Prevalence and sociodemographic factors associated with amblyopia in preschool children

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Abstract

Objective: to estimate the prevalence of amblyopia and its treatment in preschool children in the province of Alicante over a long time period, and assess the influence of different sociodemographic factors.

Methods: cross-sectional descriptive observational study (2002-2015) using a validated amblyopia detection protocol (sensitivity, 89.3%; specificity, 93.1%) in preschool children aged 4 to 6 years. The primary outcome was the classification of the 140 102 examined children based on the test results («normal», «suspected amblyopia» or «in treatment») and the explanatory variables: age, sex, school year, private/public ownership of school and school location.

Results: the prevalence of children with suspected amblyopia varied significantly between school years, ranging from 8.54% to 23.9% (p=0.00000). The prevalence of suspected amblyopia was significantly higher in children aged 6 years (16.68%; p=0.00000) and lowest in those attending private schools (8.05%; p=0.00000). The probability that a child with abnormal results was already in treatment increased with age (OR 2.06; p<0.001) and with enrolment in a private school (OR 1.56; p=0.001).

Conclusions: the prevalence of suspected amblyopia was high in the study area, with a higher risk in older children and children in to the lowest socioeconomic status group. School-based screening programs for early detection of amblyopia are recommended to increase and equalize access to treatment, thereby reducing the prevalence and severity of amblyopia in children.

Key words:
- Amblyopia
- Primary health care
- Visual acuity
- Visual impairment

Prevalencia y factores sociodemográficos asociados a la ambliopía en población preescolar

Resumen

Objetivo: estimar la prevalencia de la ambliopía y su tratamiento en niños de preescolar de la provincia de Alicante (España) durante un periodo de larga duración, así como la influencia de diferentes factores sociodemográficos.

Material y método: estudio observacional descriptivo transversal (2002-2015) mediante protocolo de detección de ambliopía validado (sensibilidad 89,3%; especificidad 93,1%) en niños escolarizados de 4 a 6 años. La variable principal fue la clasificación, de los 140 102 niños examinados, según el resultado de las pruebas ("normales", "sospechosos de patología" o en "tratamiento previo") y las variables explicativas: edad, sexo, curso escolar, tipo de gestión del colegio y su ubicación.

Resultados: la prevalencia de niños con sospecha de ambliopía osciló significativamente, entre los cursos escolares, desde 8,54% hasta 23,9% ($p = 0,00000$). Los niños de 6 años presentaron valores de sospecha de ambliopía notablemente más altos (16,68%; $p = 0,00000$) y los niños matriculados en colegios privados, los más bajos (8,05%; $p = 0,00000$). La probabilidad de que un niño "no-normal" estuviera ya tratado aumentaba con la edad (OR 2,06; $p < 0,001$) y con el hecho de asistir a un colegio privado (OR 1,56; $p = 0,001$).

Conclusiones: la prevalencia de la sospecha de ambliopía fue alta en el área de estudio, siendo los niños de mayor edad y los niños pertenecientes al grupo de nivel socioeconómico más bajo los de mayor riesgo. Los programas de cribado escolar para la detección temprana de la ambliopía son recomendados para aumentar y equiparar la probabilidad de acceso al tratamiento, reduciendo así la prevalencia y la gravedad de la ambliopía en niños.

Palabras clave:
- Agudeza visual
- Ambliopía
- Atención primaria
- Disfunción visual

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INTRODUCTION

Amblyopia is defined as the reduction of best-corrected visual acuity (VA) of eyes with normal morphology.[1,2] It occurs at early ages in childhood and results in abnormal development of the cortical visual pathway.[1] The most common risk factors are strabismus and refractive errors.[2]

There are appropriate treatments for amblyopia, especially when it is not associated with a structural disorder and is detected early.[1-3] It is considered the leading cause of monocular visual disability in children and young adults in Europe.[3,4] Its prevalence ranges from 1% to 5% worldwide,[5] and has been estimated at 7.5% in the specific case of Spanish children aged 3 to 6 years.[6] The lack of consistency between studies may be due to differences in the characteristics of the study population, the VA criteria or the methodology employed.[3] As far as we know, long-term studies on the prevalence of amblyopia in children had yet to be conducted in Spain.

The objective of this study was to estimate the prevalence of amblyopia and its treatment in preschool children in the province of Alicante through the implementation of school-based paediatric vision screening campaigns, and how they changed between 2002 and 2015, in addition to assessing the influence of various sociodemographic factors.

MATERIALS AND METHODS

Paediatric vision screening campaigns

We conducted a cross-sectional observational descriptive study at annual intervals to assess the impact of amblyopia in the preschool population in the province of Alicante (Spain) through vision screening campaigns carried out by the Fundación Jorge Alió. The tests were performed by a team of optometrists under the direction of ophthalmologists in 13 consecutive school years (2002-2015) and on children aged from 4 to 6 years enrolled in early childhood education centres in the province of Alicante in urban (population greater than 25 000, 74.2%), semi-urban (10 000 to 25 000, 8.2%) and rural areas (less than 10 000, 17.6%).

Based on the results obtained in the screening tests, the children were classified as "normal" cases (no impairment suggesting a visual abnormality), "suspected" and yet untreated amblyopia cases (VA was below the standard value for the child's age[7]; an impairment was detected in ocular alignment or motility or the child did not pass the stereopsis test[2]) or "in treatment" (children with a previous diagnosis already receiving ophthalmological treatment).

The exclusion criteria were lack of express consent from the parents/guardians, absence from school on the day of testing and lack of cooperation with testing. In each annual screening campaign, children aged 4, 5 and 6 years newly admitted to participating schools were assessed, in addition to any children who had been classified as a suspected case in the previous year's campaign.

This study adhered to the principles of the Declaration of Helsinki and followed all the applicable institutional and governmental regulations in relation to the ethical use of human volunteers in medical research.[2]

Vision screening

The following were performed: (a) VA test at a distance of 3 m with Lea symbols (house, apple, square and circle), in logarithmic progression of decreasing size from 0.1 to 2.0[8]; (b) visual axis alignment study using the test of covering and uncovering the eye (cover test)[9]; (c) external eye examination with a torch, assessing the eyelids, corneal transparency, anterior chamber structures and pupillary glow (ruling out leukocoria)[9,10] and (d) TNO random-dot stereogram test with red and green spectacles to measure stereopsis.[9]

The reliability of the tests used in the screening was validated by Casas-Llera et al.[2] in a previously published study (sensitivity 89.3%, specificity 93.1%, positive predictive value 83.3%, negative predictive value 95.7%, positive likelihood ratio 12.86 and negative likelihood ratio 0.12).

Data processing

To better reflect the source population of the database, we cleansed the data by identifying the first visit for each child and excluding subsequent visits in "suspected" cases.

The primary outcome was the ophthalmological classification based on the screening results ("normal", "suspected" and "in treatment").

Starting from this classification, we established two binary (yes/no) outcome variables: (a) the abnormal results variable (grouping "suspected" and "in treatment" participants into a single "abnormal" category) and (b) the "in treatment" variable (which took the value "yes" in participants in treatment and "no" in untreated suspected cases, without assigning a value to participants with normal screening results, as they did not require treatment).

The explanatory variables were age (4, 5 or 6 years), sex, school year (2002 to 2015), location of school (rural, semi-urban or urban) and type of school (public, private with state subsidy, private).

Statistical analysis of the data

We summarised screening results by calculating the relative frequency of each category in each explanatory variable. We then compared these percentages by means of the χ^2 test.

In the graphic analysis of time trends, we calculated the proportion of proportion of participants in each school year that corresponded to each possible screening result, in addition to the age distribution of participants.

We also fitted two multiple logistic regression models, one for each of the established binary outcome variables, to assess which of the explanatory variables under study could be associated to abnormal vision in the child or to already being in treatment at the time of enrolment in the study.

RESULTS

The study included a total of 140 102 children, tested and classified according to the screening results. Tables 1 and 2 present the distribution of the sample by school year, sex, age, location and type of school.

Over the course of the 13 annual screening campaigns, we observed substantial differences in the proportions of children categorised as "normal", "suspected" or "in treatment" (Table 1). Thus, the prevalence of "suspected" cases ranged between 8.54% and 12.12% in the first six campaigns. However, from this proportion gradually increased from the 2008-2009 school year, peaking at 23.89% in the 2011-2012 school year. Similarly, we observed an increasing trend in the proportion of children "in treatment" from the 2008-2009 school year onwards (Table 1) (Fig. 1).

Suspected amblyopia was not associated with sex; the proportions were very similar in boys and girls (12.84% and 12.52%, respectively) (Table 2). It is worth highlighting that the proportion of suspected cases was notably higher in children aged 6 years compared to those aged 4 and 5 years (Table 2).

Moreover, we found a weak association between the setting of the school and the prevalence of suspected amblyopia. The prevalence was lower in rural areas (12.23%), and slightly higher in urban and semi-urban areas (12.81 and 12.97% respectively) (Table 2).

The type of school had a significant effect on the prevalence of suspected cases. It was lowest in private schools (8.05%). At the same time, the proportion of children in treatment was considerably lower in public schools (4.02%) (Table 2).

To identify the factors associated with abnormal test results and the probability of being in treatment, we conducted two logistic regression analyses, each corresponding to one of the dichotomous outcome variables: (a) comparison of children with normal and abnormal results (with the latter encompassing the "suspected" and "in treatment"

Table 1. Distribution (%) of children into "normal", "suspected" and "in treatment" categories by school year

Variables	Normal		Suspected		In treatment	
School year	%	n	%	n	%	n
2002-2003	82.17%	13 731	12.12%	2025	5.71%	955
2003-2004	87.46%	13 902	8.54%	1358	3.99%	635
2004-2005	86.07%	12 755	9.94%	1473	3.99%	592
2005-2006	87.72%	13 162	9.10%	1366	3.18%	477
2006-2007	85.05%	5409	11.78%	749	3.18%	202
2007-2008	83.66%	13 839	11.66%	1928	4.69%	775
2008-2009	83.61%	13 186	12.80%	2019	3.59%	566
2009-2010	81.41%	11 205	14.81%	2039	3.78%	520
2010-2011	78.47%	10 200	17.59%	2286	3.95%	513
2011-2012	71.33%	3451	23.89%	1156	4.77%	231
2012-2013	76.98%	3511	18.53%	845	4.49%	205
2013-2014	77.94%	1413	17.43%	316	4.63%	84
2014-2015	74.46%	764	20.76%	213	4.78%	49
p	0.00000		0.00000		0.00000	

n: sample size; **p:** statistical significance.

categories) and (b) within the abnormal group, comparison of children in treatment and children not in treatment (Table 3).

In Model 1 in Table 3, it can be seen that the odds of having an abnormal result increased by 5% each school year ($p < 0.001$). Similarly, the odds in-

Figure 1. **Distribution of children as "normal", "suspected" and "in treatment" by age: changes in test results over the school years.**

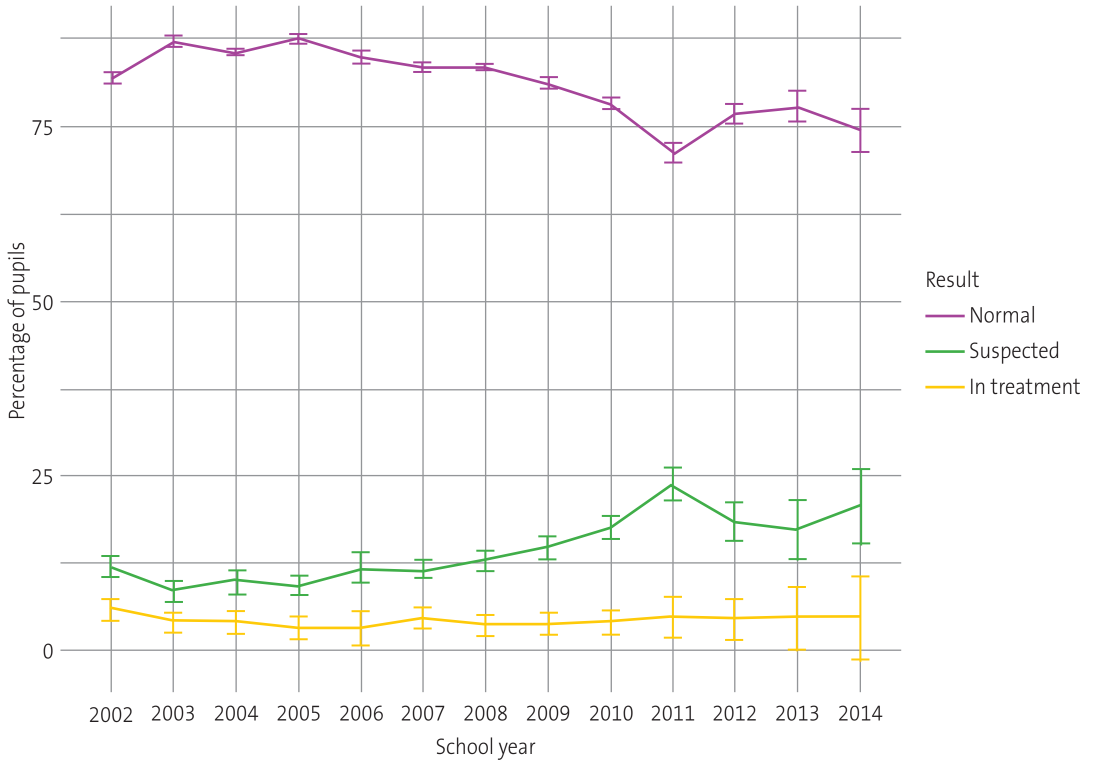

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Table 2. Distribution (%) of children into "normal", "suspected" and "in treatment" categories based on the explanatory variables: sex, age and location and type of school.

Variables	Normal		Suspected		In treatment	
Sex	%	n	%	n	%	n
Male	82.96%	59 745	12.84%	9248	4.19%	3020
Female	83.39%	56 661	12.52%	8507	4.09%	2779
p	0.03393		0.07164		0.33714	
Age						
4 years	86.02%	79 601	11.17%	10 341	2.81%	2600
5 years	78.71%	27 726	15.26%	5375	6.04%	2126
6 years	74.58%	9198	16.68%	2057	8.74%	1078
p	0.00000		0.00000		0.00000	
Type of location	%	n	%	n	%	n
Rural	83.42%	20 613	12.23%	3022	4.35%	1075
Semi-urban	82.63%	9372	12.97%	1471	4.40%	499
Urban	83.12%	85 517	12.81%	13 180	4.07%	4192
p	0.17311		0.03452		0.05628	
Type of school	%	n	%	n	%	n
State	83.00%	85 711	12.99%	13 410	4.02%	4148
Private with state subsidy	83.25%	27 322	12.19%	4000	4.56%	1496
Private	87.59%	1871	8.05%	172	4.35%	93
p	0.00000		0.00000		0.00000	

n: absolute frequency; **p:** significance.

Tabla 3. Regression models. Model 1: factors associated with the classification as "abnormal". Model 2: factors associated with a child with abnormal results being in treatment

	Model 1			Model 2		
Variables	**OR**	**CI**	**p**	**OR**	**CI**	**p**
School year						
School year	1.05	1.05-1.06	<0.001	0.92	0.91-0.93	<0.001
Sex						
Boy	Reference			Reference		
Girl	0.97	0.94-1.00	0.048	1.00	0.94-1.06	0.945
Age						
4 years	Reference			Reference		
5 years	1.63	1.58-1.68	<0.001	1.63	1.52-1.74	<0.001
6 years	2.07	1.98-2.17	<0.001	2.06	1.88-2.25	<0.001
Type of location						
Rural	Reference			Reference		
Semi-urban	1.03	0.97-1.10	0.261	0.99	0.88-1.13	0.935
Urban	1.01	0.97-1.05	0.544	0.83	0.77-0.90	<0.001
Type of school						
State	Reference			Reference		
Private with state subsidy	1.00	0.97-1.03	0.972	1.30	1.21-1.40	<0.001
Private	0.65	0.57-0.74	<0.001	1.56	1.20-2.02	0.001

OR: odds ratio; **CI:** 95% confidence interval; **p**: significance.

creased significantly with age; compared with age 4, the odds increased by 63% by age 5 years (OR 1.63; $p < 0.001$) and had doubled at 6 years (OR 2.07; $p < 0.001$). We also found slightly lower odds in girls (OR 0.97; $p = 0.048$). Lastly, the odds were significantly lower in private schools (OR 0.65; $p < 0.001$).

Among the factors that made it more likely for a child with abnormal results to be in treatment, we ought to highlight attendance to a private school (OR 1.56; $p = 0.001$) and older age. Compared with age 4, the odds increased by 63% at the age of 5 ($p < 0.001$) and doubled at 6 ($p < 0.001$) (Table 3, Model 2). Moreover, the probability of being in treatment was lower in schools in urban areas (OR 0.83; $p < 0.001$) and the probability that children newly included in the study would already be receiving treatment decreased each successive year during the study period, (OR 0.92; $p < 0.001$) (Table 3, Model 2).

The model for predicting who was in treatment was very accurate, with a mean error of 0.96% and a χ^2 of 0.21 for the difference between expected and observed values (data not shown). The results obtained by placing the individuals into 10 groups (deciles) according to their expected risk did not differ much from what was actually observed (Table 4).

DISCUSSION

The prevalence of suspected amblyopia among the 140 102 children from Alicante included in the study varied throughout the various paediatric ophthalmological campaigns, with a maximum of 23.9% and a minimum of 8.54% (Table 1). Both values are well above the international mean, established at 1% to 5%,[5,11,12] although the lower values are more in line with those found in prevalence studies in other parts of Spain (7.5-9.8%).[13,14]

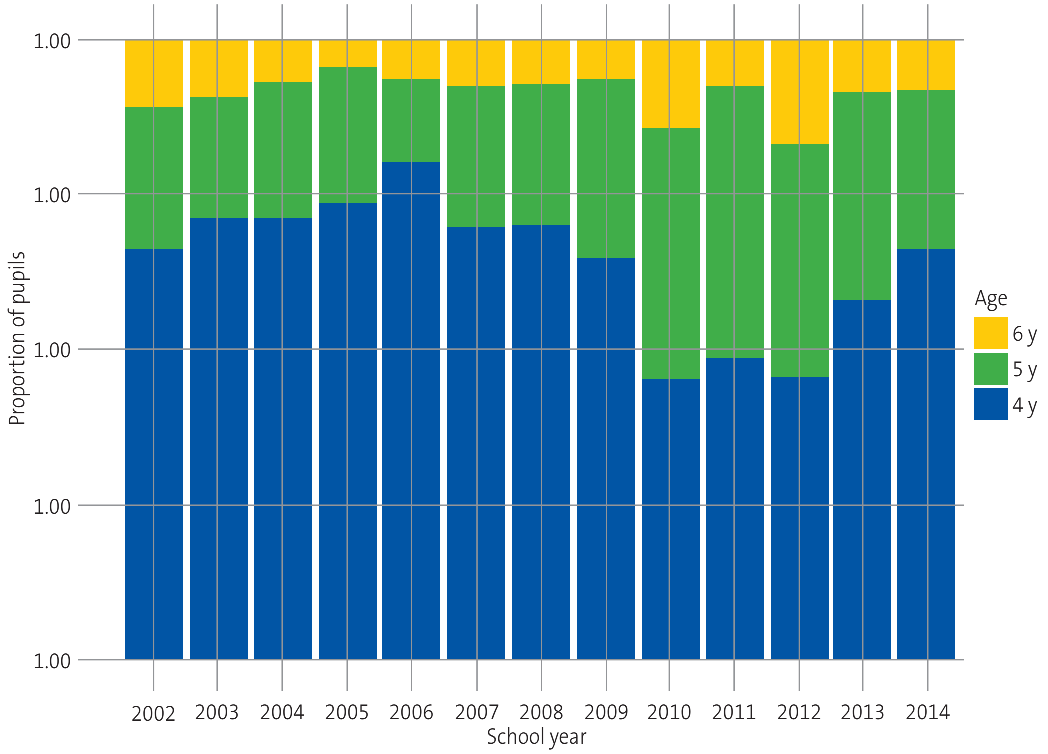
The high prevalence of suspected amblyopia from school year 2008-2009 onwards (12.80-23.89%) (Table 1) could be attributed to differences in the age distribution of the sample between the school years (Fig. 2). Given the association between suspected amblyopia and age (Table 2 and Fig. 1) and between suspected amblyopia and school year within the study period (Table 1 and Fig. 1), school years in which children were older had a higher proportion of suspected cases (Fig. 2). These results agree with those obtained by other authors on the importance of very early detection campaigns to achieve early treatment in children.[15-19] On the other hand, the disparity in the results on the prevalence of amblyopia between published studies could be due to the lack of standardised criteria in relation to the most appropriate age for screening in the paediatric population, specific screening tests, diagnostic criteria or training of

Table 4. Calibration of the distribution of expected and observed cases into the probability gradient of a child with abnormal results being treated

Decile	n	Expected mean risk	Observed mean risk	95% CI	
				Observed lower bound	Observed upper bound
D1	2512	14.33%	13.69%	12.35%	15.04%
D2	2484	17.04%	17.59%	16.10%	19.09%
D3	2007	18.91%	19.38%	17.65%	21.11%
D4	2468	20.89%	19.49%	17.93%	21.05%
D5	2524	22.70%	23.73%	22.07%	25.39%
D6	2155	24.66%	23.53%	21.74%	25.32%
D7	2311	26.37%	28.17%	26.34%	30.00%
D8	2291	29.12%	28.68%	26.83%	30.53%
D9	2263	33.23%	32.57%	30.64%	34.50%
D10	2304	40.24%	40.58%	38.58%	42.59%

n: absolute frequency; **CI**: confidence interval.

Figure 2. Distribution of age groups by school year



the staff performing the evaluations, among other factors.[20-22]

Consistent with previous studies,[23,24] we found no effect of sex on the prevalence of suspected amblyopia in the study population (Table 2), which could be explained by the uniformity of the sex distribution in in the sample (data not shown).

The current literature on the prevalence of amblyopia in children from rural communities is contradictory.[25-27] We found a slightly lower prevalence in rural compared to semi-urban and urban areas[25] (Table 2), despite the fact that the rural population usually has greater difficulties in gaining access to quality healthcare (public or private).[28] This could be attributed to the fact that children in rural areas live in a much healthier environment that those in urban or semi-urban areas.

The results obtained after the data were dichotomised into "normal" and "abnormal" categories support the idea that children from private schools are more likely to have access to treatment for amblyopia than those from other schools (Table 3) for the socioeconomic reasons mentioned. The fact that the likelihood of access to treatment is higher in older children cannot be attributed to the effect of raising the awareness of parents through previous screening campaigns, as the data in the analysis came from children being screened for the first time. Perhaps the reason for the observed trend is that at older ages the symptoms of amblyopia become more obvious and children can be more cooperative.

The decreased probability of accessing treatment for amblyopia over the course of the study period and in urban areas is difficult to explain (Table 3), in the latter case chiefly on account of the accessibility of public and/or private healthcare. However, the very low prediction error of the model used suggests that factors such as a decrease in the early diagnosis of amblyopia in children and therefore in treatment initiation may be involved in these results.

The results of our study show that there is a high frequency of cases of suspected amblyopia in children in the province of Alicante, mainly in older children and children of low socioeconomic status. It is therefore reasonable for us to conclude by emphasising the great importance of programmes for the prevention and detection of amblyopia in early childhood, given that the effectiveness of treatment depends on making an early diagnosis, consequently equalising the chances of access to treatment for amblyopia. It is essential that international bodies standardise various criteria such as the optimal age to screen young children, the specific screening tests and diagnostic criteria to be applied and the required qualifications of staff performing the evaluations, in order to facilitate research on its prevalence.

CONFLICTS OF INTEREST

Jorge l. Alió is the president of the Foundation that bears his name. The other authors have no relevant commercial interests to declare with respect to this study.

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ABBREVIATIONS

VA: visual acuity.

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