive more diligently to achieve the outcome. Few glaucoma studies have assessed outcome expectations,

but a validated 4-item scale does exist.[74] We theorized that patients may anticipate a greater likelihood of successful control of their IOP after watching the video and be more persistent in trying to achieve successful IOP control by using their eye drops regularly. Therefore, it was important to control for outcome expectations when modeling the effect of the intervention on eye drop technique and medication adherence.

2.6.6 Eye drop technique self-efficacy

Self-efficacy is the main predictor of performance of a behavior in Social Cognitive Theory. Eye drop technique self-efficacy was expected to be influenced by patient characteristics and the intervention, and higher self-efficacy was expected to lead to better technique (Figure 2.3). Better eye drop technique self-efficacy has been associated with better technique in several previous studies,[53,59,74] although at least one study found no association.[61]

2.6.7 Eye drop instillation technique

Eye drop instillation technique is the primary outcome measure in this study. In accordance with Social Cognitive Theory and the eye drop technique literature cited above, eye drop instillation technique was expected to be influenced by technique self-efficacy, patient characteristics, outcome expectations, and the video intervention (Figure 2.3). Higher technique self-efficacy, more positive outcome expectations, and being in the intervention group rather than the control group were expected to be associated with better technique, defined as a greater number of eye drop instillation steps performed correctly, immediately after intervention and at 1 month later.

2.6.8 Medication adherence

Medication adherence was a secondary outcome measure in this study. Medication adherence is defined as the degree to which medication is taken as prescribed by a healthcare provider.[75] Medication adherence was expected to be influenced by medication technique, as patients who learn to instill their eye drops correctly should be more likely to perceive medication use as both feasible and beneficial than patients who have not mastered correct technique (Figure 2.3).[13] Social Cognitive Theory also suggests that technique should be related to adherence because patients with better technique self-efficacy and medication technique are likely to be more persistent when faced with obstacles to their medication adherence.[13] We expected that improvements in both self-efficacy and outcome expectations may thus lead to improved adherence, defined in this study as the patient taking medication correctly a greater percentage of the time as reported by Visual Analog Scale.

2.6.9 Limitations

There were a few limitations related to the use of theory in this study, mainly that not all Social Cognitive Theory constructs were measured. The exact learning processes that take place could not be readily ascertained. Future studies could compare video to other methods of teaching technique to determine whether video facilitates learning processes that are not possible with printed educational materials. Also, the Social Cognitive Theory concept of facilitation suggests that environmental changes and resources may make behaviors easier to perform. However, the environment in which patients demonstrated their technique during the study may be different from their environment at home. The clinic environment could be more stressful, unfamiliar, and challenging, but it could also be more favorable because the home environment

might not be clean and free of distractions. Through the randomized, controlled design, the study methodology increased the chance that environmental factors should be balanced across the groups and not confound the results.

2.6.10 Summary

This study aimed to improve glaucoma patients' eye drop instillation technique and medication adherence through an online educational video intervention demonstrating how to instill eye drops in an easily understood animated format. Social Cognitive Theory was an excellent foundation for the development of this intervention, since it has shown success in past studies of glaucoma medication adherence and similar behaviors.[4,6,82] In contrast, studies based on the Health Belief Model have more often found that the constructs included, especially beliefs about glaucoma or glaucoma medications, are not predictive of eye drop technique and medication adherence.[84,108] Validated instruments consistent with the principles of Social Cognitive Theory also exist for all the constructs that were measured in this study.[74,83] Thus, it was reasonable from a theoretical standpoint to expect that receiving the online educational video intervention would be associated with better self-efficacy, more positive outcome expectations, and better eye drop technique and adherence.

Chapter 3: Methods

3.1 Overview

This study aimed to determine the effectiveness of a short educational video in improving self-efficacy, eye drop technique, and eye drop adherence at two time points: immediately after watching the video and 1 month later. Based on the theoretical model in Figure 2.3, the following aims and hypotheses were proposed:

Aim 1: To determine whether glaucoma patients' eye drop self-efficacy and technique are improved immediately after watching a video instructing them on proper technique.

The following hypotheses were tested:

H1: Glaucoma patients who watch the Meducation video will have better eye drop instillation technique immediately after watching the video than control group patients who do not watch the video.

H2: Glaucoma patients who watch the Meducation video will have better eye drop technique self-efficacy immediately after watching the video compared to control group patients who do not watch the video.

Aim 2: To determine whether intervention patients have better self-efficacy, eye drop technique, and medication adherence than control patients at 1 month after study enrollment.

The following hypotheses were tested:

H3: Glaucoma patients who watch the Medication video will have better eye drop technique at 1 month after first watching the video, compared to control group patients who do not watch the video.

H4: Glaucoma patients who watch the Medication video will have better eye drop technique self-efficacy at 1 month after first watching the video, compared to control group patients who do not watch the video.

H5: Glaucoma patients who watch the Medication video will have better medication adherence at 1 month, as assessed by Visual Analog Scale, compared to control group patients who do not watch the video.

Aim 3: To describe patient perspectives on how to improve the video and how to disseminate it to other glaucoma patients.

Aim 3 was only descriptive in nature, so no specific hypotheses were developed for this aim.

To achieve the three aims, a randomized controlled trial was performed, followed by interview questions for the intervention group to guide the improvement and dissemination of the video. In the RCT (Figure 3.1), 92 glaucoma patients were randomized to watch either the 4-minute Medication video in the experimental group, or a 3-minute video on nutrition (functioning as a placebo intervention) in the control group. A previous study[6] used similar methodology by comparing asthma patients who watched a video on inhaler technique to control patients who watched a nutrition video.

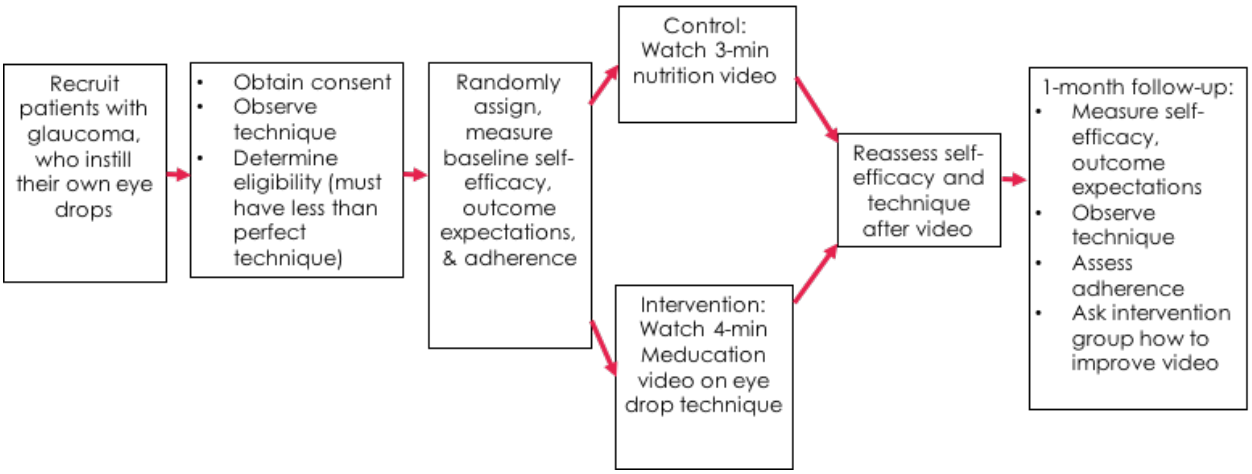


Figure 3.1: Overview of study design

3.2 Procedures

3.2.1 Recruitment and Eligibility Criteria

Adult glaucoma patients visiting an academic medical center in suburban North Carolina or a private ophthalmology clinic in urban Maryland, who self-administered their eye drops and were not blind, were referred to the research assistant (RA) by clinic staff to ask if they might be interested in participating in the study. The RA explained the study, and if the patient was interested, the RA obtained written consent. The inclusion criteria were:

1. At least 18 years of age
2. Able to speak and read English
3. Mentally competent to participate as determined by the Mental Status Questionnaire[186] (defined as making fewer than 5 errors on the 10-item questionnaire)
4. Diagnosed with primary open-angle glaucoma in their medical record
5. Prescribed at least one eye drop medication for use at least once daily (self-report)

6. Patient self-administered their own eye drops
7. Not legally blind
8. Performed at least one of 5 eye drop technique steps incorrectly
9. Willing to have their eye drop technique video-recorded

Patients who expressed interest in participating provided written consent using a document approved by the Institutional Review Board (IRB). Then they were screened for eligibility by answering the questions on the eligibility screener (Appendix A). If they met eligibility criteria, they were then videotaped demonstrating their instillation technique with a 5 mL bottle of artificial tears. If they had glaucoma in both eyes, they were instructed to instill a drop into their right eye; otherwise they instilled a drop into the affected eye. As we have done successfully in previous studies, patients used a standardized bottle of artificial tears that could be different in size or shape from what they use at home.[9] If a patient did not qualify, they were thanked for their time, and the videotape was immediately erased and was not analyzed. No payment was given to patients who did not qualify.

To be eligible, patients had to miss at least one of the five technique steps shown in Table 3.1.[11] The RA used a checklist to determine whether the patient missed any steps for the purpose of qualifying for the study. The principal investigator and RAs were trained by one of the study team ophthalmologists to accurately assess technique. However, the patient's final technique score for the purposes of analysis was determined by a masked observer who viewed the videotape at a later point (see section 3.2.5 below).

Table 3.1: Steps in eye drop technique that were scored[11]
• Squeezing the bottle to instill a single drop
• Holding open the lid with the finger
• Getting one drop accurately into the eye
• Not touching the bottle tip to the eye or face
• Closing the eye after instillation

3.2.2 Randomization

The principal investigator generated a randomization list using SAS. A single list was generated and divided amongst the two study clinics. Eligible patients were randomized 1:1 to the intervention or the control group. Opaque randomization envelopes were prepared with the group assignment for each patient. As recommended by guidelines, opaque envelopes help to protect the integrity of the randomization, assuring that research staff cannot manipulate the randomization process based on a personal desire to assign a particular patient to a particular group.[187] As each patient was enrolled, the next randomization envelope was opened and used to assign that patient to the correct group.

3.2.3 Baseline Visit

As discussed above in section 3.2.1, patients who were interested in participating provided written consent. They were determined to be ineligible if they correctly performed all 5 steps or failed to meet any other inclusion criteria. For patients determined to be eligible, the RA conducted the interview and collected all measures, including self-efficacy, outcome expectations, adherence measures, and demographics (Appendix B). The RA then opened the randomization envelope to randomize the patient to the intervention or control group. Depending

on group assignment, the patient then viewed the Meducation eye drop technique or the nutrition video. The self-efficacy and outcome expectations scales were then administered again, and the patient demonstrated his/her eye drop technique again while being videotaped. Intervention group patients were given an access code and shown how to access the video at home or on a mobile device at their convenience. All patients were asked to schedule a time for a follow-up visit at their home or a location of their choice approximately 1 month later. If they did not want to schedule the follow-up visit at that time, the RA called them about three weeks later to schedule the visit. Patients received $20 for completing the baseline visit.

3.2.4 Follow-up Visit

Although every effort was made to schedule a visit no later than 6 weeks from the baseline visit, patients who did not respond to the RA's phone calls or mailings were seen at their next visit to the clinic. The RA visited the patient's home or preferred alternative location and administered the self-efficacy, medication adherence, and outcome expectations scales by interview.[11,74,83] Then the RA video-recorded the patient's eye drop technique. Intervention group patients were also asked with whom they have watched the video, and their subjective rating of the video on a 4-point scale. Intervention group patients also completed questions about how the video should be improved and how it should be disseminated (Appendix C). All patients were granted access to the Meducation video after completion of the study, thus assuring that control group patients were not denied the opportunity to benefit from learning about eye drop technique. Patients received $20 for completing the follow-up visit.

3.2.5 Assessment of eye drop technique

Eye drop technique was assessed by videotaping the patient's technique at each time point (baseline before and after watching the intervention or control video, and at 1-month follow-up) and having a masked RA watch each video to score the patient's performance of the critical steps. The principal investigator and study ophthalmologist trained the masked RA on how to assess correct performance of each step, which was recorded on a checklist as performed correctly or incorrectly. The masked RA did not know the study hypotheses, and recordings from different time points were given to the RA in random order to minimize risk of bias.

3.3 Outcome Measures

The primary outcome of eye drop instillation technique and the secondary outcomes of eye drop technique self-efficacy and medication adherence were assessed using validated measures. Table 3.2 shows the variables that were collected, the time points when they were collected, the source, and the range as well as whether the variable was treated as continuous, categorical, or dichotomous. The outcomes of eye drop technique, eye drop technique self-efficacy, and medication adherence were all treated as continuous variables. While eye drop technique is the number of steps and therefore a count (discrete) variable, past glaucoma studies by our team have treated it as a continuous variable for analysis.[9] Vision-related quality of life was also collected to assess the clinical significance of the changes that patients experience over the study period.

Table 3.2: Key Variables, Time Points Assessed, Source and Range

Variable	Time Points	Source	Range
Outcomes			
Eye drop instillation technique[11]	Before & after video, 1-month	Assessment of video recording by masked study team member	Discrete; 0-5
Eye drop technique self-efficacy[59]	Before & after video, 1-month	6-item Eye Drop Technique Self-Efficacy Scale	Continuous; 6-18 (each item scored as 1=not at all confident, 2=somewhat confident, 3=very confident)
Medication adherence[83]	Before video, 1-month	Visual Analog Scale	Continuous; 0-100%
Vision-related quality of life[188]	Before video, 1-month	VF-14 quality-of-life scale	Continuous; 0-100
Patient characteristics			
Gender	Baseline	Patient interview	1=male, 0=female
Race	Baseline	Patient interview	1=African American, 0=non-African American
Age	Baseline	Patient interview	Continuous
REALM (Rapid Estimate of Adult Literacy in Medicine)	Baseline	Patient interview	1=eighth grade and below, 0=ninth grade and above
Severity of glaucoma	Baseline	Medical record	0=early, 1=moderate to severe
Length of time using glaucoma medications	Baseline	Patient interview	Continuous
Diagnosis of arthritis or other condition affecting manual dexterity**	Baseline	Medical record	1=yes, 0=no
Years of education	Baseline	Patient interview	Continuous
Outcome expectations[74]	Before & after video, 1-month	Glaucoma Outcome Expectations Scale	Continuous; 4-36 (Each of 4 items scored on a 9-point Likert scale)
Number of glaucoma medications being taken	Baseline	Medical record	Discrete
Number of times per day the patient takes glaucoma medications	Baseline	Medical record	Discrete
Visual acuity in better-seeing eye	Baseline	Medical record	Continuous (1.0=20/20 vision)
Patient's eyes dilated during visit	Baseline	Patient interview	1=yes, 0=no
Physician educated about technique	Baseline, 1-month	Patient interview	1=yes, 0=no
Patient's use of the Internet	Baseline	Patient interview (7 questions)	2 categorical and 5 dichotomous items
Problems in using glaucoma medications[82]	Baseline	13-item problems scale	Discrete; 0-13
Intervention-related characteristics			
Intervention versus control	Baseline	Randomization table	1=intervention, 0=control
Number of times the patient watched the video after the baseline visit	1-month*	Electronic tracking system for access code	Discrete
Perceived usefulness of video	1-month*	Patient interview	1=not at all useful, 2=a little useful, 3=fairly useful, 4=very useful
Whom the patient watched the video with	1-month*	Patient interview	Categorical (1=family member, 2=friend, 3=healthcare provider, 4=other)

*In intervention group patients only

**Asked on medical abstraction form, "Does the patient have: arthritis, tremors, Parkinson's disease, any other condition affecting manual dexterity (specify other)?"

3.3.1 Eye drop technique

Eye drop technique was assessed at all time points as the number of eye drop technique steps performed correctly, as shown above in Table 3.1. Eye drop technique could range from 0 to 5 steps performed correctly and was treated as a continuous variable.

3.3.2 Eye drop technique self-efficacy

Eye drop technique self-efficacy was assessed at all time points using the Eye Drop Technique Self-Efficacy Scale. This scale is a 6-item, validated short-form measure of a longer version of the scale.[59] Patients were asked how confident they were that they could squeeze the bottle, get the drop in their eye, consistently get the right amount into the eye, angle their head correctly, deliver the required amount of medication without missing or applying too much, and not touch their face with the bottle.[59] These tasks correspond closely to the steps covered in the Meducation video. Each of the 6 items was scored as 1 (not at all confident), 2 (somewhat confident), or 3 (very confident), and the items were summed to give a total score ranging from 6 to 18. In previous literature, the scale had a Cronbach's alpha of 0.84.[9] In the present study, Cronbach's alpha of the 6-item scale at baseline was 0.68.

3.3.3 Medication adherence

Medication adherence was assessed using a VAS measure, which had been validated against the gold standard of electronically monitored adherence in a large observational study of 279 patients.[83] Patients marked on a 10-cm line their responses to the question, "All things considered, how much of the time do you use your eye drops EXACTLY as directed?" with

endpoints “None of the time” and “All of the time”. The number of centimeters from the left end of the line to the patient’s mark was divided by 10 and then multiplied by 100 to give a percentage adherence score between 0% and 100%.

In a secondary, exploratory analysis, a new 5-item VAS adherence measure was developed. Patients marked on a 10-cm line their responses to each of 5 questions worded in the form, “How often do you miss taking your eye drops because ... ?” The 5 items were: 1) you forget; 2) they cause side effects; 3) they are too expensive; 4) you run out of eye drops before you can get a refill; 5) they are hard to use. Each item was rated on a 10-cm line with endpoints “Never” and “Very often”. There was a potential benefit to developing a new measure because although the 1-item VAS adherence measure generally has good properties,[83] a single-item measure tends to be weaker than a multi-item measure. A multi-item measure allows reliability (Cronbach’s alpha) to be calculated, and a basic factor analysis to be performed. Items were tested in an exploratory factor analysis using the Factor command in SPSS, and items that loaded too low (less than 0.6), or proved to be redundant, were dropped. Principal components analysis was performed to determine the number of factors in the scale. A scree plot was used to plot the eigenvalues of the correlation matrix, and factors with an eigenvalue greater than 1 were retained.

After factor analysis had been performed for the new 5-item scale, the overall adherence score was calculated as the mean summary score of all 5 items. Medication adherence was treated as a continuous variable with a range of 0% to 100%.

The factor analysis revealed that the new 5-item VAS for medication adherence had two factors. Three items, “How often do you miss taking your eye drops because you forget?”, “How often do you miss taking your eye drops because they are too expensive?”, and “How often do

you miss taking your eye drops before you can get a refill?" loaded on the first factor, which had an eigenvalue of 1.846. The other two items, "How often do you miss taking your eye drops because they cause side effects?" and "How often do you miss taking your eye drops because they are hard to use?" loaded on the second factor, which had an eigenvalue of 1.196. No items were dropped due to loading less than 0.6 on both factors. The results of the factor analysis are shown in Table 3.3. A parallel analysis produced a similar 2-factor solution with eigenvalues of 1.295 for the first factor and 1.121 for the second factor.

Table 3.3. Rotated component matrix for factor analysis of 5-item VAS for medication adherence.

Question	Factor 1	Factor 2
"How often do you miss taking your eye drops because you forget?"	0.580	0.388
"How often do you miss taking your eye drops because they cause side effects?"	-0.024	0.824
"How often do you miss taking your eye drops because they are too expensive?"	0.695	0.171
"How often do you miss taking your eye drops before you can get a refill?"	0.178	0.780
"How often do you miss taking your eye drops because they are hard to use?"	0.844	-0.167

3.3.4 Vision-related quality of life

Vision-related quality of life was assessed using the Visual Function-14 (VF-14) questionnaire,[188,189] which has been validated in a range of diseases including glaucoma.[188] This instrument assesses the impact of visual impairment on ability to perform each of 14 daily tasks. Each item is scored as 0 (unable to do) to 4 (no impairment). The 14 items are then averaged, and the result is multiplied by 25 to give a score between 0 (total impairment) and 100 (no impairment).[189] The minimal clinically important difference on the VF-14 in glaucoma has not

been established and was not used in this study, but in cataracts, a difference of about 16 points is considered clinically significant.[190]

3.4 Other Measures

Health literacy was measured using the REALM,[191] a commonly-used, validated measure that has been used in previous large glaucoma studies.[9] Patients were asked to pronounce each of 66 health-related terms. Those who score 61 or higher are considered to have a ninth-grade or higher level of health literacy, whereas those who score 60 or lower are considered to have an eighth-grade or lower level of health literacy. Health literacy was treated as a dichotomous variable (ninth grade or higher versus eighth grade or lower).

Outcome expectations was measured with the 4-item scale by Sleath et al.[74] This scale was validated in a study of 102 glaucoma patients and had a Cronbach's alpha of 0.83.[74] Each item was scored on a 9-point scale from 1 (not at all) to 9 (extremely), resulting in a score between 4 and 36.[74] Examples include, "How much do you think it will help your glaucoma if you come to your appointments with your eye doctor?" and "How much do you think it will help your glaucoma if you use your eye drops regularly?" In the present study, Cronbach's alpha for the outcome expectations scale at baseline was 0.86.

Problems with using medications was measured with the 13-item scale by Slota et al.[82] Cronbach's alpha for this scale has not been reported in prior studies, but in the present study Cronbach's alpha is 0.72. Each problem is scored as 0=none, 1=a little, or 2=a lot, and the responses are dichotomized (none versus a little or a lot), producing a number of problems between 0 and 13.[82] Example items include "My medication causes side effects," "It is difficult to remember all the doses," and "It is hard to pay for the medications."

Other variables that were collected (Table 3.2) include gender (dichotomous), race (dichotomous – African American versus other), age (continuous), glaucoma severity (early versus moderate to severe, based on the diagnosis recorded in the medical record for the baseline visit), length of time using glaucoma medications (continuous), diagnosis of arthritis or other condition affecting manual dexterity (dichotomous), years of education (continuous), number of glaucoma medications the patient is taking (discrete, treated as continuous), number of times per day the patient takes glaucoma medications (i.e. whether the patient is on a once-daily, twice-daily, or three-times-daily regimen; discrete, treated as continuous), visual acuity in the better-seeing eye as a continuous decimal (e.g. 20/20 vision=1.0), whether the patient's eyes were dilated during the visit (dichotomous), whether the physician educated the patient about technique (dichotomous), and how the patient uses the Internet (2 categorical questions and 5 dichotomous questions). The medical record was used to determine glaucoma severity, diagnosis of arthritis or other condition affecting manual dexterity, number of glaucoma medications the patient is taking, number of times per day the patient takes glaucoma medications, and visual acuity. Other conditions possibly affecting manual dexterity included stroke, diabetic neuropathy, numbness of fingers and toes, peripheral neuropathy, injury to hands and arms, peripheral vascular disease, neurofibromatosis, neck pain, cervical radiculopathy, decreased range of motion cervical spine, shoulder pain, spastic hemiplegia, cognitive disorder, vascular dementia, carpal tunnel syndrome, muscle pain, and gout.

3.4.1. Evaluation measures for intervention patients only

For intervention patients only, the number of times the patient watched the video after the baseline visit (discrete, treated as continuous), subjective evaluation of the video's usefulness (4-

point scale), and with whom the video was watched (categorical), were also collected. Subjective evaluation of the video's usefulness was scored as 1 (not at all useful), 2 (a little useful), 3 (fairly useful), or 4 (very useful). With whom the video was watched had the following response choices: friend, family member, healthcare provider, other (specify), or no one. Patients could choose multiple options ("check all that apply"). The evaluation questions are the same as those used by the same research team in a study of an online diabetes educational video[149] and in an ongoing RCT of an online educational video intervention for adolescents with asthma.[192]

The patient's access code was used to determine the number of times the patient watched the video after the baseline visit. We worked with Polyglot Systems, which had the ability to electronically track who used an access code to watch the video and when they watched it.

Intervention group patients were also asked the evaluation questions (Appendix C):

1. "Would you suggest that other patients watch the video?"
2. "How would you change the video?"
3. "What other topics would you like to cover in videos?"
4. "In what ways did the video help you?"
5. "How would you want the video to be made available?"
6. "What do you think is the best way to make the video available to other glaucoma patients?"

3.5 Sample Size

Our previous study of 279 glaucoma patients showed that for patients meeting the inclusion criteria for the present study – not having perfect technique at baseline and self-administering their eye drops – the mean number of steps performed correctly was 1.54 of 3

steps with a standard deviation of 0.53.[61] There were no previous studies that have intervened on eye drop technique with a similar intervention that could be used to determine an expected effect size. If we used the same three steps, we estimated that the video intervention would improve technique by at least one step per three patients. Using the standard deviation computed from the previous observational study,[61] a difference of one step per three patients is 0.3333/0.53=0.63 standard deviations and considered a clinically important difference. Using SAS PROC POWER, we calculated that to have 80% power to detect a difference of 0.63 SD with two-sided α=0.05, we would need 42 subjects per group. Allowing for 10% loss to follow-up, we needed 46 subjects per group for a total of 92 subjects. This was considered to be a conservative estimate given that measuring 5 steps, as opposed to 3, may increase power. Although using more steps could also increase the standard deviation and thus decrease the effect size, using more steps also gives patients an opportunity to show at least a minimal one-step improvement on a wider range of different potential technique issues.

3.6 Preliminary Analyses

All data were analyzed using SPSS 24 (IBM SPSS, Armonk, New York). All statistical tests were performed as two-sided tests at the α=0.05 level. Preliminary analyses were performed to examine the distributional properties of the data and check reliability of scales. Frequencies and descriptive statistics of each variable were generated to check for outliers and potential errors. Reliability of all scales was calculated using Cronbach's alpha. Preliminary bivariate analyses also included t-tests for continuous variables, or chi-square tests for dichotomous variables, to assess the unadjusted differences between intervention and control groups in technique, adherence, and self-efficacy at both the baseline and 1-month time points.

3.7 Aim 1 Analysis

Aim 1: To determine whether glaucoma patients' eye drop self-efficacy and technique are improved <u>immediately after</u> watching a video instructing them on proper technique.

The following hypotheses were tested:

> *H1: Glaucoma patients who watch the Medication video will have better eye drop instillation technique immediately after watching the video than control group patients who do not watch the video.*

A multivariable linear regression model was used to predict the number of eye drop technique steps performed correctly immediately after watching the video at the baseline visit. The key independent variable was group assignment (intervention versus control). Baseline technique (number of steps performed correctly prior to watching the video) was included as a covariate to minimize the impact of baseline differences between the intervention and control groups, and baseline self-efficacy was included due to its relationship with technique in the theoretical model.

The other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193] Covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was previously educated about technique.

There were two possible ways to account for baseline technique in the model: using the technique score at the later time point, with adjustment for baseline technique, or using a change score (i.e. number of steps improvement). Using the technique score at the later time point with adjustment for baseline technique was preferred because it is more conservative and less biased.[194] A significant imbalance in baseline values between intervention and control groups would allow one group more room for improvement, which could bias the comparison between groups if a change score were used.[194]

Additionally, a multivariable logistic regression was performed to predict the single step of getting one drop accurately into the eye. This analysis was performed because the ophthalmologists on the study team considered getting the drop into the eye to be a particularly important step, and expected that readers of ophthalmology journals would be especially interested in knowing the effect of the video on this step. The key independent variable was group assignment (intervention versus control). As in the main model, getting the drop accurately into the eye prior to watching the video (yes/no) was included as a covariate, and other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193] The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was previously educated about technique.

H2: Glaucoma patients who watch the Meducation video will have better eye drop technique self-efficacy immediately after watching the video compared to control group patients who do not watch the video.

A multivariable linear regression model was used to predict the eye drop technique self-efficacy score immediately after watching the Meducation or nutrition video. The key independent variable was group assignment (intervention versus control). Eye drop technique self-efficacy prior to watching the video was included as a covariate.

Other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193] The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was previously educated about technique.

Techniques to handle missing data will be discussed in section 3.9.

3.8 Aim 2 Analysis

Aim 2: To determine whether intervention patients have better self-efficacy, eye drop technique, and medication adherence than control patients at <u>1 month</u> after study enrollment.

The following hypotheses were tested:

H3: Glaucoma patients who watch the Medication video will have better eye drop technique at 1 month after first watching the video, compared to control group patients who do not watch the video.

A multivariable linear regression model was used to predict the number of eye drop technique steps performed correctly at 1-month follow-up. The key independent variable was group assignment (intervention versus control). Baseline technique (number of steps performed correctly prior to watching the video) was included as a covariate to minimize the impact of baseline differences between the intervention and control groups, and baseline self-efficacy was included due to its role in the theoretical model.

Other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193] The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was educated about technique.

Additionally, a multivariable logistic regression was performed to predict the single step of getting the drop accurately into the eye at 1 month. The key independent variable was group assignment (intervention versus control). As in the main model, getting the drop accurately into the eye prior to watching the video (yes/no) was included as a covariate, and other covariates included in the model were selected as those that either 1) were significantly associated with the

outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193]

The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was educated about technique.

H4: Glaucoma patients who watch the Medication video will have better eye drop technique self-efficacy at 1 month after first watching the video, compared to control group patients who do not watch the video.

A multivariable linear regression model was used to predict the eye drop technique self-efficacy score at 1-month follow-up. The key independent variable was group assignment (intervention versus control). Eye drop technique self-efficacy prior to watching the video was included as a covariate.

Other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193] The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, and visual acuity in the better-seeing eye.

H5: Glaucoma patients who watch the Medication video will have better medication adherence at 1 month, as assessed by Visual Analog Scale, compared to control group patients who do not watch the video.

A multivariable linear regression model was used to predict medication adherence at 1-month follow-up. The key independent variable was group assignment (intervention versus control). Baseline adherence was included as a covariate. Other covariates included in the model were selected as those that either 1) were significantly associated with the outcome in a correlation matrix with $p<0.05$, or 2) changed the regression coefficient associated with group assignment by at least 10% when included in the regression model.[193]

The covariates considered for inclusion were age, race, gender, health literacy, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, and problems with using glaucoma medications. As discussed above in section 3.3.3, the single-item VAS was used as the main secondary outcome measure, and the new 5-item VAS was used in an exploratory analysis.

3.9 Missing data

Missing data occurred due to patients being lost to follow-up or refusing to respond to certain questions during the patient interviews, because some of the video recordings did not show certain steps clearly, and also because a few patients could not see well enough to complete the REALM.

3.9.1. Missing data for covariates

For missing covariate data resulting from failure to answer a question, the mean value of the missing variable across all subjects at the relevant time point became the imputed value. For example, if a patient refused to answer their number of years of education, the mean number of years of education for all study subjects was imputed as that patient's value. If only some items from a scale were missing, the missing values were imputed as the mean value of the other items from the scale for that patient at the same time point. Since REALM scores were being treated as a dichotomous variable, it was not possible to impute a value and we instead used years of schooling, which was highly correlated with REALM score ($r=-0.460$, $p<0.001$), in all the analyses. Due to the missing data and the fact that imputation of health literacy was not feasible, health literacy was not included in any regression models. Overall, a total of five patients were missing REALM scores, one patient refused to respond to the question about years of education, and self-efficacy scores were missing for one patient at baseline, one patient immediately after the video, and two patients at 1 month.

3.9.2. Missing data for outcomes

To address missing outcome data, the main analysis used complete case analysis. A sensitivity analysis assessed whether the results differ when using simple imputation of the missing values. For Aim 1, we imputed missing eye drop technique steps using two scenarios: treating all unscorable steps as performed incorrectly, and treating all unscorable steps as performed correctly. For Aim 2, the sensitivity analysis was done using a best-case and worst-case scenario, where the best-case assumed that any improvement observed at the end of the baseline visit was maintained, and the worst-case assumed that the entire effect of the video had

worn off by 1 month. Therefore, the best-case scenario used last observation carried forward (LOCF) for losses to follow-up, while the worst-case scenario carried forward the pre-intervention value. Both best-case and worst-case scenarios used imputation of the mean value of the variable for cases where the patient refused to respond to a question. For both the best-case and worst-case analyses, steps that were unscorable at baseline were treated as correctly performed, since this was deemed the most conservative approach.

Complete case analysis, also known as listwise deletion, involves analyzing only the subjects with complete data.[195] Complete case analysis is a common and conservative method, but could introduce bias if the data are not missing completely at random (MCAR).[196,197] In particular, bias would be likely to result if the reasons for dropping out of the study are related to the key independent variable (intervention or control group) or covariates. Complete case analysis would also be the most likely method to lose a substantial amount of statistical power since any patient with any missing data would have to be excluded.[197]

Simple imputation involves imputing a certain value for patients with missing data, usually the last available value for patients lost to follow-up.[195] The main drawback of simple imputation was the potential for bias if the unknown values for study dropouts were actually systematically different from those of patients completing the study, or if the assumption of no change from baseline was seriously flawed. Overall, simple imputation by last observation carried forward is considered a conservative method, tending to produce bias toward the null.

3.10 Aim 3 Analysis

Aim 3: To describe patient perspectives on how to improve the video and how to disseminate it to other glaucoma patients.

Descriptive statistics were computed for all the video evaluation and dissemination questions to describe where and with whom the intervention group patients watched the video, how the video helped them, whether they would recommend the video to others, how the video should be modified, and how the video should be made available to other glaucoma patients. In addition, responses to open-ended questions were classified into response categories using open coding, and the most common responses were tabulated to inform the future dissemination plan. A single coder coded the responses, which has limitations because interrater reliability cannot be calculated as it could with multiple coders. We also collected the number of times that each patient watched the video using the tracking system for the access codes. The evaluation and dissemination results will inform a future dissemination and implementation study. We are working with Polyglot Systems to determine the best ways to distribute the video nationwide in light of the patients' recommendations.

Chapter 4: Descriptive Statistics and Bivariate Associations Among the Independent Variables at Baseline

This chapter will discuss the population that was enrolled and the patient characteristics and clinical characteristics of that population. Then the chapter will present bivariate associations among the independent variables at baseline.

4.1. Participants

Eighty-two participants were enrolled at an academic ophthalmology clinic in suburban North Carolina between May and October 2017, and 10 were enrolled at a private ophthalmology clinic in urban Maryland during November 2017. Follow-up continued at both sites until December 2017. The CONSORT flow diagram for enrollment is shown in Figure 4.1.

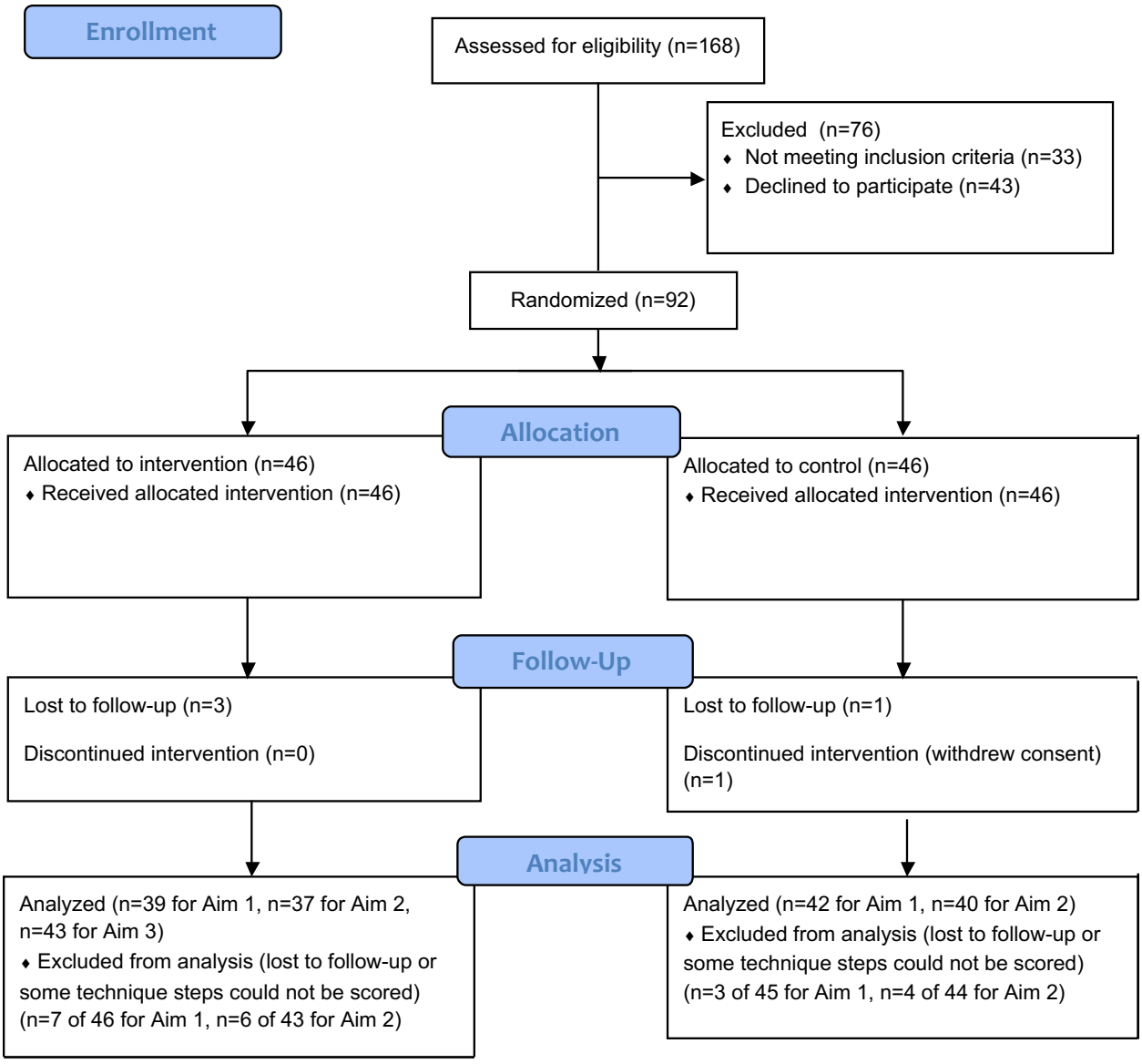


Figure 4.1. CONSORT flow diagram for study enrollment.

A total of 168 patients were approached and 43 patients refused to participate, for a participation rate of 74% of people approached, or 68% of eligible participants. Thirty refused because of lack of time or needing to get to another appointment, seven because they thought

they would not benefit from the study, three because they were not available for a follow-up in 1 month, one because their eyes were too tired, one because they wanted to take the consent form home to have a family member read it, and one said they would participate at their next visit but was experiencing serious issues with blurred vision upon the return visit.

A total of 33 patients were found to be ineligible; eleven potential subjects were ineligible because they had perfect technique, nine because they did not instill their own eye drops, five because they were unwilling to be video recorded, two because they were legally blind, two because they could only use preservative-free artificial tears, two because they did not read English, one because their spouse had already been randomized, and one because they always used a mechanical device to instill drops.

One control group patient withdrew consent approximately two weeks after the baseline visit, mailing the study team a copy of the consent form stating "withdraw consent" without giving a reason. This patient's data were destroyed and not included in any analyses, so 91 patients were available for inclusion in baseline analyses. Three intervention group patients and one control group patient were lost to follow-up after the baseline visit and did not complete the 1-month visit. Study staff were unable to reach these patients to determine why they dropped out. In addition, one other intervention group patient was unable to return for a follow-up visit, but completed the follow-up interview over the phone.

The demographics of the patients are shown in Table 4.1. The mean age of the 91 participants was 69.2 with a standard deviation of 10.7. Fifty-four patients (59%) were non-Hispanic White, 33 (36%) were Black or African American, 3 (3%) were Asian/Asian Indian/South Asian, and 1 (1%) was Hispanic. The mean number of years of schooling was 15.8

(SD: 3.3). Seventy-seven percent scored at ninth grade or above on the REALM. Five patients were missing REALM scores because their vision was too poor to see any of the words.

Table 4.1. Demographics of participants (N=91).

	Percent (n)	
Race		
Non-Hispanic White	59.3 (54)	
Black or African American	36.3 (33)	
Asian/Asian Indian/South Asian	3.3 (3)	
Hispanic	1.1 (1)	
Gender		
Male	50.5 (46)	
Female	49.5 (45)	
Health literacy (REALM)[a]		
Ninth grade or above	76.7 (66)	
Eighth grade or below	23.3 (20)	
Clinical characteristics		
Arthritis or another condition affecting manual dexterity	31.9 (29)	
Moderate to severe glaucoma	59.3 (54)	
Dilated during appointment	35.2 (32)	
	Mean (SD)	**Range**
Age	69.2 (10.7)	23 - 89
Years of schooling	15.8 (3.3)	8 - 24
Years using eye drops for glaucoma	9.7 (10.0)	<1 - 45
Number of glaucoma medications being taken	1.93 (0.81)	1 - 4
Number of times per day the patient takes glaucoma medications	3.11 (1.73)	1 - 8
Visual acuity in the better-seeing eye	0.77 (0.22)	0.1 - 1.0

[a]Five patients missing data because they were unable to see the REALM well enough to read any words.

With regard to clinical characteristics, patients had used eye drops for glaucoma for an average of 9.7 years (SD: 10.0). Fifty-nine percent had moderate to severe stage glaucoma. The

mean visual acuity in the better eye was 0.77 (SD: 0.22), equating to slightly worse than 20/25 corrected vision. A total of 32% had arthritis or another condition affecting manual dexterity; 17% had arthritis, 20% had another condition, and 4% had both. Thirty-three percent were currently taking one glaucoma medication, 44% were taking two, 20% were taking three, 2% were taking four, and 1% were taking five. Patients used a mean number of 1.93 glaucoma medications and were prescribed a mean of 3.11 doses per day. Thirty-five percent of patients had their eyes dilated during their appointment.

Data on Internet usage and Internet-capable devices used are shown in Table 4.2. A slight majority (53%) considered themselves very comfortable with using the Internet. Sixty-three percent used the Internet daily, 13% used it a few times a week, 3% a few times a month, 4% hardly ever, and 17% never. Ninety-one percent had a cell phone and 61% of those (or 51% of all participants) used it to access the Internet. Thirty-three percent also used iPads, 13% used tablets, 36% used desktop computers, and 49% used laptop computers. Forty-two percent had used the Internet to learn about glaucoma.

Table 4.2. Participants' usage of Internet and Internet-capable devices (N=91).

	Percent (n)
How comfortable with using the Internet	
Very comfortable	52.7 (48)
Somewhat comfortable	22.0 (20)
Not very comfortable	6.6 (6)
Not at all comfortable	18.7 (17)
How often patient uses the Internet	
Once or more a day	62.6 (57)
A few times a week	13.2 (12)
A few times a month	3.3 (3)
Hardly ever	4.4 (4)
Never	16.5 (15)
Own a cell phone	91.2 (83)
Use cell phone to go on the Internet	56.0 (51)
Internet access in home	85.7 (78)
Ever used the Internet to learn more about glaucoma	41.8 (38)
Other Internet-capable devices used besides phone*	
iPad	32.9 (30)
Tablet	13.2 (12)
Desktop computer	36.3 (33)
Laptop computer	49.5 (45)

*Participants could choose more than one

The mean score on the scale of problems with using medications at baseline was 2.9 (SD 2.5) with a range of 0 to 10 problems. The mean outcome expectations score at baseline was 33.9 (SD 4.6) with a range of 12 to 36.

4.2. Baseline characteristics of intervention versus control group

The comparison between the intervention and control groups on baseline characteristics is shown in Table 4.3.

Table 4.3. Baseline characteristics of intervention versus control participants (N=91).

	Intervention group percent (n)	**Control group percent (n)**	**P-value**
Race			0.36
Non-Hispanic White	60.9 (28)	57.8 (26)	
African American	32.6 (15)	40.0 (18)	
Other	6.5 (3)	2.2 (1)	
Gender, male	60.9 (28)	40.0 (18)	0.046
Health literacy, eighth grade or below	25.0 (11)	21.4 (9)	0.70
Glaucoma severity, moderate to severe	60.9 (28)	57.8 (26)	0.76
Diagnosis of arthritis or other condition affecting manual dexterity	34.8 (16)	28.9 (13)	0.55
Eyes dilated	30.4 (14)	40.0 (18)	0.34
Previously educated about glaucoma eye drop technique	50.0 (23)	46.7 (21)	0.75
	Intervention group mean (SD)	**Control group mean (SD)**	**P-value**
Age	69.0 (12.2)	69.5 (9.2)	0.82
Years using glaucoma medications	9.6 (10.4)	9.9 (9.6)	0.89
Years of education	16.1 (3.7)	15.5 (2.8)	0.35
Outcome expectations	33.5 (5.0)	34.2 (4.1)	0.48
Self-efficacy	16.6 (1.5)	15.5 (2.1)	0.004
Number of glaucoma medications being taken	1.89 (0.80)	1.98 (0.84)	0.62
Number of times per day the patient takes glaucoma medications	3.09 (1.67)	3.13 (1.80)	0.90
Visual acuity in the better-seeing eye	0.80 (0.18)	0.73 (0.25)	0.16
Eye drop technique*	2.65 (1.23)	2.25 (1.43)	0.17

*Three intervention group participants and one control group participant are not included here because they could not be scored on some steps.

Unadjusted for covariates, the variables that showed a statistically significant difference between intervention and control groups at baseline were eye drop technique self-efficacy (t=3.01, df=77.173, p=0.004) and gender (Pearson χ^2=3.96, df=1, p=0.046). Participants assigned to the intervention group had higher mean baseline self-efficacy and were more likely to be male than

participants assigned to the control group. The intervention group had slightly better baseline eye drop technique, but the difference was not statistically significant (p=0.17).

4.3. Bivariate relationships among the variables at baseline

Bivariate relationships among patient characteristics, clinical characteristics, and baseline values of the outcomes are shown in Table 4.4.

	Baseline self-efficacy	Baseline eye drop technique	Baseline med adherence	Age	Gender, female	Race (African American)	Years schooling	How long used drops
Baseline self-efficacy	1							
Baseline eye drop technique	-0.016	1						
Baseline med adherence	.318**	0.144	1					
Age	-0.059	-0.001	0.020	1				
Gender, female	-0.127	-0.030	0.090	0.140	1			
Race (African American)	-0.036	-0.131	-0.093	-0.135	-0.060	1		
Years of schooling	-0.021	0.043	0.073	.283**	0.129	-.470**	1	
How long used drops	.220*	0.032	.233*	.280**	0.048	-0.061	0.198	1
REALM	0.042	-0.133	-0.078	-0.151	-0.152	.440**	-.460**	-0.153
Previously educated about technique	0.080	-.248*	-0.003	0.021	0.099	0.139	0.154	.269*
Dilated	0.041	-0.026	0.029	-0.067	-0.038	.258*	-.283**	-0.073
Glaucoma severity	-0.037	-0.137	-0.065	-0.039	-.300**	0.113	-0.175	-0.113
# glaucoma meds	-0.020	0.081	-0.100	-0.022	-0.001	0.033	0.040	0.019
Doses taken/ day	0.001	0.002	-0.105	-0.076	-0.050	0.071	-0.044	0.086
Visual acuity - better eye	0.083	0.097	0.065	-0.128	0.124	-0.109	0.149	-0.117
Outcome expectations	0.074	0.153	.367**	0.062	0.147	-0.183	-0.099	0.098

	REALM	Previously educated about technique	Dilated	Glaucoma severity	# glaucoma meds	Doses taken/ day	Visual acuity - better eye
Baseline self-efficacy							
Baseline eye drop technique							
Baseline med adherence							
Age							
Gender, female							
Race (African American)							
Years of schooling							
How long used drops							
REALM	1						
Previously educated about technique	0.038	1					
Dilated	.264*	-0.114	1				
Glaucoma severity	0.145	-0.005	0.141	1			
# glaucoma meds	-0.047	-0.030	0.117	.375**	1		
Doses taken/ day	0.022	0.015	0.047	.365**	.921**	1	
Visual acuity - better eye	-0.128	-.212*	-0.076	-.273**	-0.208*	-.233*	1
Outcome expectations	-.244*	0.021	-0.098	-0.189	-0.143	-0.182	0.037

Table 4.4. Correlation matrix showing bivariate relationships among the variables.
*p<0.05; **p<0.01

4.3.1. Associations between patient and clinical characteristics

Older age was associated with more years of schooling (p=0.007) and with using eye drops for a longer time (p=0.007). Female gender was associated with less severe glaucoma (p=0.004). African American race was associated with fewer years of schooling (p<0.001) and was associated with higher likelihood of having REALM scores of eighth grade or lower (p<0.001). Fewer years of schooling (p<0.001) and having been dilated (p=0.014) were also associated with REALM scores of eighth grade or lower. Having used eye drops for a longer time was positively associated with having been shown how to use eye drops before (p=0.01). Worse visual acuity in the better eye was associated with higher likelihood of reporting having been shown how to use eye drops (p=0.044), possibly because patients with worse visual acuity had had glaucoma longer. More severe glaucoma was associated with being prescribed more medications (p<0.001), more doses per day (p<0.001), and having worse visual acuity in the better eye (p=0.009). Being prescribed more glaucoma medications was also associated with being prescribed more doses per day (p<0.001) and worse visual acuity was associated with being prescribed more doses per day (p=0.026) and with more glaucoma medications (p=0.047).

4.3.2 Associations between patient and clinical characteristics, and baseline values of outcome variables

Having used eye drops for a longer time was associated with better baseline self-efficacy (p=0.037) and better baseline medication adherence (p=0.026). Better baseline self-efficacy (p=0.002) and better baseline outcome expectations (p<0.001) were associated with better baseline adherence. Surprisingly, baseline technique was negatively associated with self-reports

of having been shown how to use eye drops before (p=0.021). Patients who did not report prior education had better technique. Low literacy was associated with worse baseline outcome expectations (p=0.024).

4.4. Summary

Patient and clinical characteristics were well balanced across the intervention and control groups at baseline, except for self-efficacy and gender. Most of the associations among patient and clinical characteristics and baseline outcomes were not surprising, except that having been previously educated about technique was associated with worse baseline eye drop technique.

Chapter 5: Eye drop technique and self-efficacy results immediately after the video

This chapter will discuss the results from Aim 1, which sought to determine whether eye drop technique and self-efficacy were better in the intervention group than the control group immediately after exposure to the intervention or control video.

5.1. Hypothesis 1: Eye drop technique immediately after the video

H1: Glaucoma patients who watch the Meducation video will have better eye drop instillation technique immediately after watching the video than control group patients who do not watch the video.

5.1.1. Distribution of eye drop technique scores

Patients' eye drop technique scores are shown in Table 5.1.

Table 5.1. Summary of eye drop technique scores at all time points.

Scale (Range of possible scores)	Mean (SD), range score before video (N=87)	Mean (SD), range score after video (N=85)	Mean (SD), range score at 1 month (N=81)
Eye drop instillation technique (0-5)	2.45 (1.35)	3.19 (1.37)	3.09 (1.35)

The mean technique score was 2.45 steps correct before watching the video (SD: 1.35), 3.19 immediately after watching the video (SD: 1.37), and 3.09 at 1 month (SD: 1.35). The number of people who performed each step correctly at each time point is shown in Table 5.2.

Table 5.2. Number of participants who performed each step correctly at each time point (N=91).

Step	Percent (n) performing correctly before video	Percent (n) performing correctly after video	Percent (n) performing correctly at 1 month
Squeezing the bottle to instill a single drop	53.4 (47/88)	66.7 (58/87)	65.1 (54/83)
Holding open the lid with the finger	62.6 (57/91)	73.3 (66/90)	69.8 (60/86)
Getting the drop accurately into the eye	64.8 (59/91)	76.1 (67/88)	71.1 (59/83)
Not touching the bottle tip to the eye or face	62.5 (55/88)	70.8 (63/89)	80.0 (68/85)
Closing the eye after instillation (for at least 10 seconds)	4.4 (4/90)	25.8 (23/89)	18.6 (16/86)

The only step where patients continued to improve at 1 month was not touching the eye or face. Performance on other steps remained the same or declined slightly.

5.1.2. Unadjusted comparison between intervention and control groups immediately after the video

Patients' eye drop technique scores immediately after watching the video are shown in Table 5.3. Unadjusted for covariates, the intervention group performed better than the control group ($t=4.182$, $df=83$, $p<0.001$).

Table 5.3. Summary of eye drop technique scores immediately after watching the video.

Scale (Range of possible scores)	Intervention group mean (SD) score (n=42)	Control group mean (SD) score (n=43)	P-value
Eye drop instillation technique (0-5)	3.76 (1.12)	2.63 (1.36)	<0.001

Intervention and control group patients' scores on specific steps immediately after watching the video are shown in Table 5.4. The steps that showed a significant between-group difference immediately after the video were squeezing the bottle to instill a single drop, holding open the lid with the finger, and closing the eye after instillation.

Table 5.4. Number of participants who performed each step correctly immediately after the video, by group.

Step	P-value for Pearson chi-square test	Percent (n) performing correctly	
		Intervention group	Control group
Squeezing the bottle to instill a single drop	0.049	76.7 (33/43)	56.8 (25/44)
Holding open the lid with the finger	0.017	84.4 (38/45)	62.2 (28/45)
Getting the drop accurately into the eye	0.26	81.4 (35/43)	71.1 (32/45)
Not touching the bottle tip to the eye or face	0.18	77.3 (34/44)	64.4 (29/45)
Closing the eye after instillation (for at least 10 seconds)	<0.001	44.4 (20/45)	6.8 (3/44)

5.1.3 Bivariate analyses

Bivariate analyses showed that outcome expectations were significantly associated with better technique immediately after the video (r=0.222, p=0.041), and African American race was significantly associated with worse technique (t=2.144, df=83, p=0.035). Age, gender, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, whether the patient's eyes were dilated, and whether the patient was previously educated about technique were not significantly associated with technique immediately after the video.

5.1.4. Linear regression model predicting eye drop technique immediately after the video

5.1.4.1 Multivariable analyses: main regression model for complete case analysis

In the main analysis, 81 participants -- 39 intervention group participants and 42 control group participants -- were analyzed. The reason that participants were not included in this complete case analysis was that the eye drop technique score could not be determined with certainty from the video (4 participants before the video and 6 participants immediately after).

The results of the linear regression model predicting eye drop technique immediately after the video are shown in Table 5.5. Besides baseline technique and baseline self-efficacy, the covariates that met the criteria for inclusion in the model were baseline outcome expectations and race, because they were significantly associated with technique immediately after the video; participants with more positive outcome expectations and those who were non-African American had better technique in the bivariate analysis. No covariates met the criterion of changing the

coefficient associated with the intervention by at least 10%. After adjusting for covariates, intervention group patients performed 0.75 steps better than controls (p=0.002). The covariates that were statistically significant were baseline eye drop technique (p<0.001) and baseline self-efficacy (p=0.029). Baseline outcome expectations (p=0.21) and race (p=0.14) did not have significant effects in the multivariable analysis.

Table 5.5. Linear regression model predicting eye drop technique immediately after watching the video (N=81).

	Beta (95% CI)
Independent variables	
Intervention	0.75 (0.27, 1.22)**
Covariates	
Baseline technique	0.42 (0.25, 0.60)***
Baseline self-efficacy	0.13 (0.01, 0.24)*
Baseline outcome expectations	0.04 (-0.02, 0.09)
Race, African American	-0.36 (-0.83, 0.12)

*p<0.05; **p<0.01, ***p<0.001

5.1.4.2 Sensitivity analyses

After imputing the missing values, the results of the linear regression model predicting eye drop technique immediately after the video are shown in Table 5.6. In Table 5.6a, all steps that were not scorable were assumed to have been performed incorrectly. In Table 5.6b, all steps that were not scorable were assumed to have been performed correctly. When assuming that missing steps were performed incorrectly, the effect size for the intervention decreased to 0.64 but remained statistically significant (p=0.023). When assuming that missing steps were performed correctly, the effect size for the intervention decreased to 0.67 and also remained statistically significant (p=0.005). Baseline eye drop technique remained significant in both models (p<0.001). Baseline self-efficacy was significant only in the model where steps that were not scorable were assumed to have been performed correctly (p=0.043).

Table 5.6a. Linear regression model predicting eye drop technique immediately after watching the video, with missing steps imputed as incorrectly performed (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.64 (0.09, 1.19)*
Covariates	
Baseline technique	0.43 (0.23, 0.63)***
Baseline self-efficacy	0.07 (-0.07, 0.20)
Baseline outcome expectations	0.06 (0.00, 0.11)
Race, African American	-0.53 (-1.08, 0.02)

*p<0.05; **p<0.01, ***p<0.001

Table 5.6b. Linear regression model predicting eye drop technique immediately after watching the video, with missing steps imputed as correctly performed (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.67 (0.21, 1.12)**
Covariates	
Baseline technique	0.50 (0.33, 0.66)***
Baseline self-efficacy	0.11 (0.00, 0.22)*
Baseline outcome expectations	0.05 (0.00, 0.09)
Race, African American	-0.31 (-0.76, 0.15)

*p<0.05; **p<0.01, ***p<0.001

5.1.5. Getting the drop in the eye immediately after the video

5.1.5.1 Bivariate analyses

Bivariate analyses revealed that neither the intervention nor any covariates were significantly associated with getting the drop in the eye immediately after the video, so no covariates qualified to be in the model on the basis of a significant bivariate association with the outcome.

5.1.5.2 Multivariable analyses: main regression model for complete case analysis

Three patients, all in the intervention group, were not included because it was impossible to tell if they got the drop in the eye from the recording immediately after the video. The results of the logistic regression model predicting whether the patient got the drop in the eye are shown in Table 5.7. Being dilated, length of time using drops, number of glaucoma medications, gender, visual acuity, number of doses taken per day, and arthritis or other condition affecting manual dexterity qualified for the model due to changing the estimate associated with the intervention by at least 10%. As in the bivariate analysis, the effect of the intervention was not statistically significant (p=0.35). Getting the drop in the eye before the video (p=0.001) and not being dilated during the visit (p=0.031) were associated with a higher likelihood of getting the drop in the eye immediately after the video.

Table 5.7. Logistic regression model predicting whether the patient got the drop in the eye immediately after watching the video (N=88).

	OR (95% CI)
Independent variables	
Intervention	0.51 (0.13, 2.10)
Covariates	
Getting the drop in the eye before the video	9.30 (2.35, 36.78)**
Baseline self-efficacy	1.31 (0.97, 1.77)
Dilated during visit	0.23 (0.06, 0.88)*
How long patient has used drops	1.07 (0.99, 1.17)
Number of glaucoma medications	0.15 (0.01, 1.51)
Gender, female	0.29 (0.07, 1.16)
Visual acuity in the better eye	4.12 (0.25, 69.20)
Number of doses taken per day	1.92 (0.68, 5.45)
Arthritis or other condition affecting manual dexterity	4.62 (1.00, 21.39)

*p<0.05; **p<0.01, ***p<0.001

5.1.5.3. Sensitivity analyses

After imputing the missing values, the results of the logistic regression model predicting whether the patient got the drop in the eye are shown in Table 5.8. The effect of the intervention

continued to be nonsignificant in both models. Getting the drop in the eye before the video (p=0.005 when imputing missing values as incorrect and p=0.001 when imputing missing values as correct), and not being dilated (p=0.023 when imputing missing values as incorrect and p=0.046 when imputing missing values as correct), were still significantly associated with a higher likelihood of getting the drop in the eye immediately after watching the video. Gender became statistically significant when missing values were imputed as incorrectly performed; female gender was associated with a lower likelihood of getting the drop in the eye in this analysis (p=0.047).

Table 5.8a. Logistic regression model predicting whether the patient got the drop in the eye immediately after watching the video, with missing values imputed as incorrectly performed (N=91).

	OR (95% CI)
Independent variables	
Intervention	0.45 (0.12, 1.60)
Covariates	
Getting the drop in the eye before the video	5.65 (1.68, 18.98)**
Baseline self-efficacy	1.19 (0.90, 1.56)
Dilated during visit	0.24 (0.07, 0.82)*
How long patient has used drops	1.08 (1.00, 1.17)
Number of glaucoma medications	0.21 (0.03, 1.77)
Gender, female	0.28 (0.08, 0.99)*
Visual acuity in the better eye	4.12 (0.29, 57.86)
Number of doses taken per day	1.88 (0.71, 4.96)
Arthritis or other condition affecting manual dexterity	3.57 (0.94, 13.65)

*p<0.05; **p<0.01, ***p<0.001

Table 5.8b. Logistic regression model predicting whether the patient got the drop in the eye immediately after watching the video, with missing values imputed as correctly performed (N=91).

	OR (95% CI)
Independent variables	
Intervention	0.61 (0.16, 2.39)
Covariates	
Getting the drop in the eye before the video	9.54 (2.45, 37.17)**
Baseline self-efficacy	1.32 (0.98, 1.80)
Dilated during visit	0.26 (0.07, 0.98)*
How long patient has used drops	1.07 (0.99, 1.16)
Number of glaucoma medications	0.17 (0.02, 1.66)
Gender, female	0.34 (0.09, 1.27)
Visual acuity in the better eye	3.62 (0.22, 59.47)
Number of doses taken per day	1.85 (0.66, 5.22)
Arthritis or other condition affecting manual dexterity	4.06 (0.91, 18.16)

*p<0.05; **p<0.01, ***p<0.001

5.2. Hypothesis 2: Self-efficacy immediately after the video

H2: Glaucoma patients who watch the Meducation video will have better eye drop technique self-efficacy immediately after watching the video compared to control group patients who do not watch the video.

5.2.1. Distribution of eye drop technique self-efficacy scores

Patients' eye drop technique self-efficacy scores at all time points are shown in Table 5.9.

Table 5.9. Summary of scores on eye drop technique self-efficacy scale at all time points.

Scale (Range of possible scores)	Mean (SD), range score before video (N=90)	Mean (SD), range score after video (N=90)	Mean (SD), range score at 1 month (N=85)
Self-efficacy (6-18)	16.1 (1.9), 12 - 18	16.5 (1.9), 11 - 18	15.8 (2.1), 8 - 18

5.2.2. Unadjusted comparison between intervention and control groups immediately after the video

Patients' eye drop technique self-efficacy scores immediately after watching the video are shown in Table 5.10. Unadjusted for covariates, self-efficacy was higher in the intervention group than in the control group immediately after the video ($t=3.829$, $df=70.186$, $p<0.001$).

Table 5.10. Summary of scores on eye drop technique self-efficacy scale immediately after watching the video.

Scale (Range of possible scores)	Intervention group mean (SD) score (n=46)	Control group mean (SD) score (n=44)	P-value
Self-efficacy (6-18)	17.2 (1.3)	15.8 (2.2)	<0.001

5.2.3. Bivariate analyses

Besides baseline self-efficacy, no other covariates were significantly associated with self-efficacy immediately after the video in bivariate analyses, and no other covariates changed the estimate associated with intervention by more than 10% when included in the model; therefore, no other covariates met the criteria for inclusion in the multivariable model.

5.2.4. Multivariable analyses: main regression model for complete case analysis

One control group patient's self-efficacy at both time points was missing because the research assistant did not record answers for one or more items. Forty-six intervention group patients and 44 controls were included in the main analysis. The results of the linear regression model predicting self-efficacy are shown in Table 5.11. The intervention group had significantly better self-efficacy than the control group (p=0.024).

Table 5.11. Linear regression model predicting eye drop technique self-efficacy immediately after watching the video (N=90).

	Beta (95% CI)
Independent variables	
Intervention	0.62 (0.08, 1.15)*
Covariates	
Baseline self-efficacy	0.73 (0.59, 0.88)***

*p<0.05; **p<0.01, ***p<0.001

5.2.5. Sensitivity analyses

After imputing the missing values, the results of the linear regression model predicting self-efficacy are shown in Table 5.12. One patient's self-efficacy at both time points had to be imputed because the research assistant did not record answers for one or more items. Besides baseline self-efficacy, no other covariates were significantly associated with self-efficacy

immediately after the video in bivariate analyses, and no other covariates changed the estimate associated with intervention by more than 10% when included in the model; therefore, no other covariates met the criteria for inclusion in the model. The intervention still had a statistically significant effect (p=0.032). No notable changes from the complete case analysis were observed.

Table 5.12. Linear regression model predicting eye drop technique self-efficacy immediately after watching the video, after imputing the missing values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.60 (0.05, 1.14)*
Covariates	
Baseline self-efficacy	0.79 (0.66, 0.92)***

*p<0.05; **p<0.01, ***p<0.001

5.3. Summary of eye drop technique and self-efficacy results immediately after the video

The results supported Hypothesis 1 and Hypothesis 2, which stated that eye drop technique and self-efficacy would be significantly better in the intervention group than in the control group immediately after the video. All the sensitivity analyses supported the base case results with p-values remaining below 0.05. Besides the intervention and baseline technique, only baseline self-efficacy significantly predicted eye drop technique immediately after the video. Baseline outcome expectations and race, which were significant in bivariate analyses, were not significant predictors of technique in the multivariable model.

The results did not support the idea that intervention group patients would be more likely to get the drop in the eye immediately after the video. The results of this analysis remained nonsignificant after imputing missing values. We did not power on this outcome and therefore the analysis may have been underpowered.

Chapter 6: Eye drop technique, self-efficacy, and medication adherence results at 1 month

This chapter will discuss the results from Aim 2, which sought to determine whether eye drop technique, self-efficacy, and medication adherence were better in the intervention group than the control group at 1 month after study enrollment.

6.1. Hypothesis 3: Eye drop technique at 1 month

H3: Glaucoma patients who watch the Meducation video will have better eye drop technique at 1 month after first watching the video, compared to control group patients who do not watch the video.

6.1.1. Unadjusted comparison between intervention and control groups at 1 month

Patients' eye drop technique scores at 1 month are shown in Table 6.1. Unadjusted for covariates, the intervention group had better eye drop technique than the control group (t=3.025, df=79, p=0.003).

Table 6.1. Summary of eye drop technique scores at 1 month.

Scale (Range of possible scores)	Intervention group mean (SD) score (n=40)	Control group mean (SD) score (n=41)	P-value
Eye drop instillation technique (0-5)	3.53 (1.28)	2.66 (1.30)	0.003

Intervention group participants performed 0.87 steps better than controls in eye drop technique at 1 month.

Intervention and control group patients' scores on specific steps at 1 month are shown in Table 6.2.

Table 6.2. Number of participants who performed each step correctly at 1 month, by group.

Step	Percent (n) performing correctly in intervention group	Percent (n) performing correctly in control group	P-value for Pearson chi-square test
Squeezing the bottle to instill a single drop	70.7 (29/41)	59.5 (25/42)	0.28
Holding open the lid with the finger	73.8 (31/42)	65.9 (29/44)	0.43
Getting the drop accurately into the eye	77.5 (31/40)	65.1 (28/43)	0.21
Not touching the bottle tip to the eye or face	92.7 (38/41)	68.2 (30/44)	0.005
Closing the eye after instillation (for at least 10 seconds)	35.7 (15/42)	2.3 (1/44)	<0.001

The steps that showed a significant between-group difference at 1 month were not touching the bottle tip to the eye or face ($p=0.005$), and closing the eye after instillation ($p<0.001$). The other steps showed positive but not statistically significant effects.

6.1.2. Bivariate analyses

Bivariate analyses showed that baseline outcome expectations were significantly associated with better technique at 1 month ($r=0.311$, $p=0.005$), and self-reports of previously having been educated about technique was significantly associated with worse technique at 1

month (t=2.211, p=0.030). Age, race, gender, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, and whether the patient's eyes were dilated were not significantly associated with technique at 1 month.

6.1.3. Linear regression model predicting eye drop technique at 1 month

6.1.3.1. Multivariable analyses: main regression model for complete case analysis

In the main analysis, 37 intervention group participants and 40 control group participants were analyzed. The reasons that participants were not included in this complete case analysis were that they were lost to follow-up (5 participants), and the technique score could not be determined with certainty from the video (4 participants before the video and 5 at 1 month).

Besides baseline technique and self-efficacy, the other covariates that met the criteria for inclusion in the model were baseline outcome expectations and previously having been educated about technique, because they were significantly associated with the outcome in bivariate analyses. No covariates qualified for the model on the basis of changing the coefficient associated with the intervention by at least 10%. The results of the linear regression model predicting eye drop technique at 1 month are shown in Table 6.3. After adjusting for covariates, intervention patients performed 0.63 steps better than controls (p=0.011). As in the bivariate analysis, higher baseline outcome expectations were still associated with better 1-month technique (p=0.001), and having been previously educated about technique was associated with worse 1-month technique (p=0.036), perhaps because people with worse technique are more

likely to receive instruction. Baseline technique was also a significant predictor of 1-month technique ($p<0.001$).

Table 6.3. Linear regression model predicting eye drop technique at 1 month (N=77).

	Beta (95% CI)
Independent variables	
Intervention	0.63 (0.15, 1.10)*
Covariates	
Baseline technique	0.44 (0.26, 0.61)***
Baseline self-efficacy	0.00 (-0.11, 0.12)
Baseline outcome expectations	0.09 (0.04, 0.15)**
Previously educated about technique	-0.50 (-0.96, -0.03)*

*p<0.05; **p<0.01, ***p<0.001

6.1.3.2. Sensitivity analyses

The results of the best-case analysis, in which we assumed that improvement observed immediately after watching the video was sustained until the 1-month time point for patients lost to follow-up, are shown in Table 6.4. The effect size of intervention rose to 0.74 ($p=0.001$). Baseline technique ($p<0.001$) and baseline outcome expectations ($p=0.001$) remained statistically significant, while having been previously educated about technique was no longer significant ($p=0.12$).

Table 6.4. Linear regression model predicting eye drop technique at 1 month, with best-case analysis used to impute missing follow-up values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.74 (0.30, 1.18)**
Covariates	
Baseline technique	0.45 (0.29, 0.61)***
Baseline self-efficacy	0.02 (-0.09, 0.12)
Baseline outcome expectations	0.08 (0.04, 0.13)**
Previously educated about technique	-0.34 (-0.76, 0.09)

*p<0.05; **p<0.01, ***p<0.001

The results of the worst-case analysis, in which we assumed that patients lost to follow-up reverted to their scores at the beginning of the study, are shown in Table 6.5. The effect size of intervention remained essentially the same as in the base case, and the p-value was 0.008. Baseline technique ($p<0.001$), baseline outcome expectations ($p=0.001$), and having been previously educated about technique ($p=0.045$) remained significant in this model.

Table 6.5. Linear regression model predicting eye drop technique at 1 month, with worst-case analysis used to impute missing follow-up values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.62 (0.16, 1.08)**
Covariates	
Baseline technique	0.45 (0.29, 0.62)***
Baseline self-efficacy	0.03 (-0.08, 0.14)
Outcome expectations	0.09 (0.04, 0.13)**
Previously educated about technique	-0.45 (-0.89, -0.01)*

*p<0.05; **p<0.01, ***p<0.001

6.1.4. Getting the drop in the eye at 1 month

6.1.4.1. Bivariate analyses

Bivariate analyses showed that previously having been educated about technique was significantly associated with getting the drop in the eye at 1 month. Patients who reported prior education about technique were less likely to get the drop in the eye ($\chi^2=5.932$, $p=0.015$). Patients who had more positive baseline outcome expectations were more likely to get the drop in the eye in the correlation matrix ($r=0.301$, $p=0.006$), but a t-test did not show a significant relationship ($t=1.954$, $df=24.709$, $p=0.062$). The t-test produced a different result because the groups had unequal variances ($p<0.001$ for Levene's test of equality of variances) and therefore the t-test with unequal variances was used. The t-test is a more precise test, so baseline outcome

expectations did not meet the inclusion criterion of being significantly associated with the outcome. Age, race, gender, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, visual acuity in the better-seeing eye, and whether the patient's eyes were dilated were also not significantly associated with getting the drop in the eye immediately after the video.

6.1.4.2. Multivariable analyses: main regression model for complete case analysis

Eighty-three participants were included; five were excluded because they were lost to follow-up, and three because it was impossible to tell from the recording whether they got the drop in the eye at follow-up. Previously having been educated about technique was included as a covariate because it was significantly associated with the outcome in the bivariate analyses, and outcome expectations, number of doses per day, visual acuity, and years of schooling were included because they changed the coefficient associated with intervention by at least 10%. The results of the logistic regression model predicting whether the patient got the drop in the eye at 1 month are shown in Table 6.6. The intervention did not have a statistically significant effect (p=0.14). Getting the drop in the eye before the video (p=0.008) and more positive outcome expectations (p=0.009) were associated with higher odds of getting the drop in the eye at 1 month, while having been previously educated about technique (p=0.004) and better visual acuity (p=0.023) were associated with lower odds of getting the drop in the eye at 1 month.

Table 6.6. Logistic regression model predicting whether the patient got the drop in the eye at 1 month (N=83).

	OR (95% CI)
Independent variables	
Intervention	2.78 (0.73, 10.61)
Covariates	
Getting the drop in the eye before the video	5.46 (1.55, 19.19)**
Baseline self-efficacy	1.02 (0.78, 1.35)
Baseline outcome expectations	1.30 (1.07, 1.57)**
Previously educated about technique	0.11 (0.02, 0.49)**
Number of doses taken per day	0.71 (0.48, 1.07)
Visual acuity in the better eye	0.02 (0.00, 0.55)*
Years of schooling	1.22 (0.99, 1.51)

*p<0.05; **p<0.01, ***p<0.001

6.1.4.3. Sensitivity analyses

In the best-case sensitivity analysis, intervention participants had 3.95 times the odds of getting the drop in the eye compared to controls (95% CI: 1.11, 13.28), and the intervention had a statistically significant effect (p=0.030). Getting the drop in the eye at baseline (p=0.007), and more positive baseline outcome expectations (p=0.027), remained significant predictors of getting the drop in the eye at 1 month. Having been previously educated about technique remained a significant predictor of lower odds of getting the drop in the eye at 1 month (p=0.042), but visual acuity was no longer significant (p=0.080). The results of the best-case analysis are shown in Table 6.7.

Table 6.7. Logistic regression model predicting whether the patient got the drop in the eye at 1 month, with best-case analysis used to impute missing values (N=91).

	OR (95% CI)
Independent variables	
Intervention	3.95 (1.15, 13.60)*
Covariates	
Getting the drop in the eye before the video	4.65 (1.53, 14.15)**
Baseline self-efficacy	0.97 (0.75, 1.24)
Baseline outcome expectations	1.14 (1.02, 1.29)*
Previously educated about technique	0.29 (0.09, 0.95)*
Number of doses taken per day	0.78 (0.56, 1.08)
Visual acuity in the better eye	0.08 (0.01, 1.35)
Years of schooling	1.03 (0.87, 1.23)

*p<0.05; **p<0.01, ***p<0.001

In the worst-case sensitivity analysis, the effect of the intervention was not significant (p=0.098). Getting the drop in the eye at baseline (p=0.002), and more positive outcome expectations (p=0.006), remained significant predictors of getting the drop in the eye at 1 month. Having been previously educated about technique remained a significant predictor of lower odds of getting the drop in the eye at 1 month (p=0.006), but visual acuity was no longer significant (p=0.15). The results of the worst-case analysis are shown in Table 6.8.

Table 6.8. Logistic regression model predicting whether the patient got the drop in the eye at 1 month, with worst-case analysis used to impute missing values (N=91).

	OR (95% CI)
Independent variables	
Intervention	2.80 (0.83, 9.48)
Covariates	
Getting the drop in the eye before the video	6.05 (1.90, 19.24)**
Baseline self-efficacy	1.06 (0.82, 1.36)
Baseline outcome expectations	1.22 (1.06, 1.40)**
Previously educated about technique	0.16 (0.04, 0.59)**
Number of doses taken per day	0.78 (0.55, 1.09)
Visual acuity in the better eye	0.13 (0.01, 2.29)
Years of schooling	1.14 (0.95, 1.37)

*p<0.05; **p<0.01, ***p<0.001

6.2. Hypothesis 4: Self-efficacy at 1 month

H4: Glaucoma patients who watch the Meducation video will have better eye drop technique self-efficacy at 1 month after first watching the video, compared to control group patients who do not watch the video.

6.2.1. Unadjusted comparison between intervention and control groups at 1 month

Patients' scores on the eye drop technique self-efficacy scale at 1 month are shown in Table 6.9. Unadjusted for covariates, the intervention group had higher eye drop technique self-efficacy at 1 month than the control group ($t=4.100$, $p<0.001$).

Table 6.9. Summary of scores on eye drop technique self-efficacy scale at 1 month.

Scale (Range of possible scores)	Intervention group mean (SD) score (n=42)	Control group mean (SD) score (n=43)	P-value
Self-efficacy (6-18)	16.7 (1.4)	14.9 (2.4)	<0.001

Intervention group participants had a self-efficacy score 1.8 points higher than controls, up from a 1.1-point difference prior to the video.

6.2.2. Bivariate analyses

Besides baseline self-efficacy ($r=0.669$, $p<0.001$), no other covariates were significantly associated with self-efficacy at 1 month in bivariate analyses, and no other covariates changed the estimate associated with the intervention by more than 10% when included in the model; therefore, no other covariates met the criteria for inclusion in the multivariable model.

6.2.3. Multivariable analyses: main regression model for complete case analysis

The results of the linear regression model predicting self-efficacy are shown in Table 6.10. Intervention group participants had self-efficacy of 0.82 points better at 1 month (p=0.015) after adjusting for baseline self-efficacy. Baseline self-efficacy was also a significant predictor of 1-month self-efficacy (p<0.001).

Table 6.10. Linear regression model predicting eye drop technique self-efficacy at 1 month (N=84).

	Beta (95% CI)
Independent variables	
Intervention	0.82 (0.16, 1.47)*
Covariates	
Baseline self-efficacy	0.66 (0.48, 0.84)***

*p<0.05; **p<0.01, ***p<0.001

6.2.4. Sensitivity analyses

The results of the best-case analysis, in which we assumed that improvement observed immediately after watching the video was sustained until the 1-month time point for patients lost to follow-up, are shown in Table 6.11. In the best-case analysis, the coefficient associated with intervention rose to 0.90 and the p-value dropped to 0.005. Baseline self-efficacy remained a significant predictor of 1-month self-efficacy (p<0.001).

Table 6.11. Linear regression model predicting eye drop technique self-efficacy at 1 month, with best-case analysis used to impute missing follow-up values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.90 (0.28, 1.53)**
Covariates	
Baseline self-efficacy	0.68 (0.53, 0.83)***

*p<0.05; **p<0.01, ***p<0.001

The results of the worst-case analysis, in which we assumed that patients lost to follow-up reverted to their scores at the beginning of the study, are shown in Table 6.12. The estimated effect size for intervention was 0.86 (p=0.007). Baseline self-efficacy remained a significant predictor of 1-month self-efficacy (p<0.001).

Table 6.12. Linear regression model predicting eye drop technique self-efficacy at 1 month, with worst-case analysis used to impute missing follow-up values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	0.86 (0.24, 1.48)**
Covariates	
Baseline self-efficacy	0.68 (0.53, 0.83)***

*p<0.05; **p<0.01, ***p<0.001

6.3. Hypothesis 5: Medication adherence at 1 month

H5: Glaucoma patients who watch the Meducation video will have better medication adherence at 1 month, as assessed by Visual Analog Scale, compared to control group patients who do not watch the video.

6.3.1. Distribution of medication adherence scores

Patients' scores on the visual analog scales of medication adherence are shown in Table 6.13.

Table 6.13. Summary of medication adherence scores at all time points.

Scale (Range of possible scores)	Mean (SD), range score before video (N=91)	Mean (SD), range score at 1 month (N=87)
Single-item VAS (0-100%)	80.8% (23.6), 4 - 100%	85.1% (18.6), 1 - 100%
5-item VAS (0-100%)	94.2% (8.5), 49.2 - 100.0%	94.6% (7.3), 64.8 - 100.0%

6.3.2. Unadjusted comparisons between intervention and control groups at 1 month

Patients' scores on the visual analog scales of medication adherence at 1 month are shown in Table 6.14. The differences between groups were not statistically significant, both on the single-item scale (p=0.34), and the 5-item scale (p=0.38).

Table 6.14. Summary of medication adherence scores at 1 month.

Scale (Range of possible scores)	Intervention group mean (SD) score (n=43)	Control group mean (SD) score (n=44)	P-value
Adherence, single-item VAS (0-100%)	87.1% (13.6)	83.3% (22.5)	0.34
Adherence, 5-item VAS (0-100%)	95.3% (6.2)	94.1% (8.3)	0.38

6.3.3. Medication adherence on the single-item Visual Analog Scale at 1 month

6.3.3.1. Bivariate analyses

Bivariate analyses revealed that besides baseline adherence ($r=0.547$, $p<0.001$), no other covariates were significantly associated with adherence at 1 month.

6.3.3.2. Multivariable analyses: Main regression model for complete case analysis

Four patients were not included because they were lost to follow-up and did not complete the 1-month interview, leaving a total sample size of 87. The results of the linear regression model predicting medication adherence on the single-item VAS are shown in Table 6.15.

Besides baseline adherence, the other covariates that met the criteria for inclusion in the model were age and gender, because they changed the estimate associated with intervention by at least 10%. No covariates qualified for the model on the basis of significant bivariate association with the outcome. The effect of the intervention on adherence was positive but not statistically significant (p=0.40). Baseline adherence was a significant predictor of 1-month adherence (p<0.001). Older age was associated with worse adherence (p=0.009).

Table 6.15. Linear regression model predicting medication adherence on the single-item VAS at 1 month (N=87).

	Beta (95% CI)
Independent variables	
Intervention	2.8 (-3.8, 9.5)
Covariates	
Baseline adherence	4.2 (2.8, 5.6)***
Age	-0.4 (-0.7, -0.1)*
Gender, female	6.4 (-0.3, 13.0)

*p<0.05; **p<0.01, ***p<0.001

6.3.3.3. Sensitivity analyses

The results of the worst-case analysis, in which we assumed that patients lost to follow-up reverted to their scores at the beginning of the study, are shown in Table 6.16. The intervention still had a nonsignificant effect (p=0.51). Baseline adherence still significantly predicted 1-month adherence (p<0.001). Older age remained associated with worse adherence (p=0.004), and female gender was associated with better adherence (p=0.049).

Table 6.16. Linear regression model predicting medication adherence on the single-item VAS at 1 month, with worst-case analysis used to impute missing follow-up values (N=91).

	Beta (95% CI)
Independent variables	
Intervention	2.1 (-4.3, 8.5)
Covariates	
Baseline adherence	4.3 (3.0, 5.7)***
Age	-0.4 (-0.7, -0.1)*
Gender, female	6.4 (0.0, 12.9)*

*p<0.05; **p<0.01, ***p<0.001

A best-case analysis was not possible for medication adherence since there was no measurement at the end of the baseline visit after the video.

6.3.4. Medication adherence on the 5-item Visual Analog Scale at 1 month

6.3.4.1. Bivariate analyses

Bivariate analyses revealed that gender and number of problems with using medications were significantly associated with medication adherence at 1 month; women (t=2.796, df=69.728, p=0.007) and patients reporting fewer problems with their medications (r=-0.288, p=0.007) had better adherence. Baseline adherence was also significantly associated with 1-month adherence (r=0.453, p<0.001). Age, race, glaucoma severity, length of time using glaucoma medications, diagnosis of arthritis or other condition affecting manual dexterity, years of education, baseline outcome expectations, number of glaucoma medications being taken, number of times per day the patient takes glaucoma medications, and visual acuity in the better-seeing eye were not significantly associated with medication adherence at 1 month.

6.3.4.2. Multivariable analyses: main regression model for complete case analysis

Besides baseline adherence, the other covariates that met the criteria for inclusion in the model were gender and number of problems, because these variables were significantly associated with the outcome in bivariate analyses. No additional covariates qualified for the model due to changing the coefficient associated with the intervention by at least 10%. The results of the linear regression model predicting medication adherence on the 5-item VAS at 1 month are shown in Table 6.17. The intervention did not have a statistically significant effect on adherence (p=0.38). Patients with better baseline adherence (p<0.001), women (p=0.001) and patients reporting fewer problems with using medications (p=0.004) had better 1-month adherence.

Table 6.17. Linear regression model predicting medication adherence on the 5-item VAS at 1 month (N=87).

	Beta (95% CI)
Independent variables	
Intervention	1.2 (-1.5, 3.9)
Covariates	
Baseline adherence	0.4 (0.2, 0.5)***
Gender, female	4.5 (1.8, 7.1)**
Problems using medications	-0.8 (-1.3, -0.3)**

*p<0.05; **p<0.01, ***p<0.001

6.3.4.3. Sensitivity analyses

The results of the worst-case analysis, in which we assumed that patients lost to follow-up reverted to their scores at the beginning of the study, are shown in Table 6.18. The effect of intervention remained nonsignificant (p=0.56). Better baseline adherence (p<0.001), female gender (p=0.001) and fewer problems using medications (p=0.006) continued to be associated with better 1-month adherence.

Table 6.18. Linear regression model predicting medication adherence on the single-item VAS at 1 month, with worst-case analysis used to impute missing follow-up values.

	Beta (95% CI)
Independent variables	
Intervention	0.8 (-1.9, 3.4)
Covariates	
Baseline adherence	0.4 (0.3, 0.6)***
Gender, female	4.6 (2.0, 7.3)**
Problems using medications	-0.8 (-1.3, -0.2)**

*p<0.05; **p<0.01, ***p<0.001

A best-case analysis was not possible for medication adherence on the 5-item VAS since there was no measurement at the end of the baseline visit after the video.

6.4. Summary of eye drop technique, self-efficacy, and medication adherence results at 1 month

The results supported Hypothesis 3 and Hypothesis 4, which had predicted that eye drop technique and self-efficacy would be better in the intervention group than the control group at 1 month. All the sensitivity analyses for these hypotheses supported the same conclusions as the base case results. In addition to the intervention, higher baseline outcome expectations and not having been previously educated about technique predicted better technique. In the base case, the analysis of getting the drop in the eye did not support the idea that intervention group patients were more likely to get the drop in the eye than controls at 1 month, although the best-case analysis did show a statistically significant positive effect.

The results did not support Hypothesis 5, which had predicted that medication adherence would be significantly higher in the intervention group than the control group at 1 month. Results were similar for the single-item VAS and 5-item VAS measures. Female gender predicted better adherence at 1 month after enrollment. In addition, younger age predicted better adherence in the

model predicting the single-item VAS score, while fewer problems using medications predicted better adherence in the model predicting the 5-item VAS score.

The trends in eye drop technique over time are shown in Figure 6.1. Technique scores rose by more than a full step from baseline to immediately after the video in the intervention group, and rose slightly in the control group. At 1 month, the scores in the control group were almost unchanged from immediately after the video, and the scores in the intervention group had declined slightly but remained significantly higher than the control group scores after adjusting for the baseline difference.

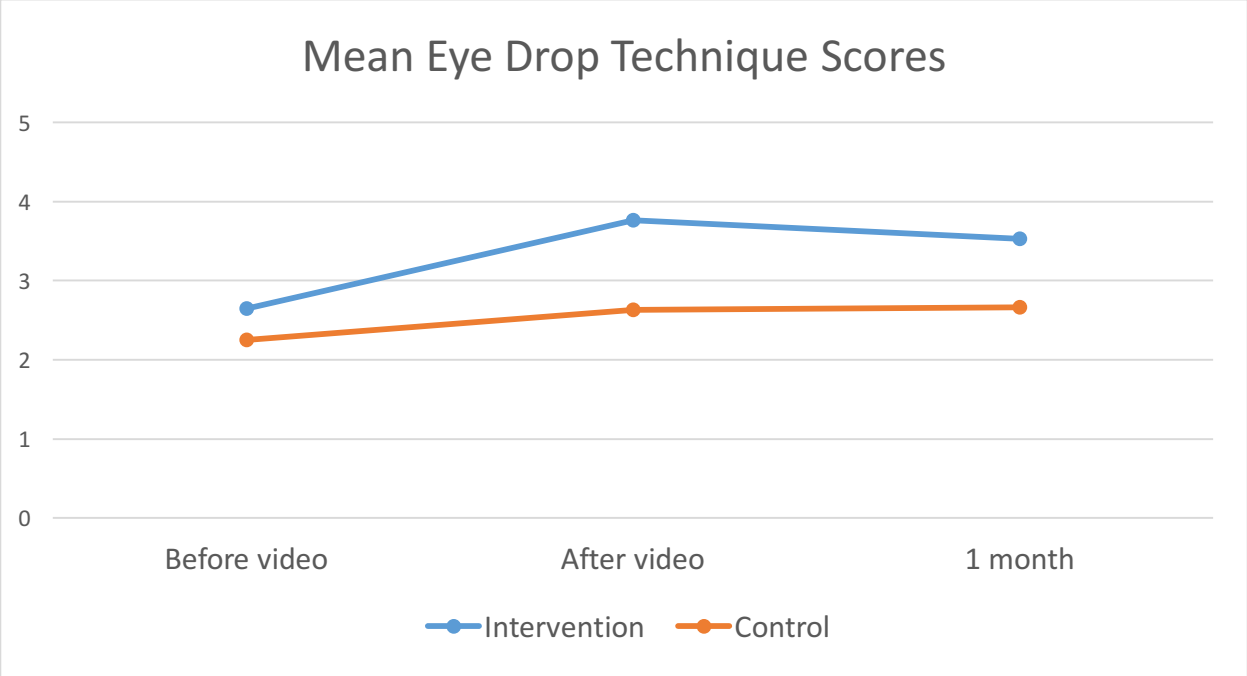


Figure 6.1. Eye drop technique scores by group over time (N=91 before video; N=81 after video; N=77 at 1 month).

The trends in eye drop technique self-efficacy over time are shown in Figure 6.2. Both groups experienced some improvement immediately after the video, followed by declines in both groups at 1 month, although the between-group difference continued to increase, from 0.62

points immediately after to 0.82 points at 1 month. Despite the significant baseline difference (p=0.004), the differences at both later time points remained statistically significant after adjusting for the baseline difference.

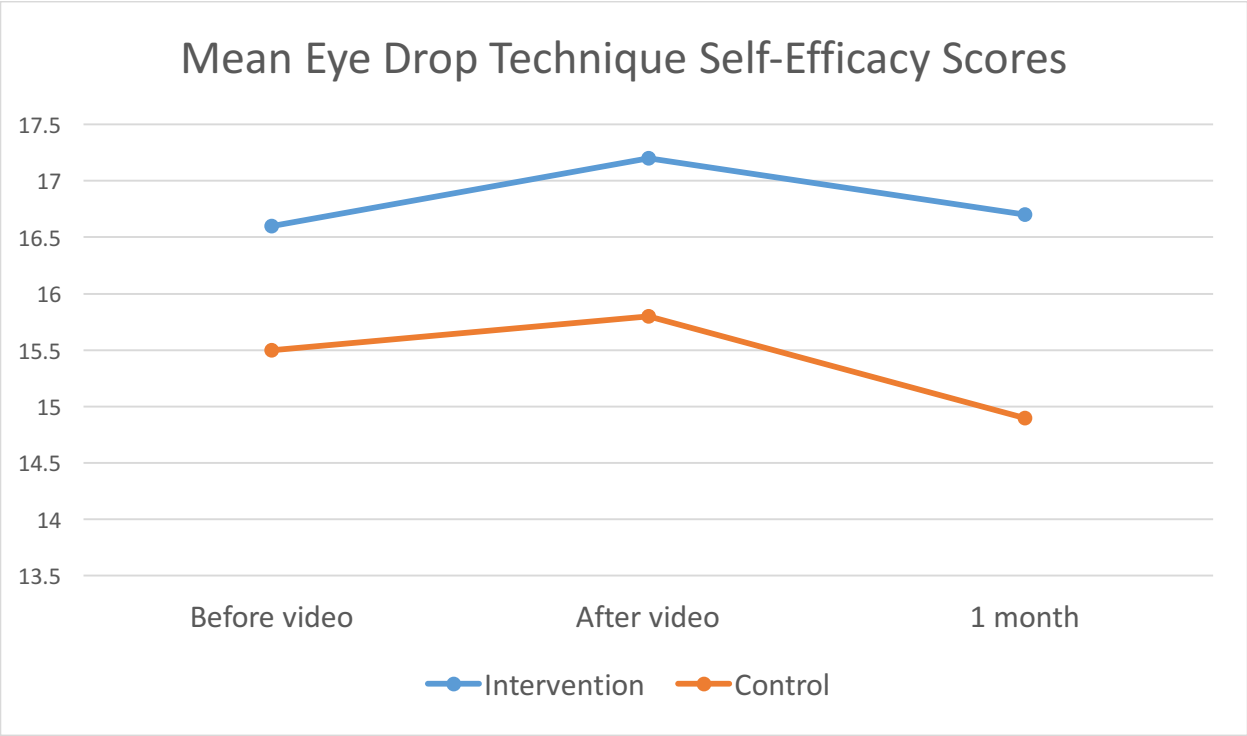


Figure 6.2. Mean eye drop technique self-efficacy by group over time.

Chapter 7: Evaluation and dissemination results

This chapter presents the results of Aim 3, which sought to determine patients' perspectives on how to improve the video and disseminate it to other glaucoma patients.

7.1. Descriptive statistics for evaluation questions

To inform dissemination of the video, data from 43 intervention group participants were analyzed for Aim 3. These data included all intervention group participants except for three who were lost to follow-up. The tracking data for access codes revealed that a total of five participants (11.6%) watched the video at least once after their baseline visit. Including the baseline visit, two (4.7%) watched the video a total of two times each, and three (7.0%) watched it three times each.

In addition to the video instruction, two patients (4.7%) reported that someone had shown them how to use eye drops since the baseline visit. One said they had been educated by the doctor, and one said they had been educated by both the doctor and the ophthalmic technician.

Descriptive statistics for the evaluation questions are shown in Table 7.1. All 43 patients said they would recommend that others watch the video. No patients reported that they watched the video with anyone else. On a 4-point scale ranging from 1 "Not at all useful" to 4 "Very useful", the mean rating of the video was 3.40 (SD: 0.85). Patients who said they thought the video was not at all useful or only a little useful tended to say that they knew most of the material

in the video already, but the video might be more useful for people who were just starting to use eye drops.

African American patients rated the video at a mean of 3.85, compared to 3.20 for non-African Americans (t=3.257, df=40.943, p=0.002). Patients who had used eye drops for a longer time gave the video lower ratings (r=-0.338, p=0.027). Other patient and clinical characteristics, including age, gender, years of schooling, previously having been educated about technique, being dilated, severity of glaucoma, arthritis or other condition affecting manual dexterity, number of glaucoma medications, number of doses taken per day, and visual acuity in the better eye, were not significantly associated with patient rating of usefulness of the video. In general, patients who gave the video ratings of "Not at all useful" or "A little useful" were 100% White or Asian, tended to have used drops for a long time (mean: 16.8 years) and report few problems with their medications (mean: 1.13 problems).

Table 7.1. Descriptive statistics for evaluation questions.

	Percent (n)
***With whom patient watched the video**	
Family member	0.0 (0)
Friend	0.0 (0)
Healthcare provider	0.0 (0)
No one	100.0 (43)
Would you recommend that others watch the video?	
Yes	100.0 (43)
No	0.0 (0)
How useful was the video?	
Not at all useful	2.3 (1)
A little useful	16.3 (7)
Fairly useful	20.9 (9)
Very useful	60.5 (26)

*Participants could choose more than one answer to this question ("check all that apply")

7.2. How the video helped participants

The coding categories resulting from the coding of participants' responses to the question, "How did the video help you?" are shown in Table 7.2.

Table 7.2. Coding categories for how the video helped patients (N=43).

Code number	Category	Definition
1	Angling head/head back	Comments about angling the head or putting the head back in a proper position
2	Putting cap on its side	Comments about putting the cap down on its side rather than upright to avoid contamination
3	Hand hygiene	Comments about washing hands or not using hand sanitizer
4	Not touching eye	Comments about avoiding touching the eye
5	Holding open lid	Comments about holding open the eyelid or how to hold open the eyelid
6	Block tear duct with finger	Comments about holding the finger to block the tear duct (punctal occlusion)
7	Time between two medications	Comments about the time to wait between two drops or two separate medications
8	Distance to hold bottle	Comments about how far away to hold the bottle to instill the drop
9	Technique (general)	General comments about learning proper technique that do not fit any other category
10	Mixing/not shaking medication	Comments about mixing the bottle, not shaking the bottle, or avoiding bubbles in the medication
11	Keeping eye closed after instillation	Comments about keeping the eye closed, length of time to keep the eye closed, or not blinking after instillation
12	Lying down	Comments about lying down to instill the drop more easily
13	Angling/holding bottle	Comments about how to angle or hold the bottle to instill drops
14	Where to aim drop	Comments about where to aim the drop (at the pocket or well of the eye)
15	Check expiration date	Comments about checking the expiration date on the bottle
16	Not sharing bottles	Comments about not sharing bottles with others
17	Wipe off medication	Comments about removing excess medication
18	Not missing eye	Comments about how to not miss the eye
19	Keeping bottle or tip clean	Comments about keeping the bottle or bottle tip clean, other than putting cap on the side or not touching the eye

Participants' responses to the question, "How did the video help you?" are summarized in Table 7.3. The greatest number of participants said that the video helped them by teaching them to block the tear duct with the finger (32.6%), put the cap on its side (27.9%), mix the medication correctly (25.6%), or keep the eye closed after instillation (25.6%).

Table 7.3. How participants said the video helped them (N=43).

Response	**Percent (n)**
Block tear duct with finger	32.6 (14)
Putting cap on its side	27.9 (12)
Mixing/not shaking medication	25.6 (11)
Keeping eye closed after instillation	25.6 (11)
Angling head/head back	18.6 (8)
Hand hygiene	16.3 (7)
Not touching eye	16.3 (7)
Holding open lid	16.3 (7)
Technique (general)	14.0 (6)
Where to aim drop	14.0 (6)
Keeping bottle or tip clean	14.0 (6)
Angling/holding bottle	11.6 (5)
Time between two medications	7.0 (3)
Lying down	4.7 (2)
Distance to hold bottle	2.3 (1)
Check expiration date	2.3 (1)
Not sharing bottles	2.3 (1)
Wipe off medication	2.3 (1)
Not missing eye	2.3 (1)

7.3 Suggestions for improving the video

Participants' responses to the question, "How could the video be improved?" are shown in Table 7.4. The most common suggestion was to use a real person instead of an animation.

Table 7.4. Suggestions for improving the video (N=43). Patients could choose as many options as desired, or none.

Response	Percent (n)
Use a real person instead of an animation	32.6 (14)
Other	32.6 (14)
Make it easier to view on my phone	16.3 (7)
Explain the steps differently	4.7 (2)
Add other topics	4.7 (2)

Suggestions that participants made in the "Other" category included expressing the distance from the eye in inches rather than centimeters (4.7%); it was not realistic to expect people to wait 5 minutes or more in between drops (4.7%); it was not realistic to expect people to throw away a contaminated bottle (2.3%); if you use links to other topics put links at bottom but not in video itself (2.3%), cap rolls on counter when cap is placed on its side (2.3%); we should explain more fully what glaucoma is (2.3%); add reminder of life after opening and shelf life (2.3%); talk slower with more time before the next topic (2.3%); warn the patient to check how long the bottle will last (2.3%); how important the drops are (2.3%); tell patients to keep a list to check off morning, noon, and night (2.3%); use the point of view of the user because they can't see what they are doing (2.3%); add some tips that would help get the drop in the right place (2.3%); the doctor should demonstrate on themselves in person in addition to the video (2.3%); say a relative can do it for you if you're having trouble (2.3%); stress the importance of getting the right amount in the eye (2.3%); to address whether bubbles are bad because the last couple of drops are naturally bubbles (2.3%); discussion of how to make sure eyes are completely open, and looking straight up (2.3%); how to deal with different bottles (2.3%); and to remove Visine because it is not a good eye drop (2.3%).

7.4. Suggestions for dissemination

Participants' responses to the question, "How would you want the video to be made available?" are shown in Table 7.5.

Table 7.5. Participants' preferences for dissemination of the video (N=43).

Response	Percent (n)
On the doctor's office website	79.1 (34)
In the waiting room at the doctor's office	76.7 (33)
In the exam room at the doctor's office	76.7 (33)
On a social media site such as YouTube	74.4 (32)
On a DVD or flash drive that you could take home	53.5 (23)
Other	23.3 (10)

The "other" category when asking about patient preferences for dissemination included the hospital website (7.0%), through Google or search engines (4.7%), other glaucoma sites (4.7%), having the video on its own site (4.7%), and advertising it on TV (2.3%) (Table 7.5). Two patients (4.7%) also suggested providing the same information in print format.

Participants' responses to the question, "What do you think is the best way to make the video available to other glaucoma patients?" are shown in Table 7.6.

Table 7.6. Participants' first-choice preferences for dissemination of the video (N=43).

Response	Percent (n)
Doctor's office exam room	30.2 (13)
Website (other)	18.6 (8)
Doctor's office and online	14.0 (6)
Social media	7.0 (3)
DVD/Flash drive	7.0 (3)
Doctor's office (unspecified whether exam room or waiting room)	7.0 (3)
No preference or preferred format other than video	7.0 (3)
Doctor's office waiting room	4.7 (2)
Doctor's office website	2.3 (1)
Family member	2.3 (1)

The greatest number of participants (30.2%) favored disseminating the video by showing it in the exam room. Unlike when allowed multiple options, when patients were asked for the best way to make the video available, the exam room was clearly preferred over the waiting room, which was selected by only 4.7%. A website (other than social media or the doctor's office website) was the most frequently mentioned option for watching the video outside of the doctor's office. Some patients mentioned that having the video come up first when people typed relevant terms into a search engine would maximize dissemination. Several wanted to show it in the doctor's office and also have an online option. Some of these thought that an online option would be preferred by younger people, but they personally preferred to see the video in the doctor's office.

In total, 41.9% endorsed an online option (other website, doctor's office and online, social media, or doctor's office website), while 55.8% endorsed one of the options that involved showing the video in the doctor's office (exam room, doctor's office and online, doctor's office unspecified, or waiting room).

7.5. Summary

Patients rated the video highly, with 100% saying they would recommend that others watch it, and more than 60% saying it was very useful. Patients most commonly reported that they were helped by learning about punctal occlusion, keeping the bottle clean by putting the cap on its side, closing the eye after instillation, and mixing the medication without shaking. About one-third of patients suggested improving the video by using a real person instead of an animation, and about one-third had a suggestion other than the ones on our list.

When asked to choose all dissemination options they endorsed, approximately three-quarters of the patients endorsed each of the top four options: placing the video on social media, showing in the doctor's office waiting room, showing it in the doctor's office exam room, and placing it on the doctor's office website. However, when patients were asked to choose their top choice alone, the doctor's office exam room was much more popular than the other options.

Chapter 8: Discussion

This chapter presents our findings in the context of our theoretical model and prior literature. It also assesses limitations and strengths of the study, and presents clinical and policy implications of the findings.

8.1 Eye drop technique

Results of eye drop technique assessment prior to intervention were similar to previous studies. The number of patients touching the eye or face (38%) was near the middle of the range from previous studies,[5,9,16-18,50,51,57-59] and the number squeezing out multiple drops (47%) and missing the eye (35%) were near the high end of the range previously observed.[5,9,16,17,50,51,53,63,66] The percentage closing the eye after instillation prior to intervention (4%) was much lower than in one study that reported that 40% closed the eye correctly,[66] but similar to the figure of 3% from another study.[10]

Immediately after the video, the intervention had a statistically significant positive effect on performance of three of the five steps: squeezing the bottle to instill a single drop, holding open the lid with the finger, and closing the eye after instillation. At 1 month, not touching the eye with the bottle and closing the eye after instillation showed significant between-group differences, but the other three steps did not. The remaining steps, including getting the drop in the eye at both time points, showed a positive but not statistically significant effect. Power to

detect effects on getting the drop in the eye was limited since only about one-third of the participants performed this step wrong at baseline. Also, getting the drop in the eye may require more significant effort and practice-based skills training for patients to perform this step correctly, whereas holding open the lid with the finger and closing the eye are easier to change. Similar to our results, both Feng et al. (using an educational video intervention) and McVeigh and Vakros (using printed instructions) reported significant improvement in duration of closing the eye or duration of duct occlusion, and Feng et al. also reported significant improvement in squeezing out a single drop and holding down the lower eyelid to form a pocket, whereas neither study found significant improvement in getting the drop in the eye or not touching the eye.[10,11] Lazcano-Gomez et al. did achieve a significant improvement in not touching the eye, but they had a very high rate of touching the eye prior to intervention (64.4%) and used a live physician education intervention that physicians might not have time to perform in everyday settings.[12]

Our results concur with a prior observational study by Carpenter et al. that found no association between eye drop technique self-efficacy and eye drop technique, and no evidence that self-efficacy mediated the positive relationship between patient-provider communication and improved IOP.[61] Our study also found that eye drop technique self-efficacy was not significantly associated with baseline eye drop technique. Patients may not be aware of how well they perform, causing some patients with poor technique to report high self-efficacy. From a theoretical perspective, this finding may indicate that focusing on self-efficacy is not as helpful when patients do not have an accurate idea of whether they are performing a task correctly. However, teaching the skill effectively may be able to improve both self-efficacy and technique.

The results showed that after adjusting for baseline technique, intervention participants performed 0.75 steps better than controls immediately after the video and 0.63 steps better than

controls at 1 month. This shows that the positive effect of the video was partially sustained until the 1-month time point. To our knowledge, this is the first study to measure the effectiveness of an educational intervention for eye drop technique both immediately after the intervention and 1 month later. McVeigh and Vakros only measured the effect 1 month later, while Feng et al. and Lazcano-Gomez et al. only measured the effect immediately after the intervention.[10-12]

Most participants did not watch the video again after the baseline visit, so they might have additional potential for improvement that could be realized if the video were watched more than once (i.e., dose response). Future studies should look at eye drop technique over a longer time to try to understand whether patients need to be reassessed and shown the video again.

Besides the intervention, the other variables that were significant predictors of better eye drop technique were baseline technique, baseline self-efficacy (only in the model predicting technique immediately after the video), outcome expectations (only in the model predicting 1-month technique), and not having been previously educated about technique (only in the model predicting 1-month technique). Unlike some previous studies,[9,16,17,54,56,58,76,81,84,87,89,94,102,103,107] other patient characteristics such as age, race, and gender, and clinical characteristics such as glaucoma severity and arthritis, were not significant predictors of eye drop technique at any time point. The apparent negative effect of having been previously educated about technique may be an artifact of recall bias in which participants cannot actually remember whether they ever received instruction. Providers should probably be skeptical when their patients report having received prior instruction on eye drop technique, and should not assume that these patients are more proficient at instilling drops.

Our theoretical model[13,73] and prior literature[9,16,17,54,56,58,76,81,84,87,89,94,102,103,107] had suggested that patient characteristics and clinical characteristics might have more of an effect on

eye drop technique, but we did not observe an effect. Therefore, our results suggest that theoretical constructs from Social Cognitive Theory, such as self-efficacy and outcome expectations, might be more relevant in predicting patients' eye drop technique than patient or clinical characteristics. Sleath et al. found that outcome expectations were associated with better electronically monitored adherence in a large observational study.[4] The present study suggests that outcome expectations also predict eye drop technique. Providers may want to routinely assess self-efficacy and outcome expectations to identify patients who are at risk of poor eye drop technique.

8.2. Eye drop technique self-efficacy

The intervention group had better eye drop technique self-efficacy than the control group immediately after the video and at 1 month, after adjusting for the baseline value. Interestingly, both groups experienced some improvement immediately after the video, followed by declines in both groups at 1 month, although the between-group difference continued to increase, from 0.62 points immediately after to 0.82 points at 1 month. The decline in both groups at 1 month may be because as some patients commented, they did not realize that there was a correct way to perform certain steps. Not knowing correct technique would likely have made them overconfident at the beginning. Also, participants could have realized after the baseline visit that they had problems they had never realized before. For example, they may have realized that they touch the eye with the bottle more frequently than they thought. The research assistant did not provide feedback on participants' performance, but the content of the interview questions could have inadvertently served as a reminder of what the important steps were.

Besides the intervention and baseline self-efficacy, no other covariates qualified for the regression models predicting self-efficacy at either time point. Our theoretical model had suggested that patient and clinical characteristics might be associated with self-efficacy,[13,59,73] but this association was not observed. Having used drops for a longer time was associated with higher baseline self-efficacy, but was not associated with self-efficacy immediately after the video nor at 1-month in either bivariate or multivariable analyses. One study by Sleath et al. found that eye drop technique self-efficacy was higher in patients who had a longer glaucoma disease duration,[59] but other studies had found no association between eye drop technique self-efficacy and patient characteristics or clinical characteristics.[9,53,61]

8.3. Discussion of medication adherence results

The Meducation video did not have a significant effect on medication adherence. This might be because the video did not directly address adherence, because the VAS measure of adherence was not as sensitive as non-self-report measures, or because the 1-month timeframe was too short to detect a meaningful change. In addition, while potential participants were excluded if they had perfect technique, they were not required to have low baseline adherence, and the study was not powered on the adherence outcome. Due to ceiling effects, including patients who already have good adherence is likely to reduce the ability to detect a change. Future studies might assess whether the video could incorporate some discussion of why it is important to use medications consistently. Future studies might also benefit from using MEMS® caps or pharmacy refill data to assess adherence more objectively than a self-report measure. In the previous study by Okeke et al. that successfully used a video to improve medication

adherence, the researchers followed patients for 6 months and monitored them electronically with the Travatan Dosing Aid.[86]

Factors that were associated with better medication adherence at 1 month included female gender, younger age, and fewer reported problems with using eye drops. Younger age was only significant when adherence was measured with the single-item VAS, while problems with using eye drops was only significant when adherence was measured with the new 5-item VAS. Prior studies had not reported an effect of gender or problems with using eye drops on adherence, although few studies had explicitly measured problems with using eye drops. With regard to age, eight of 10 prior studies that found a significant difference suggested that older age was associated with better adherence.[56,76,81,84,87,89,94,102,103,107] Therefore, our results do not agree with the majority of prior studies. With a mean age of 69.2 years, our study population was somewhat older than in many other studies. If adherence peaks at a certain age and then declines, we might have captured primarily the older part of the population in which age might be negatively associated with adherence. Future studies could explore this relationship more thoroughly by enrolling a specific number of patients from each age group, and including a squared term in the regression model to determine whether there might be a nonlinear association.

8.4 Evaluation and dissemination of the video

8.4.1. Overall rating of the video

The intervention was well received with a mean rating of usefulness of 3.40 on a 4-point scale. In prior studies of eye drop technique educational interventions, patients were only asked binary questions about whether they found the intervention useful and whether it made them more confident.[10,11] In the study of a video intervention by Feng et al., 91% of patients thought

the video would help them in administering their drops and 91% felt more confident administering their drops as prescribed.[10] The ratings of a printed eye drop chart in the study by McVeigh and Vakros were lower; 64% said the chart was useful and 60% said it helped them deliver their drops correctly.[11]

The mean rating of the video was significantly higher in African Americans and in patients who had been using eye drops for a shorter time. Previous studies of educational interventions for eye drop technique and adherence did not report how ratings of the intervention varied by patient characteristics.[10,11,110] Our finding is consistent with prior studies that have found that African Americans were more interested in learning about glaucoma than patients of other races.[198,199] In a study of African American glaucoma patients by Sleath et al., 76% of survey respondents wanted education on how to use eye drops, and 84% wanted education on glaucoma medications in general.[199]

8.4.2. How the video helped patients

Patients most frequently reported being helped by the video in learning to perform punctal occlusion, lay the cap down on its side, mix the medication correctly, and close the eye after instillation. Each of these themes was mentioned by more than 25% of the intervention group participants. Less frequently, patients also mentioned topics related to the other technique steps, such as not touching the eye and getting the drop accurately into the eye. Among the five technique steps that we scored, topics related to instilling a single drop were least often mentioned. Prior glaucoma eye drop technique intervention studies did not specifically ask patients how the intervention had helped them,[10,11] so our results add to the literature in this area.

8.4.3. Improving the video

Patients most commonly suggested improving the video by using a real person instead of an animation, and a variety of other suggestions. About one-third of the patients wanted a real person in the video, such as a doctor self-administering eye drops. On the other hand, adding new topics was only supported by 4.7% of patients, and some patients specifically expressed the opinion that the video needed to be specific and not address too many different topics. Other videos that are more general, such as one that plays in the waiting room at one of our clinics, are widely available to provide general information on the nature of glaucoma and how eye drops work to stop progression of glaucoma. Our results suggest that this content should be kept separate from the Meducation eye drop technique video.

8.4.4. Disseminating the video

Most patients endorsed multiple means of disseminating the video, often including both online options, such as the doctor's office website or social media, as well as in-person options, such as the doctor's office waiting room or exam room. When allowed to choose as many options as they liked, equal numbers of patients chose the waiting room and the exam room, but when asked for their top choice, 30.2% chose the exam room while only 4.7% chose the waiting room. Giving patients the video on a DVD or flash drive was generally a less popular option than either in-person or online. Therefore, we conclude that the video needs to be disseminated in person when the drops are prescribed, most likely in the exam room, and also online in a place where patients can easily find it. There was not a great deal of consensus on where the best online location was, so it might be worthwhile to provide the video in multiple locations if

possible. For example, it could be posted on YouTube but also have links to it from doctor's office websites, hospital websites, and general glaucoma informational websites.

In general, our results agree with a prior study by Rosdahl et al. that found that ophthalmology patients tend to prefer either one-on-one education from their doctor or materials recommended by their doctor.[198] Patients seem to trust their doctors to recommend trustworthy materials, suggesting that some would not trust a video posted on social media if it was not endorsed by their doctor. When doctors do not have time to provide one-on-one education, they should make it clear what educational materials they endorse, so that patients may access the materials in a way that does not consume the physician's time.

8.5. Limitations

Some videos of patient technique failed to show certain steps clearly enough to allow accurate scoring of technique. Previous studies have also found that capturing all aspects of technique perfectly in a video recording is very difficult.[9] Sensitivity analyses suggested that the results changed little when values were imputed for the missing data, implying that the results were quite robust.

The study was powered only on the primary eye drop technique outcome. Power to detect a difference in secondary outcomes, such as medication adherence and individual technique steps such as getting the drop in the eye, was limited. For example, 81.4% of intervention patients and 71.1% of control patients got the drop in the eye immediately after the video; to have 80% power to detect a difference of the observed size at the α=0.05 level, 112 patients per group, or 224 total patients, would be required. Alternatively, excluding patients who already got the drop in

the eye at baseline could increase power to detect a difference without requiring such a large sample size.

Some patients had been dilated at their visit before we recruited them, which could have affected their ability to perform correct technique and also to be accurately tested with the REALM. However, being dilated was not significantly associated with baseline technique, and being dilated did not meet the criteria for inclusion in the main technique models at either time point (immediately after the video or at 1 month). Nonetheless, future studies should attempt to conduct the intervention before patients are dilated. In everyday clinical practice, providers would want to show the video while patients can see it best, so it is important to test the video the same way in research studies.

Performing the follow-up visit in a different setting than the baseline visit for many patients, such as at home instead of the clinic, could have affected the results. However, control group participants performed almost exactly the same immediately after the video and at 1 month, suggesting that the setting did not have a large influence.

Asking certain questions in interview style may have resulted in biased responses. About half the baseline visits and a significant minority of the follow-up visits were conducted by the principal investigator rather than by a research assistant who did not know the study hypotheses. Some questions also may have had fairly high levels of recall bias, such as whether anyone had previously educated the patient about technique. Many participants said they could not remember, but they presumed that someone must have educated them back when they first started using drops many years ago. The design of the interview did not allow for an "unsure" response to this question, so some participants may have incorrectly been counted as having received prior education. Asking the questions in interview style also could explain the

discrepancy where equal numbers of patients endorsed the waiting room and the exam room when allowed to choose multiple options, but many more patients preferred the exam room when only a single option was allowed. On the multiple-option question, "waiting room" preceded "exam room" and therefore some patients might have endorsed "waiting room" who would not have done so if they had already known "exam room" would be the next option. Social desirability bias may have affected answers to questions such as, "How useful was the video to help you learn to use your eye drops?"

A few patients were not able to complete the REALM due to poor vision, and others may have been misclassified as low literate if they were having difficulty with their vision when tested. Years of education was strongly correlated with REALM score, so we used years of education in place of REALM, and it was not strongly correlated with any of the main outcomes. Prior studies have also found that years of education is strongly associated with health literacy as measured with the REALM; for example, in a study by Marks et al., the correlation was 0.55.[200,201] However, some patients who have relatively little experience with the healthcare system and medical terminology might have low health literacy despite high overall education, while some patients with relatively little schooling might have learned medical terminology well and perform well on the REALM.

The population came from a limited number of physicians in just two clinics, and had a high average educational level of almost a bachelor's degree. Although the video was designed to explain eye drop technique in simple terminology, we cannot be sure from our results that the video would be highly effective in less educated patients. To overcome this limitation, future studies should enroll at a greater number of sites, and enroll at least a certain minimum number of patients with only a high school education or less. Also, we only enrolled English-speaking

patients and only tested the English version of the video, because we did not have the staff needed to administer the interview in languages other than English. Future studies should test the Meducation video in multiple languages. The video was also accessible outside of the clinic only for patients with Internet access.

The randomization did not balance the covariates exactly between groups. As a result, the intervention group was 61% male and had better baseline self-efficacy than the control group, so the evaluation and dissemination results may not be as representative of the opinions of women or patients with lower self-efficacy. However, gender was not significantly associated with any of the self-efficacy or technique outcomes, so the imbalance in gender between the groups had little effect on the estimates of effect of the intervention. We tried including gender in each model to see if it affected the estimate associated with the intervention by more than 10%, but this method only resulted in including gender in the adherence model, where there was no significant effect of the intervention regardless of whether gender was included. To minimize bias resulting from imbalance in demographics or self-efficacy between groups, future studies could also ask the control group to watch the video after completing all study measurements, and then ask for their feedback. Some control group patients did ask to watch the Meducation video at the end of their 1-month visit and spontaneously provided feedback, but we did not record or analyze their comments.

The patient refusal rate of 32% for participating in the study was relatively high. However, patients who refused to participate were similar in race and gender to patients who agreed to participate. The refusal rate is not expected to mean that it would be hard to implement the intervention in an actual clinic setting, since patients had to spend 30 minutes at baseline and

about 15 minutes at follow-up to participate in the study, but would only need to take 4 minutes to watch the video in everyday practice.

The study did not measure clinical outcomes such as intraocular pressure. Future studies should seek to determine how intraocular pressure may improve when patients are more successful in instilling their drops correctly. Few studies so far have measured the association between eye drop technique and IOP. The large observational study by Carpenter et al. suggested no significant association,[61] but another study by Ikeda et al. suggested that IOP was more likely to be lowered at follow-up if patients applied the drops accurately, removed excess fluid correctly, and had better knowledge of instillation technique at follow-up.[66] Ikeda's study did not state the correlation between total technique score and IOP, however.

Patients used a standardized bottle of artificial tears that could be different in size or shape from the eye drop bottle they use at home. Patients might have had more trouble using a bottle they were not accustomed to, but some also could have had better technique with the artificial tears since some patients mentioned that one of their glaucoma eye drop bottles was particularly hard to squeeze correctly. Future studies could test whether patients have similar eye drop technique when using their usual bottle compared to the standardized bottle that we used in this study.

Each patient's technique was assessed by only one masked assessor. In future studies, having multiple masked assessors score each technique video would increase confidence about whether steps were performed correctly or incorrectly.

8.6. Strengths

Unlike many prior studies which assessed only three steps, this study assessed five eye drop technique steps. Many participants showed improvement in holding open the lid with the finger and keeping the eye closed after instillation, steps that had not been assessed in most previous studies.

Statistical power was more than adequate to detect a significant effect for the primary outcome, even with some missing data on the primary outcome. The results regarding self-efficacy and eye drop technique were robust despite missing data.

The study population featured strong representation of African Americans, patients with moderate to severe glaucoma, and patients with complex regimens of multiple medications. It included significant numbers of patients with both high and low levels of using Internet and mobile technology. This suggests that the intervention can be effective for patients at multiple different levels of technological literacy.

Unlike many other studies, this study provided extensive information on patients' perspectives regarding how to improve the video and how to disseminate it to other glaucoma patients.

8.7. Clinical implications

The study results suggest that showing a short video when patients are first prescribed eye drops is likely to improve their technique significantly. Even patients who have used drops for many years should not be assumed to have good technique. Every glaucoma patient should be periodically assessed for eye drop technique and given education if they do not have good technique. When new patients come to a clinic, they may say they have received previous

education on technique, but since we found that patients who reported prior education on technique actually had worse technique, it is probable that these patients still need further technique instruction. Giving patients a link to view the video online is helpful for Internet-savvy patients who understand that they need to view the video multiple times, but for patients with limited access to technology, it may be necessary to show the video again at future visits or provide a video on a DVD or flash drive that can be viewed offline. For patients who still cannot instill drops correctly after repeated education on technique, it may be best to have another person instill the patient's drops, or a treatment other than eye drops should potentially be considered. In line with the pharmacist's responsibility to provide counseling on medications being dispensed, and recognizing that many physicians are not currently providing sufficient eye drop technique instruction, pharmacists should also be prepared to provide education, either live or using a video, whenever they see patients who are newly prescribed eye drops.

8.8. Policy implications

This study helped to determine how much a short online educational video can help to provide eye drop technique education without taking a great deal of the provider's time. The intervention is very easy to disseminate, low-cost, and expected to be valuable to all glaucoma patients who administer their own eye drops. It is also very easy for clinicians to provide at their practices without any significant time burden, showing that it is high in both feasibility and sustainability. Patients who learn to use their eye drops correctly may not only avoid loss of vision, but also avoid eye infections from contaminated bottles and systemic side effects from systemic absorption of medication. Costs to both the healthcare system and society may be reduced, since patients with better technique would waste less medication and likely achieve

better intraocular pressure control. Future work should explore provider perceptions of how the video could be integrated into their practice workflows.

Based on the success of our intervention, payers and policymakers can encourage the inclusion of online videos in routine ophthalmological care and promote development of additional videos about other tasks that patients struggle with, such as remembering to take medication on schedule. The intervention can potentially be used worldwide due to its availability in 21 languages and accessibility on mobile platforms. Completion of this study has also shown that other interventions may be needed to effectively address medication adherence. These interventions may use a similar approach, but should address the importance of adherence directly, and describe ways that patients can remember to take their medications on schedule. Health insurance benefit plans now have an interest in maximizing patient adherence to improve their reputations and earn 5-star ratings from Medicare, so they are interested in knowing what type of intervention can effectively improve adherence. Large healthcare systems, such as academic medical centers and accountable care organizations, are also interested in improving their quality ratings and reputations, and should implement effective medication technique and adherence interventions. In summary, the intervention could have a very significant effect on patients' ability to use eye drops successfully, thus preventing blindness and adverse consequences associated with blindness.

8.9. Conclusion

This study demonstrated the value of an online educational video intervention to improve eye drop technique in adult patients with primary open-angle glaucoma. It also confirmed that patients are interested in seeing the video disseminated in medical offices nationwide, as well as

online through multiple types of websites. To our knowledge, this is the first randomized controlled trial of an educational intervention to improve glaucoma eye drop technique. It confirms the results of past studies that found that educational materials either in the form of print, videos, or live in-person education were able to significantly improve glaucoma eye drop technique.[10-12] The intervention did not significantly improve medication adherence, but future studies should test videos that are more directly focused on adherence. These studies should use electronic monitoring and follow patients over a longer timeframe.

Future studies should test the Meducation eye drop technique video in other populations and other eye diseases in which eye drops are used, such as other types of glaucoma, dry eye, and allergies. Our population was mostly highly-educated and presumably affluent, while other studies could test the video in disadvantaged communities and populations who face language barriers. Future studies should also test other Meducation videos related to other medications where patients have difficulty with correct technique, such as injectable insulin, injectable biologics, topical creams, and rectal suppositories. High-quality, theory-based randomized controlled trials using objective outcome measures are recommended to demonstrate the value of these educational interventions. Implementing effective technique education interventions across many disease areas could permit the achievement of better outcomes with the same medications that are already available. Thus, the gap between efficacy and real-world effectiveness could be significantly narrowed.

APPENDICES

APPENDIX A: ELIGIBILITY SCREENER

ELIGIBILITY SCREENER FOR Meducation: A Randomized Controlled Trial of an Online Educational Video Intervention to Improve Glaucoma Eye Drop Technique and Adherence

Patient Inclusion Criteria

1. Are you at least 18 years of age?

☐$_1$ Yes - CONTINUE WITH Q #2

☐$_0$ No – STOP, EXPLAIN, THANK

2. Do you speak and read English?

☐$_1$ Yes - CONTINUE WITH Q #3

☐$_0$ No – STOP, EXPLAIN, THANK

3. Have you been diagnosed with primary open-angle glaucoma?

☐$_1$ Yes - CONTINUE WITH Q #4

☐$_0$ No – STOP, EXPLAIN, THANK

4. Have you ever been diagnosed as legally blind?

☐$_1$ Yes – STOP, EXPLAIN, THANK

☐$_0$ No – CONTINUE WITH Q #5

5. Are you taking at least one eye drop medication for glaucoma?

☐$_1$ Yes - CONTINUE WITH Q #6

☐$_0$ No – STOP, EXPLAIN, THANK

6. Do you administer your own eye drops?

☐$_1$ Yes - CONTINUE WITH Q #7

☐$_0$ No – STOP, EXPLAIN, THANK

MENTAL STATUS QUESTIONNAIRE

7a. What is the name of this place? _____

b. Where is it located (address)? _____

c. What is today's date? _____

d. What is the month now? _____

e. What is the year? _____

f. How old are you? _____

g. When were you born (month)? _____

h. When were you born (year)? _____

i. Who is the president of the United States? _____

j. Who was the president before him? _____

Number of errors made on Mental Status Questionnaire: _____

(*Patient is ineligible if they make at least 5 errors on the Mental Status Questionnaire.)*

Estimated technique score: ____ of 5

The technique steps are listed below. Patients are ineligible if they correctly perform ALL of the following:

• Squeezing the bottle to instill a single drop
• Holding open the lid with the finger
• Getting the drop accurately into the eye
• Not touching the bottle tip to the eye or face
• Closing the eye after instillation

IF ELIGIBLE, CONTINUE with interview.

IF NOT ELIGIBLE, STOP, explain, and thank them for their time.

PATIENT INTERVIEW
(Baseline)

1. Do you think you got the eye drop in your eye?

☐$_1$ Yes
☐$_0$ No

2. How confident are you that you can carry out the following tasks?

	Not at all confident	Somewhat confident	Very confident
a. Squeezing your eye drop bottle(s)?	1	2	3
b. Getting the medication drop(s) in your eye?	1	2	3
c. Consistently getting the right amount of eye drop medication in your eye each time you use it?	1	2	3
d. Correctly angling your head to accurately apply the eye drops?	1	2	3
e. Delivering the required amount of your eye drops to the eye without missing or applying too much medication?	1	2	3
f. Not touching your eye with the eye drop bottle?	1	2	3

3. All things considered, how much of the time do you use ALL of your glaucoma medications EXACTLY as directed?
(Interviewer: Please have the patient place a mark on the line)

Place a mark (|) anywhere on the line below to indicate your answer.

None of the time _____ **All of the time**

Demographics

4. In which eye do you have glaucoma?

☐$_1$ Left
☐$_2$ Right
☐$_3$ Both

5. How old are you?

|___|___| years

6. Please indicate whether you are male or female. (*Choose only one*)

☐$_1$ Male
☐$_2$ Female

7. Which of the following best describes your race? (*You may select more than one category*.)

☐$_a$ American Indian or Alaskan Native
☐$_b$ Asian
☐$_c$ Black or African American
☐$_d$ Native Hawaiian or other Pacific Islander
☐$_e$ White
☐$_f$ **Other: 7g. specify**_____

8. Are you Hispanic or Latino(a)? (*Check one*)

☐$_1$ Yes
☐$_0$ No

9. How many years of schooling have you completed?

|___||___| Years

10. How long have you used eye drops for your glaucoma?

|___||___| Years

11. Generally speaking, how comfortable do you feel using the Internet?

- ☐ 4 Very comfortable
- ☐ 3 Somewhat comfortable
- ☐ 2 Not very comfortable
- ☐ 1 Not at all comfortable

12. How often do you use the Internet?

- ☐ 5 Once or more a day
- ☐ 4 A few times a week
- ☐ 3 A few times a month
- ☐ 2 Hardly ever
- ☐ 1 Never_____

13. Do you own a cell phone?

- ☐ 1 Yes
- ☐ 0 No (SKIP TO #14)

14. Do you use your cell phone to go on the Internet?

- ☐ 1 Yes
- ☐ 0 No

15. Do you use any other Internet capable devices (iPads, tablets, desktop or laptop computers)?

- ☐ 1 Yes (please specify: _____)
- ☐ 0 No

16. Do you have Internet access in your home?

- ☐ 1 Yes
- ☐ 0 No

17. Have you ever used the Internet to learn more about glaucoma?

- ☐ 1 Yes
- ☐ 0 No

18. How much do you think it will help your glaucoma if you come to your appointments with your eye doctor?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

19. How much do you think it will help your glaucoma if you use your eye drops regularly?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

20. How much do you think it will help your vision if you come to these appointments with your eye doctor?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

21. How much do you think it will help your vision if you use your eye drops regularly?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

22. For each question below, please place a mark (|) anywhere on the line below to indicate your answer. *(Interviewer: Please have the patient place a mark on the line)*

a. How often do you miss taking your eye drops because you forget?

Never _____ **A lot**

b. How often do you miss taking your eye drops because they cause side effects?

Never _____ **A lot**

c. How often do you miss taking your eye drops because they are too expensive?

Never _____ **A lot**

d. How often do you miss taking your eye drops because you run out of eye drops before you can get a refill?

Never _____ **A lot**

e. How often do you miss taking your eye drops because they are hard to use?

Never _____ **A lot**

23. How much problem or concern, if any, are you having in the following areas?

		None	A little	A lot
a.	My medication causes side effects	0	1	2
b.	It is hard to remember all the doses	0	1	2
c.	It is hard to pay for the medications	0	1	2
d.	It is hard to get the plastic seal off a new bottle	0	1	2
e.	It is hard to open the container	0	1	2
f.	It is hard to get my refills on time	0	1	2
g.	It is hard to read the print on the container	0	1	2
h.	The dosage times are inconvenient	0	1	2
i.	It is hard to get the drops in my eye	0	1	2

		None	A little	A lot
j.	I cannot tell if the drops get into my eye(s)	0	1	2
k.	Too many drops come out at the same time	0	1	2
l.	Drops fall on cheeks	0	1	2
m.	It is hard to squeeze the bottle	0	1	2
n.	My medication causes other problems or concerns	0	1	2

If other problems or concerns explain:_____

24. Please rate the amount of difficulty you have had with each of the following activities:

		None	A little	A moderate amount	A great deal	Unable to do
a.	Reading small print	4	3	2	1	0
b.	Reading a newspaper or book	4	3	2	1	0
c.	Reading a large-print book or newspaper	4	3	2	1	0
d.	Recognizing people when they are close to you	4	3	2	1	0
e.	Seeing steps, stairs or curbs	4	3	2	1	0
f.	Reading traffic, street, or store signs	4	3	2	1	0
g.	Doing fine handiwork such as sewing, knitting, crocheting, or carpentry	4	3	2	1	0
h.	Writing checks or filling out forms	4	3	2	1	0
i.	Playing games such as bingo, dominos, card games, or mahjong	4	3	2	1	0
j.	Taking part in sports such as bowling, handball, tennis, or golf	4	3	2	1	0
k.	Cooking	4	3	2	1	0
l.	Watching television	4	3	2	1	0
m.	Driving during the day	4	3	2	1	0
n.	Driving at night	4	3	2	1	0

25. Has anyone ever shown you how to use your glaucoma eye drops before?

☐$_1$ Yes
☐$_0$ No (SKIP TO #26)

25a. Who showed you how to use glaucoma eye drops? (*Check all that apply*)

☐$_1$ Doctor
☐$_2$ Pharmacist
☐$_3$ Ophthalmic technician
☐$_4$ Other, specify: _____

26. Have your eyes been dilated today?

☐$_1$ Yes
☐$_0$ No

Date ___/____/_____ **Start** _____ **End** _____
STUDY ID # ___ ___ ___ ___

REALM

27. Please read as many words as you can from this list. Begin with the first word on List 1 and proceeding down the list reading aloud. Then proceed with the words on List 2 and then List 3. When you come to a word that you cannot read, do the best you can or say "blank" and go on to the next word.

List 1	List 2	List 3
Fat	Fatigue	Allergic
Flu	Pelvic	Menstrual
Pill	Jaundice	Testicle
Dose	Infection	Colitis
Eye	Exercise	Emergency
Stress	Behavior	Medication
Smear	Prescription	Occupation
Nerves	Notify	Sexually
Germs	Gallbladder	Alcoholism
Meals	Calories	Irritation
Disease	Depression	Constipation
Cancer	Miscarriage	Gonorrhea
Caffeine	Pregnancy	Inflammatory
Attack	Arthritis	Diabetes
Kidney	Nutrition	Hepatitis
Hormones	Menopause	Antibiotics
Herpes	Appendix	Diagnosis
Seizure	Abnormal	Potassium
Bowel	Syphilis	Anemia
Asthma	Hemorrhoids	Obesity
Rectal	Nausea	Osteoporosis
Incest	Directed	Impetigo

RAPID ESTIMATE OF ADULT LITERACY IN MEDICINE (REALM)©

Terry Davis, PhD • Michael Crouch, MD • Sandy Long, PhD

Reading Level _____

Grade Completed _____

Subject #_____ _____

Date _____ Clinic _____ Examiner _____

List 1		List 2		List 3	
fat	____	fatigue	____	allergic	____
flu	____	pelvic	____	menstrual	____
pill	____	jaundice	____	testicle	____
dose	____	infection	____	colitis	____
eye	____	exercise	____	emergency	____
stress	____	behavior	____	medication	____
smear	____	prescription	____	occupation	____
nerves	____	notify	____	sexually	____
germs	____	gallbladder	____	alcoholism	____
meals	____	calories	____	irritation	____
disease	____	depression	____	constipation	____
cancer	____	miscarriage	____	gonorrhea	____
caffeine	____	pregnancy	____	inflammatory	____
attack	____	arthritis	____	diabetes	____
kidney	____	nutrition	____	hepatitis	____
hormones	____	menopause	____	antibiotics	____
herpes	____	appendix	____	diagnosis	____
seizure	____	abnormal	____	potassium	____
bowel	____	syphilis	____	anemia	____
asthma	____	hemorrhoids	____	obesity	____
rectal	____	nausea	____	osteoporosis	____
incest	____	directed	____	impetigo	____

SCORE

List 1 _____

List 2 _____

List 3 _____

Raw Score _____

END OF BASELINE VISIT AFTER WATCHING VIDEO

28. How confident are you that you can carry out the following tasks?

	Not at all confident	Somewhat confident	Very confident
a. Squeezing your eye drop bottle(s)?	1	2	3
b. Getting the medication drop(s) in your eye?	1	2	3
c. Consistently getting the right amount of eye drop medication in your eye each time you use it?	1	2	3
d. Correctly angling your head to accurately apply the eye drops?	1	2	3
e. Delivering the required amount of your eye drops to the eye without missing or applying too much medication?	1	2	3
f. Not touching your eye with the eye drop bottle?	1	2	3

AFTER SECOND TIME DEMONSTRATING TECHNIQUE

29. Do you think you got the eye drop in your eye?

☐$_1$ Yes
☐$_0$ No

PATIENT INTERVIEW
(1-Month Follow-Up)

1. How confident are you that you can carry out the following tasks?

	Not at all confident	Somewhat confident	Very confident
a. Squeezing your eye drop bottle(s)?	1	2	3
b. Getting the medication drop(s) in your eye?	1	2	3
c. Consistently getting the right amount of eye drop medication in your eye each time you use it?	1	2	3
d. Correctly angling your head to accurately apply the eye drops?	1	2	3
e. Delivering the required amount of your eye drops to the eye without missing or applying too much medication?	1	2	3
f. Not touching your eye with the eye drop bottle?	1	2	3

2. All things considered, how much of the time do you use ALL of your glaucoma medications EXACTLY as directed?
(Interviewer: Please have the patient place a mark on the line)

Place a mark (|) anywhere on the line below to indicate your answer.

None of the time _____ **All of the time**

3. How much do you think it will help your glaucoma if you come to your appointments with your eye doctor?

Not at all — Somewhat — Extremely

1 2 3 4 5 6 7 8 9

4. How much do you think it will help your glaucoma if you use your eye drops regularly?

Not at all — Somewhat — Extremely

1 2 3 4 5 6 7 8 9

5. How much do you think it will help your vision if you come to these appointments with your eye doctor?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

6. How much do you think it will help your vision if you use your eye drops regularly?

Not at all				Somewhat				Extremely
1	2	3	4	5	6	7	8	9

7. For each question below, please place a mark (|) anywhere on the line below to indicate your answer. *(Interviewer: Please have the patient place a mark on the line)*

a. How often do you miss taking your eye drops because you forget?

Never _____ **A lot**

b. How often do you miss taking your eye drops because they cause side effects?

Never _____ **A lot**

c. How often do you miss taking your eye drops because they are too expensive?

Never _____ **A lot**

d. How often do you miss taking your eye drops because you run out of eye drops before you can get a refill?

Never _____ **A lot**

e. How often do you miss taking your eye drops because they are hard to use?

Never _____ **A lot**

8. Please rate the amount of difficulty you have had with each of the following activities:

		None	A little	A moderate amount	A great deal	Unable to do
a.	Reading small print	4	3	2	1	0
b.	Reading a newspaper or book	4	3	2	1	0
c.	Reading a large-print book or newspaper	4	3	2	1	0
d.	Recognizing people when they are close to you	4	3	2	1	0
e.	Seeing steps, stairs or curbs	4	3	2	1	0
f.	Reading traffic, street, or store signs	4	3	2	1	0
g.	Doing fine handiwork such as sewing, knitting, crocheting, or carpentry	4	3	2	1	0
h.	Writing checks or filling out forms	4	3	2	1	0
i.	Playing games such as bingo, dominos, card games, or mahjong	4	3	2	1	0
j.	Taking part in sports such as bowling, handball, tennis, or golf	4	3	2	1	0
k.	Cooking	4	3	2	1	0
l.	Watching television	4	3	2	1	0
m.	Driving during the day	4	3	2	1	0
n.	Driving at night	4	3	2	1	0

9. Has anyone shown you how to use glaucoma eye drops since we last met?

☐$_1$ Yes
☐$_0$ No

9a. Who showed you how to use glaucoma eye drops? (*Check all that apply*)

☐$_1$ Doctor
☐$_2$ Pharmacist
☐$_3$ Ophthalmic technician
☐$_4$ Other, specify: _____

AFTER PATIENT DEMONSTRATES TECHNIQUE

10. Do you think you got the eye drop in your eye?

☐$_1$ Yes
☐$_0$ No

(ASK THE REMAINING QUESTIONS FOR *INTERVENTION* PATIENTS ONLY)

11. With whom have you watched the video since we last met? (*Check all that apply*)

- ☐ 1 Family member
- ☐ 2 Friend
- ☐ 3 Healthcare provider
- ☐ 4 Other, specify **11a**. _____
- ☐ 5 No one

12. Would you recommend that other patients with glaucoma watch the video?

- ☐ 0 No
- ☐ 1 Yes

13. How useful was the video to help you learn to use your eye drops?

- ☐ 1 Not at all useful
- ☐ 2 A little useful
- ☐ 3 Fairly useful
- ☐ 4 Very useful

14. In what ways did the video help you?

15. How could the video be improved? (*Check all that apply*)

- ☐ 1 Make it easier to view on my phone
- ☐ 2 Explain the steps differently
- ☐ 3 Use a real person instead of an animation
- ☐ 4 Add other topics
- ☐ 5 Other, specify **15a**. _____

16. How would you want the video to be made available? (*Check all that apply*)

- ☐ 1 On a social media site such as YouTube
- ☐ 2 In the waiting room at the doctor's office
- ☐ 3 In the exam room at the doctor's office
- ☐ 4 On the doctor's office website
- ☐ 5 On a DVD or flash drive that I could take home
- ☐ 6 Other, specify **16a**. _____

17. What do you think is the best way to make the video available to other glaucoma patients?

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