Int Ophthalmol (2021) 41:4065–4073
https://doi.org/10.1007/s10792-021-01979-8

ORIGINAL PAPER

Quality of referrals for glaucoma assessment: a cross-sectional survey of clinical data and outcomes

Kira J. Szulborski · Daniel S. Weintraub · Shiyoung Roh · Amer Mosa Alwreikat · Michael Lee Cooper · Paul R. Cotran · David J. Ramsey

Received: 1 April 2021 / Accepted: 16 July 2021 / Published online: 30 July 2021

Abstract

Purpose This study assessed the completeness of clinical information provided by ophthalmological and optometric referrals to glaucoma specialists consulting for open-angle glaucoma (OAG).

Methods A retrospective, cross-sectional study of 72 internal referrals for evaluation of OAG in a multi-specialty group practice was performed. The quality of the referral was assessed based on: (1) the completeness of the clinical triad of intraocular pressure measurement, visual field (VF), and cup-to-disk ratio for each eye; (2) the availability of the data necessary to calculate an ocular hypertension treatment study (OHTS) score; and (3) the presence of retinal nerve fiber layer (RNFL) imaging by mean of optical coherence tomography.

Results The clinical triad was available in 57% of referrals, whereas an OHTS score was calculable in 24% of referrals ($p < 0.001$); RNLF imaging was available in 51% of referrals ($p = 0.859$). The completeness of clinical information was similar for ophthalmological and optometric referrals. From the date of referral to the time of the consultation, there was a significant increase in the availability of the clinical triad (57–65%; $p = 0.013$) and the OHTS score (24–5%; $p = 0.004$) but not for RNFL imaging (51–56%; $p = 0.618$). The most common missing clinical information was VF testing, which was absent in 42% of referrals.

Conclusions Key clinical data necessary for effective diagnosis and staging of OAG was lacking for many patients referred to glaucoma specialists.

Keywords Primary open-angle glaucoma · Ophthalmologist · Optometrist · Outcome

Abbreviations

OAG	Open-angle glaucoma
IOP	Intraocular pressure
VF	Visual field
CDR	Cup-to-disk ratio
OHTS	Ocular hypertension treatment study
EMR	Electronic medical record
OHT	Ocular hypertension
RNFL	Retinal nerve fiber layer
OCT	Optical coherence tomography

K. J. Szulborski · D. S. Weintraub · S. Roh · A. M. Alwreikat · M. L. Cooper · P. R. Cotran · D. J. Ramsey (✉)
Department of Ophthalmology, Lahey Hospital and Medical Center, One Essex Center Drive, Peabody, MA 01960, USA
e-mail: David.J.Ramsey@lahey.org

K. J. Szulborski · S. Roh · A. M. Alwreikat · P. R. Cotran · D. J. Ramsey
Department of Ophthalmology, Tufts University School of Medicine, Boston, MA, USA

D. S. Weintraub
Medical College of Georgia at Augusta University, 1120 15th St, Augusta, GA 30912, USA

CCT Central corneal thickness

Introduction

Many eye conditions are difficult to diagnose and manage without a specialist's input. This is particularly true for open-angle glaucoma (OAG), a progressive condition that requires longitudinal evaluation and lifelong management. Timely referral of at-risk patients to a glaucoma specialist is often a critical step in slowing disease progression [1]. The increasing number of glaucoma patients owing to an aging population, coupled with a shortage of glaucoma specialists, places an increasing strain on the ability to provide optimal care to these patients [2, 3].

The quality and completeness of information accompanying a referral govern the effectiveness of the initial consultation with a glaucoma specialist. Previous studies have evaluated the quality of glaucoma referral letters from optometrists [4], the positive predictability of a glaucoma referral based on the completeness of information provided by optometrists [5], and whether standardization of the glaucoma referral process could reduce unnecessary referrals [6]. These studies found that while many referrals lack important information, the most effective referrals included at least intraocular pressure (IOP) and cup-to-disk ratio (CDR) measurements. Additionally, formal referral with complete information promoted consistency in communicating disease classification between optometrists or general ophthalmologists and glaucoma specialists [4–8].

The aim of our study is to identify factors limiting the ability of consulting glaucoma specialists to evaluate for OAG and suspected glaucoma in patients who were referred from ophthalmological and optometric providers within an academic multispecialty group practice. We reviewed the completeness of internal referrals by comparing the availability of two related quality measures. The first was the presence of the clinical triad employed by Lockwood et al. [5], defined as an IOP measurement, reliable threshold visual field (VF) test, and assessment of the CDR for each eye. The second classification was the availability of all data required to compute an ocular hypertension treatment study (OHTS) score [9, 10], a more detailed set of criteria which expands upon the clinical triad by adding additional risk factors. Though not formally part of either the clinical triad or OHTS calculations, we also examined whether referrals had retinal nerve fiber layer (RNFL) imaging by means of optical coherence tomography (OCT). Finally, we examined the outcome of the subspecialist evaluation on the diagnosis and treatment of the patient.

Methods

Study design

The study constituted a retrospective, cross-sectional case series of internal referrals to glaucoma specialists within a multispecialty group practice. The research followed the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of the Lahey Hospital & Medical Center in Burlington, Massachusetts. Two hundred seventy-three patients seen by one of three glaucoma providers at the Lahey Hospital & Medical Center in the month of July 2016 were selected for case review. Data available at the time of and prior to the date of the initial consultation were extracted from the electronic medical record (EMR). Glaucoma was divided broadly into two groups by ICD-10 code: (1) glaucoma suspects (H40.0), including ocular hypertension (H40.05); and (2) OAG (H40.1), including primary open-angle glaucoma (POAG) (H40.10 and H40.11), low tension glaucoma (H40.12), pigmentary glaucoma (H40.13), and pseudoexfoliation glaucoma (H40.14). Exclusion criteria included (1) referral to a glaucoma specialist for something other than OAG; (2) referral from a provider outside of the multispecialty group practice; (3) an initial consultation occurring more than 5 years prior to the study inception; and/or (4) a history of IOP-lowering medication, glaucoma laser, or glaucoma surgery prior to the date of referral.

Demographic and clinical data related to ocular health and glaucoma for each subject were extracted from the patient's chart. These included dates of birth, gender, family history of glaucoma, and self-reported race or ethnicity. OAG case definitions were based on structural and/or functional evidence of glaucomatous optic neuropathy as evaluated by a glaucoma specialist through clinical evaluation of the optic disk with slit lamp biomicroscopy, supplemented by VF and/or

RNFL imaging. IOP was measured by Goldmann applanation tonometry. Anterior chamber angle/depth was determined by slit lamp examination and gonioscopy. CDR was determined by slit lamp biomicroscopy. Threshold VF testing was performed using the Humphrey Visual Field Analyzer (Carl Zeiss Meditec Inc., Dublin, California). VFs were considered reliable as long as fixation losses, false negative rate, and false positive rate were all below 20%. The retinal nerve fiber layer (RNFL) was assessed by spectral domain optical coherence tomography (OCT; Cirrus [Carl Zeiss Meditec, Inc] or Spectralis [Heidelberg Engineering, Inc, Heidelberg, Germany]) and central corneal thickness (CCT) by pachymetry (POCKET II Pachymeter; Quantal Medical, Inc, Rockwall, Texas).

Performance measures

Three measures of the completeness of clinical data available at the time of referral and subsequent consultation were used in this study: (1) the clinical triad consisting of IOP measurement, threshold VF testing, and assessment of the CDR for each eye; (2) the availability of all the data required to compute an OHTS score, comprising the patient's age together with three IOP measurements, two reliable VF measurements, a CDR, and three measurements of CCT per eye [9–11]; and (3) the presence of RNFL imaging by means of OCT.

Statistical analysis

Data were coded in Microsoft Excel 2010 (version 14.0, Microsoft Corporation, Redmond, Washington) and analyzed using RStudio version 1.1.422 (RStudio: Integrated Development for R. RStudio, PBC, Boston, Massachusetts). OHTS scores were calculated using the Point System Risk Calculator (Washington University School of Medicine, St. Louis, Missouri) [9–11]. All tests were two-sided, and p values below 0.05 were regarded as statistically significant.

Results

Demographics

A total of 144 eyes of 72 patients was included in the study. The demographics of the patients are summarized in Table 1. The dates of the initial consultation with a glaucoma specialist ranged from August 3, 2011, to July 29, 2016. At the time of referral, patients were 35 to 89 years of age (mean 69.9 $\pm$ 10.0 years), 49% female, and 93% self-reported their race as White. Fifty-four patients were referred by optometrists and eighteen by ophthalmologists. No significant differences were found in age, gender, or race between the two referral sources.

Completeness of referral

The completeness of data for each referral was evaluated both at the time of referral and on the date of consultation with the glaucoma specialist. Taken into account were the availability of the clinical triad, the data necessary to calculate an OHTS score, and the presence of RNFL imaging (Table 2). Every referral included an IOP and CDR. All instances of an incomplete clinical triad involved the absence of a reliable VF. At the time of referral, 61% of patients from optometry had a reliable VF compared to 44% of referrals from ophthalmology ($p = 0.226$). In some cases, a reliable VF test was obtained in the period between the referral and date of the initial consultation with the glaucoma specialist. This resulted in an increase in availability of the clinical triad from 57% at the time of referral to 65% at the initial glaucoma consultation ($p = 0.013$). Overall, 53 patients attempted the VF testing prior to referral to a glaucoma specialist with 4 additional patients obtaining VFs by the time of the consultation. Of 117 eyes tested, 105 yielded a reliable test result (90%). At the time of referral, 24% of patients had sufficient data with which to calculate an OHTS score (Fig. 1), increasing to 35% by the date of initial glaucoma consultation ($p = 0.004$). For the 55 patients with insufficient data for OHTS score calculation at the time of referral, 18 lacked a sufficient number of IOP measurements, 20 did not have a CCT, and 50 arrived at the consultation with fewer than two reliable VFs. OHTS calculation requires two reliable VF tests; most of these patients did not have a single reliable VF. At

Table 1 Demographics

	All (n = 72)	Optometry (n = 54)	Ophthalmology (n = 18)	p-value
Age (mean ± SD)	69.9 ± 10.0	69.1 ± 10.2	72.6 ± 8.9	0.193
Gender (%) Female	49%	50%	44%	0.688
Race (%) White	86%	83%	94%	0.403

SD: Standard deviation

Table 2 Availability of clinical data at time of consultation

Measurement	Time point	All referrals (n = 72) (%)	Optometry referrals (n = 54) (%)	Ophthalmology referrals (n = 18) (%)	p-value
Clinical triad	Referral	57	61	44	0.226
	Glaucoma Specialist	65	70	50	0.136
OHTS score [7–9]	Referral	24	26	17	0.394
	Glaucoma Specialist	35	35	33	0.888
RNFL imaging	Referral	51	54	44	0.504
	Glaucoma Specialist	56	56	56	1.000

the time of the referral, RNFL imaging was available for only 51% of eyes, increasing to 56% of eyes by the date of the consultation (p = 0.618). Family history of glaucoma was assessed for all subjects on the date of consultation, but at the time of referral was only documented in 92% of patients (p = 0.071). Assessment of family history of glaucoma was noted in only 89% of optometry referrals compared to 100% of ophthalmology referrals (p = 0.409).

Accuracy of CDR assessment

There was no difference in the average CDR for patients referred by optometrists versus ophthalmologists (0.53 ± 0.16 vs. 0.56 ± 0.16, p = 0.301), but the glaucoma specialist often judged the cup as larger for the eyes referred by optometrists (0.02 ± 0.10, p = 0.017) and ophthalmologists (0.03 ± 0.09, p = 0.046). Although there were cases where the referring eye doctor overestimated the CDR (0.03 ± 0.10, p = 0.002, range -0.2 to 0.4), the glaucoma specialist judged the cup larger more than twice as often as smaller (51 eyes vs 18 eyes). However, the intra-class correlation coefficient for CDR was 0.804 (95% CI 0.738—0.855), indicating generally good reliability and agreement in the CDR as judged by the referring optometrists and ophthalmologists and the glaucoma specialist.

Outcome of referrals

After evaluation by the glaucoma specialists, 77 eyes of 72 patients were confirmed to have glaucoma, or its suspicion: 58 eyes from optometry referrals (54% of total) and 19 eyes from ophthalmology referrals (53% of total). Of those eyes, 77% were classified as glaucoma suspects and 23% as having OAG. There was no difference in the rate of glaucoma suspects versus OAG between cases referred by optometrists compared to ophthalmologists (p = 0.462). Considering the worse eye as a means of classifying each patient, only 17 patients (24%) received a diagnosis from the glaucoma specialist that differed from the referring diagnosis (Table 3). Of those 17 patients, 15 (88%) were diagnosed by the specialist as having glaucoma rather than suspected glaucoma, and only two were downgraded from glaucoma to suspects based upon the available clinical data. Patients diagnosed with likely glaucoma at the consultation (25%) returned for the next follow-up with the glaucoma specialist within an average of 51 ± 20 days versus 170 ± 231 days for those without likely glaucoma

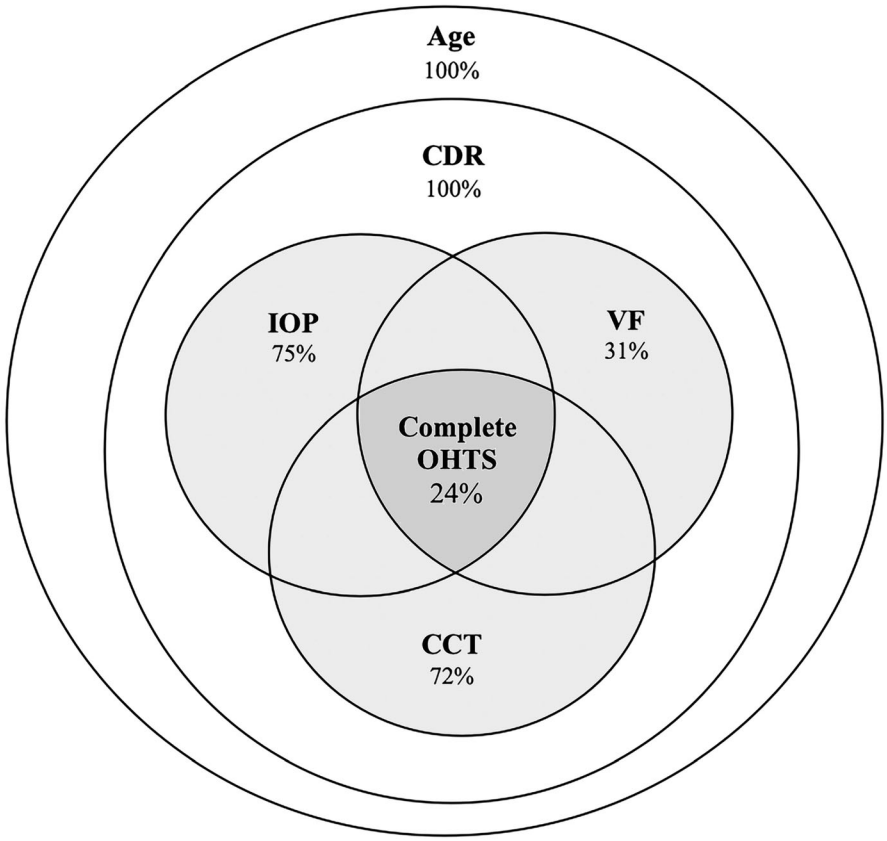

Fig. 1 Diagram of components of the OHTS score availability at the time of referral. All referrals included age and CDR. The remainder had one or more components necessary for calculating the OHTS score unavailable, *CDR*: cup-to-disk ratio, *IOP* intraocular pressure, *VF* visual field. *CCT* central corneal thickness, *OHTS* ocular hypertension treatment study

Table 3 Diagnostic outcomes

Outcome	All referrals *n* (%)	Optometry referrals *n* (%)	Ophthalmology referrals *n* (%)
Diagnosis upgraded by glaucoma specialist	15 (21%)	10 (19%)	5 (28%)
Diagnosis downgraded by glaucoma specialist	2 (3%)	2 (4%)	0 (0%)
Total change in diagnosis from referral	17 (24%)	12 (22%)	5 (28%)

($p < 0.001$); a majority of those patients had an upgrade to their diagnosis from glaucoma suspect to likely glaucoma at the consultation (83%). Those patients who had their diagnosis upgraded were also more than twice as likely to require three or more visits within the first year after the initial consultation.

Changes in glaucoma treatment, e.g., adjunctive therapy, were tracked during the first year after the initial consultation. At the initial consultation, 36 of the 72 patients in the study (50%) were prescribed medical treatment, and by the end of one year from the initial consultation, a total of 49 patients (68%) had received some form of glaucoma treatment (Table 4).

Discussion

A review of internal referrals of patients with OAG or suspected glaucoma within our academic medical center revealed that clinical information necessary to diagnose accurately and stage the disease is frequently incomplete. Only 57% of internal referrals to a glaucoma specialist had a complete clinical triad,

Table 4 Treatment changes at initial glaucoma consult and after 1 year

Therapy	Time point	All referrals *n* (%)	Optometry referrals *n* (%)	Ophthalmology referrals *n* (%)
Any adjunctive treatment	At consult	36 (50%)	28 (52%)	8 (44%)
	In year following consult	53 (74%)	38 (70%)	15 (83%)
Medication (added or changed)	At consult	36 (50%)	28 (52%)	8 (44%)
	In year following consult	49 (68%)	35 (65%)	14 (78%)
Laser	At consult	0 (0%)	0 (0%)	0 (0%)
	In year following consult	4 (6%)	3 (6%)	1 (6%)
Surgery	At consult	0 (0%)	0 (0%)	0 (0%)
	In year following consult	0 (0%)	0 (0%)	0 (0%)

and fewer than a quarter had all of the data necessary to calculate an OHTS score. RNFL imaging, an increasingly important modality for assessing the risk of glaucoma and objectively monitoring progression [12–14], was available for only about half of eyes. Complete testing by a referring clinician may not always be necessary for a glaucoma specialist to make a diagnosis and treatment plan for a patient with glaucoma, and specialists should also be expected to obtain necessary additional data if the referrals are incomplete. However, a lack of key clinical information at the time of referral further taxes the resources of the subspecialist and reduces the efficiency of the consultation process. Our study reveals that ophthalmologists and optometrists are requesting the opinion of a glaucoma specialist early in management, which is preferable to delaying subspecialist input until irreversible vision loss has taken place, but the collection of more clinical data before referral will allow for more effective use of the limited number of glaucoma specialists. Social and/or medical circumstances for referrals may vary based on their locality. For example, not all eye care practices have access to VF and OCT machines, so the problem of missing key clinical data could be even more acute in the case of outside referral sources. This was not assessed in the present study.

The diagnosis of glaucoma requires a comprehensive evaluation of the patient beyond characterizing the structure of the optic disk or observing an elevated IOP. There are other well-known risk factors for glaucoma such as family history of the disease, a thin central cornea, high refractive error, and functional testing which is needed to identify the characteristic defects indicative of a glaucomatous optic neuropathy. Even when all of these data have been collected, input by a subspecialist may still be needed to confirm the diagnosis or guide treatment. Given that Massachusetts specifically prevented optometrists from writing prescriptions for the treatment of glaucoma at the time this study was conducted, a greater number of consultations might be expected from optometrists compared to ophthalmologists, whose licenses allowed them to treat glaucoma. This could cause optometrists to be more cautious in cases of suspected glaucoma, lowering their threshold for referral. In our multispecialty group practice, optometrists and non-glaucoma specialist ophthalmologists are equal in number, yet the number of glaucoma consultation requests was three to one in favor of the former. Massachusetts state law has recently expanded the scope of practice for optometrists to allow for the medical treatment of glaucoma [15].

The prospective study of optometric referrals conducted by Lockwood et al. [5] identified the clinical triad as most predictive of a diagnosis of glaucoma. We, therefore, selected the clinical triad as the minimum standard for a high-quality referral. Lockwood's study found that 66% of patients referred for glaucoma evaluation had a complete clinical triad [5]. This is comparable to the 61% of optometric referrals in our study. In comparison, our internal referrals from ophthalmological providers had a complete clinical triad only 44% of the time. All instances of an incomplete triad resulted from missing a reliable VF for both optometry and ophthalmology

referrals. In the majority of these cases, a VF was never scheduled or attempted, as opposed to being an unreliable test result, which was the case for only 10% patient. Not all patients are capable of VF testing [16] and the presence of a reliable VF may not significantly affect a referral's diagnostic positive predictive value according to Lockwood et al. [5] and others [17]. Nevertheless, lacking clinical information at the time of subspecialist consultation reduces the efficiency of subspecialty consultation for diagnostic purposes.

VF testing is subjective and prone to inter-test variability, whereas imaging of the RNFL is objective and can be used in cases where patients are unable or unwilling to do VF testing [13]. We are unable to establish why so many patients were without VF information at the time of the consultation. If this was because of physical limitations or due to acuity, one might expect RNFL imaging to be present to a greater extent, since this provides complementary information to functional testing and may even predict functional deficits [12–14]. We did not assess whether analysis of the ganglion cell complex was performed for any of the patients in our study, but this method is increasingly being recognized as an important means of early diagnosis and monitoring of glaucoma [18, 19].

Communication between a referring eye care provider and subspecialist relies not only on the completeness of the referral, but also on the accuracy of the information provided with the referral. Although we observed a statistically significant difference in the CDR measurements between the referring doctor and the glaucoma specialist, the average difference was not clinically meaningful, and there was generally good agreement in the characterization of the optic disk for the patients referred. However, we cannot exclude the possibility that a shared EMR biased glaucoma providers' assessment of the CDR in our study. The referring diagnosis for patients sent by both optometry and ophthalmology aligned fairly well with the impression of the glaucoma specialist. Only 24% of patients had a change in their diagnosis from their referring doctor to the glaucoma specialist, and only 8% of patients were deemed to have OHT rather than a glaucoma-related diagnosis. This indicates that both optometrists and ophthalmologists are reasonably accurate in detecting glaucoma, or its suspicion. When the diagnosis of the referring doctor differed from that of the glaucoma specialist, the referring party was more likely to have underdiagnosed rather than overdiagnosed the patient.

In this study, we provide evidence that input from glaucoma specialists impacted care. Fully half of patients were prescribed medical treatment at the initial consultation, and more than two-thirds of patients had received some form of new glaucoma treatment by the end of a one-year period from the initial consultation. Glaucoma requires longitudinal management and follow-up, and short-term outcomes do not reflect the full value of subspecialist consultation. Although not every referral should be expected to identify glaucoma [20], the high rate of treatment-related events both at the time of consultation and within the year following indicate the important contribution of the glaucoma specialist to the management of these patients.

The limitations of the present study include its retrospective nature, small sample size, and heterogeneity of the patients referred for glaucoma specialty consultation. We excluded patients with a history of glaucoma treatment, including both medical and surgical management, and this may have affected the number of patients managed by ophthalmologists compared to optometrists. However, even allowing for the patients excluded, the number of consults by optometrists exceeded those from ophthalmologists, indicating that optometrists more often sought an opinion from a glaucoma specialist. The methodology of our cross-sectional survey may also overrepresent patients with positive findings or more severe disease requiring ongoing care from a subspecialist. However, given the large number of diagnostic consults for patients with suspected glaucoma that we identified, this does not seem to be the case. A future study should also seek to identify the reasons why referring providers might not be able to obtain a VF test by the time of referral, or to take into account the severity of disease in each case. It could be that referring providers are unaware that they are making referrals lacking key clinical information, or they could believe the benefits of referring patients early outweigh the burdens imposed on the glaucoma specialists who are left to collect additional clinical data.

In conclusion, our study shows that key clinical data necessary for effective management of glaucoma are often missing at initial glaucoma consultations. Provider education or implementation of decision support tools within EMRs could encourage referring

doctors to collect more complete data before sending patients to a glaucoma specialist. Additionally, support staff can be trained to recognize whether a patient has a reliable VF or available RNFL scan when scheduling an initial glaucoma consultation. When necessary, schedulers can then suggest that referring providers order additional testing prior to a subspecialty visit, as appropriate. This will improve both the efficiency and effectiveness of consultation.

Acknowledgements The authors thank Dr. Jeffery L. Marx, Dr. Jenny Jiang, Dr. Mahesh Bhardwaj, Dr. Ann Kent-Gasiorowski, Dr. Gwynn Horsburgh, Christine Gould, Miranda D. Prosniewski, as well as Carol Spencer, Lahey Hospital Librarian, for research support. D.J. Ramsey is the Harry N. Lee Family Chair in Innovation at the Lahey Hospital & Medical Center, Beth Israel Lahey Health.

Authors' contributions KJS organized, analyzed and interpreted patient data, created figures, and was a major contributor in writing the manuscript. DSW analyzed and interpreted patient data and was a contributor in writing the manuscript. SR interpreted patient data, provided overall guidance and support and was a major contributor in writing the manuscript. AMA interpreted patient data, provided overall guidance and support, and was a contributor in revising the manuscript. MLC interpreted patient data, provided overall guidance and support, and was a major contributor in writing the manuscript. PRC interpreted patient data, provided overall guidance and support, and was a major contributor in writing the manuscript. DJR was responsible for the study hypothesis and design, the development of electronic medical record reporting tools, analyzed and interpreted patient data, provided overall guidance and support, and was a major contributor in writing the manuscript.

Funding D.J.R. was supported by the Harry N. Lee Family Chair in Innovation at the Lahey Hospital and Medical Center, Beth Israel Lahey Health.

Financial support K.S. was supported by a grant from Office of Medical Education, Lahey Hospital and Medical Center, Beth Israel Lahey Health. D.S.W. was supported by a grant from Office of Medical Education, Lahey Hospital and Medical Center, Beth Israel Lahey Health. D.J.R. was supported by the Harry N. Lee Family Chair in Innovation at the Lahey Hospital and Medical Center, Beth Israel Lahey Health.

Availability of data and material The datasets generated and/or analyzed during the current study are not publicly available due to the use of internal and confidential patient medical record data stored on internal, confidential, and protected hard drives, but de-identified and redacted data are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Ethical approval The research followed the tenets of the Declaration of Helsinki and was approved as a quality improvement initiative by the institutional review board of the Lahey Hospital & Medical Center, Burlington, MA. Information was gathered and secured in compliance with the Health Insurance Portability and Accountability Act. The requirement for informed consent was waived because of the retrospective nature of the study and a waiver granted by the institutional review board of the Lahey Hospital & Medical Center, Burlington, MA.

Consent to participate N/A.

Consent to publish N/A.

References

1. Foot B, MacEwen C (2017) Surveillance of sight loss due to delay in ophthalmic treatment or review: frequency, cause and outcome. Eye(Lond) 31:771–775
2. Gupta P, Zhao D, Guallar E, Ko F, Boland MV, Friedman DS (2016) Prevalence of glaucoma in the United States: the 2005–2008 national health and nutrition examination survey. Invest Ophthalmol Vis Sci 57:2905–2913
3. Tertel Z (2015) Analyzing ophthalmology's manpower issue: how the profession can meet patient demand despite potential shortages. Ophthalmol Manage 19:28–30. https://www.ophthalmologymanagement.com/issues/2015/january-2015/analyzing-ophthalmology-8217;s-manpower-issue. Accessed 25 Apr 2019
4. Scully ND, Chu L, Siriwardena D, Wormland R, Kotecha A (2009) The quality of optometrists' referral letters for glaucoma. Ophthalmic Physiol Opt 29:26–31
5. Lockwood AJ, Kirwan JF, Ashleigh Z (2010) Optometrists referrals for glaucoma assessment: a prospective survey of clinical data and outcomes. Eye(Lond) 24:1515–1519
6. Jamous KF, Kalloniatis M, Hennessy MP, Agar A, Hayen A, Zangerl B (2015) Clinical model assisting with the collaborative care of glaucoma patients and suspects. Clin Exp Ophthalmol 43:308–319
7. Gibson T (2016) Optometry's role in managing patients with glaucoma. Clin Exp Optom 99:1–3
8. Song YJ, Kim YW, Park KH, Kim YK, Choi HJ, Jeoung JW (2019) Comparison of glaucoma patients referred by glaucoma screening versus referral from primary eye clinic. PLoS ONE 14:e0210582
9. Department of Ophthalmology & Visual Sciences. Ocular hypertension treatment study (OHTS): risk calculator. Washington University School of Medicine. 2006. https://ohts.wustl.edu/risk/. Accessed 6 Oct 2018.
10. Gordon MO, Kass MA (1999) The ocular hypertension treatment study: design and baseline description of the participants. Arch Ophthalmol 117:573–583

11. Washington University. Point system for estimating 5-Year Risk of developing POAG. 2006. https://ohts.wustl.edu/wp-content/uploads/2017/02/Points-System.pdf. Accessed 12 Mar 2019
12. Townsend KA, Wollstein G, Schuman JS (2009) Imaging of the retinal nerve fibre layer for glaucoma. Br J Ophthalmol 93:139–143
13. Sung KR, Kim JS, Wollstein G, Folio L, Kook MS, Schuman JS (2011) Imaging of the retinal nerve fibre layer with spectral domain optical coherence tomography for glaucoma diagnosis. Br J Ophthalmol 95:909–914
14. Rao HL, Zangwill LM, Weinreb RN, Sample PA, Alencar LM, Medeiros FA (2010) Comparison of different spectral domain optical coherence tomography scanning areas for glaucoma diagnosis. Ophthalmology 117:1692–1699
15. An Act promoting a resilient health care system that puts patients first. 2021 Mass. Acts 2984. 1 Jan 2021
16. Rao HL, Yadav RK, Begum VU, Addepalli UK, Choudhari NS, Senthil S et al (2015) Role of visual field reliability indices in ruling out glaucoma. JAMA Ophthalmol 133:40–44
17. Newman DK, Anwar S, Jordan AK (1998) Glaucoma screening by optometrists: positive predictive value of visual field testing. Eye (Lond) 12:921–924
18. Distante P, Lombardo S, Verticchio Vercellin AC, Raimondo M, Rolando M, Tinelli C et al (2015) Structure/function relationship and retinal ganglion cells counts to discriminate glaucomatous damages. BMC Ophthalmol 15:185
19. Bhagat PR, Deshpande KV, Natu B (2014) Utility of ganglion cell complex analysis in early diagnosis and monitoring of glaucoma using a different spectral domain optical coherence tomography. J Curr Glaucoma Pract 8:101–106
20. Medeiros FA, Weinreb RN, Sample PA, Gomi CF, Bowd C, Crowston JC et al (2005) Validation of a predictive model to estimate the risk of conversion from ocular hypertension to glaucoma. Arch Ophthalmol 123:1351–1360