

# Analysis on visual screening result of children aged 0–6 years old by using the SureSight automatic screening refractor in Binhu District, Wuxi City

Lun Zeng, Yan-Bing Wu, Xing Chen, Qing-Zhu Sun, Dan-Ying Zhou, Jian Shen

引用:曾论,吴雁冰,陈星,等. 无锡市滨湖区0~6岁儿童通过SureSight手持验光仪视力筛查结果分析. 国际眼科杂志 2022; 22(1):9-13

Department of Ophthalmology, Wuxi 9<sup>th</sup> People's Hospital Affiliated to Soochow University, Wuxi 214062, Jiangsu Province, China

Correspondence to: Jian Shen. Department of Ophthalmology, Wuxi 9<sup>th</sup> People's Hospital Affiliated to Soochow University, Wuxi 214062, Jiangsu Province, China. 63114973@qq.com

Received: 2021-01-13 Accepted: 2021-11-22

## 无锡市滨湖区0~6岁儿童通过SureSight手持验光仪视力筛查结果分析

曾论,吴雁冰,陈星,孙庆祝,周丹英,沈健

作者单位:(214062)中国江苏省无锡市,苏州大学附属无锡九院  
作者简介:曾论,毕业于南通大学,硕士,住院医师,研究方向:眼底病。

通讯作者:沈健,毕业于南京医科大学,硕士,副主任医师,研究方向:白内障专科. 63114973@qq.com

### 摘要

**目的:**了解无锡市滨湖区0~6岁儿童视力发育状况,为制定无锡市滨湖区儿童眼保健措施提供科学依据。

**方法:**对无锡市滨湖区3695名0~6岁学龄前儿童运用SureSight手持验光仪视力快速检测眼屈光状态,参照由美国伟伦公司提供的各年龄段屈光筛查转诊标准来确定筛查结果。并且在筛查视力的同时完成全面的眼部检查。

**结果:**视力筛查儿童总异常率为9.76%,可疑率为5.40%,我们发现随着幼儿年龄的增长异常和可疑检出率有上升趋势,并且各年龄段视力筛查结果有差异( $\chi^2=15.913, P=0.014$ ),但男孩和女孩之间无差异( $\chi^2=7.200, P=0.066$ )。在各个年龄组中视力异常比例最高的是散光(13.89%、17.96%、17.62%、11.50%),其次是远视(0.35%、1.91%、3.60%、8.86%)和屈光参差(0.69%、0.67%、1.64%、2.07%)。五种类型在各年龄段中分布的比例如下:远视(4.38%)、近视(0.82%)、散光(15.65%)、屈光参差(1.42%)和其他屈光问题(0.466%)。0~3岁学龄前儿童散光患病率为6.94%(95%CI:4.90%~9.00%),3~4岁为8.98%(95%CI:7.80%~10.20%),4~5岁为8.81%(95%CI:7.70%~9.90%),5~6岁为5.75%(95%CI:4.80%~6.70%)。在不同年龄组中散光患病率无差异( $\chi^2=0.872, P=0.929$ )。

**结论:**从我们的筛查结果中发现散光是学龄前儿童最常见的屈光不正类型,其次是远视和屈光参差,但我们并没有发现近视,从而证实了先前的研究,即近视并没有在早期发展。最后我们强调应定期实施学龄前儿童视力筛查,倡导社会重视学龄前儿童视力保护及眼睛的健康管理。

**关键词:**学龄前儿童;视力筛查;屈光不正;散光;屈光参差

### Abstract

• **AIM:** To provide a scientific basis for the development of children's eye health measures in Binhu District of Wuxi City by understanding the visual development status of children aged 0–6 years old in the region.

• **METHODS:** A total of 3695 children of 0–6 years old from preschool children in Binhu District received quickly check of eye's refractive status by using the SureSight automatic screening refractor, and determine the results by referring to the refractive screening referral standard norm for each age groups offered by the US Welch Allyn company. All participating preschool children have completed a vision screening and a comprehensive eye examination.

• **RESULTS:** The total of abnormal rate was 9.76%, suspicious rate was 5.40% in vision screened children, along with the age increase, the abnormal and suspicious detection rates had a tendency to rise, differences in vision screening results of each age group were statistically significant ( $\chi^2=15.913, P=0.014$ ), and differences between boys and girls had no statistical significance ( $\chi^2=7.200, P=0.066$ ). The highest proportion of abnormal vision was astigmatism (13.89%, 17.96%, 17.62%, 11.50%), followed by hyperopia (0.35%, 1.91%, 3.60%, 8.86%) and anisometropia (0.69%, 0.67%, 1.64%, 2.07%) in different age groups. Hyperopia (4.38%), myopia (0.82%), astigmatism (15.65%), anisometropia (1.42%) and any refractive (0.466%), these five types in the distribution of various age groups. The prevalence of astigmatism in preschool children in 0–3 years old were 6.94% (95%CI: 4.90%–9.00%) and the 3–4 years old were 8.98% (95%CI: 7.80%–10.20%), the 4–5 years old were 8.81% (95%CI: 7.70%–9.90%), the 5–6 years old were 5.75% (95%CI: 4.80%–6.70%). The prevalence of astigmatism in different age groups had no statistical difference ( $\chi^2=0.872, P=0.929$ ).

• **CONCLUSION:** Astigmatism was the most common type of ametropia in preschool children, followed by hyperopia and anisometropia. Although no myopia was

found, it confirmed the previous research that myopia was not formed at early age. Preschool children vision screening and eye care should be implemented regularly.

• **KEYWORDS:** preschool children; vision screening; ametropia; astigmatism; anisometropia

DOI:10.3980/j.issn.1672-5123.2022.1.02

**Citation:** Zeng L, Wu YB, Chen X, *et al.* Analysis on visual screening result of children aged 0-6 years old by using the SureSight automatic screening refractor in Binhu District, Wuxi City. *Guoji Yanke Zazhi(Int Eye Sci)* 2022;22(1):9-13

## INTRODUCTION

The development of the human eyeball is accompanied by the evolution of the refractive system. With the increase in age, the refractive state of children's eyes tends to gradually shift from hyperopia to myopia. The World Health Organization estimates that 80% of visual impairment can be prevented or cured by treatment. Globally, uncorrected refractive errors are the main cause of moderate and severe visual impairment<sup>[1]</sup>. Friedman *et al*<sup>[2]</sup> suggested that even if there is no obvious main complaint, no eye findings from a pediatrician, no significant family eye history, and no systemic risk factors, all 4-year-old children should receive a comprehensive eye examination by a pediatric ophthalmologist. If preschool children do not have a systematic and comprehensive eye examination, some diseases are easily overlooked, such as partial cataracts, small-angle strabismus, or unilateral vision loss. Some previous research results have proved that when pre-school vision screening is combined with corresponding treatment, the prevalence of amblyopia will be greatly reduced<sup>[3-6]</sup>. When examining children with ophthalmological or neurological problems, it is vital to know the normative data for a specific age and race. Refractive errors are the most common cause of children's vision loss. Several papers in different regions have documented the increasing rate of myopia<sup>[7-9]</sup>, and reports from Asia have also documented the development of early childhood myopia<sup>[10]</sup>. In recent studies, it has been found that the prevalence of amblyopia and hyperopia in preschool children is relatively high, but myopia is not found, which leads to the conclusion that myopia does not seem to be formed before the age of 10<sup>[11]</sup>. To understand the visual development of preschool children aged 0-6 years in Binhu District of Wuxi city. In this study, a total of 3 695 children were surveyed by census method from October 2019 to January 2020.

## SUBJECTS AND METHODS

**Ethical Approval** This research was reviewed by an independent ethical review board and conforms with the principles and applicable guidelines for the protection of human subjects in biomedical research. The survey followed the Helsinki Declaration and the Medical Ethics Committee of the Wuxi 9<sup>th</sup> Affiliated Hospital of Soochow University (No. LW2021028). All participants signed an informed written

consent. And all participants did not receive a stipend.

**Participants** A total of 3695 preschool children from Binhu District, Wuxi, China, were invited to participate in the vision screening project ( $n = 3695$ ). Finally, 3673 children completed the kindergarten screening and eye examination ( $n = 3673$ ). These children are invited to participate in the study, regardless of whether they have eye diseases or not. The children were screened by an experienced optometrist in the kindergarten, and then a more detailed examination by another optometrist from the Wuxi 9<sup>th</sup> Affiliated Hospital of Soochow University. Preschool children aged 0-6 are invited to participate in the vision screening program. The study was conducted from October 2019 to January 2020.

**Screening Method** Professionally trained ophthalmologists have finished the complete eye examinations for preschool child including red-reflex, external, the visual behavior, the uncorrected visual acuity, and use the U.S. Weilun SureSight handheld vision screener to perform diopter examinations. It is required that in the semi-dark room, the child mode is selected without the cycloplegia of the child, the working distance measured is 35 cm, and the child's eyeball is tested for diopter. Screener detection range: spherical lens is +6.00 D to -5.00 D, cylinder lens is +3.00 C to -3.00 C, when the detection range is exceeded, the screener displays  $\pm 9.99$ , no detection result. The number of scans of the screener  $\geq 6$  indicates good reliability. Binocular distance visual acuity was measured, uncorrected and recorded as decimal values for this study. Visual acuity is tested with the Standard Logarithmic Distance Visual Acuity E Chart (SLD-11-5m, Shang Hai), which is the most commonly used visual acuity charts in China, and the distance testing was performed at 5 m. Kay Pictures VA Chart (Kay Pictures Ltd, Tring, UK) was used, designed for children who cannot recognize the E chart. Children with abnormal screening results are notified to their parents to go to the ophthalmology department for further examination to confirm the diagnosis. Children whose screening results are in the suspicious range go to the ophthalmology clinic for follow-up review regularly.

**Criteria for Screening Results** The results are determined according to the latest norms of normal, suspicious, and abnormal eye refractive status screening for all age groups provided by Weilun Company. The specific standards are: S stands for spherical equivalent, C stands for cylindrical power<sup>[12]</sup>. The normal range of children aged 3-6  $+0.75 \text{ D} \leq S \leq +2.00 \text{ D}$ ,  $C \leq 1.00 \text{ D}$ ; Suspicious range  $+2.00 \text{ D} < S < +3.00 \text{ D}$  or  $+0.50 \text{ D} \leq S < +0.75 \text{ D}$ ,  $1.00 \text{ D} < C < 1.50 \text{ D}$ ; Abnormal range  $S \geq +3.00 \text{ D}$  or  $S < +0.50 \text{ D}$ ,  $C \geq 1.50 \text{ D}$ , where  $S \geq +3.00 \text{ D}$  is hyperopia,  $S < +0.50 \text{ D}$  is myopia tendency,  $C \geq 1.50 \text{ D}$  is astigmatism. If the child's visual acuity is below 0.5 at age 3 and below 0.6 at age 4, below 0.8 at age 5, below 1.0 at age 6, which is considered abnormal, and the child is referred to an eye clinic for a more thorough examination, including a new vision test, strabismus examination, fundus examination and refraction measurements. In our research, the normal refractive power is

**Table 1 Age and gender frequency distributions of the preschool children in the study**

Classification	Male	Female	<i>n</i> (%)
Age (y)			0.066
0-3	134 (46.53)	154 (53.47)	
3-4	572 (54.63)	475 (45.37)	
4-5	670 (52.47)	607 (47.53)	
5-6	580 (54.67)	481 (45.33)	
Total	1956 (53.25)	1717 (46.75)	

considered suspicious when the uncorrected vision acuity is abnormal. It is determined that as long as one eye has abnormal refractive power and poor uncorrected vision acuity, it is considered abnormal vision acuity.

**Statistical Method** We performed the analysis using SPSS 25.0 version (IBM, NY, USA). Categorical variables were analysed by the Chi-square test. Results were presented as the  $\bar{x} \pm s$  for continuous variables and as rates (proportions) for the categorical data. The  $\chi^2$  test was used to compare the impact of age, sex, the result of visual acuity screening, the prevalence of significant refractive error and the prevalence of astigmatism in different age groups.  $\chi^2$  tests with a 0.05 significance level were used when cluster effects were not significant. ORs and 95% CIs were also presented.

**RESULTS**

Among the 3695 preschool children, 3673 (99.40%) preschool children have completed the kindergarten screening and eye examination. After checking the data, 22 children were excluded as 17 with incomplete information and 5 beyond the age range of 0-6 years at the time of ocular examinations. The mean age of included participants was  $4.85 \pm 0.93$  years old and 53.25% were male ( $n = 1956$ ), 46.75% were female ( $n = 1717$ ). There is no statistical difference between men and women in each age group ( $\chi^2 = 7.200, P = 0.066$ ) (Table 1).

According to the results of our screening, the mean visual acuity of the right eye of 0-3 years old children is  $0.68 \pm 0.20$ , the left eye is  $0.68 \pm 0.22$ , and the mean visual acuity of the right eye of 3-4 years old children is  $0.73 \pm 0.23$ , the left eye is  $0.73 \pm 0.23$ , and the mean visual acuity of the right eye of 4-5 years old children is  $0.83 \pm 0.21$ , the left eye is  $0.82 \pm 0.21$ , and the mean visual acuity of the right eye of 5-6 years old children is  $0.91 \pm 0.21$ , the left eye is  $0.90 \pm 0.21$ .

The prevalence of each refractive error in different age groups was shown in Table 2. According to the result of visual acuity screening, 3116 preschool children were normal, 355 preschool children were diagnosed abnormal, 202 preschool children were diagnosed suspicious in different age groups by cyclopledic autorefractometry. The screening results showed that the detection rate of abnormal and suspicious were on the rise with the increase of age, and the difference in the composition of the visual acuity screening results of children in all age groups was statistically significant ( $\chi^2 = 15.913, P = 0.014$ ). Among different age groups, there is a statistical difference

between the abnormal group and the normal group ( $\chi^2 = 10.545, P = 0.014$ ), and there is no statistical difference between the other two groups ( $\chi^2 = 1.542, P = 0.677; \chi^2 = 6.020, P = 0.111$ ).

The prevalence of each refractive error in different age groups was shown in Table 3. Although there were no differences in the prevalence of myopia and any refractive among different age groups ( $\chi^2 = 4.050, P = 0.243; \chi^2 = 2.569, P = 0.466$ ), the prevalence of hyperopia, astigmatism, and anisometropia significantly increased with increasing age ( $\chi^2 = 79.055, 33.496, 9.029; P < 0.01, < 0.01, 0.028$ ), and increased fastest in children from 4-6 years old.

The Table 4 shows the result that the prevalence of astigmatism about 3673 preschool children (7346 eyes) in different age groups. The preschool children in 0-3 years old were 6.94% (95% CI: 4.90%-9.00%) and the 3-4 years old were 8.98% (95% CI: 7.80%-10.20%), the 4-5 years old were 8.81% (95% CI: 7.70%-9.90%), the 5-6 years old were 5.75% (95% CI: 4.80%-6.70%). The prevalence of astigmatism in all preschool children was 7.83% (95% CI: 7.20%-8.40%). The prevalence of astigmatism in different age groups had no statistical difference ( $\chi^2 = 0.872, P = 0.929$ ).

**DISCUSSION**

Many medical institutions recommend that preschool children undergo vision screening to detect children's vision problems and treat them at the same time<sup>[13-16]</sup>. Uncorrected severe refractive error is a common and serious problem<sup>[17-18]</sup>, especially in preschool children. Although refractive error screening programs are carried out all over China, the results of refractive errors have not received enough attention. Often some parents think that low-grade refractive error is normal and harmless in preschool children, so the doctor's advice is ignored. If it cannot be treated in time, it will have a serious impact on children's daily life. This not only causes eyestrain, headaches and poor academic performance, but also leads to amblyopia<sup>[17-19]</sup>. Strabismus and severe refractive error are the main risk factors for amblyopia<sup>[20-22]</sup>. In many countries, the purpose of children's vision screening programs is to detect and prevent serious vision problems that may affect education and daily life<sup>[23]</sup>, and to detect and treat amblyopia before it becomes incurable<sup>[1]</sup>. This project is effective for detecting serious vision threats, such as strabismus or other rare factors affecting vision.

The present study investigates the prevalence of vision screening in Binhu District of Wuxi city. Meanwhile, from the results of our comprehensive vision screening, it was found that 8 children had strabismus, 8 children had ptosis, 2 children had trichiasis, and 1 child had abnormal reflex. A comprehensive vision screening can not only find preschool children's vision problems, but also other eye diseases. The screening results of Table 3 showed that the detection rate of abnormal and suspicious were on the rise with the increase in age, and the preschool children have more and more vision abnormalities. According to the results of Table 4, we found the

**Table 2 The result of visual acuity screening in different age groups**

Classification	Visual acuity	Normal	$P^a$	Abnormal	$P^b$	Suspicious	$P^c$	$P$
Age (y)			0.014		0.677		0.111	0.014
0-3	0.5	265 (92.01)		13 (4.52)		10 (3.47)		
3-4	0.6	894 (85.39)		102 (9.74)		51 (4.87)		
4-5	0.8	1075 (84.18)		130 (10.18)		72 (5.64)		
5-6	1.0	882 (83.14)		110 (10.36)		69 (6.50)		
Total		3116 (84.84)		355 (9.76)		202 (5.40)		

$P^a$ : Comparison of normal group and abnormal group;  $P^b$ : Comparison of abnormal group and suspicious group;  $P^c$ : Comparison of normal group and suspicious group.

**Table 3 The prevalence of significant refractive error in different age groups**

Classification	0-3 years old	3-4 years old	4-5 years old	5-6 years old	All	$P$
Hyperopia	1 (0.35)	20 (1.91)	46 (3.60)	94 (8.86)	161 (4.38)	<0.01
Myopia	3 (1.04)	5 (0.48)	9 (0.70)	13 (1.23)	30 (0.82)	0.243
Astigmatism	40 (13.89)	188 (17.96)	225 (17.62)	122 (11.50)	575 (15.65)	<0.01
Anisometropia	2 (0.69)	7 (0.67)	21 (1.64)	22 (2.07)	52 (1.42)	0.028
Any refractive	2 (0.69)	9 (0.86)	14 (1.10)	16 (1.51)	41 (1.12)	0.466
Total	48 (16.66)	229 (21.88)	315 (24.66)	267 (25.17)	859 (23.39)	

Hyperopia: Spherical equivalent degree  $\geq 3.5$  D; Myopia: Spherical equivalent degree  $\geq 1.0$  D; Astigmatism: Cylinder degree  $\geq 1.50$  D with no significant spherical degree; Anisometropia was defined as  $\geq 1.5$  D interocular difference.

**Table 4 The prevalence of astigmatism in different age groups**

Classification	With astigmatism (n)	Without astigmatism (n)	Prevalence	95% CI	$P$
Age (y)					0.929
0-3	40	536	6.94	4.90-9.00	
3-4	188	1906	8.98	7.80-10.20	
4-5	225	2329	8.81	7.70-9.90	
5-6	122	2000	5.75	4.80-6.70	
Total	575	6771	7.83	7.20-8.40	

prevalence of astigmatism has the highest proportion, followed by hyperopia and anisometropia. The results of this study indicate that the prevalence of astigmatism and hyperopia and anisometropia significantly increases in preschool children. However, the Table 5 showed the results that the prevalence of astigmatism about 3 673 preschool children (7 346 eyes) in different age groups. This result indicates that the prevalence of astigmatism is very high in preschool children, and it has seriously threatened the development of young children's visual system. Furthermore, the visual impairment is becoming more and more serious in preschool children, thus warning parents, kindergarten teacher and ophthalmologists. In general, it was found from the results of vision screening that vision problems increased with age, similar to the results of previous reports<sup>[24-25]</sup>.

With the promotion of children's vision prevention work, astigmatism, as an important disease in the process of vision development, that uncorrected astigmatism can cause bilateral vision loss due to bilateral meridian amblyopia, which has attracted the attention of parents and medical staff<sup>[26]</sup>. Astigmatism is caused by uneven surface curvature of the refractive body, deviation of the optical center from the line of sight, or abnormal refractive power of the refractive body. Preschool children are prone to have a large range of astigmatism. Astigmatism not only manifests as low vision, but

also some patients have visual fatigue and visual distortion. Preschool children are in a sensitive period of visual development. Intensify the initial screening and establish a database of preschool children's visual development. It is of great significance for the detection and prevention of astigmatism. Medical workers and parents should pay close attention to the visual development of children. Preschool children are in a sensitive period of visual development. The present result is aim to intensify the initial screening and establish a database of preschool children's visual development. It is of great significance for the detection and prevention of visual impairment. Medical workers and parents should pay close attention to the visual development of children.

The research purpose of our project is to evaluate the importance of current vision screening and the possibility of combining it with other tests to be applied to the daily vision screening practice in our area. Once we find an abnormal or suspicious child, we need to recommend it to a special eye clinic for a further review. Early screening and early correction.

The revised WHO screening standards emphasize that a disease should be universal, treatment should be feasible and effective, screening should be cost-effective, and the overall benefit should outweigh the harm<sup>[27]</sup>. According to my

country's national conditions, paying attention to the vision problems of children and adolescents have become the main task of our country. Therefore, all our screening funds come from government funding.

In general, the strength of the current research lies in its large population size and detailed and accurate vision screening of all children. However, one limitation of this study is that it currently only includes kindergarten and preschool children, and they often have a good foundation of vision acuity<sup>[28]</sup>. At present, the research on vision screening for preschool children is mainly how to find the visual impairment or other children's visual system diseases that need to be treated during the critical or sensitive period of children's visual development. Our government has recently been involved in this project, attaching great importance to preschool children's vision screening to find relevant eye diseases that are essential for treatment, and to ensure that children are fully prepared for learning when they enter kindergarten or first grade. Ophthalmologists have in the past and should continue to lead the way in developing, testing, and advocating the implementation of effective, evidence based, cost-effective screening programs.

#### REFERENCES

- 1 Thorisdottir RL, Faxén T, Blohmé J, Sheikh R, Malmjö M. The impact of vision screening in preschool children on visual function in the Swedish adult population. *Acta Ophthalmol* 2019;97(8):793-797
- 2 Friedman LS, Kaufman LM. Guidelines for pediatrician referrals to the ophthalmologist. *Pediatr Clin N Am* 2003;50(1):41-53
- 3 Williams C, Northstone K, Harrad RA, Sparrow JM, Harvey I, ALSPAC Study Team. Amblyopia treatment outcomes after screening before or at age 3 years: follow up from randomised trial. *BMJ* 2002;324(7353):1549
- 4 Good WV. Vision screening in very young children-making sense of an inexorable diagnostic process. *JAMA Pediatr* 2017;171(11):1046-1047
- 5 Eppenberger L, Züst P, Kunz A, Scheitlin C, Heckmann J, Sturm V. Vision screening in children in the canton of St. Gallen. *Klin Monatsbl Augenheilkd* 2019;236(4):429-433
- 6 Lai YH, Tseng HY, Hsu HT, Chang SJ, Wang HZ. Uncorrected visual acuity and noncycloplegic autorefractometry predict significant refractive errors in Taiwanese preschool children. *Ophthalmology* 2013;120(2):271-276
- 7 Grönlund MA, Andersson S, Aring E, Hård AL, Hellström A. Ophthalmological findings in a sample of Swedish children aged 4-15 years. *Acta Ophthalmol Scand* 2006;84(2):169-176
- 8 Villarreal MG, Ohlsson J, Abrahamsson M, Sjöström A, Sjöstrand J. Myopia: The refractive tendency in teenagers. Prevalence of myopia among young teenagers in Sweden. *Acta Ophthalmol Scand* 2000;78(2):177-181
- 9 Larsson E, Holmström G, Rydberg A. Ophthalmological findings in 10-year-old full-term children - a population-based study. *Acta Ophthalmol* 2015;93(2):192-198
- 10 Dirani M, Chan YH, Gazzard G, Hornbeak DM, Leo SW, Selvaraj P, Zhou B, Young TL, Mitchell P, Varma R, Wong TY, Saw SM. Prevalence of refractive error in Singaporean Chinese children: the strabismus, amblyopia, and refractive error in young Singaporean Children (STARS) study. *Invest Ophthalmol Vis Sci* 2010;51(3):1348-1355
- 11 Sandfeld L, Weihrauch H, Tubaek G, Mortzos P. Ophthalmological data on 4.5- to 7-year-old Danish children. *Acta Ophthalmol* 2018;96

(4):379-383

- 12 Vernacchio L, Trudell EK, Nigrosh J, Focht G. Primary care implementation of instrument-based vision screening for young children. *Clin Pediatr (Phila)* 2018;57(9):1020-1026
- 13 Modest JR, Majzoub KM, Moore B, Bhamhani V, McLaughlin SR, Vernacchio L. Implementation of instrument-based vision screening for preschool-age children in primary care. *Pediatrics* 2017;140(1):e20163745
- 14 Nishimura M, Wong A, Dimaras H, Maurer D. Feasibility of a school-based vision screening program to detect undiagnosed visual problems in kindergarten children in Ontario. *CMAJ* 2020;192(29):E822-E831
- 15 Wallace DK, Morse CL, Melia M, Sprunger DT, Repka MX, Lee KA, Christiansen SP. Pediatric eye evaluations preferred practice pattern®: I. vision screening in the primary care and community setting; II. comprehensive ophthalmic examination. *Ophthalmology* 2018;125(1):184-227
- 16 Zimmerman DR, Ben-Eli H, Moore B, Toledano M, Stein-Zamir C, Gordon-Shaag A. Evidence-based preschool-age vision screening: health policy considerations. *Isr J Health Policy Res* 2019;8(1):70
- 17 Donahue SP, Arnold RW, Ruben JB. Preschool vision screening: what should we be detecting and how should we report it? Uniform guidelines for reporting results of preschool vision screening studies. *J Am Assoc Pediatr Ophthalmol Strabismus* 2003;7(5):314-316
- 18 Donahue SP, Arthur B, Neely DE, Arnold RW, Silbert D, Ruben JB. Guidelines for automated preschool vision screening: a 10-year, evidence-based update. *J Am Assoc Pediatr Ophthalmol Strabismus* 2013;17(1):4-8
- 19 Ugurbas SC, Kucuk N, Isik I, Alpay A, Buyukuyul C, Ugurbas SH. Objective vision screening using Plusoptix for children aged 3-11 years in rural Turkey. *BMC Ophthalmol* 2019;19(1):73
- 20 Pascual M, Huang JY, Maguire MG, Kulp MT, Quinn GE, Ciner E, Cyert LA, Orel-Bixler D, Moore B, Ying GS. Risk factors for amblyopia in the vision in preschoolers study. *Ophthalmology* 2014;121(3):622-629.e1
- 21 Sandfeld L, Weihrauch H, Tubaek G. Analysis of the current preschool vision screening in Denmark. *Acta Ophthalmol* 2019;97(5):473-477
- 22 Grossman DC, Curry SJ, Owens DK, et al. Vision screening in children aged 6 months to 5 years: us preventive services task force recommendation statement. *JAMA* 2017;318(9):836
- 23 Jin PY, Zhu JF, Zou HD, Lu L, Zhao HJ, Li QQ, He XG. Screening for significant refractive error using a combination of distance visual acuity and near visual acuity. *PLoS One* 2015;10(2):e0117399
- 24 Lillvis JH, Lillvis DF, Towle-Miller LM, Wilding GE, Kuo DZ. Association of state vision screening requirements with parent-reported vision testing in young children. *J Am Assoc Pediatr Ophthalmol Strabismus* 2020;24(5):291.e1-291.e6
- 25 Kemper AR, Wallace DK, Patel N, Crews JE. Preschool vision testing by health providers in the United States: Findings from the 2006-2007 Medical Expenditure Panel Survey. *J Am Assoc Pediatr Ophthalmol Strabismus* 2011;15(5):480-483
- 26 Vaughan J, Dale T, Herrera D, Karr D. Oregon elks children's eye clinic vision screening results for astigmatism. *J Am Assoc Pediatr Ophthalmol Strabismus* 2018;22(3):207-210
- 27 Andermann A, Blancquaert I, Beauchamp S, Déry V. Revisiting Wilson and Jungner in the genomic age: a review of screening criteria over the past 40 years. *Bull World Health Organ* 2008;86(4):317-319
- 28 Pan Y, Tarczy-Hornoch K, Cotter SA, Wen G, Borchert MS, Azen SP, Varma R, Multi-Ethnic Pediatric Eye Disease Study Group. Visual acuity norms in pre-school children: the Multi-Ethnic Pediatric Eye Disease Study. *Optom Vis Sci* 2009;86(6):607-612