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ORIGINAL

# Discrimination capacity of the pirate test to detect vision disorders in preschool children

## Capacidad discriminatoria de la prueba pirata para detectar trastornos de la visión en niños en edad preescolar

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## ABSTRACT

**Introduction:** The presence of amblyopia due to untreated vision disorders is a serious global problem, which prevalence will increase from 13 to 26% in 2060. Despite having stablished screening programs for early detection of vision disorders in schools and training teachers for the correct use of ophthalmic instruments. However, due to the high rate of false positive results, its validity decreased. This situation implies the need to find a simple, low cost and reproducible test that allows the detection of vision disorders without prior ophthalmological knowledge, which is the main reason why the Pirate Test was proposed. **Objective:** To determine the discrimination capacity of Pirate Test to detect vision disorders in preschool children in Piura city. **Methodology:** Diagnostic study test ("Pirate Test") was applied to 447 preschoolers by their parents and then they were evaluated by an ophthalmologist who determined if they really had vision disorders and specify the validity of the applied Test through the analysis of its sensitivity (Se), specificity (Sp), and ROC curve using SPSS v16. **Results:** The Se and Sp values to detect refractive errors were 85.4% and 78.8%, whereas for amblyopia the values were 83% and 93.7%, respectively. Also, ROC curves in both cases reported good discrimination capacity to detect visual disorders and amblyopia. **Conclusion:** Pirate Test has good discrimination capacity to detect visual disorders and amblyopia in preschoolers. The cut-off point was less than 5 minutes, which implies that the possibility of having important visual disorders or amblyopia is high.

**Keywords:** Screening; Vision Disorders; Amblyopia; Preschool (MeSH).

## Resumen

**Introducción:** La presencia de ambliopía debido a trastornos de la visión no tratados es un grave problema mundial, cuya prevalencia aumentará del 13 al 26 % en 2060. A pesar de haber establecido programas de detección temprana de trastornos de la visión en las escuelas y de haber formado a los maestros en el uso correcto de los instrumentos oftalmológicos. Sin embargo, debido a la alta tasa de resultados falsos positivos, su validez disminuyó. Esta situación implica la necesidad de encontrar una prueba sencilla, de bajo costo y reproducible que permita la detección de trastornos de la visión sin conocimientos oftalmológicos previos, lo que es la razón principal por la que se propuso la Prueba del Pirata. **Objetivo:** Determinar la capacidad de discriminación de la Prueba del Pirata para detectar trastornos de la visión en niños en edad preescolar en la ciudad de Piura. **Metodología:** Se aplicó una prueba de estudio diagnóstico (la «prueba del pirata») a 447 niños en edad preescolar por parte de sus padres y, a continuación, fueron evaluados por un oftalmólogo que determinó si realmente tenían trastornos de la visión y especificó la validez de la prueba aplicada mediante el análisis de su sensibilidad (Se), especificidad (Sp) y curva ROC utilizando SPSS v16. **Resultados:** Los valores de Se y Sp para detectar errores refractivos fueron del 85.4 % y del 78.8 %, mientras que para la ambliopía los valores fueron del 83 % y del 93.7 %, respectivamente. Además, las curvas ROC en ambos casos mostraron una buena capacidad de discriminación para detectar trastornos visuales y ambliopía. **Conclusión:** La prueba Pirate Test tiene una buena capacidad de discriminación para detectar trastornos visuales y ambliopía en niños en edad preescolar. El punto de corte fue inferior a 5 minutos, lo que implica que la posibilidad de padecer trastornos visuales importantes o ambliopía es alta.

**Palabras clave:** Detección; Trastornos de la visión; Ambliopía; Preescolar (MeSH)..

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## INTRODUCTION

Undetected and untreated visual disturbances in early childhood can lead to irreversible visual impairment, affecting the economically active adult population. Globally, about 285 million people have visual impairments, 43% due to uncorrected refractive errors, which, in adulthood, become the leading cause of preventable visual impairment and the second cause of preventable blindness after cataracts (1-3).

The prevalence of ametropia in children varies worldwide, from 3% to 21.3%, with Latin America at 13% and the United States at 69%, where strong screening programs like "Healthy People 2020" help with early diagnosis and treatment (4,5).

The increased use of digital devices has reduced outdoor activities, leading to a rise in ametropia prevalence among predisposed individuals. Varma et al. projected that by 2060, the global prevalence of ametropia would reach 26%. In Peru, Carrion et al. reported a prevalence of 46.3%, with 39% classified as severe ametropia; 40% of these children developed amblyopia, and 90% did not use corrective lenses. Similar findings were reported by Huaman et al, who found that 87.2% of children with high refractive errors did not wear glasses (6-9).

The strong accommodative ability of preschoolers often masks ametropia, leading to misdiagnoses as learning disabilities or autism. (10-12) Untreated ametropia can result in amblyopia, which affects reading comprehension, object identification (13-15), and increases the risk of mortality, eye trauma, and mental health issues like anxiety and depression in adults. Also, it doubles the risk of mortality and the chance of losing the contralateral eye due to accidents or trauma and triples the risk of anxiety and depression (16-18).

Early detection and timely treatment—ideally between 18 months and five years—can prevent 80% of these complications (19-21). Visual screening programs have demonstrated success, improving vision in 77% of cases, reducing amblyopia prevalence by 45-62%, and achieving total resolution in 27% of cases. Prioritizing vision screening in early childhood is crucial to mitigating lifelong visual impairment and associated socio-economic consequences (22,23).

In developing countries, amblyopia prevention campaigns have also been carried out, with the first one initiated in 1976 by ophthalmologists from the Peruvian Strabismus Center (CEP). This institution was founded in 1975 by members of the Peruvian Society of Ophthalmology (24).

The American Academy of Ophthalmology currently recommends visual screening for preschool children (ages 3-5) using the Lea symbol test or HOTV letters. This is because the Allen figures, Snellen chart, letter "E," and Lighthouse symbols are not standardized and exhibit lower sensitivity, making them unsuitable for screening purposes (19,25,26). Additionally, children are familiar with the Lea symbols, and their ability to correctly interpret right-left orientation does not affect their evaluation (27).

Currently, there is no consensus on the best screening method for detecting ametropia, but there is an urgent need to expand healthcare coverage through screening programs. This includes training both medical and non-medical personnel in ophthalmological tests, visual charts, and portable automated refraction equipment. However, these methods face challenges such as complexity, time requirements, and cost-effectiveness, leading to low reliability and validity (28,29).

In Peru, it has been reported that children's attendance to health services is lower than school attendance (16% vs. 82%, respectively), likely due to rugged geography, centralized resources, and cultural factors. This is the main reason why it was decided to train preschool teachers in the use of ophthalmological tests to evaluate their students. This decision was incorporated into Peru's National Sanitary Strategy for Ocular Health 2014-2020 (3,30).

It is important to note that this initiative has been underway in Peru since 1983, led by the CPE. They began training preschool teachers on visual development and amblyopia as part of a joint campaign with the Ministry of Education under Ministerial Resolution No. 1318. Six years later, in 1989, under agreement No. 726-89-ED, these campaigns were formally organized during the first two months of each year (January and February) (24).

Despite these efforts, teacher-led screening programs resulted in high false positive rates and low positive predictive values. Teachers often overdiagnosed more than half of the children evaluated, likely due to fear of misdiagnosis, improper test execution, uncooperative children, or inadequate infrastructure. As a result, many children required reevaluation by an ophthalmologist (28–31). Nevertheless, school-based screening programs, despite their limitations and costs, were considered effective by Kaur et al. and La Torre et al. in identifying children with visual impairments. Early

diagnosis and treatment led to improvements in both visual health and quality of life (28,29).

To reduce the false positive rate, we propose a simple, low-cost screening test that takes into account children's holistic developmental characteristics and does not require ophthalmological expertise. This test can be conducted by parents at home, which is particularly relevant given the restrictions on school attendance during the COVID-19 pandemic and the rise of remote work and learning.

Preschoolers have an imaginative mindset, allowing them to easily take on roles, such as pretending to be their favorite characters (32). This concept is leveraged in the proposed "Pirate Test," in which monocular occlusion is performed while children engage in low-attention activities, such as building towers, playing with dolls or cars, painting, or coloring.

A positive Pirate Test result is indicated if the child rejects the patch, has difficulty continuing their activity, or isolates themselves from peers or family members. A negative result suggests a low or nonexistent likelihood of amblyopizing refractive errors. Once results are obtained, they will be compared with the Gold Standard (Lea Test) to assess the test's discriminatory capacity, validity, and average application time.

A literature review found no prior references to the Pirate Test being used to diagnose ametropia or amblyopia. However, anecdotal evidence suggests that CPE ophthalmologists have used similar techniques to conduct letter "E" visual acuity tests in preschoolers (ages 3-5), assess fixation in children under 3, detect strabismus (including angle measurement), and assist in amblyopia treatment.

While the patch occlusion method is widely used for amblyopia treatment, precise data on its effective application time and tolerance are lacking. In 2017, Stewart C. et al. reported that to achieve a 0.2 logMar improvement in visual acuity (equivalent to a two-line improvement on the Snellen chart), occlusion should be applied for 178 to 276 hours per week (approximately 3.5 to 6 hours per day). However, the study did not provide data on tolerance rates (34).

## METHODOLOGY

447 preschoolers were enrolled in this study. We formulated the inclusion criteria as follows (1): All children aged 3 to 5 years who are relatives, acquaintances or neighbors of patients who attend the ophthalmology clinic (with or without visual alterations); (2) parents or guardians allowed them to participate in the study (3) from January 2020 to January 2021 in Piura City. Patients who met any of the following criteria were excluded (1): children wearing glasses; (2) Younger than 3 or older than 5 years; (3) children with developmental immaturity, neurological disorders (genetic, chromosomal, metabolic, nutritional causes, among others) associated or not with nystagmus, mental disorders (schizophrenia, etc.), behavioral disorders (ADHD, Autism Spectrum), among others (4); children with no permission from parents to participate in the study (5). Children who attend preschool before January 2020 or after January 2021.

This study was approved by the Medical Ethics Committee of the Cayetano Heredia Peruvian University. The procedures were in accordance with the principles of the Declaration of Helsinki and CIOMS guideline 22. All parents volunteered to cooperate and signed informed consent forms for their children, with full awareness of the study's purposes and potential risks. Physical, electronic, and procedural mechanisms were adopted to ensure the privacy and security of the participants. However, the names of the participants and their personal data were not kept anonymous during the study period, as the results were provided to parents or guardians to continue monitoring and initiate treatment with corrective lenses if necessary.

The study was conducted in Piura, northern Peru. Each patient who visited the ophthalmologist's office (principal investigator) was asked if they had children aged 3 to 5 years or if they knew any relatives, friends, or acquaintances with children in that age range. The importance of early detection of visual disturbances in children was explained, and participation in the study was offered. If they agreed, informed consent forms were provided for them to read and sign. An online meeting via Zoom was then scheduled.

The Zoom meeting lasted one hour and was divided into three parts: the first part, lasting 30 minutes, explained the role of visual disturbances in child development, the most common pathologies, and the proposed test. The second part, lasting 10 minutes, was focused on clarifying doubts and answering questions. The third part, which lasted 20 minutes, was a practice session where a video was shown to demonstrate how to correctly perform visual screening.

The test to be carried out by the parents at home was called the "Pirate Test." In this test, parents were instructed to place a pediatric eye patch, provided by the principal investigator, on their children's left eye (to evaluate the right eye). Afterward, the left eye

would be unpatched, and the right eye would be patched (to evaluate the left eye), with a maximum of 15 minutes for each occlusion. The patch was self-adhesive, hypoallergenic, latex-free, and of variable size (adjusted to the child's physiognomy). The patch featured images related to sports (for male children) or flowers (for female children).

An average time of 15 minutes for monocular occlusion was considered based on unwritten clinical evidence provided by pediatric ophthalmologists from Peru, Paraguay, Colombia, and Brazil. It is important to note that, since there was no established reference for this procedure, the monocular tolerance time to the patch was recorded for each participant.

Children's behavior was recorded either on video or in writing and then sent to the ophthalmologist. The ophthalmologist would analyze whether the child had a positive response to the Pirate Test, defined as follows: (1) immediately removing the patch, (2) having difficulty continuing activities, (3) or isolating themselves from others. If none of these behaviors were observed, the result was considered negative.

It is important to note that parents were instructed to perform the test during the daytime, when the child was in a good mood, energetic, and ready to engage, which is why specific schedules were not established. Parents could decide whether to apply the patch themselves or ask another family member to become a "Pirate" alongside their child. However, they were advised not to interfere with the child's behavior (e.g., by forcing them to keep the patch on). Parents were asked to record the child's movements and correlate them with the time spent on each eye, for the entire 15-minute test duration.

The videos were shown to or sent to the ophthalmologist, who evaluated whether the preschoolers exhibited positive behaviors and verified whether the patch tolerance time matched the data reported by the parents, in order to avoid measurement bias. All data collected was recorded in a database, and a protocolized ophthalmological evaluation was scheduled for each participant afterward.

Additionally, preparation materials and relevant instructions were provided. This included figures from Lea's test, clothing guidelines, rules, and basic care instructions to prevent contagion. The importance of social distancing was emphasized, as well as avoiding bringing food or drinks, and the mandatory use of face masks for children, along with double masking and facial shields for adults. It was stressed that the mask should fully cover the nose and mouth, extending below the chin.

The ophthalmological evaluation was conducted by the principal investigator in his private office, which was equipped with the necessary materials and equipment, and complied with the health protocols for COVID-19.

Upon arrival at the consultation, the participants were greeted by the staff responsible for executing the cleaning and disinfection protocol. The staff was properly dressed and followed the guidelines set by the Ministry of Health due to the global context of the COVID-19 pandemic. The COVID-19 protocol included cleaning and disinfecting the footwear of both the children and their companions, measuring body temperatures using a digital thermometer, applying alcohol gel to the hands of each individual, and providing disposable boots. Afterward, participants were instructed to sit in the waiting room, maintaining social distancing, and wait for their child to be called.

Once called, the participants were escorted to the ophthalmological office, where the principal investigator (ophthalmologist) was waiting, having already taken the established biosafety measures, which included wearing a double mask, surgical clothing, disposable apron, disposable boots, a surgical cap, and a face shield. The ophthalmological evaluation was then conducted.

The evaluations were carried out one child per hour, from Monday to Friday, with only one companion allowed per child. Depending on the complexity of the case, the exam could be extended as necessary. After each consultation, the office and ophthalmic instruments were cleaned and disinfected, and any disposable clothing was discarded and replaced with new attire.

The ophthalmological evaluation protocol involved measuring monocular visual acuity using the Lea symbol chart at distances of 3 meters and 40 cm. The alternating cover-uncover test was performed at 40 cm for each eye. Automated refraction was then conducted with an auto refractometer (TOPCON KR-8900) without cycloplegia. If a child exhibited a visual acuity worse than 0.1 (Log Mar) or worse than 20/25 (Snellen), automated refraction was performed under the effect of cycloplegia, and the results were confirmed with retinoscopy.

In this study, cycloplegia was performed on all evaluated children at two different times. Initially, cycloplegia was performed only on those children whose visual acuity did not meet the age-appropriate criteria (430 children). Six months later, cycloplegia was repeated for 17 children during their follow-up

appointments.

It is important to note that any child with very good visual acuity (0.0 according to LogMar or 20/20 according to Snellen) was not considered emmetropic. This is because they were still within the "golden period" of visual development, so they were only classified as having adequate visual acuity for their age.

The cycloplegia protocol used for the study participants followed the Clinical Practice Guide for the detection, diagnosis, treatment, and control of refractive errors in children over 3 years of age and adolescents, developed by Peru's Ministry of Health. The protocol involved initially applying 1 drop of proxymetacaine hydrochloride 0.5% ophthalmic solution, waiting one minute, followed by the application of 1 drop of 1% tropicamide. After 5 minutes, a second drop of tropicamide was applied, and the evaluation was carried out after 20 minutes (6).

Following cycloplegia, the anterior segment was evaluated using a slit lamp, and the posterior segment was examined with an indirect ophthalmoscope and a 30-diopter lens with a yellow filter. The findings from these examinations were recorded.

At the end of the ophthalmological evaluation, the parents were informed of the results. If a refractive defect was detected, the appropriate prescription was provided to the parent or guardian, along with the necessary corrections. If any other pathology was found, the relevant recommendations for its timely management were also given.

If glasses and eye patching were needed (for high ametropias with a high risk of amblyopia), parents were counseled on the importance of periodic follow-up. In cases of very severe conditions, a referral to a pediatric ophthalmologist was made to ensure proper management.

The obtained information was coded and recorded in Microsoft Excel for Mac v16.53 electronic template and placed in single and double entry tables. In addition, the efficacy of the test carried out was calculated by analyzing the sensitivity, specificity and the ROC curve values of the Pirate Test using the statistical program SPSS v16.

## RESULTS

A total of 447 children 3 to 5 years were included in the analysis, 221 boys (49.4%) and 226 girls (50.6%). Of them, 378 (42.28%) had refractive disorders and 282 amblyopia (31.54%); being 131 monocular (46.5%) and 151 binocular (53.5%), as observed in Table 1.

**TABLE 1. GENERAL CHARACTERISTICS OF PRESCHOOLERS**

| Variable | n = 894 | % |
|---|---|---|
| Female | 226 | 50.6% |
| Positive Pirate Test | 251 | 28.1% |
| Have refractive error | 378 | 42.3% |
| Have amblyopia | 282 | 31.5% |
| Binocular | 151 | 53.5% |
| Age (**mean ± SD**) | 4 ± 1 | |
| Tolerance time (min) (**mean ± SD**) | 12.7 ± 3.94 | |
| Visual Acuity Test (**mean ± SD**) | 0.3 ± 0.33 | |

Table 2 compared several variables, including sex, the presence of refractive errors, the presence of amblyopia, age, visual acuity, and tolerance time in relation to the response to the Pirate Test. The reliability of these comparisons was assessed using the Chi-squared (Chi2) test and the Mann-Whitney test. The results showed that 85.4% of the patients who did not tolerate the patch (i.e., had a positive Pirate Test result) had refractive errors, while 78.8% of the patients who tolerated the patch (i.e., had a negative Pirate Test result) were healthy. This difference was statistically significant.

Similarly, amblyopia was present in 83% of the patients who did not tolerate the patch (positive Pirate Test), whereas 93.7% of the patients who tolerated the patch (negative Pirate Test) were healthy. Again, this difference was statistically significant.

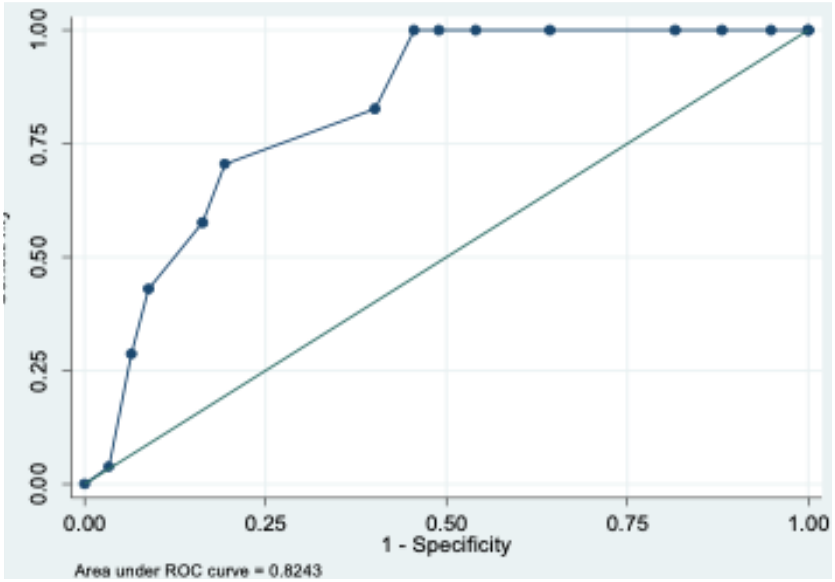
Regarding tolerance time for using the patch and visual acuity, it was found that patients who had an average tolerance of less than 5 minutes exhibited a positive Pirate Test result. Additionally, patients with visual acuity worse than 0.6 (LogMar) or 20/80 (Snellen) also had positive results. These findings were statistically significant, supporting the correlation between short patch tolerance times, poor visual acuity, and positive Pirate Test responses.

**Table 2. Analysis of variables in relation to the response to the Pirate Test**

| Qualitative variable * | Category | Pirate Test | | | | p-value |
|---|---|---|---|---|---|---|
| | | Negative pirate test | | Positive Pirate Test | | |
| | | n=600 | % | n=294 | % | |
| Sex | Female | 292 | 48.7% | 160 | 54.4% | 0.106 |
| | Male | 308 | 51.3% | 134 | 45.6% | |
| Refractive error | No refractive error | 473 | 78.8% | 43 | 14.6% | <0,001 |
| | Have refractive error | 127 | 21.2% | 251 | 85.4% | |
| Amblyopia | No amblyopia | 562 | 93.7% | 50 | 17.0% | <0,001 |
| | Have amblyopia | 38 | 6.3% | 244 | 83.0% | |
| Quantitative variable ** | | Q2 (Q1 - Q3) | | Q2 (Q1 - Q3) | | |
| Age | | 4 (3 - 5) | | 5 (4 - 5) | | 0.023 |
| Tolerance time (min) | | 15 (15 - 15) | | 6 (5 - 10) | | <0,001 |
| Visual acuity | | 0.1 (0.0 - 0.2) | | 0.7 (0.6 - 1.0) | | <0,001 |

In Graphic 1 the ROC curve of the tolerance time to the Pirate Test was related to the children's response to the Pirate test, resulting an area under the curve (AUC) of 0.8243, a standard error of 0.0162 and a confidence interval of 95% of 0.79 – 0.86.

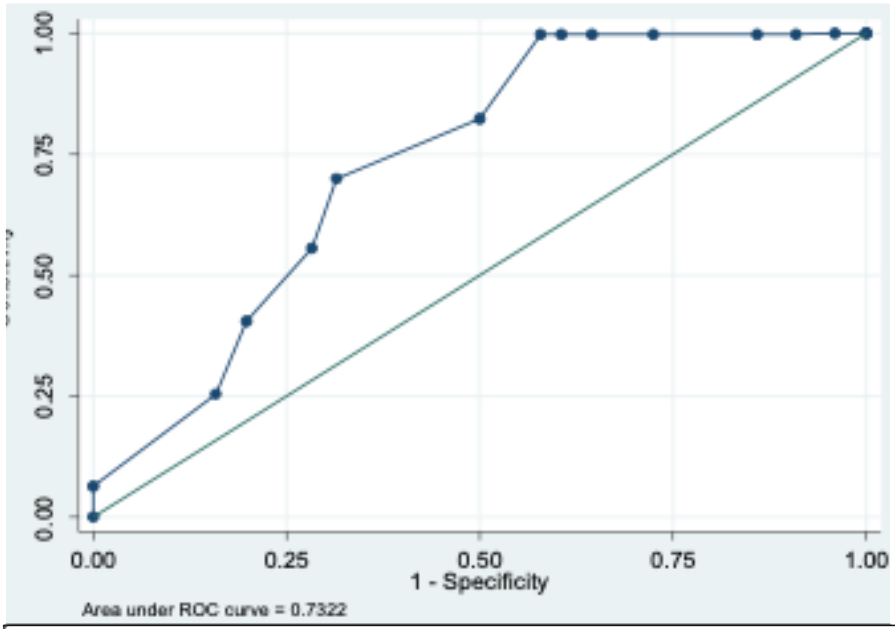
**GRAPHIC 1. ROC CURVE AND AREA UNDER THE CURVE (AUC) OF THE TOLERANCE TIME RELATED TO THE RESPONSE TO THE PIRATE TEST.**




| Obs | Area | Std. Err. | [95% Conf. | Interval] |
|---|---|---|---|---|
| 894 | 0.8243 | 0.0162 | 0.79251 | 0.85601 |

In Graphic 2, the ROC curve of the tolerance time to the Pirate Test was associated with the presence of refractive errors, finding AUC of 0.7322, a standard error of 0.0177 and a confidence interval of 95% of 0.69 – 0.77.

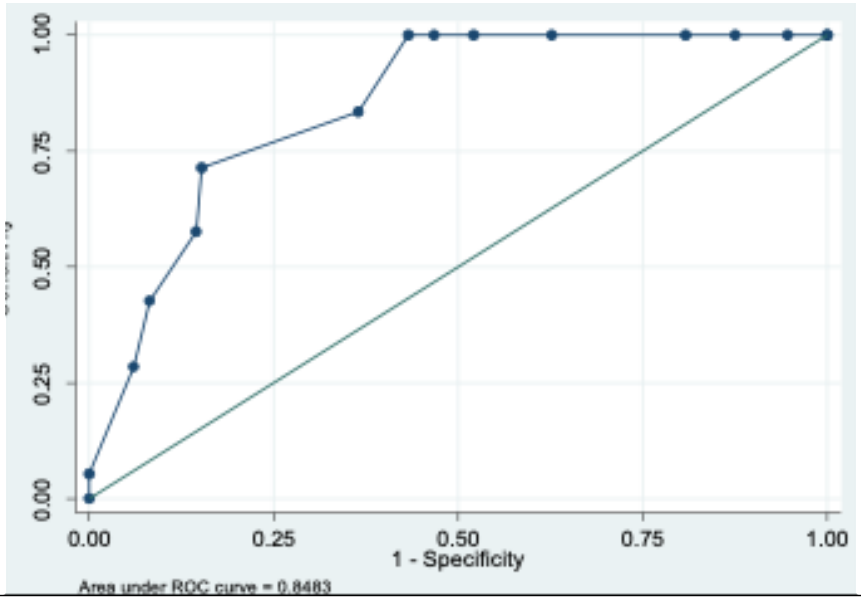
**GRAPHIC 2. ROC CURVE AND AREA UNDER THE CURVE (AUC) OF THE TOLERANCE TIME RELATED TO THE PRESENCE OF REFRACTIVE ERROR**




| Obs | Area | Std. Err. | [95% Conf. Interval] | |
|---|---|---|---|---|
| 894 | 0.7322 | 0.0177 | 0.69752 | 0.76687 |

In Graphic 3, through the ROC curve of the tolerance time to the Pirate Test related to amblyopia presence, the resulting AUC was 0.8483, with a standard error of 0.0150 and a confidence interval of 95% of 0.82 – 0.88.

**GRAPHIc 3. ROC CURVE AND AREA UNDER THE CURVE (AUC) OF THE TOLERANCE TIME RELATED TO THE PRESENCE OF AMBLYOPIA**




| Obs | Area | Std. Err. | [95% Conf. Interval] | |
|---|---|---|---|---|
| 894 | 0.8483 | 0.0150 | 0.81889 | 0.87778 |

## DISCUSIÓN

In this study, a total of 894 eyes from 447 preschoolers (ages 3 to 5 years) were included, with a slight predominance of females over males. The Pirate Test yielded positive results in nearly 30% of the children, while over 40% had refractive errors, none of whom used corrective glasses. Among these children, 31.5% had amblyopia, with a slight binocular predominance in more than half of the cases. These findings align with those reported by Carrion et al. in Peru, who observed a prevalence of refractive errors of 46.3%, with 90.25% of cases remaining uncorrected. Similarly, Huaman et al. found comparable results in their study (5,6).

The high frequency of ametropia observed in this study may be attributed to the lack of routine early detection at the primary healthcare level. Contributing factors include limited access to health services due to geographic and logistical barriers, cultural attitudes, and a shortage of trained and specialized healthcare personnel. These challenges emphasize the urgency of addressing amblyopia, which is an imminent and irreversible consequence of untreated refractive errors (3,30).

When analyzing the correlation between the Pirate Test and other variables, such as sex, presence of refractive errors, amblyopia, age, visual acuity, and patch tolerance time, statistical significance was found in all variables, except for sex. This suggests that the Pirate Test is a reliable tool for detecting refractive errors and amblyopia, regardless of the child's sex, but it is influenced by factors like visual acuity, patch tolerance, and age.

Regarding refractive errors, the Pirate Test demonstrated a sensitivity of 85.4% and a specificity of 78.8%, indicating good screening reliability. These results were statistically significant. The sensitivity in this study surpassed that reported by the Vision in Preschoolers (VIP) Study Group for a similar test, the cover-uncover test, which had a sensitivity of 16% and a specificity of 98%. When compared to the Gold Standard, which had a sensitivity of 86% and specificity of 90%, the Pirate Test performed favorably, showing comparable sensitivity and a slightly lower specificity. This highlights the Pirate Test's potential as a reliable and practical screening tool for detecting refractive errors in preschool-aged children. (25,35)

These findings validate the effectiveness of the Pirate Test in detecting preschoolers with significant refractive errors that could lead to amblyopia. Similar results have been reported by the VIP Group and Bertuzzi et al., with sensitivities and specificities of 70%, 90%, and 96%, 83%, respectively (21,35). This further supports the Pirate Test as a reliable screening tool for early detection of refractive errors.

Statistical significance was also found when comparing age groups (3, 4, and 5 years) and their response to the Pirate Test ($p=0.023$). However, given the limited sample size, potential bias should be considered, and the data should be interpreted with caution.

Analysis of patch tolerance time and visual acuity indicated that shorter tolerance times (<5 minutes) and poorer visual acuity (>0.7 LogMar or <20/100 Snellen) were associated with a higher likelihood of amblyopizing ametropia, with statistically significant results. This suggests that children with shorter patch tolerance and poorer visual acuity are more likely to have refractive errors that could lead to amblyopia, emphasizing the importance of early screening and intervention.

Receiver Operating Characteristic (ROC) curves were generated to illustrate the sensitivity and specificity of different cut-off points for patch tolerance time in relation to Pirate Test response, refractive errors, and the presence of amblyopia. The ROC curve for patch tolerance time in relation to the Pirate Test response showed an Area Under the Curve (AUC) of 0.8243, with a standard error of 0.0162 and a 95% confidence interval of 0.79 - 0.86, indicating good levels of reliability. The cut-off point with the best sensitivity and specificity was found to be 5 minutes, suggesting that if patch tolerance is <5 minutes, the evaluated eye is likely to have a high refractive error that could lead to amblyopia, and the Pirate Test will likely be positive.

In the ROC curve for patch tolerance time in relation to the presence of refractive errors, an AUC of 0.7322 was found, with a standard error of 0.0177 and a 95% confidence interval of 0.69 - 0.77, indicating good reliability. The cut-off point with the best sensitivity and specificity was 6 minutes, implying that if patch tolerance time is <7 minutes, the evaluated eye is more likely to have ametropia.

These findings support the use of patch tolerance time as a reliable indicator for identifying significant refractive errors and potential amblyopia in preschool-aged children, with specific cut-off points providing valuable thresholds for screening.

Finally, in the last ROC curve, the cut-off points of the tolerance time were correlated to the presence of amblyopia, resulting in an Area Under the Curve (AUC) of 0.8483, with a standard error of 0.0150 and a 95%

confidence interval of 0.82 - 0.88, indicating excellent reliability. The cut-off point with the best sensitivity and specificity was found to be 5 minutes, suggesting that if tolerance time is <5 minutes, the tested eye is highly likely to have amblyopia.

These values and their corresponding ROC curves demonstrate that the Pirate Test effectively differentiates healthy preschoolers from those with visual impairments, particularly amblyopia.

The Pirate Test exhibits strong discrimination capacity and is a valid and reliable tool for detecting ametropia in preschool-aged children. The recommended tolerance cut-off point is ≤5 minutes, as shorter tolerance times correlate with a higher likelihood of significant refractive errors and potential amblyopia.

As a non-invasive, low-cost, simple, and reproducible test, the Pirate Test offers a valuable screening option for non-medical personnel to detect significant visual impairments in preschoolers. Given the statistically significant differences observed by age group, further studies are warranted to confirm and refine these findings.

### CONTRIBUTION OF THE AUTHORS

JK and JO participated in the conception and design of the study. KE, LM, and SM contributed to data collection and acquisition. JO and JK participated in data analysis, while SM contributed to the interpretation of the results. All authors participated in drafting the manuscript, critical revision, and approved the final version for publication.

### EDITORIAL NOTE

La The opinions expressed in this article, as well as the methodological approach and the results presented, are the sole responsibility of the authors. This work was reviewed and approved by external reviewers within the framework of the editorial process, but it does not necessarily reflect the official stance of the journal, its editorial committee, or its editor-in-chief.

### DATA AVAILABILITY

The data are available upon request to the corresponding author. Margarita Samudio. Mail: margarita.samudio@gmail.com

### REVIEWERS' COMMENTS

The names of the external reviewers, as well as their reports, are available at the following link: Dictamen 600.pdf

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