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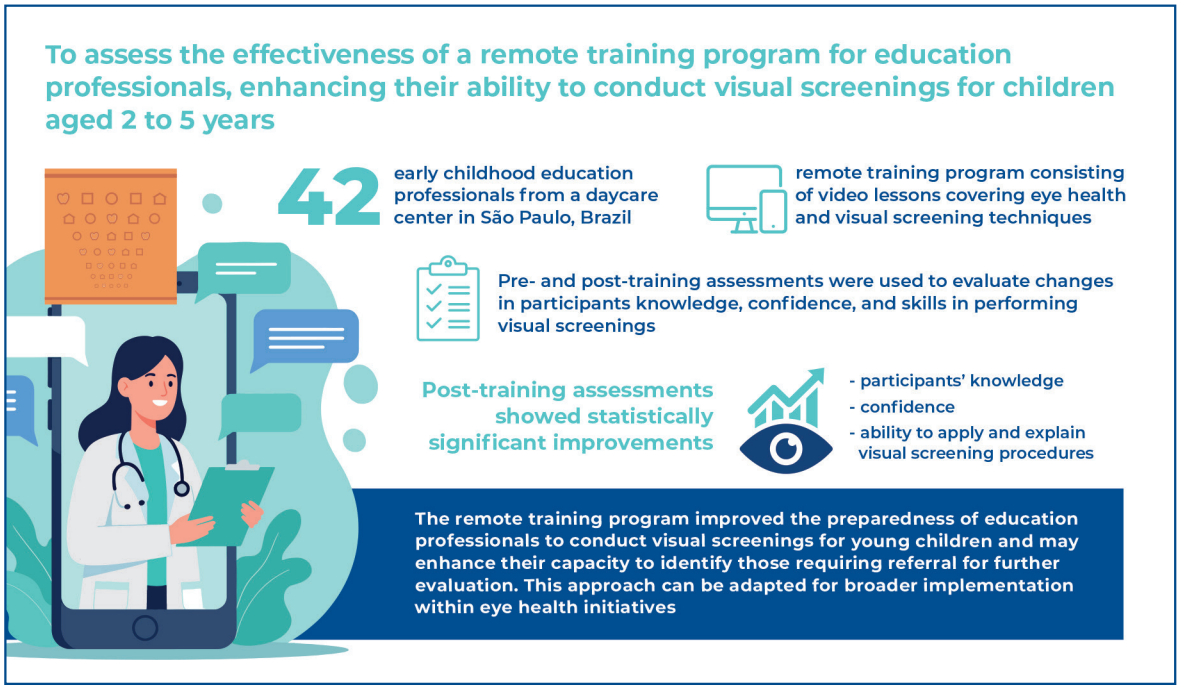
Remote visual screening education for teachers: a prospective longitudinal interventional study



Authors

Laura Goldfarb Cyrino, Paulo Vigga, Matheus Enrico Dias Vaz Monteiro, Fernanda Nicolela Susanna, Pedro Gabriel Salomão Libânio, Ana Carolina Sarmento Carneiro, Roberta Melissa Benetti Zagui

Correspondence

E-mail: lauragoldfarb@gmail.com

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In Brief

A remote training program for early childhood educators significantly improved their knowledge, practical skills, and confidence in conducting pediatric visual screening. The findings suggest that distance education can effectively equip non-ophthalmologist educators to identify early visual disorders in children aged 2–5 years.

Highlights

- Remote training significantly improved teachers' knowledge of pediatric eye diseases.
- Educators were successfully trained to perform visual screening using the LEA Symbols chart.
- Distance education increased teachers' confidence in identifying visual disorders.
- Remote training may facilitate the early detection of amblyopia in preschool settings.

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Remote visual screening education for teachers: a prospective longitudinal interventional study

Laura Goldfarb Cyrino[1], Paulo Vigga[2], Matheus Enrico Dias Vaz Monteiro[1], Fernanda Nicolela Susanna[1], Pedro Gabriel Salomão Libânio[1], Ana Carolina Sarmento Carneiro[1], Roberta Melissa Benetti Zagui[1]

[1] Ophthalmology Department, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.
[2] Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

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ABSTRACT

Objective: We aimed to assess the effectiveness of a remote training program designed to improve the ability of education professionals to conduct visual screening in children aged 2-5 years. **Methods:** This prospective longitudinal interventional study included 42 early childhood education professionals from a daycare center in São Paulo, Brazil. Participants completed a remote training program consisting of video-based lessons on eye health and visual screening techniques. Pre- and post-training assessments were conducted to evaluate changes in participants' knowledge, confidence, and practical skills related to visual screening. Statistical analyses were performed using the McNemar-Bowker and Wilcoxon tests. **Results:** Post-training assessments demonstrated statistically significant improvements in participants' knowledge, confidence, and ability to perform and explain visual screening procedures, including the use of the LEA Symbols chart and recognition of conditions such as amblyopia ($p<0.001$). **Conclusion:** The remote training program improved the preparedness of education professionals to conduct visual screening in young children and may enhance their ability to identify children requiring referral for further ophthalmologic evaluation. This approach may be adapted for broader implementation within eye health promotion initiatives. Study limitations include the absence of a control group, lack of long-term follow-up, use of a single-center convenience sample, and the absence of comparisons with alternative teaching methods.

Keywords: Vision screening; Telemedicine; Amblyopia; Early diagnosis; Education, preschool; Visual acuity tests; Child, preschool; Surveys and questionnaires

INTRODUCTION

From early childhood, adequate vision is essential for children's cognitive, social, and educational development, enabling participation in both formal and informal learning environments.[1,2] According to the World Health Organization (WHO), at the launch of the VISION 2020 initiative, approximately 19 million children younger than 15 years were living with visual impairment, including 1.4 million with irreversible blindness. Nearly half of these cases were considered preventable, with refractive errors and amblyopia representing the leading causes.[2-6]

A global systematic review and meta-analysis on the prevalence of amblyopia estimated that approximately 99.2 million individuals were affected worldwide in 2019, with projections suggesting an increase to 221 million by 2040.[7] Studies have also shown that the prevalence of amblyopia in Latino children may be higher than that in children from other ethnic groups.[8,9] In

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Associate Editor:
Celso Moura Rebello
Instituto Israelita de Ensino e Pesquisa Albert Einstein, São Paulo, SP, Brazil
ORCID: https://orcid.org/0000-0002-4637-6295

Corresponding Author:
Laura Goldfarb Cyrino
Avenida Doutor Enéas de Carvalho Aguiar, 255 - 6th floor, room 6119 - Cerqueira César
Zip code: 05403-000 – São Paulo, SP, Brazil
Phone: (11 55) 94166-7955
E-mail: lauragoldfarb@gmail.com

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a multiethnic study, amblyopia was detected in 2.6% of Hispanic/Latino children and 1.5% of African American children aged 30-72 months.[10] Several factors may contribute to the higher prevalence observed in these populations, including limited access to eye care services, underutilization of available services, insufficient public eye health policies, socioeconomic barriers, limited family support, reduced awareness of the importance of early detection, and shortages of trained professionals.[1-4]

Visual screening in children is performed to identify reduced visual acuity and risk factors that may impair visual development.[10] In this context, community settings such as daycare centers, preschools, schools, and community health groups provide valuable opportunities for screening programs aimed at detecting visual impairment and other ocular abnormalities. These screenings may be conducted by healthcare professionals, education professionals, or trained laypersons. Previous studies have demonstrated that appropriately trained non-ophthalmologists can perform visual screening with acceptable accuracy.[11-13]

In Brazil, despite public visual screening policies implemented through the Brazilian Public Health System (SUS - *Sistema Único de Saúde*) since the last century,[14-18] school-based eye health programs remain limited.[19] One major challenge is the lack of standardized training programs for education professionals responsible for implementing visual screening in schools. To date, no unified national training program has been developed to reach remote regions or to provide comprehensive eye health screening beyond visual acuity assessment alone.[10] Furthermore, most existing programs in Brazil have focused primarily on children older than 6 years.[20]

In this context, the present research aimed to develop a distance education program to train education professionals to implement an eye health program for children aged 2-5 years, incorporating current evidence and extending beyond visual acuity assessment alone. Distance learning enables educational content to be delivered through digital platforms, which expanded significantly during the COVID-19 pandemic.[21,22]

Additionally, a recent cluster-randomized controlled trial of school-based vision screening highlighted the importance of continued vision care and access to corrective eyewear, particularly for children from socioeconomically disadvantaged backgrounds. The study also emphasized the need for further intervention studies evaluating screening strategies.[23]

The proposed virtual training program is intended to facilitate earlier referral of children with suspected visual disorders while improving screening quality and scalability. This approach may support broader implementation across diverse settings and contribute to the development of a standardized, evidence-based eye health program.[24]

OBJECTIVE

We aimed to evaluate a virtual training protocol for education professionals designed to improve knowledge and skills related to pediatric eye care. The program was developed to train participants in performing visual acuity screening in children aged 2-5 years and assess the effectiveness of the intervention. The training content and assessment instruments were based on clinical guidelines and were intended to support the implementation of protocols for monitoring visual development disorders in preschool- and school-aged children.

METHODS

This prospective longitudinal interventional study included 42 early childhood education professionals from a daycare center affiliated with the São Paulo municipal government, the Aglaezinha Early Childhood Education Center, operated by the non-governmental organization *Associação Ponto de Luz*.

All study procedures were conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the *Faculdade de Medicina da Universidade de São Paulo*, São Paulo, Brazil (CAAE: 78717324.0.0000.0068; #6.823.601). Written informed consent was obtained from all participants prior to study participation. Eligible participants were selected according to predefined inclusion and exclusion criteria.

The inclusion criteria were: employment as an early childhood education professional at the Ponto de Luz daycare center, which provides care for children aged 2-5 years; availability and willingness to participate in the training program and visual screening activities; recommendation by the institutional coordinator or voluntary enrollment; and provision of written informed consent.

The research team developed educational videos focused on pediatric eye health to train education professionals working with children aged 2-5 years.

The video content emphasized the importance of ophthalmologic screening in early childhood and

was designed to support participants in conducting visual screening assessments, recognizing common eye disorders, identifying warning signs, and referring children requiring further evaluation.

The educational materials were developed in a concise and accessible format and covered the following topics: basic eye anatomy; the importance of visual screening in early childhood; recommended school-based eye health screening practices for this age group; recognition of warning signs suggestive of visual disorders; and visual acuity assessment.

The videos were made available free of charge through a secure virtual platform compliant with the Brazilian General Data Protection Law. Participants were able to access the material at any time and from any location over a 1-month period.

Education professionals completed online questionnaires before and after exposure to the educational videos to assess changes in knowledge related to pediatric eye health issues and visual screening procedures (Table 1). Additionally, participants completed a pre-training questionnaire regarding their perceptions of virtual learning, satisfaction, and expectations related to the educational content.

A synchronous virtual meeting between the research team and the education professionals was also conducted through an online platform to clarify questions, provide additional guidance, and collect participant feedback and suggestions.

Data analysis

Comparisons of the distribution of responses for each knowledge item before and after training were performed using the McNemar-Bowker test. To quantify knowledge acquisition, composite scores were generated as described in the Results section, and pre- and post-training scores were compared using the Wilcoxon signed-rank test for paired samples. Statistical significance was set at $p<0.05$. All statistical analyses were conducted using SPSS software, version 21.

Table 1. Eye health knowledge assessment questionnaire

1. Do you know the main eye conditions that can cause vision loss in children?	( ) No	( ) A little	( ) Yes
2. Do you understand the importance of vision screening for children aged 2–5 years?	( ) No	( ) A little	( ) Yes
3. Do you know what myopia is?	( ) No	( ) A little	( ) Yes
4. Do you know what hyperopia is?	( ) No	( ) A little	( ) Yes
5. Do you know what astigmatism is?	( ) No	( ) A little	( ) Yes
6. Do you know what amblyopia is?	( ) No	( ) A little	( ) Yes
7. Do you know what strabismus is?	( ) No	( ) A little	( ) Yes
8. Do you know the risk factors for amblyopia that may be observed in children?	( ) No	( ) A little	( ) Yes
9. Do you know the correct procedure for performing visual acuity testing using the LEA Symbols chart?	( ) No	( ) A little	( ) Yes
10. Do you currently feel capable of performing visual acuity testing using the LEA Symbols chart?	( ) No	( ) A little	( ) Yes
11. Do you know which visual acuity test results obtained using the LEA Symbols chart require referral to a specialist?	( ) No	( ) A little	( ) Yes
12. Regarding visual acuity testing using the LEA Symbols chart, do you know how to:	( ) No	( ) A little	( ) Yes (For each item)
a) Explain the test to the child?			
b) Position the chart on the wall at the appropriate distance using measuring tools?			
c) Proceed if the child already wears glasses?			
d) Ensure that one eye is properly occluded during testing?			
e) Correctly identify the symbols on the chart?			
13. Do you feel able to recognize the following ocular abnormalities?	( ) No	( ) A little	( ) Yes (For each item)
a) Red eye			
b) Eye deviation (strabismus)			
c) Abnormal or asymmetric red reflexes			
d) Involuntary eye movements			
e) Differences in eye appearance between the two eyes (e.g., asymmetry in size)			
14. Do you currently feel confident explaining abnormal test findings to the child's guardians?	( ) No	( ) A little	( ) Yes (For each item)
15. Do you currently feel confident explaining abnormal test findings to the child?	( ) No	( ) A little	( ) Yes (For each item)

RESULTS

The study included 42 education professionals, all of whom were women, with a mean age of 43 years. Most participants held a higher education degree (95.2%), and the majority were teachers (78.6%). All participants completed the training program and both the pre- and post-training questionnaires. None of the participants had previously participated in similar training programs (100%) (Table 2).

Table 3 demonstrates the impact of the training program on the knowledge and skills of education professionals regarding visual screening in children. Before training, many participants reported limited knowledge of common pediatric eye disorders, the importance of vision screening, and conditions such as myopia, hyperopia, and astigmatism. Following the intervention, the proportion of participants who reported knowing how to perform and explain visual acuity testing using the LEA Symbols chart increased

Table 2. Participant characteristics

Variable	n (%)
Role	
Assistant	3 (7.1)
Teacher	33 (78.6)
Coordinator	3 (7.1)
Director	3 (7.1)
Sex	
Female	42 (100.0)
Education level	
Incomplete higher education	2 (4.8)
Complete higher education	40 (95.2)
Previous participation in similar training programs	
No	42 (100.0)
Age, years Median (range)	43 (27–60)

Table 3. Comparison of education professionals before and after training

Item	Pre-training		Post-training		p value*
	n	%	n	%	
Do you know the main eye conditions that can cause vision loss in children?					
No	24	57.1	1	2.4	0.001
A little	17	40.5	35	83.3	
Yes	1	2.4	6	14.3	
Do you understand the importance of vision screening in children aged 2–5 years?					
No	14	33.3	2	4.8	0.002
A little	23	54.8	26	61.9	
Yes	5	11.9	14	33.3	
Do you know what myopia is?					
No	12	28.6	1	2.4	0.004
A little	16	38.1	27	64.3	
Yes	14	33.3	14	33.3	
Do you know what hyperopia is?					
No	28	66.7	11	26.2	0.002
A little	7	16.7	22	52.4	
Yes	7	16.7	9	21.4	

continue...

...Continuation

Table 3. Comparison of education professionals before and after training

Item	Pre-training		Post-training		p value*
	n	%	n	%	
Do you know what astigmatism is?					
No	21	50.0	9	21.4	0.001
A little	6	14.3	25	59.5	
Yes	15	35.7	8	19.0	
Do you know what amblyopia is?					
No	34	81.0	10	23.8	<0.001
A little	4	9.5	27	64.3	
Yes	4	9.5	5	11.9	
Do you know what strabismus is?					
No	10	23.8	2	4.8	0.037
A little	16	38.1	16	38.1	
Yes	16	38.1	24	57.1	
Do you know which risk factors can be observed in children?					
No	35	83.3	11	26.2	<0.001
A little	6	14.3	29	69.0	
Yes	1	2.4	2	4.8	
Do you know the correct procedure for performing visual acuity testing using the LEA Symbols chart?					
No	36	85.7	5	11.9	<0.001
A little	4	9.5	17	40.5	
Yes	2	4.8	20	47.6	
Do you currently feel capable of performing visual acuity testing using the LEA Symbols chart?					
No	30	71.4	5	11.9	<0.001
A little	7	16.7	31	73.8	
Yes	5	11.9	6	14.3	
Do you know which results obtained during visual acuity testing using the LEA Symbols chart require referral to a specialist?					
No	36	85.7	8	19.0	<0.001
A little	5	11.9	27	64.3	
Yes	1	2.4	7	16.7	
Do you know how to explain the visual acuity test to the child?					
No	31	73.8	5	11.9	<0.001
A little	7	16.7	26	61.9	
Yes	4	9.5	11	26.2	
Do you know how to position the chart on the wall at the appropriate distance using measuring tools?					
No	30	71.4	5	11.9	<0.001
A little	6	14.3	19	45.2	
Yes	6	14.3	18	42.9	
Do you know what to do if the child already wears glasses?					
No	29	69.0	3	7.1	<0.001
A little	7	16.7	18	42.9	
Yes	6	14.3	21	50.0	

continue...

...Continuation

Table 3. Comparison of education professionals before and after training

Item	Pre-training		Post-training		p value*
	n	%	n	%	
Do you know how to ensure that one of the child's eyes is properly covered during the test?					
No	29	69.0	2	4.8	<0.001
A little	2	4.8	16	38.1	
Yes	11	26.2	24	57.1	
Do you know how to point to the symbols on the chart?					
No	28	66.7	5	11.9	<0.001
A little	3	7.1	10	23.8	
Yes	11	26.2	27	64.3	
Red eye					
No	15	35.7	3	7.1	0.003
A little	14	33.3	14	33.3	
Yes	13	31.0	25	59.5	
Eye deviation (strabismus)					
No	22	52.4	5	11.9	0.001
A little	12	28.6	18	42.9	
Yes	8	19.0	19	45.2	
Different red reflexes (different brightness)					
No	27	64.3	4	9.5	<0.001
A little	8	19.0	24	57.1	
Yes	7	16.7	14	33.3	
Involuntary eye movements					
No	27	64.3	11	26.2	0.001
A little	7	16.7	16	38.1	
Yes	8	19.0	15	35.7	
Eyes with asymmetry in appearance or size					
No	17	40.5	3	7.1	0.005
A little	16	38.1	21	50.0	
Yes	9	21.4	18	42.9	
Do you currently feel confident explaining abnormal test findings to the child's guardians?					
No	22	52.4	10	23.8	0.009
A little	12	28.6	23	54.8	
Yes	8	19.0	9	21.4	
Do you currently feel confident explaining abnormal test findings to the child?					
No	24	57.1	7	16.7	0.002
A little	12	28.6	25	59.5	
Yes	6	14.3	10	23.8	

* McNemar–Bowker test.

from 4.8% to 47.6% (p<0.001). Similar improvements were observed in participants' ability to recognize common visual disorders and manage situations involving children who already wore corrective glasses.

Table 4 presents the scoring system used to quantify participants' knowledge and confidence before and after the ophthalmologic training program. Responses were scored as 0 for "No," 1 for "A little," and 2 for "Yes," with higher scores indicating greater knowledge or confidence. Four domain-specific scores were calculated: knowledge of eye disorders (0-22 points), knowledge of the use of the LEA Symbols chart (0-10

points), ability to identify ocular abnormalities (0-10 points), and confidence in explaining identified eye abnormalities (0-4 points). The total score ranged from 0 to 46 points and was calculated as the sum of all domain scores.

Table 5 presents the comparison of pre- and post-training scores among education professionals, reflecting changes in knowledge and skills following the intervention. Prior to training, participants demonstrated limited knowledge and practical ability in using the LEA Symbols chart and identifying common eye conditions. After the training, there was a substantial improvement across all assessed domains, with significantly higher scores in knowledge, practical skills, and confidence. In addition to improved knowledge and skills, participants reported increased confidence in performing visual screening and communicating findings to both children and their guardians.

Table 6 summarizes participants' feedback regarding the training program. Overall, 97.7% of participants reported an improvement in their visual screening knowledge, while 100% reported enhanced understanding of eye health in school settings and improved ability to recognize warning signs of visual disorders.

Regarding the effectiveness of the distance learning approach, 86.0% of participants considered it suitable for delivering early childhood vision screening training, while 100% agreed that it was effective for improving understanding of eye conditions and recognition of warning signs. Overall, the training program received high satisfaction ratings, with mean scores ranging from 4.3 to 4.6 out of 5.

Table 4. Questions used to construct the knowledge and confidence scores

Knowledge Score on eye disorders		Knowledge Score on the use of the LEA symbols chart	Knowledge Score on recognition of ocular abnormalities	Confidence Score in managing detected ocular abnormalities
1. Do you know the main eye conditions that can cause visual impairment in children?	7. Do you know what strabismus is?	1. Do you know how to explain the visual acuity test to the child?	1. Do you know how to recognize red eye?	1. Do you currently feel confident explaining abnormal test findings sto the child's guardians?
2. Do you understand the importance of vision screening for children aged 2–5 years?	8. Do you know which risk factors for amblyopia can be observed in children?	2. Do you know how to position the chart on the wall at the correct distance using measurement tools?	2. Do you know how to recognize eye deviation (strabismus)?	2. Do you currently feel confident explaining abnormal test findings to the child?
3. Do you know what myopia is?				
4. Do you know what hyperopia is?	9. Do you know the correct procedure for performing visual acuity testing using the LEA Symbols chart?	3. Do you know what to do if the child is already wearing glasses?	3. Do you know how to recognize abnormal red reflexes (differences in brightness)?	
5. Do you know what astigmatism is?	10. Do you currently feel capable of performing visual acuity testing using the LEA Symbols chart?	4. Do you know how to ensure that one of the child's eyes is properly covered during the test?	4. Do you know how to recognize involuntary eye movements?	
6. Do you know what amblyopia is?	11. Do you know which results obtained from visual acuity testing using the LEA Symbols chart require referral to a specialist?	5. Do you know how to point to the symbols on the chart?	5. Do you know how to recognize asymmetry between the eyes?	

Table 5. Pre- and post-training comparison of knowledge scores among education professionals

Variable	Pre-training			Post-training			p value*
	Median	Q1	Q3	Median	Q1	Q3	
Knowledge Score on Ocular Problems	5.50	1.75	10.00	11.00	11.00	14.25	<0.001
Knowledge Score on LEA Symbols Chart Use	0.50	0.00	4.25	8.00	5.00	9.00	<0.001
Knowledge Score on Recognition of Ocular Abnormalities	3.00	1.00	5.25	6.00	5.00	8.25	<0.001
Confidence Score in Actions upon Detecting Ocular Abnormalities	0.00	0.00	2.00	2.00	1.00	2.25	0.006
Overall Score	11.00	3.00	20.25	26.50	23.00	31.50	<0.001

* Wilcoxon signed-rank test for paired samples.

Table 6. Participants' evaluation of the training program

Variable	n (%)
Eye screening in early childhood	
Knowledge improved	
Neutral	1 (2.3)
Agree	24 (55.8)
Strongly agree	18 (41.9)
The distance learning method was effective	
Neutral	6 (14.0)
Agree	22 (51.2)
Strongly agree	15 (34.9)
Rating of course content and presentation	4.3±0.8
Eye health in the pediatric school environment	
Knowledge improved	
Neutral	0 (0)
Agree	28 (65.1)
Strongly agree	15 (34.9)
The distance learning method was effective	
Neutral	4 (9.3)
Agree	26 (60.5)
Strongly agree	13 (30.2)
Rating of course content and presentation of the class	4.3±0.8
Visual acuity	
Knowledge improved	
Neutral	2 (4.7)
Agree	25 (58.1)
Strongly agree	16 (37.2)
The distance learning method was effective	
Neutral	4 (9.3)
Agree	23 (53.5)
Strongly agree	16 (37.2)
Rating of course content and presentation	4.3±0.8
Eye	
Knowledge improved	
Neutral	0 (0.0)
Agree	28 (65.1)
Strongly agree	15 (34.9)
The distance learning method was effective	
Neutral	0 (0.0)
Agree	29 (67.4)
Strongly agree	14 (32.6)
Rating of course content and presentation	4.6±0.5
Recognition of warning signs	
Knowledge improved	
Neutral	0 (0.0)
Agree	27 (62.8)
Strongly agree	16 (37.2)
The distance learning method was effective	
Neutral	0 (0.0)
Agree	26 (60.5)
Strongly agree	17 (39.5)
Rating of course content and presentation	4.5±0.5

DISCUSSION

All teachers should be educated about the role of vision in learning.[25] This information can be delivered through structured teacher training and continuing education programs. To the best of our knowledge, this is the first study to evaluate the effectiveness of video-based training materials developed by our research group for educating school professionals in pediatric visual screening. We observed a statistically significant improvement across all knowledge domains assessed in our questionnaire following the remote training intervention.

Health promotion aims to improve population health outcomes by empowering communities and creating supportive environments for health. In this context, strengthening the capacity of individuals who are in close contact with potential patients is a key component of effective health promotion strategies. In the present study, most participants were teachers (78.6%), reflecting their close and continuous contact with school-aged children. However, previous studies have shown that teachers often do not associate symptoms suggestive of visual impairment with underlying ocular pathology.[26] In contrast, evidence also indicates that, with appropriate in-person training, teachers can effectively perform visual acuity assessments, achieving performance comparable to that of eye care professionals.[27]

None of the participants had previously received training in eye health awareness, and they lacked the knowledge and tools required to recognize early signs of visual impairment. This gap in awareness may negatively affect children's learning and overall development. Despite efforts by the Brazilian public health system to implement vision screening programs in public schools, the integration of eye health education into teacher training curricula remains limited. This underscores the need for comprehensive initiatives to educate teachers and strengthen early detection and intervention for visual disorders in Brazilian classrooms.[28,29]

Distance learning has the potential to substantially improve access to training, particularly in low-income settings and regions with limited resources.[30] By delivering educational content through remote platforms, knowledge can be disseminated without requiring professionals to travel physically to schools, which may be impractical at scale. Furthermore, with appropriate training, teachers may be able to identify visual problems more accurately, potentially reducing unnecessary referrals and avoiding additional burden on healthcare systems.[31]

In our study, more than 90% of participants considered distance learning effective across all assessed domains, with the exception of early childhood visual screening, which received an approval rate of 86%. The slightly lower approval in this domain may be related to the requirement for more hands-on application of screening procedures using tools that were initially unfamiliar to educators. However, overall acceptance of the distance learning approach was high. This finding is particularly relevant, as distance learning may help reduce educational disparities in underserved communities by improving access to training materials and standardizing knowledge delivery across settings.

This study has some methodological limitations that should be considered when interpreting the findings. The absence of a control group limits the ability to attribute observed improvements solely to the training intervention, as no comparison was made with untrained participants. Additionally, the use of convenience sampling from a single center may restrict the generalizability of the results to other educational settings or populations. The outcomes were based on self-reported measures of knowledge and confidence, which may be subject to social desirability bias. Furthermore, the study did not include long-term follow-up, limiting the assessment of knowledge retention over time. Clinical and practical outcomes, such as the impact of training on the identification or referral of children with visual impairments, were also not evaluated. Although the study was not designed to compare the video-based training with alternative instructional methods, these limitations should be considered when interpreting the results.

CONCLUSION

This study demonstrated that a remote training program significantly improved the knowledge, skills, and confidence of education professionals in conducting visual screening for children aged 2-5 years. The training enhanced participants' understanding of common ocular conditions, including amblyopia, myopia, hyperopia, and astigmatism, and increased their confidence in performing and explaining visual acuity testing using the LEA Symbols chart. By strengthening educators' competencies in visual screening, the broader implementation of such programs may improve the identification of children requiring referral for further ophthalmologic evaluation. However, the direct impact on clinical outcomes was not assessed in this study.

The results indicate that well-structured remote education can be an effective and feasible approach for training non-ophthalmic professionals in eye health screening, particularly in regions with limited access to specialized care. Its high acceptability supports the scalability of this distance learning approach and its potential to reduce disparities in training access across different settings.

Given the increasing burden of visual impairment, especially in underserved populations, wider implementation of such programs may contribute to more timely referrals and earlier detection of visual problems, thereby reducing the risk of avoidable developmental consequences. Future studies should evaluate the scalability of this training model and its integration into broader educational and public health systems, as well as its impact on real-world clinical outcomes.

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DATA AVAILABILITY

The data supporting the findings of this study are included within the manuscript.

AUTHORS' CONTRIBUTION

Laura Goldfarb Cyrino: conceptualization (lead), methodology (lead), investigation (equal), data curation (equal), formal analysis (equal), writing - original draft (equal), writing - review & editing (equal). Paulo Vigga, Matheus Enrico Dias Vaz Monteiro, Fernanda Nicolela Susanna, Pedro Gabriel Salomão Libânio, Ana Carolina Sarmento Carneiro, and Roberta Melissa Benetti Zagui: investigation (equal), data curation (equal), formal analysis (equal), writing - original draft (equal), writing - review & editing (equal).

AUTHORS' INFORMATION

Cyrino LG: http://orcid.org/0000-0001-6007-6662
Vigga P: http://orcid.org/0009-0001-1591-8186
Monteiro ME: http://orcid.org/0009-0000-9157-8550
Susanna FN: http://orcid.org/0000-0003-0461-4344
Libânio PG: http://orcid.org/0000-0003-4917-5963
Carneiro AC: http://orcid.org/0000-0003-4308-0568
Zagui RM: http://orcid.org/0000-0002-3682-7048

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