

**ED Slit Lamp Interdisciplinary Training with
Longitudinal Assessment in Medical Practice**

BY

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THESIS

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To my wife Maureen
and my children, Delia and Rowan
who supported me through this wonderful journey and
affirming me as an educator.

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LIST OF ABBREVIATIONS

ABEM	American Board of Emergency Medicine
ACGME	Accreditation Council for Graduate Medical Education
CFDNL	Center for Faculty Development and Nexus Learning
ED	Emergency Department
ED SLIT LAMP	Emergency Department Slit Lamp Interdisciplinary Training With Longitudinal Assessment in Medical Practice
EM	Emergency Medicine
EP	Emergency Physician
HEENT	Head Ears Eyes Nose and Throat
IRAT	Independent Readiness Assessment
PC	Patient Care
RCDP	Rapid Cycle Deliberate Practice
SBML	Simulation Based Mastery Learning
TJUH	Thomas Jefferson University
UV	Ultra Violet
WEH	Wills Eye Hospital

SUMMARY

Eye emergencies make up for nearly three percent of the United States emergency department (ED) visits. While emergency physicians (EPs) should be trained to diagnose and treat these ophthalmologic emergencies, many trainees have limited ocular exposure and report insufficient training throughout their residency to confidently conduct a thorough slit-lamp exam.

To address this learning opportunity, we created an interdisciplinary curriculum using simulation-based mastery learning curriculum and rapid cycle deliberate practice to teach emergency physicians how to complete a thorough slit-lamp exam. This curriculum also included asynchronous multi-modal learning options (i.e. video recordings, PowerPoint, text-book references) that learners can utilize before completing their respective readiness assessment exams and demonstrating their slit-lamp competency in an in-person teaching and demonstration session using a 20-item checklist. Learners must receive a minimal score of 90% (18 out of 20 checklist items) to demonstrate procedural mastery.

We enrolled 15 participants during our study period. The pre- and post-curriculum slit-lamp checklist scores significantly increased by an average of seven points. An overwhelming percent of EPs felt more confident in completing a slit-lamp exam after the curriculum and several enrolled EPs reported other learners within the 2-month post-curricular period, ranging from five to up to 30 students. The hands-on teaching was the most positively reviewed element of the curriculum.

INTRODUCTION

A. **Background**

The slit-lamp (“Slit Lamp and Binocular Microscope” 2019) (Figure 1A) is a binocular microscope that allows for a non-invasive, magnified, detailed examination of the anterior segment of the eye using the manipulation of light beams. The slit lamp enables physicians to diagnose a myriad of common ophthalmic pathologies such as corneal injuries, iritis, hyphema, hypopyon, and foreign bodies (Knoop 1995); further, it is essential for performing detailed ophthalmologic exam techniques such as lid eversion, fluorescein examination, foreign body removal, and applanation tonometry. (Seol et al. 2015) The Wood’s Lamp (“Wood’s UV Lamp” 2013) (Figure 1B), in contrast, is a hand-held device often used to characterize skin pigmentation, dermal infections, and macroscopic infections with a built-in magnifying lens and ultraviolet (UV) light. The UV capabilities can highlight fluorescein staining during external ocular exams, allowing providers to assess corneal pathologies at low magnification. While ophthalmologists and optometrists commonly use the slit lamp, emergency medicine (EM) providers must also be able to utilize its functions to perform slit lamp examinations for patients who present to the emergency department (ED) for ocular complaints.

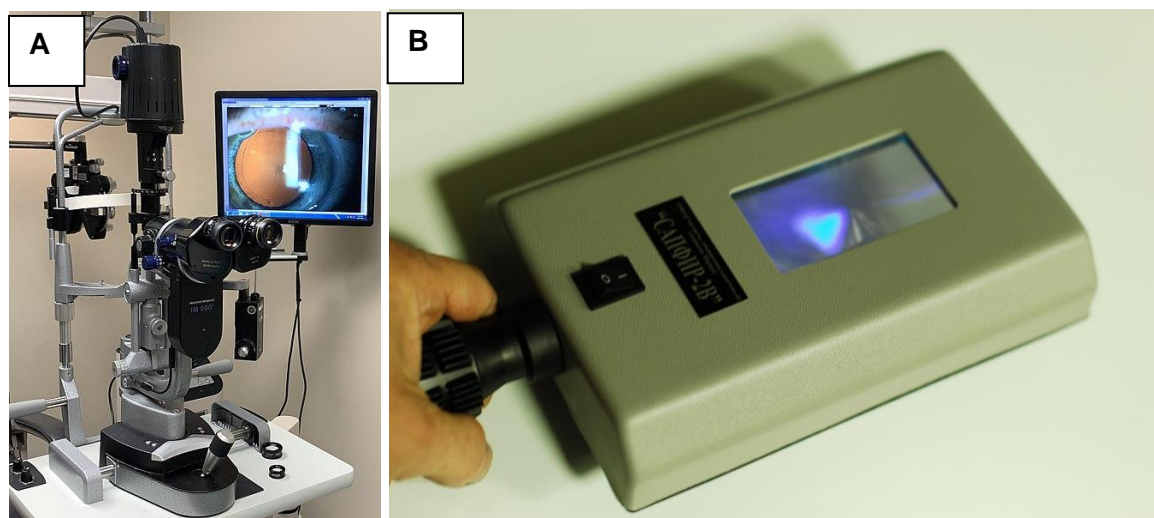


Figure 1: Slit lamp (A) and Wood's Lamp (B)

Eye emergencies make up for nearly three percent of the United States emergency department visits, the most common of which are traumatic (Babineau and Sanchez 2008; Cheung et al. 2014). The most common eye injury evaluated in the ED is corneal abrasion (superficial injury to the cornea), followed by eyelid laceration. Such injuries require magnified viewing, best visualized, and properly diagnosed using the slit lamp. (Owens and Mutter 2006) While many ocular complaints can be evaluated in the outpatient setting, ocular emergencies such as (but not limited to) traumatic globe rupture, ocular foreign body, retinal detachment, closed-angle glaucoma, and endophthalmitis must be diagnosed and managed immediately at an ED. Presently, there are only three Eye EDs in the United States; therefore, traditional emergency providers (EPs) must be capable of recognizing these diagnoses, some of which are only visible using the slit lamp (“The Wills Eye Emergency Department: All Eyes, All the Time” 2021). Delayed or incorrect care of an ophthalmic emergency can result in inappropriate consultation, excessive testing, financial burden, and even irreversible vision loss (Uhr et al. 2020).

B. **Problem Statement**

Despite the significance and frequency of ocular emergencies across the United States, many EM physicians are not confident performing a detailed ophthalmic exam (Druck, Valley, and Lowenstein 2009).

C. **Purpose of Study**

1. To perform a need-based analysis on EP knowledge and skill proficiency for common ED ophthalmologic encounters to inform the curriculum better.
2. To design an interdisciplinary course to teach EPs to complete a comprehensive slit lamp exam in diagnosing common anterior eye pathology.
3. To assess a pilot curriculum incorporating mastery learning into the EM community.

D. **Significance of the Study**

Previous literature has shown that most EM physicians receive fewer than 10 hours of ophthalmic education during residency and have low confidence in performing a comprehensive ophthalmic slit-lamp exam (Gelston and Patnaik 2019). Additionally, necessary ophthalmic education through clerkships and didactics in medical school is in decline, leading to the unpreparedness of incoming residents before any formal residency training (Gelston and Patnaik 2019; Graubart et al. 2018). Consequently, EM physicians must be equipped with the skills and confidence in identifying, managing, and treating ocular emergencies, especially with full use of the slit lamp, as indicated in part by the Accreditation Council for Graduate Medical Education (ACGME) EM Milestones Patient Care domain (PC9) – General Approach to Procedures (“Milestones by Specialty” 2021).

I. CONCEPTUAL FRAMEWORK AND RELATED LITERATURE

A. Conceptual Framework

To provide a robust learning opportunity for adult learners to fully acquire the necessary skills in performing a technically challenging procedure, the optimal learning environment should incorporate elements from both the mastery learning model and rapid cycle deliberate practice (RCDP).

B. Review of Related Literature

The mastery learning model ensures that students can master a topic if the instruction is directed toward providing unlimited time and support in learning and reviewing material until mastery proficiency is reached. Meanwhile, the RCDP model requires the learner to achieve a designated proficiency level before proceeding to the next task. (Griswold-Theodorson et al. 2015) Within medical education, simulation-based mastery learning (SBML) models are successful across various specialties, such as general surgery, critical care, and gastroenterology (Zendejas et al. 2011) (Franklin et al. 2018) (Barsuk et al. 2009). In light of successful smaller-scaled studies on the effectiveness of slit-lamp training within undergraduate medical education, we propose that incorporating SBML in a longitudinal procedural training curriculum can enable adult post-graduate learners to conduct deliberate performances of intended cognitive or psychomotor skills in sequential order with a repetitive skills assessment (Qureshi 2009; Hoonpongmanont et al. 2015; Chancey et al. 2019). Specific, informative feedback will enable sustained performance improvement to achieve slit-lamp mastery (Siddaiah-Subramanya, Smith, and Lonie 2017).

II. RESEARCH APPROACH

A. Design

To address the need for slit-lamp training among EPs, we developed and assessed the Emergency Department Slit Lamp Interdisciplinary Training With Longitudinal Assessment in Medical Practice (ED SLIT LAMP) curriculum that combines the conceptual frameworks of the mastery learning model and rapid cycle deliberate practice to ensure proficiency in conducting a comprehensive slit lamp exam. The mastery learning model ensures that participants understand a lesson entirely, at their own pace, before moving on to the next time point. The RCDP model ensures learners can practice skills repetitively while receiving brief, interspersed feedback. (Chancey et al. 2019) (Lemke et al. 2019) (Mavis et al. 2021) We believe the transdisciplinary pedagogical approach behind ED SLIT LAMP will serve as a successful scaffold for deconstructing barriers in traditional siloed medical practices and lead to improved patient care, knowledge synthesis, and resource utilization of our consulting services. This study was approved by the Institutional Review Board at Thomas Jefferson University Hospital (TJUH) in Philadelphia, PA, USA. Informed consent was obtained from participating physicians. This study was funded by the Center for Faculty Development and Nexus Learning (CFDNL) Pedagogy Grant at Thomas Jefferson University.

B. Setting

ED SLIT LAMP is a multi-centered, collaborative transdisciplinary project that took place at TJUH, a large tertiary academic center, and the Wills Eye Hospital (WEH), one of the nation's top ophthalmologic institutions from 2021 to 2023. Both institutions are equipped with their

respective EDs that are blocks apart from each other (0.2 miles), with staff from each hospital working as consultants at the other; WEH residents function as primary ophthalmology consultation for the TJUH ED, while TJUH EPs function as overnight medical emergency consultants at the WEH ED. The geographic and relationship proximity of these two institutions created ideal conditions to develop and pilot a procedural skill competence SBML curriculum.

C. **Sample**

EPs were selected as ideal learners due to needs analysis, teaching responsibilities, and convenient sampling for curricular recruitment. EPs were recruited using the TJUH ED listserv with financial incentives. For this pilot study, we required a minimum of 12 participants to meet 5% type 1 error and 80% power based on score improvement from baseline testing to post-testing, as referenced by Miller et al. (Miller et al. 2020)

D. **Curricular Development**

ED SLIT LAMP leveraged talents from content and education experts from both institutions to create an interdisciplinary procedural teaching curriculum. The success of a traditional SBML curriculum is linked to the learners' skill acquisition; our study expands this measure to include interdisciplinary collaboration, demonstrating the successful alignment between educational and patient-centered goals that benefit both departments.

To evaluate the curriculum, we employed all four levels of the Kirkpatrick model. Our measurement of success includes improved learner confidence (level 1), knowledge acquisition (level 2), willingness to incorporate their skillset in clinical practice (level 3), and dissemination

of this knowledge to junior learners (level 4) using pre- and post-test Likert scale questionnaires. Any curricular feedback and improvements were extracted for future curricular iterations.

The authors first conducted a needs-based analysis at TJUH ED that revealed that EM faculty desired hands-on slit-lamp education and training on identifying anterior segment ophthalmic complaints to provide optimal patient care. Since ophthalmology is a recognized component of the American Board of Emergency Medicine (ABEM) board exam content (5% - part of the head, ear, eye, nose & throat disorder - HEENT), we constructed the pre-test clinical content based on critical and common ocular diagnoses, most common WEH ED ophthalmology discharge diagnoses, and ‘can’t miss’ clinical identifications by the EM and ophthalmology departments.

All curricular contents (lecture materials, video recording, pre-post-post assessments, study surveys, mastery learning checklist) were created de novo by the principal investigator [XCZ] with ophthalmology co-investigators consultation [CC, MEL] based on targeted needs assessment. These materials underwent sequential review by select experts at WEH and were modified sequentially until a consensus was reached. The minimal passing checklist score was determined to be 90%, based on combined determination from ophthalmologist experts at WEH and similar threshold determined by Miller et al. (Miller et al. 2020) Each curriculum assessment (see **Appendix 1** for details) was constructed to mirror the natural knowledge, skills, and attitude progression from the ACGME EM Milestones Patient Care Domain (PC9). Due to the multifaceted nature of EM, there is no specific procedural milestone for performing a slit-lamp exam, as described in detail in the ACGME Ophthalmology PC1: Data Acquisition - Basic

Ophthalmology Exam and Testing (Level 1) (“Milestones by Specialty” 2021). However, the EM PC9 milestones provide structured language applicable to many ED procedures and advanced device-assisted medical examinations (i.e., slit-lamp exam). Please see TABLE I for the correlation between the EM milestone and our ED SLIT LAMP assessments.

TABLE I
CORRESPONDING ED SLIT LAMP ASSESSMENTS TO ACGME EM MILESTONE
GENERAL APPROACH TO PROCEDURES (PC9)

ACGME EM Milestone PC9	Bolded PC9 elements relatable to performing a slit lamp exam	Correlating ED SLIT LAMP Assessments
Level 1	Identifies pertinent anatomy and physiology for a specific procedure. Uses appropriate Universal Precautions	Appendix A – part II (Clinical Image Examination)
Level 2	Knows indications, contraindications, anatomic landmarks, equipment , anesthetic and procedural technique , and potential complications for common ED procedures Performs the indicated common procedure on a patient with moderate urgency who has identifiable landmarks and a low-moderate risk for complications. Performs post-procedural assessment and identifies any potential complications	Appendix B – part I (Slit lamp technical) Appendix B (Final checklist)
Level 3	Determines a backup strategy if initial attempts to perform a procedure are unsuccessful Correctly interprets the results of a diagnostic procedure	Appendix A – part III (Ophthalmology Exam Mix-n-Match)
Level 4	Performs indicated procedures on any patients with challenging features (e.g., poorly identifiable landmarks, at extremes of age or with co-morbid conditions) Performs the indicated procedure, takes steps to avoid potential complications, and recognizes the outcome and/or complications resulting from the procedure	Appendix B (Final checklist)
Level 5	Teaches procedural competency and corrects mistakes	Appendix C – ED SLIT LAMP Surveys

E. **Implementation**

The longitudinal curriculum included four unique time points (Time 0-3) of intervention staggered over 6 months (Appendix A, Appendix B). At Time 0, participants completed an in-person baseline pre-test video-recorded and evaluated by two study investigators: an emergency medicine physician [XCZ] and an ophthalmologist [MEL]. At Time 1, the participants gained access to an asynchronous learning packet that consisted of a PowerPoint presentation on common ED eye complaints, digital library links to the WEH Manual, and a video recording of a comprehensive slit-lamp examination (Rutledge 1996). The participants also gained access to an independent readiness assessment (IRAT), which was required to be completed within 30 days with a minimum score of 90% before proceeding to the next in-person phase of the study (Appendix A).

After EPs achieve the minimal IRAT score, they are invited to participate in the Time 2 (in-person) SBML portion of the study where they will receive an in-person demonstration of a comprehensive slit-lamp exam by a board-certified ophthalmologist [CC] on a standardized patient volunteer. Following the demonstration, participants were given unlimited time for deliberate practice with direct feedback and could complete the final exam under the observation of the ophthalmologist. To achieve mastery, participants must have completed a minimum passing score (18 out of 20) on the final mastery checklist (Appendix B).

Immediately upon completing the final checklist, the participants were asked to complete a course evaluation and learner confidence survey (Appendix C) with Likert scaling, subjective commentary, and a validated 5-item Critical Incidence Questionnaire (CIQ) for curricular

improvement. At Time 3, participants completed a 60-day post-examination survey, assessing their ocular knowledge, slit-lamp confidence, clinical teaching opportunities, and relevant interprofessional relationships.

F. **Statistical Analysis**

We used a Wilcoxon signed-rank test to differentiate the checklist scores between the curricular intervention by incorporating collected paired data before and after the training, median and interquartile range values of subtotal scores at two-time points (McNemar 1947). We used McNemar's test to comparing each categorical sub-score (Yes/No) by time points and corresponding p-value within the same population (Conover 1999). The descriptive summaries of survey questions at Time 0, Time 2, and 3-month follow-up are analyzed using Bonferroni adjusted p-values (multiplying p-value from Wilcoxon signed-rank test by the number of multiple tests, doubling the p-values), which was directly compared to the pre-specified 5% significance level. All statistical analyses were performed using R 4.1.2 ("R: The R Project for Statistical Computing" 2023).

III. RESULTS

A. Study Findings

15 EPs (6 females and 9 males) were enrolled in ED SLIT LAMP during the 2-year period; none were lost to follow-up. All participants were board-certified EPs with an average clinical experience of 7.8 years post-residency graduation. All EPs completed the final exam of the curriculum in one attempt.

TABLE II lists the 20 steps of the slit-lamp exam curriculum checklist, comparing participant results from recorded slit-lamp attempts (Time 0) to the final in-person assessment (Time 2). The intra-class correlation in test scores between EPs and ophthalmologists at Time 0 (2 raters) was 0.98. We found a significant increase between the checklist scores before and after the education initiative, 12.0 to 19.0, $p < 0.002$.

TABLE II

DESCRIPTIVE SUMMARY OF CHECKLIST EVALUATION AT PRE- AND POST-CURRICULAR AND COMPARISON BETWEEN TIME POINTS

Checklist Item	Performed	Time 0, N(%) (N=15)	Time 2, N(%) (N=15)	P-value from exact McNemar's test
1 - Identifying slit lamp anatomy	Yes	13 (86.7%)	15 (100%)	0.500
2 - Apply transparent face shield over the slit lamp (COVID)	Yes	4 (26.7%)	15 (100%)	<0.001
3 - Sanitize forehead and chin rest for the patient	Yes	5 (33.3%)	14 (93.3%)	0.004
4 - Apply topical tetracaine/proparacaine on patient's eyes	Yes	8 (53.3%)	12 (80.0%)	0.219
5 - Unlock instrument base and shift by pulling toward you	Yes	15 (100%)	15 (100%)	NA
6 - Adjust eye pieces for your interpupillary distance and refractive error	Yes	10 (66.7%)	14 (93.3%)	0.219
7 - Adjust table height and/or chair(s) - neither patient nor examiner should be hunched over	Yes	12 (80.0%)	14 (93.3%)	0.500
8 - Instruct patient to close eyes while you power up by turning on the light source at low voltage setting and focus on right eyelid. Position patient in slit lamp with forehead touching the horizontal bar and chin in the chin rest.	Yes	4 (26.7%)	15 (100%)	<0.001
9 - Set magnification on lowest settings (10x to 12x), illumination at largest aperture and widest slit beam.	Yes	12 (80.0%)	15 (100%)	0.250
10 - Adjust chin rest so the patient is sitting comfortably with their chin on the chinrest and their forehead against the headrest	Yes	12 (80.0%)	15 (100%)	0.250
11 - Practice macro and micro adjustments of the sliding base with joystick.	Yes	14 (93.3%)	15 (100%)	1.000
12 - Adjust microscope 90° to facial plane with illumination set at 45° angle (angle LEFT for patient's right eye, and RIGHT for	Yes	7 (46.7%)	15 (100%)	0.008

left eye)				
13 - Perform outer structure evaluation	Yes	14 (93.3%)	15 (100%)	1.000
14 - Perform anterior chamber evaluation	Yes	5 (33.3%)	15 (100%)	0.002
15 - Look for cells and flare	Yes	4 (26.7%)	12 (80.0%)	0.021
16 - Place a drop of tetracaine/proparacaine on a sterile fluorescein strip	Yes	15 (100%)	15 (100%)	NA
17 - The fluorescein is then placed in the inferior fornix of the eye by pulling down on the lower lid and gently touching the bulbar conjunctiva with the fluorescein strip	Yes	9 (60.0%)	15 (100%)	0.031
18 - Adjust cobalt blue filter on diaphragm wheel at maximum beam height and medium width slit setting for fluorescein evaluation	Yes	14 (93.3%)	15 (100%)	1.000
19 - Focus the slit beam at 9:00 position on limbus. Move across the cornea to the 3:00 position by tilting joystick laterally	Yes	12 (80.0%)	15 (100%)	0.250
20 - Pull instrument base toward you when finished and lock in position. Turn off	Yes	4 (26.7%)	13 (86.7%)	0.004
		Time 0, Median [IQR]	Time 2, Median [IQR]	P-value from Wilcoxon signed rank test
Subtotal score		12.0 [10, 16]	19.0 [19, 20]	0.002

The most notable differences between the pre and post-curricular intervention were: 1) instructing the patient to close their eyes while powering up and positioning the patient in the slit lamp with the forehead touching the horizontal bar and chin in the chinrest ($p<0.001$); 2) adjusting the microscope 90 degrees to facial plane with illumination set at a 45-degree angle ($p<0.008$); 3) performing an anterior chamber evaluation ($p<0.002$); 4) looking for cells and flare ($p<0.021$); and 5) placing fluorescein in the inferior fornix of the eye ($p<0.031$). The most missed steps at the baseline exam were: 1) applying a transparent face shield (26.7%); 2) instructing patients to close their eyes when the machine was turned on (26.7%); 3) looking for cells and flare (26.7%).

TABLE III identifies slit-lamp exam confidence, consultation practice, and Wood's-lamp exam confidence at the beginning of the study (Time 0), immediately after achieving procedural mastery (Time 2), and 2 months later (Time 3). Before participating in the slit-lamp curriculum, 73% of EPs also reported rarely or never performing a slit-lamp exam, while 80% of EPs reported sometimes or often using a Wood's lamp for ocular complaints. Furthermore, only 20% of physicians reported feeling confident performing a comprehensive slit-lamp exam for ocular complaints. In comparison, 53% reported being unconfident in performing this task at the start of the study. This contrasts significantly with comfort using Wood's lamp; 67% of physicians reported feeling confident, very confident, or extremely confident in its use for ocular complaints. Lastly, 60% of participants reported feeling unconfident in teaching residents how to perform a slit-lamp exam, whereas 67% reported feeling confident, very confident, or extremely confident in teaching residents how to perform a Wood's lamp exam.

TABLE III
 DESCRIPTIVE SUMMARIES OF SURVEY QUESTIONS AT TIME 0 (PRE-CURRICULAR),
 TIME 2 (IMMEDIATE POST-SBML CURRICULUM), AND TIME 3 (2 MONTH POST-
 SBML CURRICULUM)

	ED SLIT LAMP Participant Questions	Time 0, N(%) (N=15)	Time 2, N(%) (N=15)	Time 3, N(%) (N=15)
How confident are you in identifying common ocular pathology seen in your main work site (CC, MHD, Urgent Care)?	Not at all confident	0 (0.0%)	-	0 (0.0%)
	Somewhat confident	9 (60.0%)	-	1 (6.7%)
	Confident	3 (20.0%)	-	7 (46.7%)
	Very confident	3 (20.0%)	-	5 (33.3%)
	Extremely confident	0 (0.0%)	-	2 (13.3%)
[Over the past 3 months] How often do you: 0 (0.0%) Perform an independent slit lamp exam for ocular complaints?	Never	6 (40.0%)	-	2 (13.3%)
	Rarely	5 (33.3%)	-	7 (46.7%)
	Sometimes	3 (20.0%)	-	2 (13.3%)
	Often	1 (6.7%)	-	3 (20.0%)
	Always	0 (0.0%)	-	1 (6.7%)
[Over the past 3 months] How often do you: 0 (0.0%) Use a wood lamp (with access to a slit lamp) for ocular complaints?	Never	1 (6.7%)	-	1 (6.7%)
	Rarely	2 (13.3%)	-	4 (26.7%)
	Sometimes	5 (33.3%)	-	1 (6.7%)
	Often	7 (46.7%)	-	6 (40.0%)
	Always	0 (0.0%)	-	3 (20.0%)
[Over the past 3 months] How often do you rely on ophthalmology consultation to: 0 (0.0%) Help modify your treatment plan for ocular complaints?	Never	0 (0.0%)	-	1 (6.7%)
	Rarely	2 (13.3%)	-	3 (20.0%)
	Sometimes	10 (66.7%)	-	8 (53.3%)
	Often	3 (20.0%)	-	3 (20.0%)
	Always	0 (0.0%)	-	0 (0.0%)
[Over the past 3 months] How often do you rely on ophthalmology consultation to: 0 (0.0%) Reinforce your treatment and plan for ocular complaints?	Never	1 (6.7%)	-	2 (13.3%)
	Rarely	4 (26.7%)	-	4 (26.7%)
	Sometimes	8 (53.3%)	-	8 (53.3%)
	Often	2 (13.3%)	-	1 (6.7%)
	Always	0 (0.0%)	-	0 (0.0%)
[Over the past 3 months] How often do you rely on ophthalmology consultation	Never	0 (0.0%)	-	1 (6.7%)
	Rarely	3 (20.0%)	-	0 (0.0%)

to: 0 (0.0%) Provide additional information and guidance to your treatment and plan for ocular complaints?	Sometimes	5 (33.3%)	-	10 (66.7%)
	Often	7 (46.7%)	-	4 (26.7%)
	Always	0 (0.0%)	-	0 (0.0%)
Based on your current practice patterns, how confident are you in: 0 (0.0%) Performing a comprehensive slit lamp exam for ocular complaints?	Not at all confident	8 (53.3%)	0 (0.0%)	0 (0.0%)
	Somewhat confident	4 (26.7%)	2 (13.3%)	4 (26.7%)
	Confident	3 (20.0%)	3 (20.0%)	5 (33.3%)
	Very Confident	0 (0.0%)	6 (40.0%)	3 (20.0%)
	Extremely Confident	0 (0.0%)	4 (26.7%)	3 (20.0%)
Based on your current practice patterns, how confident are you in: 0 (0.0%) Teaching residents to perform a comprehensive slit lamp exam for ocular complaints	Not at all confident	9 (60.0%)	0 (0.0%)	2 (13.3%)
	Somewhat confident	3 (20.0%)	4 (26.7%)	3 (20.0%)
	Confident	3 (20.0%)	5 (33.3%)	4 (26.7%)
	Very Confident	0 (0.0%)	2 (13.3%)	5 (33.3%)
	Extremely Confident	0 (0.0%)	4 (26.7%)	1 (6.7%)
How likely are you to teach learners (i.e. residents, advanced practice practitioner, medical student) in performing a comprehensive slit lamp exam for ocular complaints?	Not at all likely	8 (53.3%)	0 (0.0%)	-
	Somewhat likely	4 (26.7%)	2 (13.3%)	-
	Likely	3 (20.0%)	1 (6.7%)	-
	Very Likely	0 (0.0%)	8 (53.3%)	-
	Extremely Likely	0 (0.0%)	4 (26.7%)	-
Based on your current practice patterns, how confident are you in: 0 (0.0%) Performing a comprehensive woods lamp exam for ocular complaints?	Not at all confident	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Somewhat confident	5 (33.3%)	1 (6.7%)	2 (13.3%)
	Confident	2 (13.3%)	2 (13.3%)	4 (26.7%)
	Very confident	6 (40.0%)	5 (33.3%)	3 (20.0%)
	Extremely confident	2 (13.3%)	7 (46.7%)	6 (40.0%)
Based on your current practice patterns, how confident are you in: 0 (0.0%) Teaching residents to perform a comprehensive woods lamp exam (with access to a slit lamp) for ocular complaints?	Not at all confident	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Somewhat confident	5 (33.3%)	2 (13.3%)	2 (13.3%)
	Confident	2 (13.3%)	1 (6.7%)	5 (33.3%)
	Very confident	6 (40.0%)	5 (33.3%)	2 (13.3%)

	Extremely confident	2 (13.3%)	7 (46.7%)	6 (40.0%)
How likely are you to teach learners (i.e. residents, advanced practice practitioner, medical student) in performing a comprehensive woods lamp exam (with access to a slit lamp) for ocular complaints?	Not at all likely	1 (6.7%)	0 (0.0%)	-
	Somewhat likely	4 (26.7%)	0 (0.0%)	-
	Likely	3 (20.0%)	4 (26.7%)	-
	Very likely	5 (33.3%)	2 (13.3%)	-
	Extremely likely	2 (13.3%)	9 (60.0%)	-
On average, how many eye pathologies do you see at the main work site (CC, MHD, Urgent care)?	Mean (SD)	12.4 (11.1)	-	8.3 (7.6)
	Median [IQR]	10 [4, 15]	-	5 [3, 12.5]
On average, how many eye pathologies do you see at other facilities (i.e. Wills Eye), if applicable?	Mean (SD)	32.1 (46.1)	-	36.1 (29.4)
	Median [IQR]	12 [0, 40]	-	37.5 [13.5, 50]
	* SD: standard deviation, IQR: Inter quartile range			

‘-‘ Denotes missing data

After completing the slit-lamp curriculum (Time 2), 86.7% of physicians reported feeling confident, very confident, or extremely confident performing a comprehensive slit-lamp exam for ocular complaints. Participants were also more confident in teaching residents how to perform a slit-lamp exam, with 73.3% reporting feeling confident, very confident, or extremely confident in teaching this task. Most participants strongly agreed that the ED SLIT LAMP curriculum helped them perform an independent slit-lamp exam and identify critical findings for common ocular complaints (80%), enhancing their learning more than traditional lectures and reading alone (86.7%). Of the asynchronous materials, the video demonstration was the most utilized (53% used it ‘a lot’ or a ‘great deal’); the PowerPoint lecture and WEH Manual were the least utilized. At 2 months post-ED SLIT LAMP (Time 3), 73% and 67% of participants

expressed extreme confidence in performing and teaching a resident how to perform a slit-lamp exam. Five out of 15 physicians reported teaching learners within the 2-month post-curricular period, ranging from five to up to 30 students.

TABLE IV summarizes the statistically significant findings from the survey responses based on the three timeframes. There was a statistically significant increase in self-reported confidence in 1) performing a comprehensive slit lamp exam and 2) teaching residents to perform this exam between Time 0 to Time 2 and Time 0 to Time 3 ($p < 0.001$). There was no difference in reliance on ophthalmology consultation to modify or reinforce a treatment plan for ocular complaints when comparing Time 0 to Time 3 ($p = 0.701$, $p = 0.814$). There was also no statistical difference in the number of patients with ocular complaints evaluated by the study participants at the TJUH ED and WEH ED throughout the study ($p = 0.136$, $p = 1.000$).

TABLE IV

STATISTICAL ANALYSIS OF SURVEY QUESTIONS BETWEEN THE THREE
DIFFERENT STUDY TIMEFRAMES

Survey Question	Time 0 Median [IQR]^a	Time 2 Median [IQR]^b	Time 3 Median [IQR]^c	Bonferroni adjusted P value from Wilcoxon signed rank test Time 0 vs. Time 2	Bonferroni adjusted P value from Wilcoxon signed rank test Time 0 vs. Time 3
Slit lamp					
Based on your current practice patterns: how confident are you in: Performing a comprehensive slit lamp exam for ocular complaints?	1 [1, 2]	4 [3, 4.5]	3 [2.5, 4]	<0.001	<0.001
Based on your current practice patterns, how confident are you in: Teaching residents to perform a comprehensive slit lamp exam for ocular complaints	1 [1, 2]	3 [2.5, 4.5]	3 [2, 4]	<0.001	0.004
How often do you: Perform an independent slit lamp exam for ocular complaints?	2 [1, 2.5]	n/a*	3 [3, 3]	n/a*	0.064
Wood's Lamp					
Based on your current practice patterns, how confident are you in: Performing a comprehensive Wood's lamp exam for ocular complaints?	4 [2, 4]	4 [4, 5]	4 [3, 5]	0.016	0.030
Based on your current practice patterns, how confident are you in: Teaching residents to perform a comprehensive Wood's lamp exam (with access to a slit lamp) for ocular complaints?	4 [2, 4]	4 [4, 5]	4 [3, 5]	0.028	0.082
How often do you: Use a wood lamp (with access to a slit lamp) for ocular complaints?	3 [3, 4]	n/a*	3 [3, 3]	n/a*	1.000
Ophthalmology Consultation Habits					
How confident are you in identifying common ocular pathology seen in your	2 [2, 3]	n/a*	3 [3, 4]	n/a*	0.018

main work site (CC, MHD, Urgent Care)?					
On average, how many eye pathologies do you see at the main work site?	10 [4, 15]	n/a*	5 [3, 12.5]	n/a*	0.136
On average, how many eye pathologies do you see at other facilities?	12 [0, 40]	n/a*	37.5 [13.5, 50]	n/a*	1.000
How often do you rely on ophthalmology consultation to: Help modify your treatment plan for ocular complaints?	3 [3, 3]	n/a*	3 [2.5, 3]	n/a*	0.701
How often do you rely on ophthalmology consultation to: Reinforce your treatment and plan for ocular complaints?	3 [2, 3]	n/a*	3 [2, 3]	n/a*	0.814
How often do you rely on ophthalmology consultation to: Provide additional information and guidance to your treatment and plan for ocular complaints?	3 [3, 4]	n/a*	3 [3, 3.5]	n/a*	1.000

Confidence levels: 1 = Not at all confident, 5 =Extremely confident

Frequency levels: 1 = Never, 5 =Always

^a Time 0 = pre-curricular evaluation

^b Time 2 = immediate post SBML exam. Frequency of slit lamp and Wood's lamp use were intentionally omitted for Time 2 due to the close proximity between Time 0 and Time 2, thus resulting in 'n/a' for some calculations.

^c Time 3 = three months after SBML exam

IV. DISCUSSION

A. Slit-lamp Confidence

The ED SLIT LAMP curriculum meets the need for training EPs to increase their use and confidence performing slit-lamp exams in the ED. The impetus for the project arose from EPs' intrinsic motivation to provide better patient care. Our participant population consisted primarily of junior faculty who were initially uncomfortable performing an independent, comprehensive slit-lamp exam or identifying common ocular pathology using this device before the ED SLIT LAMP curriculum, with a greater preference towards using the Wood's lamp for patient diagnosis and student education. Wood's lamp is mechanically easier to operate and teach, and it is more readily available in an ED when compared to a slit lamp. By the conclusion of the SBML curriculum, however, the same group of EPs demonstrated a significant increase in self-reported confidence in using the device for patient evaluation and were even teaching it to multiple junior learners within the department.

B. Slit-lamp Competency

The significant improvement between the pre-and post-curricular procedural competency also demonstrates the importance of understanding and reviewing the technical nuances of the slit-lamp exam and practicing critical device movement, such as careful patient positioning, adjusting of the chin straps, changing the microscope angulation, and adjusting varying slit-lamp beam lengths and widths for careful evaluation of the anterior chamber. Mastery of these techniques is crucial for diagnosing a wide range of ophthalmic pathology, and these skills are drastically different than those required to operate Wood's lamp, which acts primarily as a magnifying glass with blue light capabilities.

C. **Curricular Effectiveness**

The results of ED SLIT LAMP demonstrated success in achieving three out of the four Kirkpatrick goals. The majority of the participants (over 80%) reported positive reaction to the curriculum (the curriculum helped them perform slit lamp exam, evaluate for common pathologies, and offered more than traditional lectures) (Level 1); all of the participants demonstrated procedural mastery at Time 2 (Level 2); upwards of fifty learners received instructions from the study participants on how to use the slit lamp at Time 3 (Level 3). While the reliance on ophthalmology consultation did not reveal statistically significant changes, we posit that improved procedural acumen will result in targeted consultation questioning and improved rapport between the medical disciplines.

Given that the participants were board-certified EPs with limited availabilities, we were unsurprised to discover that the most valued component of the curriculum was the in-person session with the ophthalmologist attending (Time 2). This was reflected in almost every item of CIQ, with specific mention of the benefit of direct guidance in positioning the beam to look for cells and flare. The most surprising element to many participants was how many ocular diagnoses required the slit-lamp exam and that learning the procedure was not as complicated as they had initially anticipated. In contrast, many of the participants felt most distanced or removed from the curriculum in reviewing the asynchronous learning materials (i.e., Wills Eye Manual, PowerPoint, and the Video Demonstration),

D. **Wood's Lamp Use**

Since this curriculum was designed to teach EPs how to use the slit lamp, we were unsurprised to see the confidence levels in using Wood's lamp unchanged between the three different time frames. While the slit lamp offers a superior and in-depth evaluation of the anterior segment of the eye, we acknowledge that a comprehensive slit-lamp exam is time and resource-consuming and may not affect the provider's management if the suspected pathology involves larger lesions, foreign bodies, or specific reaction to fluorescein staining. The Wood's lamp remains an easier and more portable diagnostic tool for some ocular pathologies, and its use in the clinical arena is still acceptable in certain situations.

E. **Limitations**

This was a curricular study based at a single-site, large tertiary academic center with an affiliated ophthalmology hospital and supported with internal grant funding. While the results were overwhelmingly positive, multiple limitations can prevent this study from being replicated on a larger scale or at other institutions. One of the most significant challenges is scheduling in-person evaluations in the pre-curricular session, as well as the final in-person training and examination. We encountered significant logistical challenges in creating a schedule that was amenable to the ophthalmologists, EPs (with unpredictable shift schedules), and research investigators, as well as finding a consistent space in the WEH and WEH ED that had access to an attached-observer scope to ensure the participants were focused on the correct anatomic structure during their procedural demonstration. The scheduling proved to be significantly more difficult than expected, delaying the original timeline of the study by several months.

Due to the longitudinal nature of this study and several in-person components, maintaining participant recruitment and engagement was also difficult. Over 50 clinically active, board-certified TJUH EPs were eligible for the study, but only 15 EPs volunteered to participate. The primary deterrence, when discussed with many eligible EPs who elected not to participate, was time restraints and commuting into the city for in-person evaluations and examinations. We suggest implementing dedicated teaching days (i.e., Conference Days or Faculty Meetings) for larger participant recruitment and subsequent follow-up and examination for GME or continued medical education (CME).

This study was funded by an internal grant that provided minor financial incentives for the participants and standardized patient volunteers. While the previous needs-based analysis suggested participants placed less emphasis on financial incentives and more on self-driven adult learning and promoting better patient care, many of the participants expressed appreciation for the staggered gift cards, which also incentivized them to complete each timeline-specific survey. All other investigators' efforts, in contrast, were in-kind and required dedicated non-academic and non-clinical time to enroll participants, record all of the interactions, and provide unrestricted time availabilities for the final mastery assessment. While this study was unanimously supported by departmental leadership at both WEH and TJUH to promote a better collegiate relationship and interdisciplinary education opportunity between organizations, the two principal investigators held unique leadership positions, ophthalmology consulting director [CC] and EM clerkship director [XCZ] and were passionate in promoting the success of this transdisciplinary training curriculum.

Lastly, this study was conducted at an academic hospital in an urban setting. It has been suggested in previous studies that centers with these characteristics likely overestimate EP comfort and confidence in the diagnosis and management of ophthalmic emergencies. (Uhr et al. 2020) Furthermore, the proximity between both EDs may skew the data, as these EPs are likely exposed to fewer ophthalmic emergencies than hospitals without a nearby eye-focused ED. Finally, we elected against reexamining EPs' repeat slit-lamp exam at Time 3 (two months post mastery demonstration) due to limited staffing and scheduling challenges. We hypothesized that the participants had mastered the material and would continue to practice the correct techniques post-curriculum. Furthermore, we also provided all participants with a checklist for review as part of their training, and we encouraged them to review it at any time during clinical practice in case they required referencing. Future studies should be considered to add a final examination (procedure or multiple-choice question) to validate our results.

F. **Conclusion**

EPs are expected to evaluate, diagnose, and manage ocular complaints as part of their training and clinical practice. This project highlighted a significant need for slit-lamp exam training within our institution that led to a successful transdisciplinary SBML curriculum that resulted in improved confidence in performing slit-lamp exams and teaching it to future healthcare providers. We encourage other institutions to leverage SBML as a teaching modality for procedural-based training and advocate cross-disciplined education initiatives. Future investigation could include creating a multi-center study to implement this curriculum at other academic institutions and potentially include it in EM residency training.

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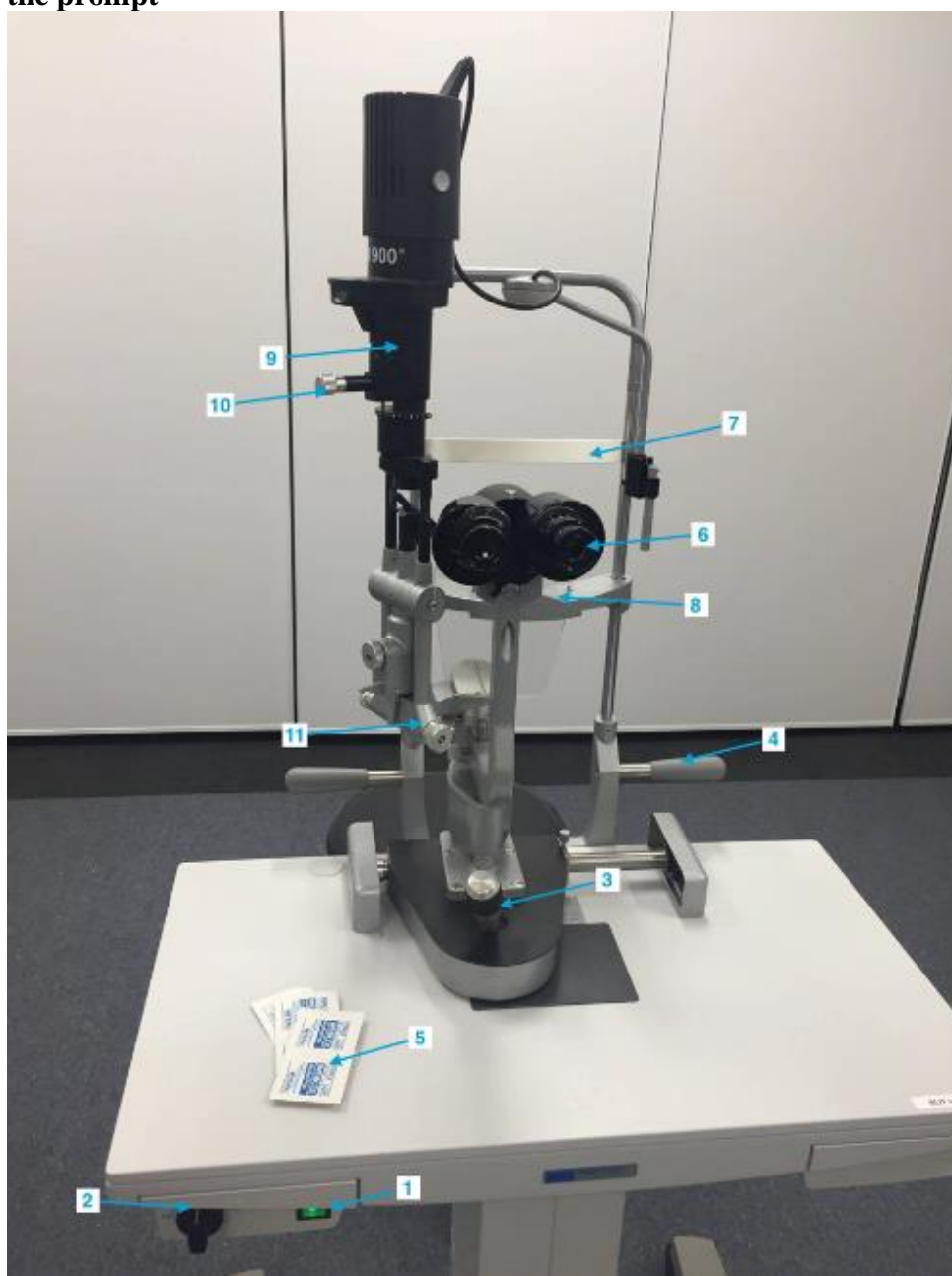
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APPENDICES

Appendix A - Independent Readiness Assessment Test (IRAT)

PART I: Slit Lamp Technical Pre-test (HIGHLIGHTED SECTIONS ARE ANSWERS)

- 1) Identify Slit-lamp Structures by placing the label number that correctly identifies the prompt



- a. Slit beam length knob 10
 b. Forehead Rest 7
 c. Filter Changing Knob 9

Appendix A (Continued)

- d. On/Off switch 1
 - e. Eyepieces 6
 - f. Joystick 3
 - g. Chin rest 8
 - h. Slit beam width knob 11
 - i. Illumination 2
 - j. Handles for patient 4
- 2) **Choose the first step from the list:**
 - a. Instruct the patient to close his/her/their eyes
 - b. Adjust the table height and chairs
 - c. Sanitize the forehead and chin rest
 - d. Adjust the eyepieces for your interpupillary distance and refractive error
 - 3) **Circle True or False: Adjust the chin rest to align patient's lateral canthus with black level (height) marker ring (below the forehead rest)**
 - a. TRUE
 - b. FALSE
 - 4) **Choose the correct adjustment with the desired height of the light beam**
 - a. **i.**
 - b. Rotate the side joystick clockwise and counterclockwise
 - c. Move the base joystick sideways for fine adjustments
 - d. Move the joystick forward and backward for coarse adjustments
 - e. Rotate the power supply clockwise and counterclockwise
 - 5) **Circle True or False: on initial exam, magnification should be set on low power (10x to 12x), illumination at largest aperture, widest slit beam**
 - a. TRUE
 - b. FALSE
 - 6) **Circle True or False: Turn on the light source by locating the box under the table with the rotary switch at the highest voltage setting**
 - a. TRUE
 - b. FALSE
 - 7) **To check anterior chamber depth, ADJUST slit beam to a thin beam to and focus at which position on limbus?**
 - a. 12:00
 - b. 6:00
 - c. 4:00
 - d. 9:00
 - 8) **Circle True or False: The cobalt blue filter should be used for fluorescein evaluation**
 - a. TRUE
 - b. FALSE
 - 9) **Which anatomic landmark should you apply fluorescein?**
 - a. Inferior fornix
 - b. Superior sclera

Appendix A (Continued)

- c. Medial lacrimal duct
 - d. Anterior uvea
- 10) How should you adjust the magnification, height, and width of your light beam to best see anterior cells and flare?**
- a. Low magnification, tall & wide
 - b. Low magnification, short and wide
 - c. High magnification, tall & thin
 - d. High magnification, short and thin
- 11) In what order would you assess for corneal abrasion?**
- a. Examine with blue light → instill fluorescein → Instill proparacaine → examine at slit lamp with white light
 - b. Instill fluorescein → Instill proparacaine → examine at slit lamp with white light → examine with blue light
 - c. Instill proparacaine → examine at slit lamp with white light → instill fluorescein -> examine with blue light
 - d. Instill proparacaine → instill fluorescein → examine at slit lamp with white light → examine with blue light
- 12) If you have trouble focusing, what are the likely causes?**
- a. Improper patient head position
 - b. Oculars misaligned or set incorrectly
 - c. A&B are both correct
 - d. None of the above

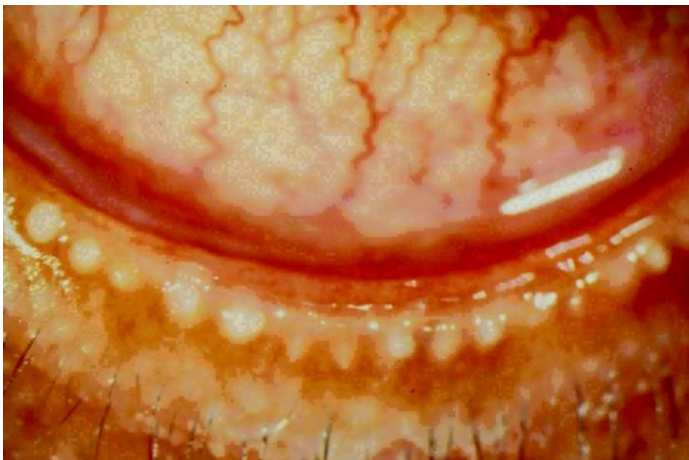
Appendix A (Continued)**PART II: Clinical Image Examination (HIGHLIGHTED SECTIONS ARE ANSWERS)**

Quiz contents:

- Blepharitis
- Glaucoma
- Hyphema
- Cells and flares
- Synechia
- Hypopyon
- Lens dislocation
- Globe rupture
- Pseudodentrite/dentrite
- Follicular conjunctivitis
- Sty
- Perilimbal flush
- Corneal ulcer
- Corneal abrasion
- Keratoconjunctivitis Sicca
- Cataract

Image sources: courtesy from study investigator [CC] and from Wikimedia/Wikipedia

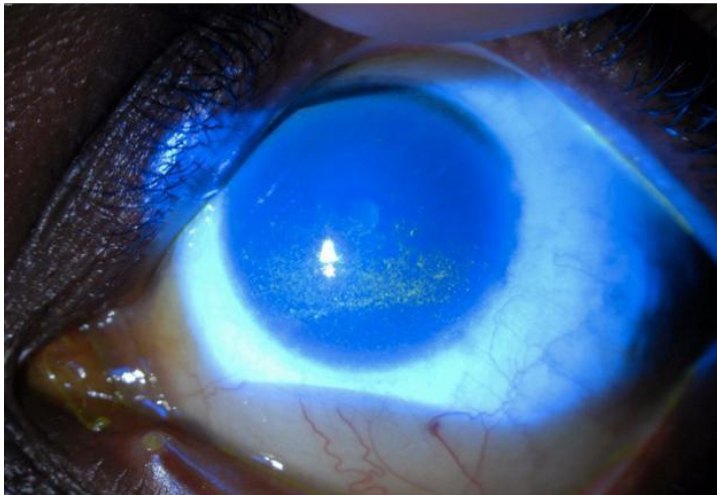
What are the following diagnoses?



1.
 - a. **Blepharitis**
 - b. Conjunctivitis
 - c. Sty
 - d. Synechia

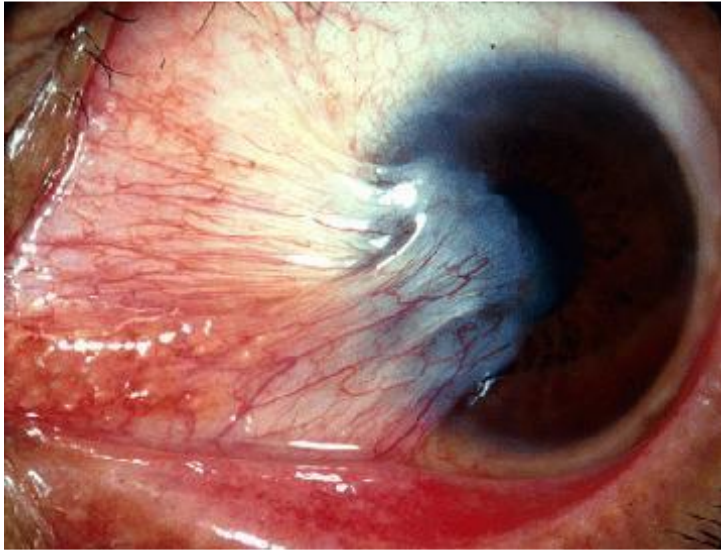
Appendix A (Continued)

- 2.
- a. Blepharitis
 - b. Chalazion
 - c. Dacrocystitis
 - d. Periorbital cellulitis

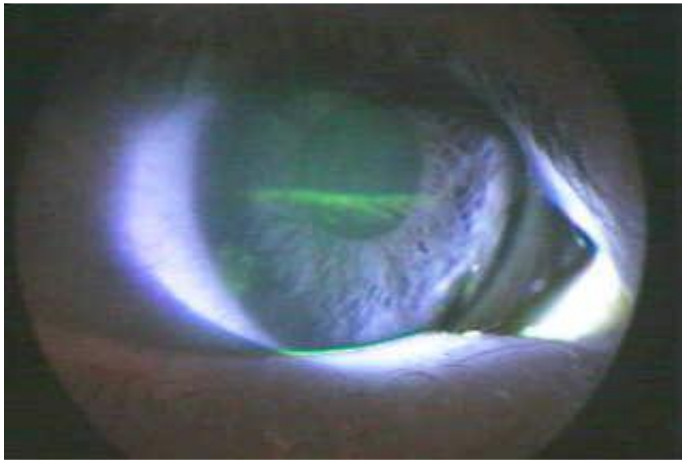


- 3.
- a. Corneal abrasion
 - b. Glaucoma
 - c. Herpes ophthalmicus
 - d. Keratoconjunctivitis sicca

Appendix A (Continued)



- 4.
- a. Arterio-venous malformation
 - b. Pinguecula
 - c. Pterygium
 - d. Subconjunctival hemorrhage

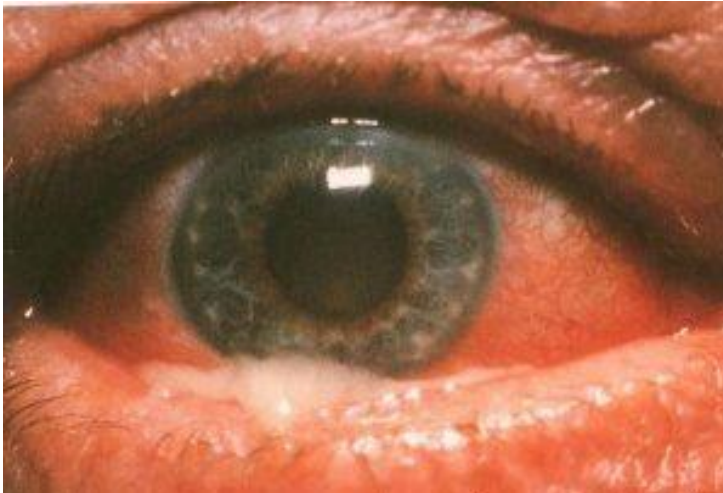


- 5.
- a. Conjunctival abrasion
 - b. Corneal foreign body
 - c. Globe rupture
 - d. Hypopyon

Appendix A (Continued)

6.

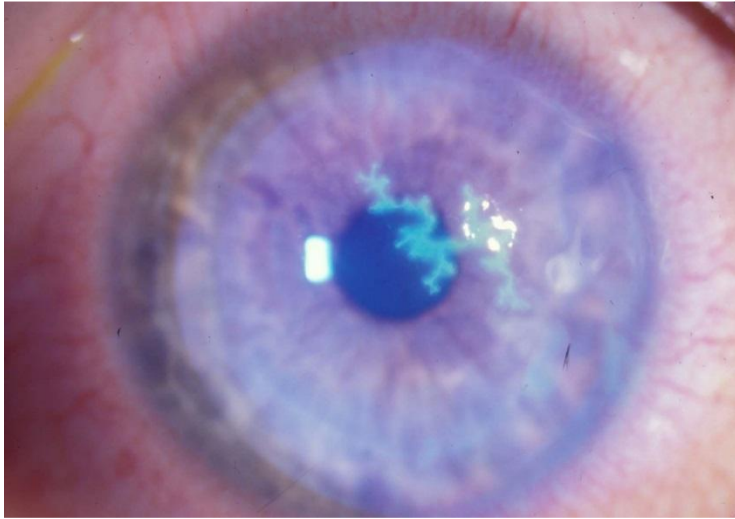
- a. Follicular conjunctivitis
- b. Keratoprecipitate
- c. Subconjunctival hemorrhage
- d. Uveitis



7.

- a. Bacterial conjunctivitis
- b. Hyphema
- c. Styne
- d. Uveitis

Appendix A (Continued)



8.

- a. Cataract
- b. Corneal abrasion
- c. Herpes keratitis
- d. Keratoprecipitate



9.

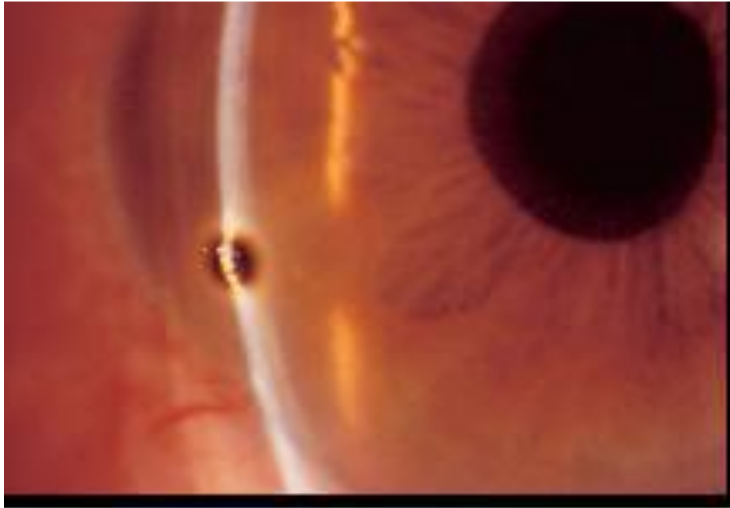
- a. Ciliary flush
- b. Conjunctivitis
- c. Subconjunctival hemorrhage
- d. Synechia

Appendix A (Continued)

- 10.
- a. Acute angle glaucoma
 - b. Endophthalmitis
 - c. Globe rupture
 - d. Uveitis



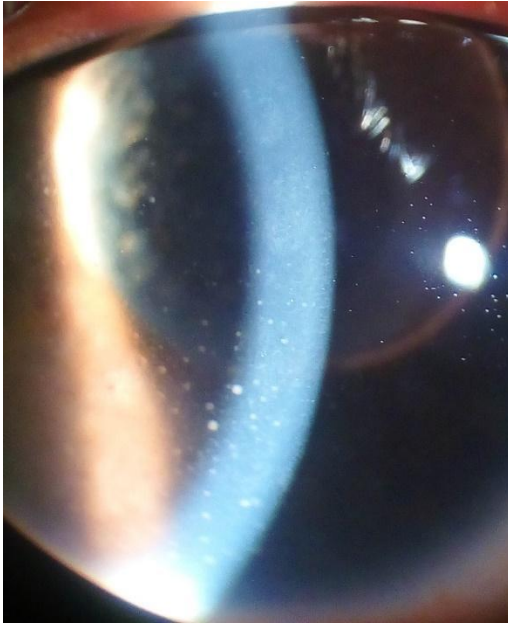
- 11.
- https://commons.wikimedia.org/wiki/File:Orbital_cellulitis.jpg
- a. Blepharitis
 - b. Erysipelas
 - c. Orbital cellulitis
 - d. Styte

Appendix A (Continued)

- 12.
- a. Cells and flares
 - b. Chemical burn
 - c. Corneal foreign body
 - d. Corneal melanoma



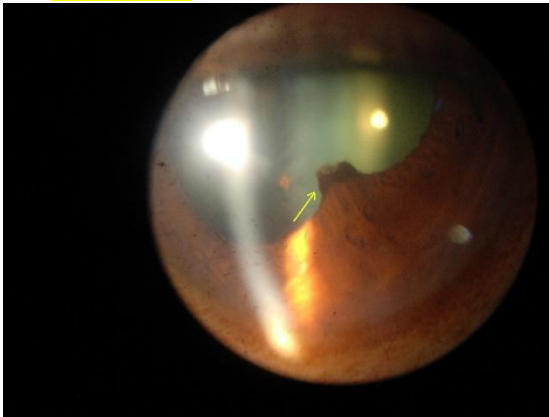
- 13.
- https://commons.wikimedia.org/wiki/File:Hyphema_-_occupying_half_of_anterior_chamber_of_eye.jpg
- a. Chemical injury
 - b. Hyphema
 - c. Lens dislocation
 - d. Vitreous hemorrhage

Appendix A (Continued)

14.

https://en.wikipedia.org/wiki/Uveitis#/media/File:Keratic_precipitate2.jpg

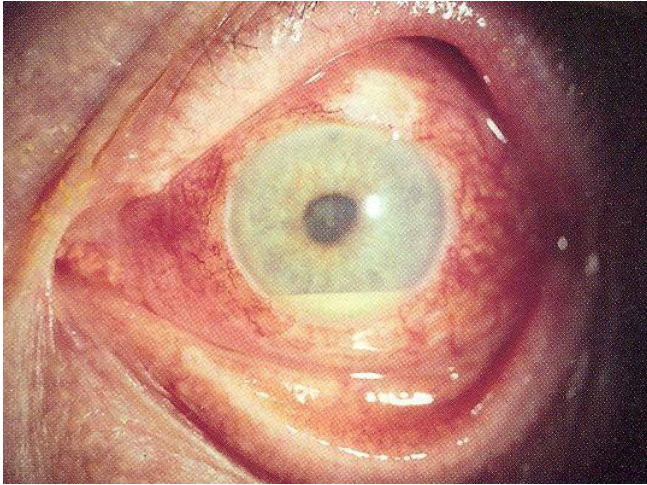
- a. Cataracts
- b. Corneal laceration
- c. Lens dislocation
- d. Uveitis



15.

[https://en.wikipedia.org/wiki/Synechia_\(eye\)#/media/File:Posterior_synechia.jpg](https://en.wikipedia.org/wiki/Synechia_(eye)#/media/File:Posterior_synechia.jpg)

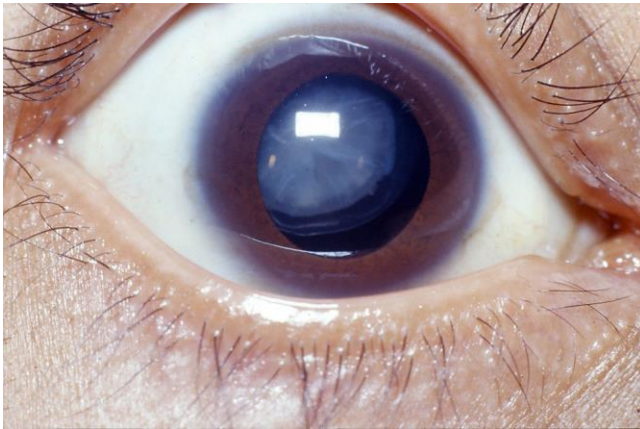
- a. Glaucoma
- b. Iritis
- c. Squamous cell carcinoma
- d. Synechia

Appendix A (Continued)

16. <https://en.wikipedia.org/wiki/Uveitis#/media/File:Hypopyon.jpg>
- a. Acute angle glaucoma
 - b. Globe rupture
 - c. Hyphema
 - d. Hypopyon



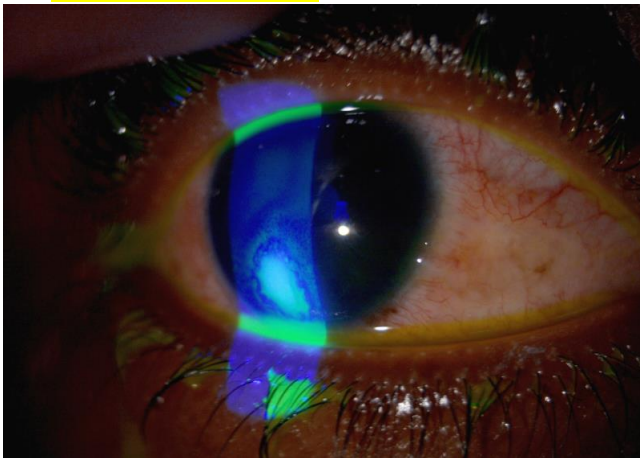
- 17.
- a. Anterior uveitis
 - b. Glaucoma
 - c. Globe rupture
 - d. Hypopyon

Appendix A (Continued)

18.

<https://www.flickr.com/photos/communityeyehealth/8411381000>

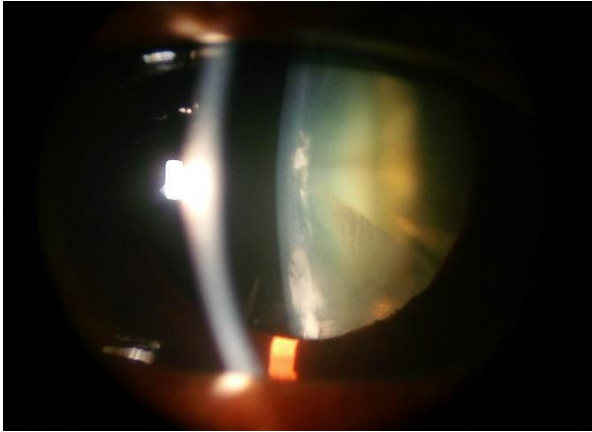
- a. Anterior uveitis
- b. Glaucoma
- c. Globe rupture
- d. Lens subluxation



19.

https://en.wikipedia.org/wiki/Corneal_ulcer#/media/File:Corneal_Ulcer.png

- a. Corneal abrasion
- b. Corneal foreign body
- c. Corneal ulcer
- d. Hypopyon

Appendix A (Continued)

20.

https://commons.wikimedia.org/wiki/File:Cortical_Cataract.jpg

- a. **Cataract**
- b. Glaucoma
- c. Lens dislocation
- d. Ocular prosthesis

Appendix A (Continued)**PART III: Ophthalmology Exam Mix-n-Match (HIGHLIGHTED SECTIONS ARE ANSWERS)**

Please select at least three (3) from the following list of clinical exam findings to describe the following diagnoses:

List of ocular findings:

1. Lids swelling
2. Conjunctival injection
3. Eye discharge
4. Pseudomembrane
5. Palpebral follicular reaction
6. Cell and flare
7. Conjunctival injection
8. Kerotoprecipitate
9. Synechia
10. Cornea disruption
11. Anterior chamber [flat]
12. Iris abnormality
13. Sclera injection
14. Hypopyon
15. Hazy cornea
16. Non-reactive, mid-dilated pupil
17. Anterior chamber [shallow]
18. Meibomian gland inflammation
19. Lids/lashes debris
20. Superficial punctate keratitis
21. Dendrite
22. Pseudodendrite
23. Vesicles on lids
24. Follicular conjunctivitis

Appendix A (Continued)

List of Common Eye Pathologies w/ Highlighted Findings (answers)

Conjunctivitis

- Conjunctival injection
- Discharge
- Lids swelling
- Palpebral follicular reaction
- Pseudomembrane

Uveitis

- Cell and flare
- Conjunctival injection
- Keratoprecipitate
- Synechia

Ruptured globe

- Ant chamber flat
- Corneal disruption
- Injected
- Iris abnormality

Endophthalmitis

- Cells and flare
- Conjunctival injection
- Hazy cornea
- Hypopyon

Angle-closure glaucoma

- Conjunctival injection
- Corneal haze
- Non-reactive, mid-dilated pupil
- Anterior chamber [flat]

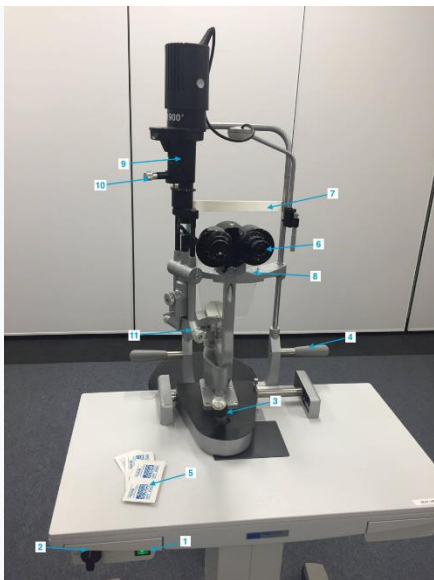
Blepharitis

- Lids/lashes debris
- Conjunctival injection
- Meibomian gland inflammation
- Superficial punctate keratitis

Herpes simplex

- Conjunctival injection
- Dendrite
- Follicular conjunctivitis
- Vesicles on lid

Appendix B - Slit Lamp Final Checklist

Steps	Checkbox
Step 1: Identifying slit lamp anatomy	
<ol style="list-style-type: none"> 1. On/off switch 2. Illumination 3. Joystick 4. Handles for patient 5. Alcohol swabs 6. Eyepieces 7. Forehead rest 8. Chin rest 9. Filter Changing Knob 10. Slit beam length knob 11. Slit beam width knob 	1 <input type="checkbox"/>
	
Step 2: Prepare instrument and patient	
• Apply transparent face shield over the slit lamp (COVID).	2 <input type="checkbox"/>
• Sanitize forehead and chin rest for the patient.	3 <input type="checkbox"/>
• Apply topical tetracaine/proparacaine on patient's eyes.	4 <input type="checkbox"/>
• Unlock instrument base and shift by pulling toward you.	5 <input type="checkbox"/>
• Adjust eye pieces for your interpupillary distance and refractive error.	6 <input type="checkbox"/>

Appendix B (continued)

<ul style="list-style-type: none"> Adjust table height and/or chair(s) – neither patient nor examiner should be hunched over. 	7 <input type="checkbox"/>
<ul style="list-style-type: none"> Instruct patient to close eyes while you power up by turning on the light source at low voltage setting and focus on right eyelid. Position patient in slit lamp with forehead touching the horizontal bar and chin in the chin rest. 	8 <input type="checkbox"/>
<ul style="list-style-type: none"> Set magnification on lowest settings (10x to 12x), illumination at largest aperture and widest slit beam. 	9 <input type="checkbox"/>
<ul style="list-style-type: none"> Adjust chinrest so the patient is sitting comfortably with their chin on the chinrest and their forehead against the headrest. 	10 <input type="checkbox"/>
Step 3: Illuminate ocular structures	
<ul style="list-style-type: none"> Practice macro and micro adjustments of the sliding base with joystick. 	11 <input type="checkbox"/>
<ul style="list-style-type: none"> Adjust microscope 90° to facial plane with illumination set at 45° angle (angle LEFT for patient's right eye, and RIGHT for left eye). 	12 <input type="checkbox"/>
<ul style="list-style-type: none"> Perform outer structure evaluation: <ul style="list-style-type: none"> The mirror should be slightly at an angle (more comfortable to the patient). Start laterally, look at the lids and the lashes and lacrimal apparatus while moving medially. Next, exam the conjunctiva, sclera and cornea. <p>Must complete for RIGHT EYE and LEFT EYE.</p>	13 <input type="checkbox"/>

Appendix B (continued)

<ul style="list-style-type: none"> ● Perform anterior chamber evaluation: <ul style="list-style-type: none"> • Adjust the light beam to maximum height and minimum width • Focus thin slit beam at 9:00 position on limbus. Move across the cornea to the 3:00 position by tilting joystick laterally. <ol style="list-style-type: none"> i. For the RIGHT eye, move the mirror to your left at a 45° angle. ii. For the LEFT eye, move the mirror to your right at a 45° angle. • Note the position of the curved corneal beam relative to the flat iris beam, and the space between the beams. Anterior chamber depth is wide if space between beams = corneal thickness just inside the limbus. A/C is shallow if space is $< 1/4^{\text{th}}$ cornea. <div data-bbox="203 688 1266 1102"> </div> <p>https://bjo.bmj.com/content/103/7/960</p> <p>Must complete for RIGHT EYE and LEFT EYE</p>	14 □
<ul style="list-style-type: none"> ● Look for cells and flare <ul style="list-style-type: none"> • Shorten the height of the beam to 3-4mm and keep beam as narrow as possible. • Switch the magnification lever to the higher setting. • Focus on the cornea, then slide the joystick forward slightly to focus on the anterior surface of the lens. • Slowly slide the joystick backwards to focus on a point midway between the cornea and the anterior surface of the lens. • Keep the beam centered over the pupil (the black background makes it easier to see cells and flare). • Angle beam about 45 degrees <p>Must complete for RIGHT EYE and LEFT EYE</p>	15 □

Appendix B (continued)

Step 4: Perform fluorescein evaluation	
• Place a drop of tetracaine/proparacaine on a sterile fluorescein strip.	16 <input type="checkbox"/>
• The fluorescein is then placed in the inferior fornix of the eye by pulling down on the lower lid and gently touching the bulbar conjunctiva with the fluorescein strip.	17 <input type="checkbox"/>
• Adjust cobalt blue filter on diaphragm wheel at maximum beam height and medium width slit setting for fluorescein evaluation.	18 <input type="checkbox"/>
• Focus the slit beam at 9:00 position on limbus. Move across the cornea to the 3:00 position by tilting joystick laterally	19 <input type="checkbox"/>
Must complete for RIGHT EYE and LEFT EYE	
Step 5: Exam completion	
• Pull instrument base toward you when finished and lock in position. Turn off.	20 <input type="checkbox"/>

Appendix C - Slit Lamp Surveys

Time 0 - Pre-curricular survey

Q1-3: Demographics

1. What is your gender? (select all that apply)
 - a. Male
 - b. Female
 - c. Trans male/man
 - d. Trans female/woman
 - e. Genderqueer/Gender non-conforming
 - f. Different Identity
 - g. Do not wish to disclose
2. I identify myself as the following race/ethnicity. Please indicate all that apply.
 - a. American Indian or Alaska Native
 - b. Asian
 - c. Black or African American
 - d. Hispanic/Latino
 - e. Native Hawaiian or Pacific Islander
 - f. White
 - g. Other
3. My age range is:
 - a. 25-29 years old
 - b. 30-34 years old
 - c. 35-39 years old
 - d. 40-44 years old
 - e. 45+ years old
4. How long have you practiced EM post residency graduation?
 - a. 1-3 years
 - b. 4-6 years
 - c. 7-9 years
 - d. 10+ years

Please answer the following questions #5-9 to the best of your recollection:

Over the **past 3 months...**

5. On average, how many eye pathologies do you see at the main work site (CC, MHD, Urgent care)? (SLIDING SCALE 0-20)
6. On average, how many eye pathologies do you see at other facilities (i.e. Wills Eye), if applicable? (SLIDING SCALE 0-20)
7. On average, how often do you perform an independent slit lamp exam for ocular complaints? (SLIDING SCALE 0-20)
8. On average, how often do you use a wood lamp (with access to a slit lamp) to evaluate eye pathology for ocular complaints? (LIKERT)
9. On average, how many times do you rely on ophthalmology consultation to help:
 - a. Modify your treatment and plan for ocular complaints?
 - b. Reinforce your treatment and plan for ocular complaints?
 - c. Provide additional information and guidance to your treatment and plan for ocular complaints?

Appendix C (continued)

The following questions refer to familiarity with the **slit lamp**...(LIKERT SCALE)

10. How confident are you in performing a comprehensive **slit lamp** exam for ocular complaints?
11. How confident are you in your ability to teach residents to perform a comprehensive **slit lamp** exam for ocular complaints?
12. How likely are you to teach learners to perform a comprehensive **slit lamp** exam for ocular complaints?

The following questions refer to familiarity with the **woods lamp** (WITH ACCESS TO A SLIT LAMP)...(LIKERT SCALE)

13. How confident are you in performing a comprehensive **woods lamp** exam for ocular complaints?
14. How confident are you in your ability to teach learners to perform a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
15. How likely are you to teach learners in performing a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
16. How confident are you in identifying common ocular pathology seen in your main work site (CC, MHD, Urgent care)?

Time 2 - Post Mastery Checklist survey

The following questions refer to familiarity with the **slit lamp**...(LIKERT SCALE)

1. How confident are you in performing a comprehensive **slit lamp** exam for ocular complaints?
2. How confident are you in your ability to teach residents to perform a comprehensive **slit lamp** exam for ocular complaints?
3. How likely are you to teach learners to perform a comprehensive **slit lamp** exam for ocular complaints?

The following questions refer to familiarity with the i.e., **woods lamp** (WITH ACCESS TO A SLIT LAMP)...(LIKERT SCALE)

4. How confident are you in performing a comprehensive **woods lamp** exam for ocular complaints?
5. How confident are you in your ability to teach learners to perform a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
6. How likely are you to teach learners in performing a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
7. How confident are you in identifying common ocular pathology seen in your main work site (CC, MHD, Urgent care)?

The following questions refer to the **ED SLIT LAMP mastery learning curriculum**... (LIKERT SCALE)

8. This curriculum helped you perform an independent, comprehensive slit lamp exam
9. The curriculum helped you evaluate for critical clinical findings for common ocular complaints presenting in your main work site
10. The knowledge from this curriculum would help during your future career
11. This curriculum enhanced learning more than traditional lectures and reading alone

Appendix C (continued)

12. Which elements of the asynchronous ED SLIT LAMP learning materials did you most utilize, before your in-person session. (LIKERT)

- a. Powerpoint
- b. Video demonstration
- c. Checklist
- d. Wills Manual
- e. Other_____

End of the course evaluation (**Critical Incident Questionnaire**): (FILL IN THE BLANK)

- 13. At what moment during the activity did you feel most engaged with what was happening?
- 14. At what moment during the activity did you feel most distanced from what was happening?
- 15. What action did anyone (i.e., faculty member or peer) take during the activity that you found most affirming and helpful?
- 16. What action did anyone (i.e., faculty or peer) take during the activity that you found most puzzling or confusing?
- 17. What about the activity surprised you the most? (This could be something about your own reactions to what went on, or something that someone did, or anything else that occurs to you.)

Time 3 - ED SLIT LAMP follow up survey

Since completing the mastery learning curriculum (approximately 3 months ago)

- 1. On average, how many eye pathologies do you see at the main work site (CC, MHD, Urgent care)? (SLIDING SCALE 0-20)
- 2. On average, how many eye pathologies do you see at other facilities (i.e. Wills Eye), if applicable? (SLIDING SCALE 0-20)
- 3. On average, how often do you perform an independent slit lamp exam for ocular complaints? (SLIDING SCALE 0-20)
- 4. On average, how often do you use a wood lamp to evaluate eye pathology for ocular complaints? (LIKERT)
- 5. On average, how many times do you rely on ophthalmology consultation to help:
 - a. Modify your treatment and plan for ocular complaints?
 - b. Reinforce your treatment and plan for ocular complaints?
 - c. Provide additional information and guidance to your treatment and plan for ocular complaints?
- 6. On average, how many eye pathologies do you see at the main work site (CC, MHD, Urgent care)? (SLIDING SCALE 0-20)
- 7. On average, how many eye pathologies do you see at other facilities (i.e. Wills Eye), if applicable? (SLIDING SCALE 0-20)

Appendix C (continued)

8. On average, how often do you perform an independent slit lamp exam for ocular complaints? (SLIDING SCALE 0-20)
9. On average, how often do you use a wood lamp (with access to a slit lamp) to evaluate eye pathology for ocular complaints? (LIKERT)
10. On average, how many times do you rely on ophthalmology consultation to help:
 - a. Modify your treatment and plan for ocular complaints?
 - b. Reinforce your treatment and plan for ocular complaints?
 - c. Provide additional information and guidance to your treatment and plan for ocular complaints?

The following questions refer to familiarity with the **slit lamp**...(LIKERT SCALE)

After completing the mastery learning curriculum...

11. How confident are you in performing a comprehensive **slit lamp** exam for ocular complaints?
12. How confident are you in your ability to teach residents to perform a comprehensive **slit lamp** exam for ocular complaints?
13. How likely are you to teach learners to perform a comprehensive **slit lamp** exam for ocular complaints?

The following questions refer to familiarity with the i.e., **woods lamp** (WITH ACCESS TO A SLIT LAMP)...(LIKERT SCALE)

After completing the mastery learning curriculum...

14. How confident are you in performing a comprehensive **woods lamp** exam for ocular complaints?
15. How confident are you in your ability to teach learners to perform a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
16. How likely are you to teach learners in performing a comprehensive **woods lamp** exam (with access to a slit lamp) for ocular complaints?
17. How confident are you in identifying common ocular pathology seen in your main work site (CC, MHD, Urgent care)?

Since completing the mastery learning curriculum (approximately 3 months ago)...

18. Have you instructed other learners on how to use a slit lamp? If yes, please indicate the level of the learner (EP, resident, APP, medical student, PA student), and number of learners you have instructed.
19. How many patients have you treated or evaluated and dispositioned an eye complaint in the ED that you would have previously consulted ophthalmology for?

VITA

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EDUCATION	B.S., Mechanical Engineering, Tufts University, 2008
	M.S., Biomedical Engineering, Tufts Graduate School of Engineering, 2009
	M.D., Tufts Medical School, 2013
TEACHING	Department of Emergency Medicine, Thomas Jefferson University, Philadelphia, PA
RANK	Clinical Instructor, Thomas Jefferson University, Philadelphia, PA, 2017
	Assistant Professor, Thomas Jefferson University, Philadelphia, PA, 2019
HONORS	Medical Education Fellowship, Thomas Jefferson University, Philadelphia, PA, 2019
	Gregory D. Jay Resident Research Award, Providence, RI, 2017
	Distinction in Research, Providence, RI, 2017
	Best Poster, Thomas Jefferson University Graduate Medical Education Innovations Poster Session, Philadelphia, PA, 2017
	Best Poster, Undergraduate Medical Education Innovation Abstract, Council of Emergency Medicine Residency Directors Academic Assembly, San Antonio, TX, 2018
	Golden Key International Honour Society, University of Illinois at Chicago, IL, 2018
	Delaware Valley Patient Safety and Quality Award - 1st place prize, Healthcare Improvement Foundation, 2019
	Dean's Award for Excellence in Education, Philadelphia, PA, 2021
	Education Honor Roll, Sidney Kimmel Medical School, Philadelphia, PA, 2020-21

Education Honor Roll, Sidney Kimmel Medical School, Philadelphia, PA, 2021-22

Joy in Teaching – Faculty Educator Award, Philadelphia, PA, 2022
Best Medical Student Abstract and Presentation (Mentor), SAEM22, New Orleans, LA, 2022

Yeo Writing Prize Award – Honorable Mention, Sidney Kimmel Medical School, Philadelphia, PA, 2022

Hobart Amory Hare (HAH) Society Presentation – Nominated Speaker, Sidney Kimmel Medical School, Philadelphia, PA, 2023

Best of the Best Abstract – Council of Emergency Medicine Residency Directors Academic Assembly, Las Vegas, NV, 2023

The Pennsylvania Medical Society's (PAMED) Top Physicians Under 40 Award, 2023

PROFESSIONAL MEMBERSHIP

American Medical Association (AMA) (Member, 2009-)

American Medical Student Association (AMSA) (Member, 2009-)

Society for Academic Emergency Medicine (SAEM) (Member, 2009-)
Member, Education Committee (2022-23)
Member, Grants Committee (2022-23)

American College of Emergency Physicians (ACEP) (Member, 2009-; FACEP, 2021)

Association of American Medical Colleges (AAMC) (Member, 2013-)

Council of Emergency Medicine Residency Directors (CORD)
Medical Student Advisement Task Force (SATF)
Member, 2013-
Council Member, 2014-17
Applying Team Leader, 2015-16
International Medical Graduate Team Leader, 2016-17
Advising Student Committee in Emergency Medicine (ASCEM)
VSAS Team Leader 2017-22
Co-Vice Chair 2022-23
Co-Chair 2023-24

Emergency Medicine Residents' Association (EMRA)
Member, 2013-

Member, EMRA Simulation Division, 2015-
 Vice Chair, EMRA Simulation Division, 2016-17
 Chair, EMRA Simulation Division, 2016-18

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