Oregon Elks Children’s Eye Clinic vision screening results for astigmatism

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BACKGROUND
In the Elks Preschool Vision Screening program, which uses the plusoptiX S12 to screen children 36-60 months of age, the most common reason for over-referral, using the 1.50 D referral criterion, was found to be astigmatism. The goal of this study was to compare the accuracy of the 2.25 D referral criterion for astigmatism to the 1.50 D referral criterion using screening data from 2013-2014.

METHODS
Vision screenings were conducted on Head Start children 36-72 months of age by Head Start teachers and Elks Preschool Vision Screening staff using the plusoptiX S12. Data on 4,194 vision screenings in 2014 and 4,077 in 2013 were analyzed. Area under the curve (AUC) and receiver operating characteristic curve (ROC) analysis were performed to determine the optimal referral criteria. A t test and scatterplot analysis were performed to compare how many children required treatment using the different criteria.

RESULTS
The medical records of 136 (2.25 D) and 117 children (1.50 D) who were referred by the plusoptiX screening for potential astigmatism and received dilated eye examinations from their local eye doctors were reviewed retrospectively. Mean subject age was 4 years. Treatment for astigmatism was prescribed to 116 of 136 using the 2.25 D setting compared to 60 of 117 using the 1.50 D setting.

CONCLUSIONS
In 2013 the program used the 1.50 D setting for astigmatism. Changing the astigmatism setting to 2.25 D; , 85% of referrals required treatment, reducing false positives by 34%. (J AAPOS 2018;22:207-210)
Our analysis showed that using the referral criterion of 1.50 D for astigmatism by the plusoptiX S12 was the primary reason for over-referrals. The goal of this study was to determine the accuracy of the option 4 astigmatism referral criterion of 2.25 D.

**Subjects and Methods**

Approval was obtained from the Oregon Health & Science University Institutional Review Board to collect and review data on 4,194 vision screenings in 2014 and 4,077 vision screenings in 2013. The screenings were conducted on Head Start children 36-72 months of age by Head Start teachers and Elks Preschool Vision Screening staff. Screenings were performed using the plusoptiX S12. The device takes binocular readings at a distance of 1 meter in less than one second. It reports measurement values for refraction (sphere, cylinder, axis), pupil diameter and pupil distance, and symmetry of corneal reflexes. A pass or refer screening result is presented immediately. With five levels of sensitivity and specificity available, the program chose the plusoptiX S12 factory default referral criteria (option 5).15-19 In 2014 the program changed the referral criteria to option 4. See Table 1.

Children referred by the plusoptiX S12 received a recommendation to obtain a complete dilated eye examination and were provided a list of local eye doctors whose past chart notes indicated dilation when performing cycloplegic refractions on preschool children. Follow-up was conducted on all referrals and chart notes were obtained for those who went to their local optometrist or ophthalmologist.

Medical records from 117 dilated examinations were reviewed for children who had been referred by the plusoptix S12 for astigmatism 1.50 D (option 5) and from 136 children referred for astigmatism 2.25 D (option 4) settings. A comparative analysis of these plusoptix S12 referrals was conducted. Only notes from eye examinations noting dilation during cycloplegic refraction were included in the study.

Logistic regression was used to produce a receiver operating characteristic (ROC) curve in children screened using the option 5 settings. Criterion to identify optimal cut-off points include closest distance to (0,1), because this demonstrates a perfect classifier, as well as sensitivity and specificity equality. Positive predictive values were determined for each of the optimal cutoff points, and 95% confidence intervals were calculated using the exact binomial method. Data was analyzed using SAS (version 9.3 and 9.4; SAS Institute Inc, Cary, NC). A two-sample test of proportions was applied to the data to see if there was a statistically significant difference between the proportions of treatments to referral criterion of 1.50 D and 2.25 D. Comparisons, including scatterplots, were constructed in R (3.3.0; R Development Core Team, Vienna, Austria).

**Results**

Using the option 5 setting (1.50 D) referral criterion for astigmatism (Figure 1), dilated eye examinations were recommended for 1,067 children (26%). Of these, 117 were referred for astigmatism by the plusoptix S12. The mean age of children referred for astigmatism was 4.11 ± 0.59 years (standard deviation). Of those referred for astigmatism, 60 (51.3%) required treatment. The final decision for treatment was made by the respective optometrist or ophthalmologist’s cycloplegic refraction. Using the option 4 setting (2.25 D) for astigmatism, dilated eye examinations were recommended for 671 (16%) children. The mean age of these children was 4.22 ± 0.6 years. Of these, 136 were referred for astigmatism; 116 referrals (85%) required treatment. See Table 2.

The ROC analysis of the records from 56 statewide optometrists and ophthalmologists who performed dilated

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**Table 1. Referral criteria options for plusoptiX S12 and AAPOS guidelines**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Option 5</th>
<th>Option 4</th>
<th>AAPOS 31-48 months old</th>
<th>AAPOS ≥49 months old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anisometropia</td>
<td>≥1.00 D</td>
<td>≥1.00 D</td>
<td>≥2.00 D</td>
<td>≥1.50 D</td>
</tr>
<tr>
<td>Astigmatism Cylinder</td>
<td>≥1.50 D</td>
<td>≥2.25 D</td>
<td>≥2.00 D</td>
<td>≥1.50 D</td>
</tr>
<tr>
<td>Hyperopia</td>
<td>SE at least 2.50 D</td>
<td>SE at least 2.50 D</td>
<td>SE at least 4.00 D</td>
<td>SE at least 3.50 D</td>
</tr>
<tr>
<td>Myopia</td>
<td>SE ≤ -1.50 D</td>
<td>SE ≤ -2.25 D</td>
<td>SE ≤ -3.000 D</td>
<td>SE ≤ -1.50 D</td>
</tr>
</tbody>
</table>

D, diopter; SE, spherical equivalent.

*Studies pertinent to options 1-3 of the plusoptix S12 appear in their respective order in the references.15-17

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**FIG 1.** Bar chart of astigmatism referrals requiring treatment by the plusoptix S12 using the option 5 and option 4 settings. Solid blue represents referrals in which patients were prescribed treatment at the conclusion of a dilated eye examination, and solid orange lines represent referrals in which patients were not prescribed treatment.
examinations suggested two potential cutoff points for astigmatism: 2.00 D and 2.20 D (Figure 2). The referral criterion of 2.00 D produces a greater area under the curve, or the optimal balance between sensitivity and specificity. However, a cutoff at 2.20 D produces a slightly better positive predictive value. The cutoff point of 2.00 D produces a positive predictive value of 68.1% (95% CI, 56.9-81.3). The referral criteria of 2.20 D produces a positive predictive value of 69.1% (95% CI, 56.9-81.3) and a negative predictive value of 64.5% (95% CI, 52.6-76.4). Option 4 settings with a 2.25 D referral criterion for astigmatism should produce similar results, because 2.20 D is not an option on the plusoptiX S12.

Using the 1.50 D referral criterion (Figure 3A), only 51% of children referred for astigmatism were prescribed treatment. Of the 49% of children referred who were not prescribed treatment, the majority appear below the 2.25 D astigmatism referral criterion. If the 2.25 D astigmatism criterion had been utilized instead, 40% false positives (34.2%) would have passed the screening and not been referred for a dilated eye examination. With the 2.25 astigmatism referral criterion, there was a significant reduction in over-referrals who were not prescribed treatment (Figure 3B).

The accuracy of the astigmatism referrals by the plusoptiX S12 increased by 34% when using the 2.25 D astigmatism referral option: 85% of children referred for astigmatism using the 2.25 D criterion were prescribed treatment. The mean age of children in this analysis was 4.22 years old.

A two-sample test of proportions revealed that there was a statistically significant difference between the proportions of treatments to referrals when using an astigmatism referral criterion of 1.50 D or 2.25 D (P value of <0.0001).

Table 2. Potential astigmatism cutoff points using ROC analysis on dilated eye examinations

<table>
<thead>
<tr>
<th>Cutoff</th>
<th>PPV</th>
<th>95% CI</th>
<th>NPV</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>69.1</td>
<td>56.9-81.3</td>
<td>64.5</td>
<td>52.6-76.4</td>
</tr>
<tr>
<td>2.0</td>
<td>68.1</td>
<td>57.1-79.1</td>
<td>68.1</td>
<td>60.4-85.5</td>
</tr>
</tbody>
</table>

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

**Discussion**

The Elks Preschool Vision Screening Program’s goal is to achieve high-quality vision screening referrals. In our 2014 study, astigmatism was the most common reason...
for plusoptiX S12 false positives using the plusoptiX S12 1.50 D astigmatism setting (option 5). In 2014 only 51.3% of the astigmatism referrals were prescribed treatment. With the aim of improving the quality of our screening referrals for preschool children, the referral criterion for astigmatism was changed to option 4 setting of 2.25 D. The decision to change the astigmatism referral criterion to 2.25 was based on receiver operating curve (ROC) analysis of notes from statewide optometrists and ophthalmologists who performed dilated eye examinations. In order to make a decision based on high-quality eye examinations, only charts that recorded the type of dilating drop used were included in this study. The Elks Preschool vision screening 2-year data analysis represents real-world diagnosis and treatments prescribed by 86 different pediatric eye care providers. There were 23 unique ophthalmologists and 63 unique optometrists who participated in this study. On average, the ophthalmologists diagnosed 2.3 participants, and the optometrists diagnosed 3.1 participants. Only 53% of ophthalmologists and 50% of optometrists prescribed treatment when using the 1.50 D referral criteria. With referral criteria changed to 2.25 D, 72% of the ophthalmologists and 89% of the optometrists prescribed treatment. Overall, analysis of the 2.25 D astigmatism referrals showed that 85% of the referrals were prescribed treatment, a 34% improvement over the previous screening year. One possible reason for the improved accuracy of the 2.25 D plusoptiX S12 referral criterion for astigmatism may be the differences in the AAPOS studies used in finalizing their referral criteria. Sensitivity and specificity values are dependent on the populations from which the study groups are drawn. For example, we would expect a higher sensitivity in studies that draw from a pediatric ophthalmic setting population than one that draws a study group from the general pediatric population. The AAPOS recommendations for astigmatism referral criterion of 1.50 D for 49- to 60-month-olds may create an unacceptable level of over-referrals for large-scale vision screening programs. When screening children 48-60 months old with the plusoptiX S12, we will continue to use the 2.25 D for astigmatism to prevent over referrals.

The plusoptiX S12 option 4 referral criterion for astigmatism has reduced the number of Elks Preschool Vision Screening false positive referrals for astigmatism. Our data specifically applies to the 3- to 5-year-olds and cannot necessarily be extrapolated to other age groups. Our program recommends that children <3 years of age be screened during their well-child visits.

Acknowledgments

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References