


Mandated Kindergarten Eye Examinations in a US Suburban Clinic: Is It Worth the Cost?

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Purpose: The state of Illinois has required an examination by an optometrist or ophthalmologist prior to mandatory kindergarten since 2008. This requirement has allowed us to gather information regarding disease prevalence in a local suburban population.

Methods: A retrospective chart review was undertaken of kindergarten eye examinations performed at the Wheaton Eye Clinic between September 2008 and February 2017. Inclusion criteria included school eye examination as a reason for the visit, and a cycloplegic refraction was completed.

Results: Of 3612 patient charts identified, 1085 satisfied the inclusion criteria, of which 48% were female. The average age of the patients was 5.3 years (range, 3.8 to 6.7). Historical characteristics showed 143 (13%) were premature, 28 (3%) patients were autistic and 109 (10%) were developmentally delayed. On examination, 56 (5%) had <20/40 (WHO mild visual impairment) vision in better seeing eye, 34 (3%) had spherical equivalent refractive error in either eye > +3.50 diopters and one < -3.00 diopters. Fifty-eight patients (5%) were diagnosed with amblyopia and 101 patients (9.3%) were given glasses. Abnormal external exam finding was found in 218 (20%) while 16 (1.5%) had an abnormal fundus finding. Thirteen percent (146/1085) had a clinically relevant diagnosis in our examinations, with a cost of \$1635/diagnosis. In total, our follow-up rate was 83% (78/94).

Conclusion: Our rate of treatable ocular conditions discovered via state-mandated kindergarten eye examinations is similar to large-scale screening programs. The cost per condition found with full examinations was substantially higher; however, follow-up was more consistent.

Keywords: refractive error, kindergarten, cost analysis, vision screening, amblyopia

Introduction

Early vision screening programs have been developed over the last several decades involving multiple locations such as schools, primary care offices, public libraries, customized vans, and community health fairs.¹⁻³ Screening evaluations have ranged in complexity from simple visual acuity measurements to more sophisticated digital photo-screening analyses. Debate has existed as to whether or not vision screening programs provide adequate predictive values to ensure a cost-effective effort.^{2,4-10} Follow up with an eye care provider is essential to guarantee a successful screening program, and compliance with timely follow-up varies.^{4-7,9,10}

In January 2008, Illinois became the third state in the United states to mandate a complete ocular examination by optometrist or ophthalmologist prior to entry into Kindergarten.¹¹ The exams include measurements of vision at distance and near without correction and best corrected, external exam, posterior segment, pupillary

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reflex, stereopsis, accommodation and vergence, color vision, glaucoma evaluation, and oculomotor assessment. These exams are to be paid for by the families unless their socio-economic status provides them with the State of Illinois public aid. The examination time period is from October prior to starting Kindergarten to October after starting kindergarten. This study was designed to gather data on ocular disease prevalence in a suburban population of children who presented to our pediatric ophthalmology practice prior to kindergarten and to perform cost analysis and assess the rate of follow-up in comparison to traditional screening programs.

Methods

This study was approved by the Institutional Review Board of Northwestern University and conformed to the requirements of the United States Health Insurance Portability and Privacy Act. A retrospective chart review was undertaken of kindergarten eye examinations performed at the Wheaton Eye Clinic, a private practice of over 30 ophthalmologists, between September 2008 and February 2017. Informed consent was not needed due to the minimal risk of this retrospective review, and patient identifiers were not collected. Using our electronic medical record system, all four to 6-year-old eye examinations performed were identified. A total of 3612 unique patients were collected within this age group. Inclusion criteria in this study included that the kindergarten eye examination was the primary reason for the visit and that a cycloplegic refraction was completed even though it was not required. Cycloplegic refraction became the standard of care in 2010 at our eye clinic, but could still be refused by the parents. Cycloplegia was achieved using a compounded eye drop of cyclogyl 1%, tetracaine 0.5%, phenylephrine 2.5%, and tropicamide 1%. Stereo acuity was measured using Titmus fly (Stereo Optical, Chicago, IL). Intraocular pressure was measured when clinically indicated either via Tonopen (Reichert, Buffalo, NY) or iCare (iCare USA, Raleigh, NC). External examination was done via slit lamp in most cases and posterior segment examination was done with an indirect ophthalmoscope and a 20 or 28 diopter lens whenever possible. All children capable of alternate cover testing had one preformed to assess strabismus. The three ophthalmologists who completed essentially all these exams were trained in accredited pediatric ophthalmology and strabismus fellowship programs in the United States.

Of 3612 patients, 1085 satisfied the inclusion criteria. Data were collected regarding patient demographics,

family history, past medical/birth history, all exam findings, whether glasses were given and final diagnoses. The results from data collection were then tabulated and compared to data from other studies of childhood vision screening in the medical literature.

Results

The 1085 patients who satisfied the inclusion criteria had an average age of 5.3 years (range, 3.8 to 6.7). Females comprised 48% of this patient population. Past Medical history is summarized in Table 1. While demographic data regarding socioeconomic status or ethnicity were not routinely collected, according to the US census during this decade, our catchment area had a median household income of 92,800 USD and most populous race include 79.5% white (14.6% Hispanic or Latino), 5.3% Black, and 12.7% Asian. Our clinic accepts insurance from all socioeconomic backgrounds in our area.

Almost a quarter of parents (22%) had concerns regarding their child's vision including blurred vision (5%), failed vision screening (2%), light sensitivity (2%), excessive blinking (2%), redness (2%), itchy eyes (1%), headaches (1%), strabismus (1%), ptosis (1%), anisocoria (0.8%), eye pain/irritation (0.8%), and head turn/tilt (0.6%). Two parents were concerned about their child having diplopia. Nine parents (0.8%) were seeking a second opinion regarding their child needing glasses.

The general health problems of these children included 31 (3%) with heart disease, 18 of which were innocent murmurs. Twenty-nine (3%) were diagnosed with asthma. One hundred and eleven patients (10%) had seasonal allergies. Six patients had central nervous system disorders: three with seizures, one with tethered spinal cord, one with cerebral palsy, and one did not specify. One patient had a possible mitochondrial disorder.

A positive family history for the following conditions were reported in 1028:601 (59%) myopia, 205 (20%) hyperopia, 145 (13%) strabismus or "lazy eye," and 61 (5.9%) amblyopia. In total, out of 1085 patients in this

Table 1 Past Medical History of Patients

Characteristics	Percentage of Patients
Female	48%
Prematurity of any kind	13%
Oxygen at birth (for any amount of time)	5.8%
Autism (historically collected)	2.6%
Attention Deficit Disorder (historically collected)	0.4%
Developmental delay (historically collected)	10%
Already in Glasses	1%

study, 65% had any family history of ocular conditions but only 19% had a history of amblyopia or strabismus.

On examination 58 patients (5%) had monocular amblyopia based on BCVA >two lines vision difference or binocular amblyopia if BCVA \leq 20/40 in each eye after the first examination. On examination, 56 (5%) had mild visual impairment less than 20/40 vision per World Health Organization guidelines^{12,13} (38% of whom were diagnosed with amblyopia) 15 (1%) had moderate visual impairment less than 20/60 (100% of those were diagnosed with amblyopia), 2 had less than 20/200 or severe

vision impairment per WHO guidelines in better seeing eye. The most common visual acuity measurement was 20/25 (Figure 1). Twenty-two patients (2%) could not comply with vision testing and received a Fix and Follow for vision. Stereo acuity using Titmus Fly was measured in 1060 patients. An acuity of 40 arc seconds was the most frequent, and 92 (8.6%) had an acuity worse than 100 arc seconds (Figure 2). The spherical equivalent refraction was calculated for all patients. In the more affected eye, 34 patients (3.2%) had hyperopia greater than 3.50 diopters and 50% of those patients both eyes were affected.

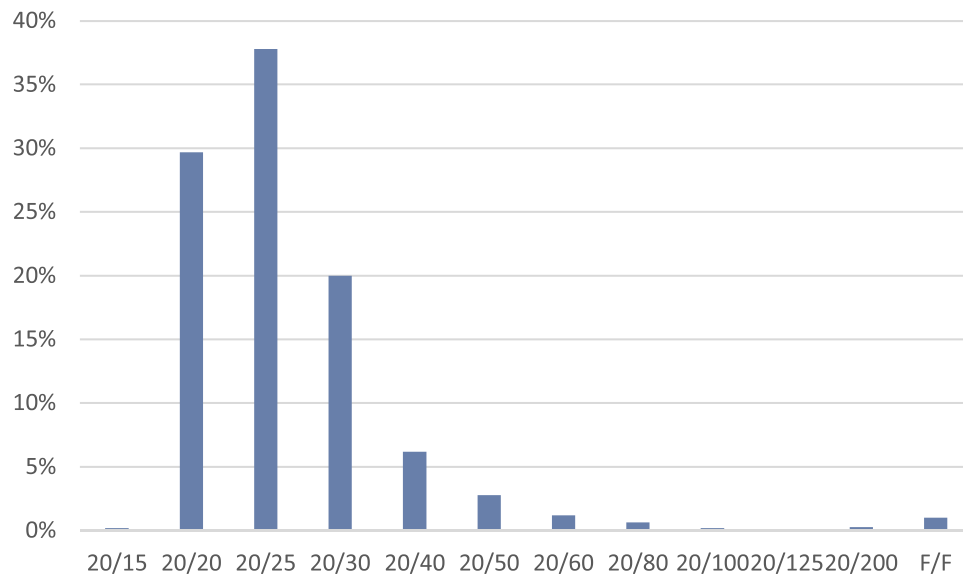


Figure 1 Vision in better seeing eye.

Abbreviations: F/F, fix and follow for non-verbal children.

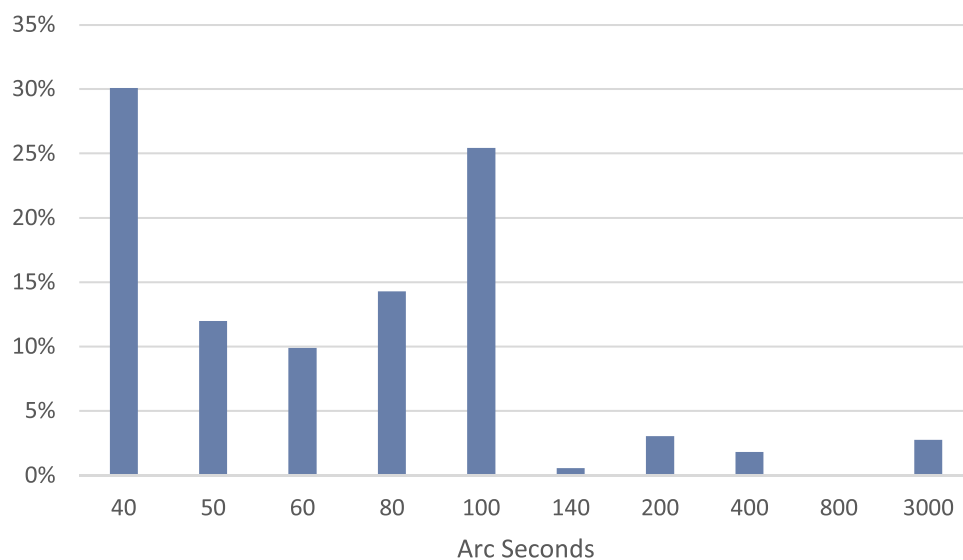


Figure 2 Stereoacuity measurements.

One patient had myopia greater than 3.00 diopters which was in both eyes and 29 (2.6%) had myopia of greater than 0.50 diopters in either eye. Fifty-nine patients (5.4%) had greater than 1.5D of astigmatism in either eye. The average cycloplegic refraction in the entire cohort was +1.25 diopters (Figure 3). Anisometropia of greater than 1.5 diopters was identified in 61 (5.6%) children: 53 had spherical, 3 had cylindrical and 5 had both spherical and cylindrical. Intraocular pressure was measured on 97 patients with 3 patients having IOP greater than 21 mmHg bilaterally, but none had IOP greater than 30 mm Hg. Eleven patients (1%) were diagnosed as glaucoma suspects, defined as a cup to disc ratio higher than 0.5 or IOP higher than 21, but no patient was diagnosed with definitive glaucoma. Only one of the eleven with glaucoma suspect was myopic. Abnormal external exam or slit lamp findings were found in 218 (20%): 45 with conjunctivitis, of which 35 appeared allergic; 30 blepharitis; 20 epicanthus; 15 ptosis; 15 superficial punctate keratitis; 11 with an external nevus; nine with chalazia, eight with epiblepharon; seven had iris color abnormality; seven with media opacities; five had scleral pigmentation. Only 16 patients (1%) had an abnormal fundus finding: 11 had pigment alteration of the retina one had bear tracks, two had pseudopapilledema, one had myelinated nerve fibers, and one had a choroidal nevus.

A total of 101 patients (9%) were given spectacles per the ophthalmologist's discretion. Overall, 94 (8.7%) children were asked to return for follow-up within a year to

review treatment or to monitor a condition. Sixty-nine were to return within 1 year and a further nine returned later (83% follow-up).

Of the 243 patients who presented for their examination with a parental concern, 141 (58%) of them had a pathological diagnosis and/or required glasses. Of the 28 patients identified as autistic, 10 (36%) had strabismus and 3 required glasses.

A total of 146 unique patients (13%) had a clinically relevant diagnosis, including either a diagnosis of amblyopia, a manifest strabismus (excluding phorias), convergence insufficiency and/or were given glasses (Table 2). One hundred and one patients (9.3%) were given glasses.

Donahue's¹⁴ calculation for amblyopia risk factors includes greater than +3.50 or less than -3.00 bilateral refractive error, bilateral astigmatism greater than 1.50 diopters, anisometropia greater than 1.50 diopters, manifest strabismus, media opacity or ptosis. Using these risk factors, we found 126 unique patients or 11.6% of our patient population had amblyopia risk factors. Eighteen of these patients had multiple risk factors. Among the 126 patients with amblyopia risk factors, 58 (46%) were diagnosed with amblyopia.

Most of the examinations were billed using the US CPT code 92004, although this particular charge was not strictly enforced. This code charges \$220 based upon the 2018 Medicare fee schedule to the patients or more often to the insurance providers in the US. Extrapolating this charge across the entire cohort, we found that the cost per

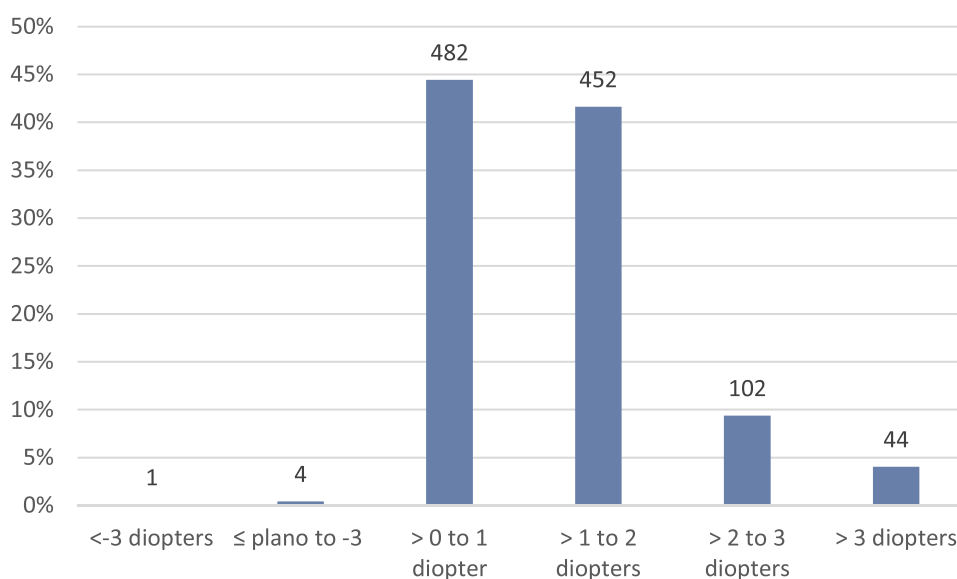


Figure 3 Spherical equivalence in both eyes in diopters.

Table 2 Summary of Diagnoses at the End of Examinations

Diagnosis	Number (Percentage)
Amblyopia	58 (5%)
Glaucoma suspect	11 (1%)
Anisometropia	66 (6%)
Esotropia	2 (0.2%)
Exotropia	12 (1.1%)
Esophoria	37 (3.4%)
Exophoria	94 (9%)
Vertical strabismus	1 (0.1%)
Convergence Insufficiency	20 (1.8%)

relevant diagnosis on the 146 individual patients was \$1635 and the cost per eyeglasses given was \$2363. These could be considered the costs to the general population of our geographic area per relevant diagnosis. This cost did not include the cost of glasses.

Discussion

This study of a large cohort of children undergoing routine kindergarten eye examinations by specialty-trained ophthalmologists at a large suburban eye clinic provides valuable insight into the rate of various ocular diagnoses for this age group. This is the first known report of clinical findings for this particular eye examination mandate since its inception in 2008. In total, 9% of patients required glasses or needed follow-up in less than 1 year to treat or monitor various conditions. The average kindergartener in this cohort had visual acuity better than 20/30, stereo acuity of 60 arc seconds or better, no clinically significant external or fundus exam findings, and an average cycloplegic refraction of mild hyperopia.

Amblyopia was diagnosed per the pediatric ophthalmologist based upon standard criteria of greater than 2 lines of best-corrected visual acuity difference. Our rate of amblyopia risk factors (11.6%) and clinically relevant diagnoses (12%) are similar to previous publications on childhood vision screening programs. Donahue reported a 10% referral rate for photoscreening of 3100 one- to five-year olds in Tennessee,⁸ while Traboulsi et al³ found that 10% of their large population of over 63,000 pre-schoolers to first graders screened required either glasses or treatment for amblyopia or strabismus. It is important to note, as Silverstein and Donahue¹⁵ have shown, that earlier amblyopia detection in preschool may have even better outcomes.

Autistic children may be more likely to have eye disorders based upon our results, and this is consistent with findings by Chang et al.¹⁶ These patients are more difficult to screen, and probably should be required to have full eye examinations before beginning school. A pediatric eye specialist is best suited for these more challenging examinations.

Our rate of myopia of -0.50 diopters to -8 diopters in this population (2.6%) was still low despite the increasing incidence of myopia across the globe.¹⁷ This finding may imply that the increasing rate of myopia in children does not have its onset until after kindergarten in US patients.

Our cost per clinically relevant finding and cost per glasses given were higher compared to some other reported studies. Lowry et al in 2016⁹ found that their costs per case detected in a San Francisco screening program with community-based follow-up versus mobile unit follow-up were \$664 and \$776, respectively. Traboulsi³ calculated a cost per student screened per year at \$23, excluding glasses. Our higher cost is not surprising given the increased expense of performing complete eye examinations in our children. One benefit, however, to complete eye examinations performed in the office setting is having the screening completed and treatment initiated in one sitting. No further referral is necessary. The largest obstacle reported to effective screening programs is the lack of follow-up to an eye care provider. Arnold et al⁴ reported a 65% follow-up rate of their cohort of 6300 children screened, 5% of whom required referral. Lowry et al⁹ reported follow-up rates between 55% and 59% of their community-based mobile programs. Su and Marvin¹⁰ published a 46.6% follow-up rate, and they showed that the main reason why parents did not follow-up on failed vision screening was lack of knowledge of failure in 29.3%. We, on the other hand, had a very high follow-up rate at 83%.

Despite the fact that children presented for routine kindergarten examinations, 22% of parents still voiced concerns regarding their child's eye health and 58% of these ended up having some type of medical diagnosis including simple phorias. It is possible that our population did not represent a true sample of suburban kindergarten students requiring routine eye examination since our practice is a referral-based medical clinic. This may have skewed our cohort toward one with a higher rate of pathology. Despite the multitude of clinically relevant problems found in the patients of our large cohort, there were no life-threatening or ocular health-threatening diagnoses made.

There are several limitations to this retrospective study. Only patients who received cycloplegic refractions were included. This could have skewed the results in a higher rate of pathology or need for glasses with only 30% of patients meeting our inclusion criteria. At the commencement of the kindergarten eye examinations in 2008, not all patients were dilated during their visit. Dilation became a standard suggestion after 2010. We had a very high rate of children presenting with a family history of amblyopia, strabismus or wearing glasses. One might expect that those patients with a family history of eye disorders are more likely to seek kindergarten eye examinations at an established pediatric ophthalmology practice, which may have also skewed the cohort to one with a higher rate of abnormal findings. Finally, as with all retrospective studies, there was no ability to control for missing information during the examination.

The rate of significant abnormal findings within this cohort of suburban children undergoing kindergarten eye examinations was consistent with previous screening programs. Given these data, and the fact that the cost per positive finding was relatively high, one could argue that a less expensive digital screening program or using well-trained vision screeners may be a more cost-effective way to screen children for vision problems before school. Any cost savings from such screening programs, however, need to be weighed against the inconsistent follow-up to an eye care provider that is endemic with these programs. If vision screening programs were able to mandate follow-up with eye care providers, then these more expensive state-mandated complete ocular examinations may become unnecessary.

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Disclosure

The authors have no conflicts of interest in this work.

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