ORIGINAL ARTICLE

Eastern Journal of Medicine
East J Med 28(3): 527-535, 2023
DOI: 10.5505/ejm.2023.59376

Proposal for a Common Nomenclature and Risk-Based Approach to Pediatric Eye Health Screening and Examinations: Why, Who, and How?

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ABSTRACT

Although the eye and visual system show structurally and functionally normal development in most infants, some may have pathologies that can result in moderate or severe vision loss. Many of these conditions can be treated if noticed in infancy or early childhood. Amblyopia is a relatively frequent entity and highly treatable, especially when recognized in the first years of life. Therefore, the early detection and timely treatment of all vision problems in infants, particularly amblyopia, is necessary to avoid preventable vision loss. Eye examinations in infants and children differ substantially from the standard adult eye examination. Therefore, the infant/child eye examination often cannot be performed with traditional methods. Describing all the procedures performed only as vision screening or eye examination is inadequate in some cases. Although the term "vision screening" is usually used, "eye health screening" is preferable for more comprehensive procedures. We recommend a new classification of infant and child eye screening and examinations into five distinct groups referred to as follows: eye health screening examination, instrument-based eye health screening, visual acuity screening, comprehensive eye examination, and preterm infant eye examination. We believe that this system can be implemented with little effort and may contribute to reduce preventable vision loss in future generations.

Keywords: Amblyopia, eye examination, pediatric eye health, vision screening

Introduction

Some eye and vision problems of infants and children may not be noticed by their families and pediatricians or family physicians in the early period (1-3). Vision loss caused by these unrecognized problems may lead to difficulties in life, including issues in education and employment (4). These problems are more common in countries with consanguineous marriage and inadequate pregnancy and neonatal care services. Therefore, it is generally accepted that eye health and vision examinations should be performed at appropriate times for all infants and children, especially at-risk infants with a higher likelihood of vision problems. These examinations should include methods that provide sufficient clinical information without causing the baby physical or psychological trauma or exposing them to unnecessary side effects of screening procedure. Thus, it may be possible to reduce preventable vision loss with an examination that is comfortable and safe for the baby, family, and physician (1,5).

There are differences between countries in the recommended timing and methods used in examinations to detect eye problems in infants and children. Screening or examination content, timing, and procedures vary according to nations' health systems and funding (6). It is seen that the terms *eye health*, *vision*, *screening*, and *examination* are used without due consideration of their differences and similarities. Another negative factor is some institutions' unwillingness to provide health funding to allocate sufficient resources to infant eye health screening. Even amblyopia, which causes vision loss in one eye, meets the World Health Organization screening criteria (7, 8). Although cost is an essential factor in health services, it is also necessary to consider the direct, indirect, and intangible costs of preventable visual and functional loss to the individual, family, and society (4,5,9). Considering the reasons stated above, there is an apparent

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Received: 19.12.2022, **Accepted:** 10.04.2023

need for methods that have a common language and are widely available and easily applicable, even in different regions and conditions, to reduce vision loss and blindness that can be prevented in childhood.

This article provides information for a safe and cost-effective pediatric eye health screening and examination program that can be implemented in nearly every country by ophthalmologists and family physicians/pediatricians. First, we propose a nomenclature to establish a common language in this area, then outline recommendations for when, by whom, and how these examinations and screenings should be performed. These recommendations can be quickly and easily implemented by pediatricians and family physicians, and even parents or school teachers. The recommended practices incorporate flexibility, and an ethical system is proposed in which the family participates in the decision-making process within the framework of the general health risks to the infant (10). Our objective is to reduce preventable pediatric vision loss and associated education and employment issues in an international context.

The Importance of Early Pediatric Eye Examination: In most infants, the eye and visual system develop within normal limits structurally and functionally. However, some infants have pathologies that may cause moderate or severe vision loss in one or both eyes. Although there are differences between countries, an estimated 19 million children worldwide are visually impaired, and 1.4 million children are blind (11). In a screening conducted by Turan et al. in schools for the visually impaired in Turkey in 2002, 962 students were examined, and macula-retinopathy was detected in 28.1%, congenital cataract in 16.3%, optic atrophy in 15.8%, globe problems in 12%, and glaucoma in 10.9% (12). In a more recent study, causes of visual impairment were reported as retinal dystrophy in 24.2%, premature retinopathy in 17.5%, congenital eye anomalies in 14.2%, congenital glaucoma in 11.7%, cortical blindness in 10%, and congenital cataract and albinism in 5.8% of cases (13).

Many of these conditions can be treated if noticed in infancy or early childhood. Another study conducted in Turkey in the early 2000s indicated that approximately two-thirds of childhood blindness was preventable (14). These studies reported conditions that cause severe bilateral vision loss, i.e., visual impairment. Besides these severe vision problems, amblyopia is also an essential condition for eye health screening. Amblyopia generally causes unilateral vision loss and occurs in approximately 2-2.5% of the population; in other words, it affects nearly one in every 40 to 50 people (15). Amblyopia is highly treatable, especially when recognized in the first years of life. Although individuals with amblyopia do not experience significant problems in daily life other than employment in areas such as the military, there is a greater likelihood of visual impairment due to conditions that affect the healthy eye (16). Therefore, the early detection and timely treatment of all vision problems in infants, especially amblyopia, is necessary to avoid preventable vision loss.

Nomenclature and Classification: Eye examinations in infants and children differ substantially from the standard adult eye examination. The infant/child eye examination often cannot be performed with traditional methods. This examination should be performed in a manner that includes flexibility based on the infant or child's age, development, cooperation with the examination, general health problems, existing risk factors for eye disorders, and the health risks associated with the examination itself. Therefore, describing all of the procedures performed only as *vision screening* or *eye examination* is inadequate in some cases. Vision is a function of the eye, and although it is an essential indicator of ocular health, it is only one screening parameter. The phrase *eye examination* has a broader connotation, suggesting that it provides an understanding of eye health beyond vision alone. For this reason, although the term *vision* is sufficient for screenings, the term *eye health* is preferable for more comprehensive procedures.

We recommend classifying infant and child eye screening and examinations into five distinct groups referred to as follows: *eye health screening examination*, *instrument-based eye health screening* (17), *visual acuity screening*, *comprehensive eye examination*, and *preterm infant eye examination*. As instrument examinations are not limited to vision screening, we prefer the expression *instrument-based eye health screening* instead of *instrument-based vision screening*. Furthermore, retinopathy is not the only ocular pathology seen in preterm infants; we like the broader description of *preterm infant eye examination* instead of specifying retinopathy of prematurity (ROP). We also consider it beneficial to refer to procedures conducted by eye care professionals qualified to perform eye *examinations* and those done by persons without this qualification as *screening* to clarify the difference between the two.

Eye health screening examinations can be

performed in a single session with an ophthalmoscope or a strong light source by a physician or others qualified to perform eye examinations and has no side effects for the infant. This examination should also include a binocular red reflex test (18). A comprehensive eye examination is performed in one or more sessions, sometimes under sedation, with all stages of the examination conducted by ophthalmologists. Although rare, some systemic side effects may occur during sedation or anesthesia (18); this procedure should be preferred only in high-risk conditions. Preterm infant eye examination (previously "ROP examination") refers to a method in which a blepharostat is used to keep the eyelids open and also to visualize the peripheral retina. It may cause some serious systemic side effects (19). Instrument-based and visual acuity screening is described as screening because non-health professionals can also perform them.

Classification of Patients by General Health Risk: In the system we propose, all infants are grouped as high, moderate, or low risk in terms of their likelihood of developing ocular diseases. The risk factors associated with each group, the recommended examination time and method, and their possible side effects and risks are presented in Table 1.

In our proposed system, every infant will undergo an eye health screening examination as part of the postnatal general health examination, performed with an ophthalmoscope (preferably) or a strong light source, as described in the Methods section below. This examination is performed by a pediatrician or family physician within the first month (preferably the first days) after birth. If any pathology is detected or suspected, the patient is referred to the ophthalmologist without delay. The program below is recommended according to the infant's eye health risk profile if no problems are detected in this examination.

It is known that ROP is still the most significant risk to infant eye health. Therefore, any infant at risk for ROP should be examined by an ophthalmologist experienced in preterm infant eye examination (ROP examination). Although there are different recommendations regarding ROP examination programs, a program similar to the one in the table below should be implemented within the framework of the recommendations of local health authorities or international working groups based on the country's conditions (20, 21). In addition to the general advice to perform ROP examination for infants with a gestational age of 32 weeks or less or a birth weight of 1500 g or less, it is also considered prudent to examine preterm infants who have received cardiopulmonary supportive treatment and those who the following clinician believes are at risk of developing ROP (20, 21).

The preterm infant eye examination should avoid systemic risks to the infant as much as possible. Although rare, serious side effects of mydriatic drops, eyelid opening tools (blepharostat/eye speculum), and ocular pressure can occur in these infants, especially those with systemic conditions. Significant and relatively frequent side effects include apnea, bradycardia, hypoxia, tachycardia, and emesis (19). Less severe side effects such as photophobia, skin redness, fever, and restlessness can also be seen. For these reasons, a preterm infant eye examination should only be performed on infants in the risk group, with the family's informed consent. The infant's family should be informed about the possible risks of the examination, and the informed consent form signed by the family should be included in the patient files. Moreover, it should be ensured that there is a medical environment and personnel who can intervene if serious side effects occur during ROP examinations performed in the first months of life.

After ROP, other high-risk conditions that warrant early eye examination are consanguinity, family history of early eye disease, and systemic/neurological problems in the infant (22). These infants should also undergo a comprehensive eye examination by an ophthalmologist within the first three months. These patients' examinations may not require inserting a blepharostat and applying pressure to the eye as in the ROP examination. Instead, examination with pupil dilation may provide sufficient information. The treatment and follow-up program for these infants should be determined by their initial examination findings and existing pathologies.

In our proposed system, the infant is considered low risk if they are not preterm and have no other systemic/neurological problems, prenatal or perinatal problems, and normal family history (Table 1). In this case, if the pediatrician or family physician detects no suspicious findings in the eye health screening examination performed after birth or within the first month, at around six months, we recommend a comprehensive eye examination or, if this is not possible, instrument-based eye health screening. This proposal differs slightly from the recommendation of examination

Fig. 1. Examination of the Anterior Segment of the Eye with an Ophthalmoscope

at around the age of 1 year that is widely accepted in the United States (18, 23). We recommend examination at around six months because examining infants is relatively more accessible than those around one year of age and older. Children between the ages of nine months and three years react to devices brought near their face, which causes difficulties when using the skiascopy rack and indirect ophthalmoscope lens. Suspicious findings in an uncooperative child necessitate examination under anesthesia. Especially children who remember experiences such as vaccination and blood collection react to eye examination between the ages of nine months and three years. Therefore, we believe it is crucial to perform the first eye examination at around six months and the latest nine months, when the examination is less traumatic for the infant. Refractive state and optic media pathologies can be determined more easily by skiascopy.

The second reason for recommending examination or at least instrument-based eye health screening before the age of about nine months is the early detection of anisometropia, which increases the likelihood of amblyopia. In the first months of life, infants develop rapidly in terms of visual function and are in the early stages of the "critical period" (24). In addition, since the infant is still under the close supervision of the mother or a caregiver, it is harder for babies to remove the occlusive tape used in the treatment of amblyopia. As the visual function of the infant's healthy eye is still not yet fully developed, and the difference in vision between the two eyes is not very pronounced, the infant is more likely to comply with occlusion therapy. When the child reaches the age of three to four years, occlusion therapy is often more difficult because the difference in visual function between the amblyopic and healthy eye is more pronounced, and there is less family supervision. Therefore, we believe that every infant should undergo their first

Fig. 2. Binocular Skiascopy for Simultaneous Examination of the Retinal Reflex of Both Eyes

comprehensive eye examination or at least instrument-based eye health screening, preferably at six months after birth or up to nine months.

If any pathology is detected in examinations performed in the first months, an ophthalmologist should determine and implement the follow-up and treatment program necessary for this pathology. If no pathology is seen in examinations performed within the first nine months, instrument-based eye health screening can be done until the age of three to 3.5 years, after which the child becomes cooperative with examination. Visual acuity, indispensable in adult eye examination, can be measured in children between three and four years. It is also rational to have the child and family work at home with the readily accessible "tumbling E" chart before the eye examination around the age of 3.5 years. Plan the first visual acuity examination when the child can perform this examination. Teachers in preschools can also perform visual acuity examinations to screen children who have not previously undergone an eye examination. Having teachers screen every child who enters preschool using pediatric visual acuity charts is beneficial.

Recommended Method for Pediatric Eye Examinations: Pediatricians/family physicians can perform an eye health screening examination in any newborn as part of the neonatal examination. We think it is unrealistic to expect pediatricians or family physicians to perform a complete eye examination of the infant or child (25, 26). However, even if only ophthalmologists can perform comprehensive eye examinations, all physicians can examine the anterior segment of the eye, the eyelids, and the eyebrows. An ophthalmoscope is used for fundus examination in this examination and magnifies the anterior segment to facilitate visualization (Figure 1). As shown in the figure, the ophthalmoscope is held so that one finger can move the dial and used with

Table 1. Proposed Eye Health Risk Groups and Recommended Examinations for Infants

Risk Group	Risk Factor	Examination Time	Examination Method and Examiner	Possible Side Effects and Risks
High Risk	Low birth weight* Low gestational age* Significant prenatal or perinatal pathology Down syndrome and neurological disorders Consanguineous parentage Family history of systemic disease of the eye or affecting the eye from infancy Hereditary and systemic disease	Within 4 to 6 weeks after birth (See Table 2 for preterm infants)	ROP examination if preterm by an ophthalmologist experienced in ROP examination, and comprehensive eye examination if other risk factors are present	The use of a blepharostat and the pressure applied may cause stimulation of the oculocardiac reflex stimulation, apnea, bradycardia, hypoxia, tachycardia, and emesis (19) Symptoms such as skin redness, fever, and discomfort are relatively common with the instillation of mydriatic drops
Moderate Risk	Family history of amblyopia or strabismus Distant consanguinity	Between 3-6 months, if the pediatrician/family physician did not detect any eye pathology in postnatal examination	Comprehensive eye examination by an ophthalmologist	Possible side effects of drops instilled in the eyes (19)
Low Risk	Normal pregnancy, birth, and growth/ development No history of ocular pathology in the family	Between 6-9 months, if the pediatrician/family physician did not detect eye pathology in the postnatal examination	Comprehensive eye examination by an ophthalmologist If that is not possible, instrument-based screening.	Possible side effects of drops instilled in the eyes (19)

*See Table 2

the light beam at its widest and medium intensity. Before approaching the infant, the physician adjusts the lens power of the ophthalmoscope until they can see their hand clearly from approximately 15-20 cm. Then they approach to within 10-20 cm of the infant, direct the light into the infant's eye, and adjust the ophthalmoscope dial until they can see the eye structures.

The physician notes whether the eyebrows and lids are symmetric and have normal structure and function. Because infants generally do not open their eyes in the first months, it may not be possible to evaluate eyelid and eye movements fully. However, the physician can hold the ophthalmoscope in one hand and open the infant's eyelids with the other hand to examine the conjunctiva/sclera, cornea, iris, and anterior lens. Although an ophthalmoscope is preferred for this examination, an eye health screening examination can also be performed if one is not available by directing a strong light source such as a mobile phone light into the eye and approaching the infant to a distance of 20-30 cm. The examiner inspects the cornea and pupil to detect any white/gray spots in the cornea or irregularity in pupil contour. If there is suspicion of an abnormal appearance, especially in the cornea, iris, and lens, the infant should be referred to the ophthalmologist without alarming the family.

The red reflex test is an essential part of the pediatric eye health screening examination (27). The red reflex test is observing light from the ophthalmoscope being reflected from the retina and appearing as a reddish color through the

Table 2. Timing of Infant Eye Examination According to Gestational Age (20)

Gestational age (weeks)	Initial Examination Postmenstrual age (weeks)	Time Chronological age (weeks)
22*	31	9
23*	31	8
24*	31	7
25	31	6
26	31	5
27	31	4
28	32	4
29	33	4
30	34	4
31	35	4
≥ 32	36	4

* Infants Born Before 25 weeks of Gestational Age Can Be Examined At Postnatal Six Weeks

pupil. In the first months of life, the pupil is miotic, and infants mostly sleep and do not look around, making it difficult even for ophthalmologists to view the red reflex. Therefore, pediatricians/family physicians may not be able to view the red reflex, especially in the first months. This should not be regarded as medical error or carelessness of the screener.

The red reflex test, which can be performed with an ophthalmoscope, facilitates the detection of conditions that cause severe vision loss, such as infantile cataracts. This test can be performed under optimum conditions when the baby can hold his/her head upright and look around (after about three months). Although the test is described in different ways, the most helpful information is obtained by simultaneously directing the ophthalmoscope light on both eyes from approximately 40-60 cm when the infant is awake with eyes open. In this examination, the ophthalmoscope lens is adjusted by turning the dial to focus on the physician's hand at 50 cm. In a dark or dim room, the physician opposite the infant directs the light simultaneously into both eyes from around 50 cm. A pink/red reflection should be seen in the pupils of both eyes when the light shines into them. The ophthalmoscope is adjusted to see this reflection, which may vary depending on gaze direction. Reflections that are symmetric in terms of roundness, shape, and color are considered normal. However, a black spot in either reflection may indicate a cataract, while unequal redness in the two eyes may be an indicator of pathologies such as advanced refractive error.

Although the red reflex test is beneficial, evaluating the reflections is difficult, especially without acquiring experience. To improve one's skills in this examination, clinicians can first gain experience in cooperative children over four years of age and then apply it to the younger age group. The benefit of this test can be enhanced by educating the family physicians and pediatricians who are expected to perform it.

Comprehensive Eye Examination in Infants and Children: Ophthalmological examination in infants, especially in the first months, begins with observing the anterior eye structures with an ophthalmoscope as described above. Although the anterior segment structures can be observed in more detail with a hand-held biomicroscope, this device is not always necessary when performing a healthy infant screening examination. The ophthalmologist checks whether the infant exhibits age-appropriate visual behaviors and again tries to view the red reflex with an ophthalmoscope. This is followed by an evaluation of bilateral refraction status, especially for the presence of anisometropia and ocular media transparency with skiascope/retinoscope. If the skiascope light is directed horizontally into both eyes from a distance of slightly more than 50 cm, the two reflections can be compared side by side. Afterward, the two eyes are scanned in succession with vertical light, and their skiascopy reflexes are compared simultaneously. This method, called binocular skiascopy (5), may facilitate the diagnosis of anisometropia (Figure 2). The infant eye examination should not be considered complete without skiascopy. After skiascopy, the optic nerve and central retina should be viewed by indirect ophthalmoscopy. If no risk factor is detected in the central and observed peripheral retinal areas during this

examination, inserting a blepharostat in an attempt to view the entire peripheral retina is not necessary and should only be performed after informing and obtaining consent from the family.

In the first examinations of infants in the group of infants at low risk in terms of eye health, conducted at around six months, families should be informed about the possible side effects of mydriatic drops, and a joint decision should be made about whether to examine with dilation. It is an ethical imperative to inform the family that mydriatic drops may cause side effects such as skin redness, fever, and restlessness, especially in the first three months of life (10). For families concerned about the side effects of mydriatic drops, skiascopy and indirect ophthalmoscopy (with 28-30 D lens) can also provide sufficient information without pupil dilation in most children older than three months. Performing instrument-based eye health screening for low-risk infants between 3 and 6 months, when they can hold their heads upright and look around, can also make an important contribution to identifying risk factors. We also consider it rational for a dilated eye examination in infants at low risk for eye disease and have no suspicious findings to be postponed to around six months of age, when side effects are less frequent.

Visual acuity screening at around 3.5 years of age can be performed in preschools as a screening program outside of health institutions. It may also detect pathologies in children who missed previous examination stages. Central health authorities or ophthalmologist organizations can also conduct screening programs by sending paper or digital charts to schools. Visual acuity screening can be performed by international standards after 3 in children. In this screening, the *E*'s are compared to a table, and the child indicates with their fingers which way the legs of the table are facing. Each eye is covered in turn, and the screener determines the smallest letter sequence the child can read from a distance of 4 m, wearing their glasses if applicable. Children who cannot read the 0.6 or 20/32 line are referred for an eye examination.

Another important topic related to infant and child eye health is instruments that perform automatic eye health screening (17). These devices provide essential information to both ophthalmologists and pediatricians/family physicians. These instruments are only eye health screening devices and have significant advantages, deficiencies, and limitations. The benefits are that screening can be performed relatively easily and quickly, enabling measurements to be obtained from afar in uncooperative children. Infants and children who cannot be measured with these instruments or have findings outside normal limits should also be referred to an ophthalmologist for examination without delay. In our proposed system, these instruments can be used for low-risk children at around six months and between the ages of one to three years, when routine eye examination is difficult. For infants in the low-risk group who undergo eye examinations between one and nine months and are determined to be within normal limits, these instruments can conduct yearly screening tests until the children are approximately 3.5 years of age. It should be noted that these devices only screen and must be combined with an eye examination to establish a diagnosis. Although these instruments have essential benefits, it should be kept in mind that they provide much less information than skiascopy/retinoscopy and ophthalmoscopy.

With simple changes in the daily practice of pediatricians/family physicians and ophthalmologists, vision losses caused by eye health problems in infants and children can be reduced. A meaningful way to achieve this is to establish a common language among pediatricians/family physicians and ophthalmologists and design and implement a consistent screening/examination system. A unified system that involves the relevant occupational groups and uses technological opportunities appropriately and cost-effectively while taking risk factors into account may enable the earlier detection of some critical eye problems. Using a risk-based approach, safe practices that take into account the views and expectations of the family without exposing infants to unnecessary side effects can be developed. Thus, the incidence of vision loss that may cause problems in adulthood can be decreased. Bilateral visual impairment due to preventable vision loss is a problem that must be overcome with the opportunities afforded by modern medical advances. With the strong cooperation between professions, it is possible to reduce vision loss in our future generations. To accomplish this, we propose a system that will overcome pediatricians' and family physicians' concerns about not being able to perform eye examinations properly. This system is also recommended for ophthalmologists to perform pediatric examinations with minimal difficulty and risk to the infant, family, and physician. We believe that this system can be

implemented with little effort and can reduce preventable vision loss in future generations.

Main Points

- Many ocular pathologies and childhood blindness can be prevented if noticed in infancy or early childhood.
- There are several infant and childhood eye screening programs to detect eye pathologies early. However, there is no consensus on when, by whom, and how they will be implemented.
- In this article, we have defined a new classification for childhood eye screening and examinations.
- We believe that this system can be implemented with little effort and can reduce preventable vision loss in future generations.

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