Published in final edited form as:

J AAPOS. 2008 August ; 12(4): 344–348. doi:10.1016/j.jaapos.2008.02.012.

Retinopathy of prematurity care: Patterns of care and workforce analysis

Alex R. Kemper, MD, MPH, MS¹, Sharon F. Freedman, MD², and David K. Wallace, MD, MPH²

¹*Program on Pediatric Health Services Research, Department of Pediatrics, Duke University, Durham, NC*

²*Departments of Ophthalmology and Pediatrics, Duke University, Durham, NC*

Abstract

PURPOSE—To describe the workforce that provides retinopathy of prematurity (ROP) care.

METHODS—We surveyed a random sample of ophthalmologists' offices by telephone (n=1,504) and then sent a mail survey to those who were reported to provide care to infants (n=486). Workforce estimates were based on the total number of ophthalmologists in the US.

RESULTS—Thirty percent of ophthalmologists were reported to care for children less than one year of age; 11% of all ophthalmologists examine for (1,815, 95% confidence interval [CI]: 1,340–2,379) and 6% treat ROP (983, 95% CI: 649–1,421). ROP exams are provided by an equal number who have completed fellowship training in pediatric ophthalmology and strabismus (254, 95% CI: 182–327) as have not completed any fellowship training (236, 95% CI: 163–345). Ophthalmologists with fellowship training in any subspecialty provide 86% of the ROP exams, with those trained in pediatric ophthalmology providing 50% overall. Some (9%) of the ophthalmologists who examine for ROP, regardless of whether or not they completed a fellowship (p= 0.22), report that their training did not adequately prepare them to do so. In contrast to exams, most treatment is provided by ophthalmologists who are fellowship trained in retina and vitreous diseases.

CONCLUSIONS—ROP care is offered by ophthalmologists with different training backgrounds. Future work is needed to understand the relationship between the availability of ophthalmologists and ROP care delivery and the role of new modes of care delivery (e.g., telemedicine).

Introduction

Appropriately timed treatment for retinopathy of prematurity (ROP) can lead to significant improvements in visual outcome. Such care is dependent on eye exams for those children at risk for developing ROP. These comprehensive eye exams are often referred to as “screening exams” because their purpose is to detect the presence of ROP. ROP screening exams are recommended for those with: birth weight of less than 1500 grams; gestational age of 30 weeks or less; or, birth weight between 1500 and 2000 grams or gestational age of more than 30 weeks and an unstable clinical course.¹ These recommendations, released in 2006, represent an expansion of the previous guideline, which recommended a gestational age threshold of 28

Corresponding Author: Alex R. Kemper, MD, MPH, MS, alex.kemper@duke.edu, North Pavilion, 2400 Pratt Street, Room 0311 Terrace Level, Durham, NC 27705, Phone: 919-668-8038 Fax: 919-668-7058.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conflict of Interest: None

weeks.² The current guidelines also recommend treating selected eyes earlier than in the past, when “threshold” ROP was the indication for laser treatment.

The primary objectives of this study were to describe the size and characteristics of the workforce of ophthalmologists who provide ROP care. Our secondary objectives were to describe the criteria used by ophthalmologists for ROP screening and the degree to which ophthalmologists use retinal imaging devices in an attempt to decrease the number of ROP screening exams that need to be performed.

Subjects and Methods

Sampling Frame

Because most ophthalmologists do not provide care for young children, we developed a two-stage survey process to identify subjects. First we selected a simple random sample of ophthalmologists from the American Medical Association (AMA) Masterfile, a database of all licensed physicians in the United States. This sample included ophthalmologists in direct patient care, but excluded physicians in training, those who practice at military or federal facilities, and those who did not have an office telephone number within the database. We initially included 1,504 of the 16,693 ophthalmologists (9%) in the AMA Masterfile. In February and March 2007, we telephoned each ophthalmologist’s office and asked the receptionist, “Does Dr. [Name] see children less than one year of age, either as inpatients or outpatients?” If the answer to this question was “yes,” the ophthalmologist was included in a subsequent mail survey. By using this two-stage approach, we were able to efficiently target eligible subjects and also obtain sufficient data to estimate the total size of the ophthalmologist workforce that provides eye care for young children in general and ROP care in specific.

Survey Instrument Development and Administration

The instrument was pilot tested by a small group of ophthalmologists who provide ROP care and was revised for content validity and to ensure clarity. Reliability was not assessed. The final instrument (available at <http://www.XXX.XXX>) consisted of 11 questions which were primarily multiple-choice and Likert scales of agreement, and took fewer than ten minutes to complete. The first survey mailing, accompanied by a cover letter, an inexpensive incentive gift, and a business reply envelope, was sent during April 2007. Two subsequent mailings to nonrespondents were sent at 3-week intervals.

Data Analysis

Initially, general frequency responses to all survey items were determined. After this, Pearson χ^2 tests of independence were used to test for associations among the categorical variables. The Mann-Whitney two-sample statistic was used to evaluate the relationship between selected categorical variables and non-normally distributed continuous variables (e.g., medical school graduation year, number of screening exams or treatments performed). We estimated the proportion of ophthalmologists who provide ROP care by combining findings from the telephone and mail surveys. These proportions were converted to absolute numbers, extrapolated from the total number of ophthalmologists in the AMA Masterfile. To evaluate the impact on nonresponse bias, we conducted two sensitivity analyses. Because those who do not provide ROP care may be less interested than those who do in filling out a survey on the topic, the first sensitivity analysis was a recalculation of our estimate of the proportion of ophthalmologists who provide ROP care assuming that none of the nonrespondents provide ROP care. To illustrate the potential upper bound of the workforce, the second sensitivity analysis was based on the assumption that all nonrespondents provide ROP care. All reported confidence intervals [CIs] around proportions are based on a binomial distribution. We considered $P < 0.05$ to be statistically significant. All analyses were performed with Stata 8.2

software (Stata, College Station, TX). The Duke University Health System institutional review board approved this project.

Results

Response Rates

We were able to contact the office of 1,279 of the 1,504 ophthalmologists by telephone (85%), of which 486 (38%) reported that the ophthalmologist provides care of children less than one year of age. We received completed mailed surveys from 285 of these 486 ophthalmologists, for an overall response rate of 59%. However, two reported that they had retired and 99 reported that they do not provide care for children less than one year of age, yielding an adjusted response rate of 48% (184 completed surveys from 385 eligible subjects).³

Demographic Characteristics

Characteristics of the mail survey respondents, who provide care to children less than one year of age, are listed in Table 1. Nearly all were board certified in ophthalmology. About half had completed fellowship training, most commonly in pediatric ophthalmology and strabismus. Those with fellowship training were more likely to have primary academic appointments (75% vs. 40%; $p<0.001$). More respondents whose main practice setting is urban had a primary academic appointment than those in rural (52% vs. 13%; $p<0.001$) or suburban practices (52% vs. 26%; $p<0.01$). The median year of medical school graduation was 1985 (interquartile range [IQR]: 1977–1991). Recent graduates were more likely to have completed a fellowship (e.g., 71% of those who graduated in 1991 or later vs. 39% who graduated earlier than 1977; $p<0.01$).

Workforce Estimates

We estimate that 30% (95% CI: 28%–33%) of all ophthalmologists, or a total of 5,025 (95% CI: 4,607–5,488) ophthalmologists, provide care for children less than one year of age. Among the respondents to the mail survey who provide care for children less than one year of age, 15% (95% CI: 10%–21%) both screen for and treat ROP, 21% (95% CI: 15%–27%) only screen, and 4% (95% CI: 2%–8%) only treat. Table 2 lists our estimates of the total workforce that provides care for ROP based on responses to the survey and based on the sensitivity analysis, in which nonrespondents were considered not to provide ROP care. Based on the surveys, our best estimate is that 11% of all ophthalmologists screen for ROP. However, the sensitivity analysis suggests that the true number may be as low as about 5%. The size of the workforce that treats ROP is about half the size of the workforce that screens for ROP.

Factors Associated with ROP Care

Among the ophthalmologists in our sample who provide care for children less than one year of age, those who completed fellowship training in pediatric ophthalmology and strabismus were more likely ($p=0.001$) to screen for ROP (61%) than those who did not report fellowship training (28%) or who completed other fellowships (32%). However, the number of ophthalmologists who provide care for children less than one year of age and who screen for ROP is similar between those who have completed fellowship training in pediatric ophthalmology and strabismus (254, 95% CI: 182–327) and those who did not report fellowship training (236, 95% CI: 163–345). This counter-intuitive finding is a result of the underlying distribution of ophthalmologists; among those who care for children less than one year of age, there were twice as many without fellowship training compared to those who completed fellowship training in pediatric ophthalmology and strabismus.

Most (82%) ophthalmologists who provide care to children less than one year of age and who have completed fellowship training in retina and vitreous diseases reported that they treat ROP.

In contrast, only 29% of those who have completed fellowship training in pediatric ophthalmology and strabismus reported that they treat ROP ($p<0.001$). There are about 50% more who have completed fellowship training in pediatric ophthalmology and strabismus than in retinal and vitreous diseases among those ophthalmologists who provide care for children less than one year of age. Overall, the size of the workforce that treats ROP among those that provide care for children less than one year of age is twice as high among those who have completed fellowship training in retina and vitreous diseases (128, 95% CI: 98–138) compared to those who have completed fellowship training in pediatric ophthalmology and strabismus (69, 95% CI: 39–187). Only one respondent who had not completed fellowship training reported treating ROP; this ophthalmologist graduated from medical school in the 1960s.

Most (82%) respondents who provide care for children less than one year of age reported that their training prepared them to screen for ROP. Among those who screen, most, but not all (91% vs. 9%; $p=0.04$), report that their training prepared them to do so. The likelihood of reporting adequate training did not vary with the completion of a fellowship ($p=0.22$).

More respondents with a primary academic appointment reported that they screen for ROP than those who do not have a primary academic appointment (46% vs. 31%). This difference was just above our threshold for statistical significance ($p=0.05$). In contrast, the difference between those with and without a primary academic appointment for ROP treatment was statistically significant (33% vs. 13%; $p<0.01$). There was no statistically significant difference ($p=0.39$) in the likelihood of reporting ROP screening by urban (44%), suburban (34%) or rural (32%) practice setting; however, the likelihood of reporting ROP treatment was greater ($p=0.004$) in urban (34%) than suburban (16%) or rural (9%) areas. The likelihood of reporting ROP screening ($p=0.12$) or treatment ($p=0.90$) did not vary by medical school graduation year.

Frequency of ROP Screening Exams and Treatment

Among those who screen, the median number of screening exams per week was greater for those who had completed fellowship training (7, IQR: 3–10) than those who did not (2, IQR: 1–4; $p<0.001$). As a result, fellowship-trained ophthalmologists provide most of the ROP screens (those who have not completed fellowship training provide 14%; those who have completed fellowship training in pediatric ophthalmology and strabismus 50%; and, those who have completed other fellowship training 36%). Among those who treat ROP, most (68%) report that they do less than one case per month on average.

Criteria for ROP Screening

Among those who screen, those with fellowship training were more likely than those who did not complete fellowship training to use gestational age (88% vs. 67%, $p=0.04$) or birth weight (88% vs. 54%, $p<0.01$) as criteria to identify neonates who should receive ROP screening, and less likely to only use clinical course or recommendation of the attending neonatologist (10% vs. 29%, $p=0.04$). Overall, among those who used gestational age as a criterion, the threshold ranged from 25 to 37 weeks. Most used a threshold of 30 weeks (19%) or higher (75%), but some (6%) used a threshold of fewer than 30 weeks. Among those who used birth weight as a criterion, the threshold ranged from 1,000 to 2,000 grams. Most used a threshold of 1,500 grams (65%) or higher (18%), but some (16%) used a threshold of fewer than 1,500 grams. Although the median gestational age and birth weight used as the threshold by ophthalmologists who screen for ROP did not vary by whether they had completed fellowship training, there was a slight decrease in the overall distribution for both criteria among those who had completed fellowship training (gestation age, $p=0.03$; birth weight = 0.02). Of the three who used a gestational age threshold of 28 weeks or less to identify children for screening, two, both of whom completed fellowship training in retina and vitreous diseases, also used a birth

weight of less than 1,500 grams as a criterion and the other, who did not complete fellowship training, did not use birth weight as a criterion.

Retinal Imaging Devices

Overall, 18% of the ophthalmologists who provide care for children less than one year of age reported that their main practice site owns a retinal imaging device. Uses of the retinal imaging included evaluation of suspected child abuse (56%), monitoring of retinal tumors (53%), evaluation of adults with retinal problems (53%), ROP screening (15%), and research (24%). The most common reason (68%) for not having a retinal imaging device was that there was no need for one within the practice. However, 22% of those without one reported that the reimbursement was inadequate for the expense of the device. Few (4%) reported concerns about insufficient image quality as a reason for not having one.

Availability of Services

Among those ophthalmologists who provide care for children less than one year of age, 30% reported that there are not enough ophthalmologists to screen for ROP and 28% reported that there are not enough ophthalmologists to treat ROP. The perception about the availability of services did not vary by urban/suburban/rural practice setting for both those who screen ($p=0.64$) and those who treat ROP ($p=0.41$). However, more than twice as many of those who screen compared to those who do not believe that there are not enough ophthalmologists to screen (46% vs. 21%; $p<0.001$) and more than twice as many of those who treat compared to those who do not believe that there are not enough ophthalmologists to treat (45% vs. 18%; $p<0.001$).

Reasons for Not Providing ROP Care

Table 3 lists the reasons for not providing ROP care by those ophthalmologists who otherwise provide care for children less than one year of age. The most commonly reported reason not to screen or treat is the belief that others provide the service. No respondent who had completed fellowship training in pediatrics and strabismus reported that lack of training or experience as a reason that they do not screen for ROP. However, 20% who had completed fellowship training in pediatrics and strabismus reported that they do not treat ROP because they lack of training or experience. Liability risk was reported by about 25% as a reason not to screen or treat; however, only two respondents reported involvement in a malpractice suit related to ROP, both of which were settled out-of-court. One of these respondents screens for ROP, but neither will treat.

Discussion

Approximately one-third of ophthalmologists provide care to children less than one year of age, however substantially fewer provide ROP care. We were surprised to find that ROP screening is offered by a similar proportion of ophthalmologists who have not completed any fellowship training as those who have completed fellowship training in pediatric ophthalmology and strabismus. Although those who have completed fellowship training provide most of the ROP screening exams, those who have completed fellowship training in pediatric ophthalmology and strabismus provide only half of the screening exams. In contrast to ROP screening, treatment is only rarely provided by ophthalmologists who have not completed fellowship training. Although ROP treatment is provided by more ophthalmologists who have completed fellowship training in retinal and vitreous diseases than in pediatrics and strabismus, the overall number of ophthalmologists providing treatment for ROP is small.

Over the past two decades, landmark multicenter studies have defined best practices for the prevention and treatment of ROP.⁴⁻⁶ Unfortunately, a recent survey conducted by the

American Academy of Ophthalmology of pediatric ophthalmologists and retinal specialists found that half have either stopped or are planning to stop providing ROP care.⁷ Among these respondents, the most common barriers were financial, including medical liability (67%) and poor reimbursement (37%). Additionally, half considered the complexity of scheduling ROP care to be a barrier. No data are available from this survey, or any other recent study, to evaluate the current size of the workforce for ROP care.

Although there is concern about the size of the workforce to provide ROP care among ophthalmologists and neonatologists,⁸ no population-based data are available regarding the degree to which premature infants in non-research settings receive appropriate care. One small study suggests that infants not screened in the neonatal intensive care unit prior to discharge or transfer to community hospitals may miss ROP care.⁹ However, assuring follow-up ROP care, at least for those infants who are discharged, may be more strongly related to scheduling follow-up prior to discharge than to any workforce insufficiency.¹⁰

This study has several limitations. Office staff may have misclassified ophthalmologists who do provide care for children less than one year of age, which would lead to an underestimate of the available workforce. Survey non-response could bias our estimates of the workforce size. To evaluate the potential effect of non-response bias, we conducted sensitivity analyses. Second, surveys cannot directly assess the care that is provided. Finally, this study evaluates workforce supply but not the service delivery need. It is possible that pediatric ophthalmologists provide care to the neonates at the highest risk of developing ROP. Despite these limitations, there are important implications regarding quality of care and future training and organization of the workforce for ROP care.

This study did identify factors that could potentially lead to variations in ROP care. For example, some ophthalmologists who screen for ROP do not use explicit gestational age or birth weight criteria to identify infants for ROP screening. A few ophthalmologists also use criteria that are more restrictive than current recommendations for identifying children for ROP screening,¹ and a few ophthalmologists who screen report that their training did not prepare them to do so. It is unknown whether differences in training, experience, or practice lead to variations in screening or treatment outcomes.

Telemedicine is a prime target for extending the reach and reducing variability in screening for ROP. Few ophthalmologists own a retinal imaging device for ROP screening. However, a better gauge of the penetration of retinal imaging devices will be surveys of neonatal intensive care units. Significant effort is underway to reduce the current high degree of variability in interpreting digital images for the detection of ROP.¹¹ Research will be needed, both in well-controlled settings and in the community to assess the impact of telemedicine on ROP care delivery.

As with the American Academy of Ophthalmology survey,⁷ we found issues of liability risk and reimbursement as reasons not to offer ROP care. However, perceived lack of demand and the perception that others provide these services were more commonly reported as a reason for not offering either ROP screening or treatment. This finding is in contrast to the perception of neonatologists, who believe that the workforce supply is inadequate.⁸ To be successful, any efforts to increase the workforce supply for ROP care will have to address a complex range of issues related to training and the need for ROP care in addition to addressing financial and liability concerns.

Unlike many other aspects of health care delivery, explicit guidelines have been developed that identify the best practices for both ROP screening and treatment. We believe that the next step in improving ROP care is to directly assess the ROP care received by at-risk infants. Such basic work could identify the complex relationships between workforce need, workforce

availability, actual service delivery, and ROP outcomes. Such findings are critical for developing quality improvement activities¹² to assure ROP care according to best practice guidelines.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Financial Support: National Eye Institute (K23-EY14023)

References

1. American Academy of Pediatrics, Section on Ophthalmology, American Academy of Pediatrics, American Academy of Ophthalmology, American Association for Pediatric Ophthalmology and Strabismus. Screening examination of premature infants for retinopathy of prematurity. *Pediatrics* 2006;117:572–576. [PubMed: 16452383]Errata. 2006;2118:1324.
2. American Academy of Pediatrics, Section on Ophthalmology. Screening examination of premature infants for retinopathy of prematurity. *Pediatrics* 2001;108:809–811. [PubMed: 11533356]
3. Council of American Survey Research Organizations. On the definition of response rates. [accessed January 22, 2008]. Available at <http://www.casro.org/resprates.cfm>
4. Cryotherapy for Retinopathy of Prematurity Cooperative Group. Multicenter trial of cryotherapy for retinopathy of prematurity. *Arch Ophthalmol* 2001;119:110–1118.
5. Early Treatment for Retinopathy of Prematurity Cooperative Group. Revised indications for the treatment of retinopathy of prematurity. *Arch Ophthalmol* 2003;121:1684–1694. [PubMed: 14662586]
6. The STOP-ROP Multicenter Study Group. Supplemental therapeutic oxygen for prethreshold retinopathy of prematurity (STOP-ROP), a randomized, controlled trial. I: Primary outcomes. *Pediatrics* 2000;105:295–310. [PubMed: 10654946]
7. Altersitz, K.; Piechocki, M. Survey: physicians being driven away from ROP treatment. *Ocular Surgery News U.S. Edition*. 2006 [accessed January 22, 2008]. Available at <http://www.osnsupersite.com/view.asp?rID=18018>
8. Kemper AR, Wallace DK. Neonatologists' practice and experience in arranging retinopathy of prematurity screening services. *Pediatrics* 2007;120:527–531. [PubMed: 17766525]
9. Attar MA, Gates MR, Iatrow AM, Lang SW, Bratton SL. Barriers to screening infants for retinopathy of prematurity after discharge or transfer from a neonatal intensive care unit. *J Perinatol* 2005;25:36–40. [PubMed: 15496873]
10. Aprahamian AD, Coats DK, Paysse EA, Brady-McCreery K. Compliance with outpatient follow-up recommendations for infants at risk for retinopathy of prematurity. *J AAPOS* 2000;4:282–286. [PubMed: 11040477]
11. Chiang MF, Jiang L, Gelman R, Du YE, Flynn JT. Interexpert agreement of plus disease diagnosis in retinopathy of prematurity. *Arch Ophthalmol* 2007;125:875–880. [PubMed: 17620564]
12. Institute of Medicine. *Crossing the Quality Chasm*. Washington, D.C.: National Academy Press; 2001.

Table 1

Characteristics of the respondents who provide care for children less than one year of age ($N = 184$) and the proportion who screen or treat ROP by characteristic

	%* (n)	Screen	Treat
Ophthalmology qualification			
Board certified	97% (178)	36%	20%
Board eligible	3% (6)	17%	0%
Fellowship training			
Pediatric ophthalmology and strabismus	23% (42)	60%	29%
Retinal and vitreous diseases	15% (28)	54%	82%
Cornea	4% (8)	0%	0%
Glaucoma	3% (5)	0%	0%
Ophthalmic plastic, orbital, and reconstructive surgery	2% (4)	25%	0%
Neuro-ophthalmology	2% (3)	0%	0%
Other	2% (3)	0%	0%
None	49% (89)	27%	1%
Missing	1% (2)	0%	0%
Primary appointment in an academic medical institution	31% (57)	46%	33%
Main practice setting			
Urban	30% (56)	44%	34%
Suburban	45% (82)	34%	16%
Rural	25% (45)	32%	9%
Missing	1% (1)	0%	0%

* Categories may not add to 100% due to rounding.

Table 2

Projected size of the U.S. workforce that provides ROP care as measured by the proportion of all ophthalmologists and the absolute number of ophthalmologists who screen or treat ROP, estimated by survey response and subsequent sensitivity analyses in which all survey nonrespondents were considered not to provide ROP care (Sensitivity Analysis One) and in which all survey nonrespondents were considered to provide ROP care (Sensitivity Analysis Two).

		Survey estimate	Sensitivity analysis	
			One	Two
Screen	Proportion (95% CI)	11% (8–14%)	5% (4–7%)	21% (18–24%)
	Number (95% CI)	1,815 (1,340–2,379)	857 (618–1,158)	3,508 (2,991–4,060)
Treat	Proportion (95% CI)	6% (4–9%)	3% (2–4%)	19% (16–22%)
	Number (95% CI)	983 (649–1,421)	469 (305–692)	3,093 (2,603–3,627)

Table 3**Reasons for not screening or not treating ROP**

	Not screening (n = 115)	Not treating (n = 148)
No demand	41%	26%
Insufficient reimbursement	7%	5%
Too time consuming	16%	8%
Cost of malpractice coverage	7%	6%
Liability risk	26%	25%
Lack of training or experience	12%	43%
Others provide this service locally	57%	57%

As reported by respondents who otherwise provide care for children less than one year old. Each respondent could report more than one reason.