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The Sensitivity, Specificity and Predictive Values of Snellen Chart Compared to the Diagnostic Test in Amblyopia Screening Program in Iran

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Abstract

Introduction

Amblyopia is a leading cause of visual impairment in both childhood and adult populations. Our aim in this study was to assess the epidemiological characteristics of the amblyopia screening program in Iran.

Materials and Methods

A cross-sectional study was done on a randomly selected sample of 4,636 Iranian children who were referred to screening program in 2013 were participated in validity study, too. From each provinces the major city were selected. Screening and diagnostic tests were done by instructors in first stage and optometrists in second stage, respectively. Finally data were analyzed by Stata version 13.

Results

The sensitivity was ranged from 74% to 100% among the various provinces such that Fars and Ardabil province had maximum and minimum values, respectively. The pattern of specificity was differ and ranged 44% to 84% among the provinces; Hormozgan and Fars had maximum and minimum values, respectively. The positive predictive value was also ranged from 35% to %81 which was assigned to Khuzestan and Ardabil provinces, respectively. The range of Negative Predictive value was 61% to 100% which was belonged to Ardabil and Fars provinces.

Conclusion

The total sensitivity (89%) and negative predictive values (93%) of screening test among children aged 3-6 years is acceptable, but only 51% of children refereed to second stage are true positive and this imposes considerable cost to health system.

***Key Words*:** Amblyopia, Child, Iran, Sensitivity and Specificity, Screening.

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1- Introduction

Amblyopia, derived from the Greek word meaning "blunt or blurry vision," is commonly defined as defective Visual acuity (VA) not attributed to an overt pathologic cause(1). Amblyopia is a form of defective central visual processing, manifested as decreased visual acuity in one eye(2). It is a leading cause of visual impairment in both childhood (3-6) and adult populations (7, 8). Based on the different criteria and definitions, the prevalence of amblyopia among the preschool and school children ranged from 0.2% to 4.3% and 0.8 to 4.6%, respectively(9). Sources of variation in amblyopia prevalence estimates may be include the methods used to sample and screen the population, the response rate achieved, dominant age group in sample, and the extent of successful treatment in the population.

The risk of vision loss is increased 1.2% among the amblyopic children(10). Factors associated with vision loss include: hyperopia, astigmatism, anisometropia, and strabismus(11, 12). Amblyopia can be treated effectively in young children, if left uncorrected, this vision problem can lead to abnormal neurodevelopment of the vision system and then vision loss may be permanent(3). According to animal studies early detection and treatment of visual impairments is more effective than treatment later in life (13, 14). The early detection of amblyopia is by chance unless it is accompanied with strabismus. One of the options which could address this problem is screening. Currently there are great deal of suggestions and recommendations for identifying and diagnosis of childhood amblyopia; for example, some guidelines believe that comprehensive examination of all preschool-aged children should take by an ophthalmologist (15). Others guidelines suggest that vision screening can be conducted by a wide range of health professionals (e.g., general practitioners or nurses) (16).

Children age is one of the important factors in screening of amblyopia. Some ophthalmologists believe that 6 or 7 years is upper age limit for successful treatment while others consider 9 or 10 years (9, 17-20). In addition to the children age, the performance and epidemiological characteristics of the screening test (sensitivity, specificity, negative predictive value and positive predictive values) should be regarded and if one of these factors was not met resulting to the ineffective screening test.

In spite of availability of large number of screening tests, there is little information about the effectiveness and diagnostic accuracy of these tests. To be effective, a screening test most have high sensitivity (identify a high proportion of children who have the target condition) and high specificity (identify a high proportion of children without any visual disorders). The amblyopia screening test has begun from 1996 in Iran, but its epidemiological characteristics were not assessed yet. So, our aim of this study was to assess the epidemiological characteristics of the amblyopia screening program in Iranian provinces, 2013

2- Materials and Methods

2.1-Screening program

The vision disorder screening program in Iran was intoduced from 1996 and is continued to the present (21). Preschool children aged 3-6 years old were screened in two stages. In the first stage, screening was done by one of the instructors including: preschool health staff, or Behvarz, and or staffs of Non Governmental Organizations. The suspected children diagnosed in the first stage were referred to second stage. The referred patients were screened by optometrist. Finally, optometrist confirmed children was referred to ophthalmologist

for full diagnostic and treatment evaluations (Figure.1).

Screenig program was done using the two types of centes; temporary and permanent ones. The temporary centers including kindergartens and Health Houses were public and non-public organizations which screened the children periodically during the November and Decembers 2013. The screened children in this centers were aged 3-6 years. The permanent centers were public and non-public which screened the children aged 3-6 years using the E-chart and vision screening device.

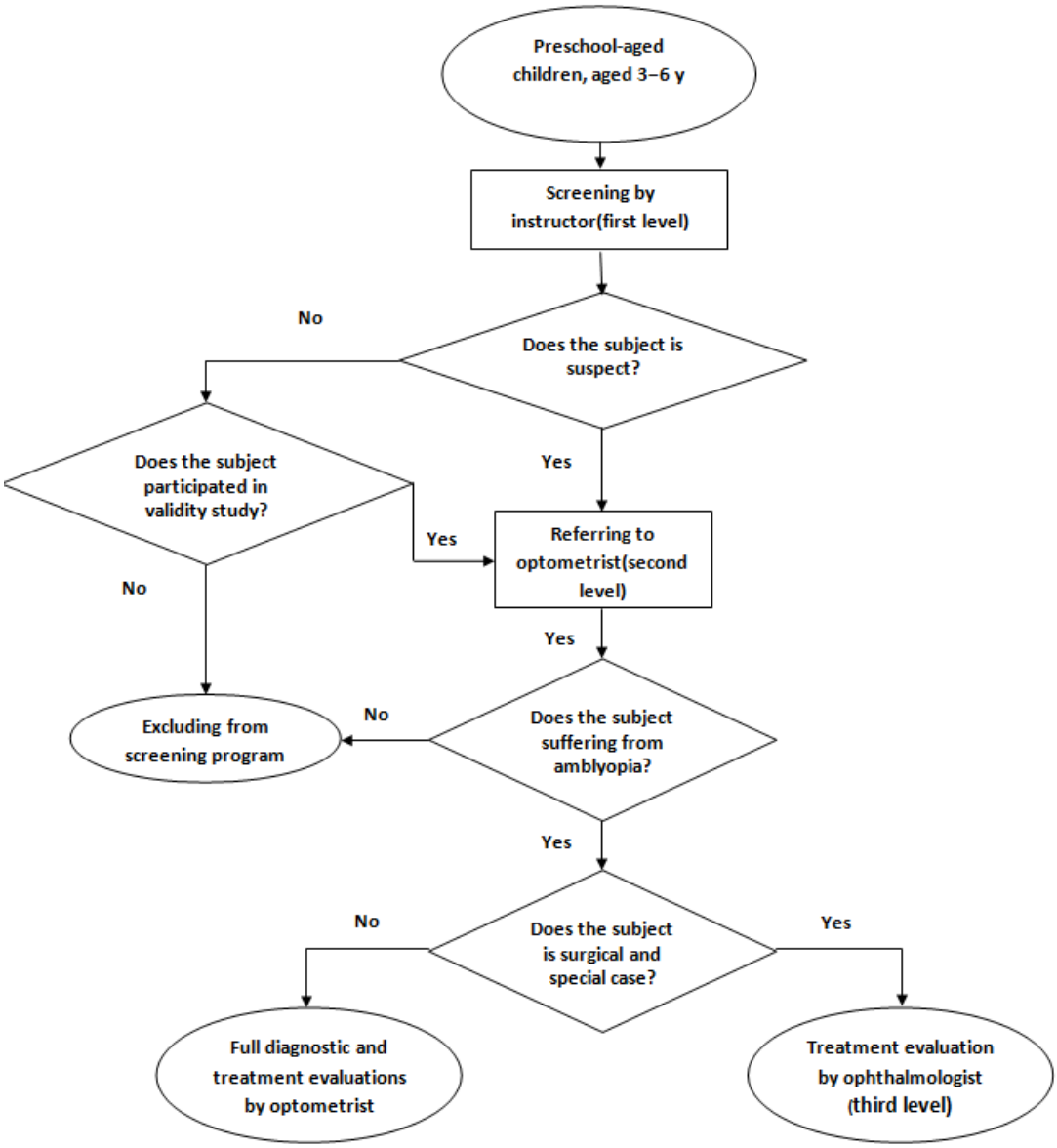

Fig.1: Flow-diagram of the validity study in the screening program

2.2-Validity study

In order that most of children with amblyopia risk factors never develop amblyopia, the progress and validation of screening practices that can recognize children with amblyopia or strabismus directly would be a major advance(12). In this work validity study was designed to determine the sensitivity, specificity, positive predictive value, and negative predictive value of Snellen chart screening test in comparison to the diagnostics tests in 13 out of the 31 provinces in Iran. Screening tests were done by instructors in first stage and diagnostics test were done by optometrists in second stage.

2.3-Selection of centers and children

A cross-sectional study was done on 4,636 children (a randomly selected sample of children) who were referred to screening program during the November and Decembers 2013. The major city of provinces was preferred to include in the design. The coverage rate for each province to include in validity study was determined regarding to the percent of suspected children in the same province. At least fifty suspected children was needed for including the province in the study; for example if the percent of suspected children is 10% in specified province, the 500 children was needed to include and attained 50 suspected ones.

The centers listed according to the number of the cover aged children and an ID number was assigned to each of the centers. First center was selected among the first twenty centers using the random digit table. Then systematic sampling was used in a way centers were selected fifty by fifty. The selection of centers was continued until reached to centers less than fifty suspected children. This selection process was repeated more than one time to reach anticipated sample size. This method ensured that all types of center were included in the study. Suspected children in each center were completed the optometrist form and referred to second stage. Some of the healthy children were also referred to second stage to use for validity study (Figure.1).

2.4-Amblyopia definition

In this study, patients suffering from Amblyopia and those suspected to suffer were classified as any amblyopia. According to the Multi-Ethnic Pediatric Eye Disease Study (MEPEDS), amblyopia is an eyesight disorder which is divided into unilateral and bilateral subtypes (22). Unilateral amblyopia is a 2-line difference in presentation of VA between 2 eyes with where the eye with the poor eyesight has a rating of ≤ 20/32. Unilateral ambylopia is associated with several factors including, constant or intermittent strabismus, strabismus surgery history, consistent anisometropia associated with the affected eye (≥ 1.00 diopter (D) spherical equivalent (SE) aniso-hyperopia, ≥ 3.00 D SE anisomyopia, or ≥1.50 D anisoastigmatism) and/or evidence of past or present vision axis obstruction for ≥1 week (e.g., cataract, pseudophakia, aphakia, significant corneal opacity, ptosis, or eyelid hemangioma). Bilateral amblyopia is a bilateral reduction in VA presentation due to history of either obsruction in bilateral vision axis or significant bilateral ametropia (≥4.00 D SE hyperopia, ≥6.00 D SE myopia, or ≥2.50 D astigmatism). The inclusion criteria of this study involved those with a previous history of amblyopia or amblyopia treatment. The exclusion ctieteria consist of children who suffering with fundus or anterior segment abnormalities. These cases were not considered amblyopic.

2.5-Statistical analysis

The epidemiological characteristic of screening program was obtained from the studied provinces and then were analyzed by Stata version 13.

3- Results

The validity determination of Snellen chart screening test was done among the 4,636 children referred to one of the studied centers. As can see in (Table.1) the sensitivity was ranged from 74% to 100% among the various provinces such that Fars and Ardabil province had maximum and minimum values, respectively. The pattern of specificity was differ and ranged from 44% to 84% in the provinces; Hormozgan and Fars had maximum and minimum values, respectively. The positive predictive value was also ranged from 35% to 81% which was assigned to Khuzestan and Ardabil provinces, respectively. The range of Negative Predictive value was 61% to 100% which was belonged to Ardabil and Fars provinces. The total sensitivity, specificity, positive predictive value, negative predictive value was 89%, 62%, 51% and 93%, respectively (Table.1). Also, the percentage of true positive, false negative, true negative and false positive by the provinces was reported in (Figure.2).

Table 1: The sensitivity, specificity, positive predictive value, and negative predictive value of Snellen chart screening test compared to the diagnostic test in provinces, 2013

Province	Optometrist / Instructor	Amblyopic	Healthy	Total	Sens	Spec	PPV	NPV
Isfahan	Suspected	140	159	299	90%	64%	47%	95%
	Healthy	15	284	299				
	Total	155	443	598				
Fars	Suspected	74	126	200	100%	44%	37%	100%
	Healthy	0	100	100				
	Total	74	226	300				
Hamedan	Suspected	136	64	200	84%	73%	68%	87%
	Healthy	26	174	200				
	Total	162	238	400				
Kerman	Suspected	157	43	200	95%	77%	78%	95%
	Healthy	8	142	150				
	Total	165	185	350				
Yazd	Suspected	104	66	170	99%	69%	61%	99%
	Healthy	1	149	150				
	Total	105	215	320				
Hormozgan	Suspected	42	12	54	93%	84%	77%	95%
	Healthy	3	63	66				
	Total	45	75	120				
Gilan	Suspected	28	172	200	96%	47%	14%	99%
	Healthy	1	149	150				
	Total	29	321	350				
Ardabil	Suspected	162	38	200	74%	71%	81%	61%
	Healthy	58	92	150				
	Total	220	130	350				
Bushehr	Suspected	114	86	200	96%	70%	57%	97%
	Healthy	5	195	200				
	Total	119	281	400				
Chahammahal and Bakhtiari	Suspected	85	115	200	89%	62%	43%	95%
	Healthy	10	190	200				
	Total	95	305	400				
Khuzestan	Suspected	70	130	200	87%	52%	35%	93%
	Healthy	10	140	150				
	Total	80	270	350				
North Khorasan	Suspected	72	127	199	94%	60%	36%	97%
	Healthy	4	195	199				
	Total	76	322	398				
Lorestan	Suspected	73	77	150	88%	64%	49%	93%
	Healthy	10	140	150				
	Total	83	217	300				
Total	Suspected	1257	1215	2472	89%	62%	51%	93%
	Healthy	151	2013	2164				
	Total	1408	3228	4636				

Sens: Sensitivity; PPV: Positive Predictive Value; Spec: Specificity; NPV: Negative Predictive Value.

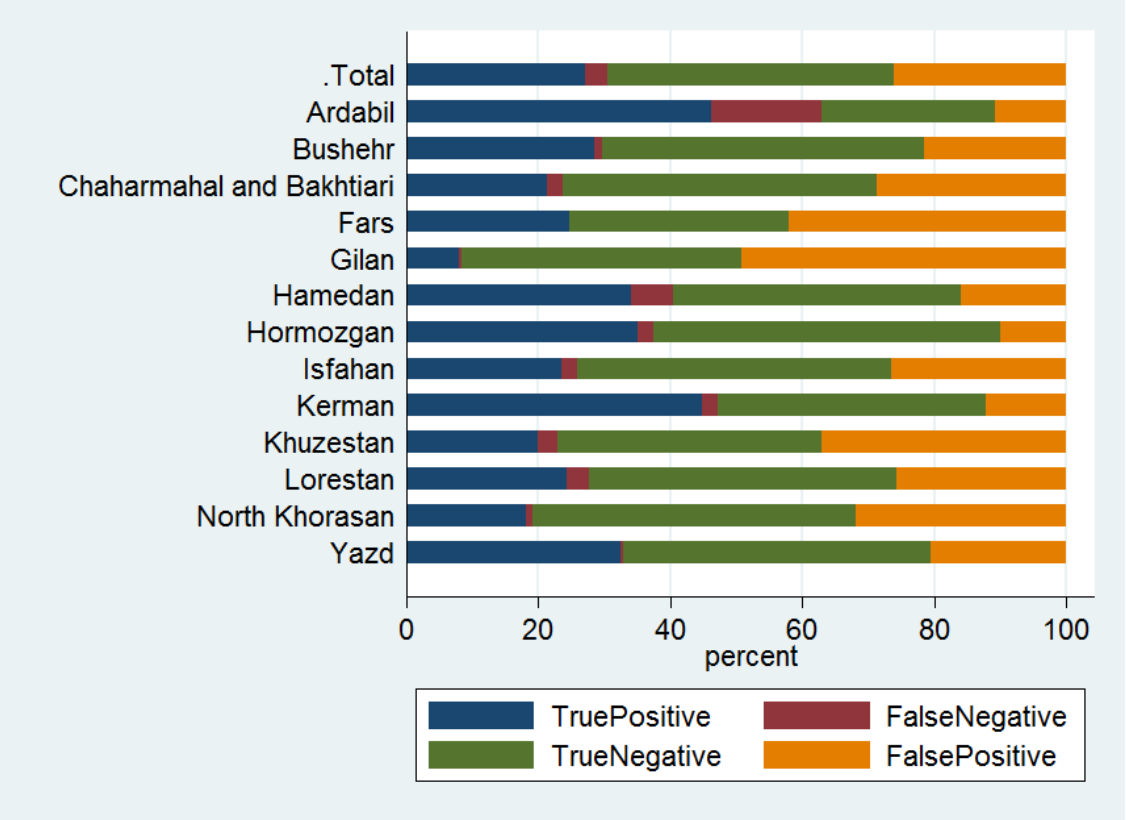

Fig. 2: The percentage of true positive, false negative, true negative and false positive in the screening of amblyopia among the some provinces of Iran

4-Discussion

Out of 31 provinces, 13 provinces of Iran were selected to be studied in the validity study. About 4,636 subjects in this study were selected from who referred to screening program during November and December in 2013. The four validity indexes were differ by provinces; the difference between the predictive values is being attributed to factors including prevalence, to some extent. Among the high prevalence provinces the high positive predictive values is expected. The sensitivity and specificity of test is independent of prevalence and is related to education of instructors and their adherence to research protocol.

The total sensitivity for all provinces was appropriate (89%), but it was ranged from 74% to 100% for Ardabil and Fars provinces, respectively. The total specificity for all provinces was 62% and it was ranged from 44% to 84% for Fars and Hormozgan, respectively. The total positive predictive value was 51% and it was ranged from 14% to 81% for Gilan and Ardabil provinces, respectively. The total negative predictive value was 93% and it was ranged from 61% to 100% for Ardabil and Fars provinces, respectively. It is obvious that there is a trade off between these indices such that when the sensitivity is being increased the specificity and positive predictive values will be decreased.

For example in Gilan, the sensitivity of screening test by instructors is 96% and this means that the high proportion of amblyopic patients were identified and involved in the screening program but on the other hand false positive cases will be increased. The increment in false positives

led to less proportion of true positive cases to false positive cases and means that less proportion of positive screening results are true positive, decrease in positive predictive value. Also, it also notable that when the false positive cases increase the proportion of true negative cases to false positive cases decreased and led to lower specificity of test. This relationship between the indices could be extrapolated to other provinces, too.

It is important that studied outcome should be considered in the trade off between the indices; for example high sensitivity and low specificity should not be suggested in diseases with stigma but could be more useful in disease with no stigma and disease which early detection prevent from more sever outcomes. On the other hand it should be considered when the sensitivity is high the more false positive cases will be referred to second stage in the screening program and the program cost will be increased. Amblyopia is disease which has no stigma and early detection is important and if left uncorrected, this vision problem can lead to abnormal neurodevelopment of the vision system and then vision loss may be permanent and screening test with high sensitivity is suggested, provided that economical aspects is considered.

Our findings showed that total sensitivity of screening test is acceptable (89%), but the positive predictive value (51%) is not acceptable. This means that 89% of cases in the population could be identified in this screening program totally, but among the positive screening results only 51% are true positive and the rest of them were referred to second stage incorrectly which impose considerable additional cost to health system. This findings confirmed by study has been done by Heshmat et al. to assess the amblyopia screening test among the children aged 6-10 years. They found that the sensitivity, specificity, positive predictive value and negative predictive value were 95%, 60%, 42% and 97%, respectively(23).

Other study has been done by Fotouhi et al. to assess the validity of screening program of vision disorders (not specifically amblyopia) among the children aged 7-14 years did not confirm our findings and showed that the sensitivity and specificity, positive predictive value and negative predictive value of were 25%, 97%, 13% and 98%, respectively(24). This means that amblyopia screening program has high sensitivity and low positive predictive value among the children aged less than 6 years and impose additional cost to health system, but among the children more than 6 years it has very low sensitivity and considerable proportion of amblyopic children were not identified. Low positive predictive value was also could be attributed to low prevalence of amblyopia among the children more than 6 years.

Several aspects of this study can limit the application of the findings: first, cross-sectional nature of the study can only act as evidences for the relationship between the independent variables and cigarette visual impairment and does not show the causality; and the second, despite using quite satisfactory methodology and sampling method, generalization of the study results is limited to the children of selected cities.

5-Conclusion

It could be concluded that, the sensitivity and negative predictive values of screening test among children aged 3-6 years is acceptable. About 51% of children refereed to second stage are true positive and this imposes considerable cost to health system. Due to this percent of positive predictive values, considerable proportion of amblyopic children were not recognized. As a highly sensitive possible, workshops are suggested for instructors to

promote positive predictive value with highly sensitive.

6-Funding

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7-Authors' Contributions

All of the authors participated in this study equally.

8-Conflict of Interest: None.

9-Acknowledgments

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