

## Assessing a deep learning tool for cataract detection using a public dataset

Avaliação de uma ferramenta de *deep learning* para detecção de catarata utilizando um banco de dados públicoMauro Gobira<sup>1</sup> , Matheus Gobira<sup>2</sup> , Carolina Oliveira de Ávila<sup>3</sup> <sup>1</sup> Departamento de Oftalmologia, Instituto Paulista de Estudos e Pesquisas em Oftalmologia, São Paulo, SP, Brazil.<sup>2</sup> Programa de Pós-Graduação, Faculdade de Minas, Belo Horizonte, MG, Brazil.<sup>3</sup> Faculdade Zarns, Itumbiara, GO, Brazil.

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**Conflict of interest:**

Mauro Gobira declares that he is the founder of the company Gobvision, mentioned in this study, and that the company developed the Artificial Intelligence tool under evaluation. No other conflicts of interest were declared by the remaining authors.

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**ABSTRACT****Objective:** To assess the diagnostic accuracy of a deep learning tool for cataract detection using retinal images from the Ocular Disease Intelligent Recognition (ODIR) public dataset.**Methods:** The study was conducted using a publicly available dataset, with a web-based Artificial Intelligence tool. This was an observational, cross-sectional study. A total of 230 fundus images were selected from the ODIR dataset, equally divided between 115 cataract cases and 115 non-cataract cases. The images were processed using the Gobvision Artificial Intelligence tool, which employs a convolutional neural network (MobileNet-V2) to classify the presence of cataract. Key performance metrics such as sensitivity, specificity, and accuracy were calculated.**Results:** The deep learning model for cataract diagnosis, tested on 230 eyes, achieved an accuracy of 94.35%, with a sensitivity of 93.91%, specificity of 94.78%, positive predictive value of 94.74%, and negative predictive value of 93.97%. The F1-score was 0.94, and Cohen's Kappa of 0.89 indicated high agreement with clinical diagnoses.**Conclusion:** Gobvision Artificial Intelligence demonstrated high accuracy and reliability in detecting cataract using fundus images. This Artificial Intelligence tool has significant potential to enhance cataract screening, especially in regions with limited access to ophthalmologists.**RESUMO****Objetivo:** Avaliar a acurácia diagnóstica de uma ferramenta de *deep learning* para detecção de catarata utilizando imagens de retina do banco de dados público Ocular Disease Intelligent Recognition (ODIR).**Métodos:** O estudo foi conduzido com o uso de um banco de dados de domínio público e de uma ferramenta de Inteligência Artificial baseada na web, em um delineamento observacional e transversal. Um total de 230 imagens de fundo de olho foram selecionadas do banco ODIR, sendo 115 casos de catarata e 115 casos sem catarata. As imagens foram processadas pela ferramenta de Inteligência Artificial Gobvision, que utiliza uma rede neural convolucional (MobileNet-V2) para classificar a presença de catarata. Foram calculadas métricas de desempenho como sensibilidade, especificidade e acurácia.**Resultados:** O modelo de *deep learning* para diagnóstico de catarata, testado em 230 olhos, alcançou uma acurácia de 94,35%, com sensibilidade de 93,91%, especificidade de 94,78%, valor preditivo positivo de 94,74% e valor preditivo negativo de 93,97%. O F1-score foi 0,94, e o coeficiente Kappa de Cohen, de 0,89, indicou alta concordância com os diagnósticos clínicos.**Conclusão:** A Inteligência Artificial Gobvision demonstrou alta precisão e confiabilidade na detecção de catarata por meio de imagens de fundo de olho, apresentando grande potencial para aprimorar o rastreamento de catarata, especialmente em regiões com acesso limitado a oftalmologistas.

## INTRODUCTION

A cataract is defined as an opacity or clouding of the eye's lens, leading to a reduction in visual function and, if left untreated, can eventually result in blindness.<sup>(1,2)</sup> It is the leading cause of blindness and visual impairment worldwide, affecting millions of people, particularly in regions with high exposure to sunlight and ultraviolet radiation.<sup>(3,4)</sup> While cataract most commonly affects older adults, they can also occur earlier due to factors such as trauma, metabolic disorders, or prolonged use of corticosteroids.<sup>(5,6)</sup>

The pathogenesis of cataract involves multiple factors, including oxidative stress from reactive oxygen species, which can damage the lens.<sup>(2)</sup> In diabetic patients, cataracts can develop rapidly and present with various morphologies, such as subcapsular vacuoles and cortical opacities.<sup>(7)</sup> The genetic basis of cataract is significant, with mutations affecting enzymes involved in lanosterol synthesis, which are crucial for lens transparency.<sup>(8)</sup> These findings suggest potential avenues for non-surgical prevention and treatment.<sup>(8)</sup> However, at present, phacoemulsification surgery remains the only effective treatment for cataract, ensuring the removal of the clouded lens and the restoration of vision in most cases.<sup>(2)</sup>

Although cataract can be effectively treated through surgery, access to such services remains limited in many regions, highlighting the need for improvements in healthcare provision and patient education.<sup>(9)</sup> Technological advancements, such as automatic cataract classification systems based on fundus image analysis, aim to facilitate early detection and grading of cataract, making diagnosis more accessible and efficient.<sup>(10)</sup> The development of these systems is crucial given the shortage of ophthalmologists and the time-consuming nature of traditional examination methods.<sup>(10)</sup>

This study aimed to assess the diagnostic accuracy of a deep learning tool for cataract detection using retinal images from the Ocular Disease Intelligent Recognition (ODIR) public dataset. By enhancing diagnostic precision and enabling earlier detection, Artificial Intelligence has the potential to address critical gaps in cataract care, particularly in underserved regions.

## METHODS

### Ethical approval and study design

This research project adhered strictly to the guidelines of the Declaration of Helsinki. The study used a public and anonymized database, the ODIR dataset, and thus did not require the collection of Informed Consent Forms (ICF)

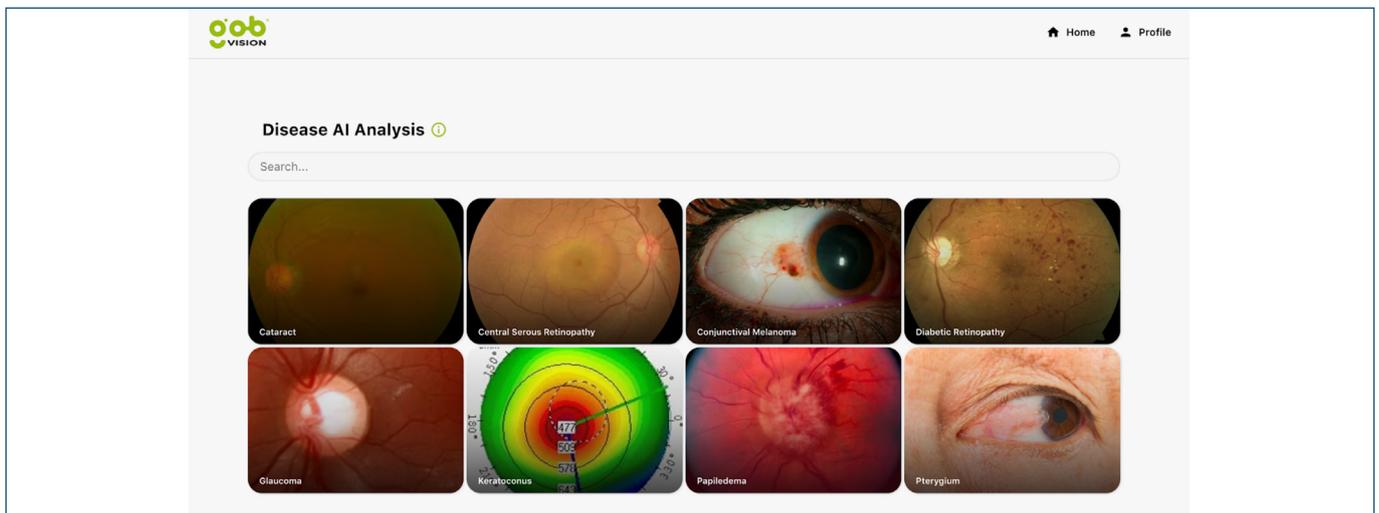
from participants. The IRB approval was not required for this study.

This cross-sectional study evaluates the accuracy of a web-based AI tool for cataract diagnosis, using retinal image analysis.<sup>(11)</sup> The foundation of this research is the publicly available ODIR dataset (<https://www.kaggle.com/andrewmvd/ocular-disease-recognition-odir5k>), a comprehensive resource sponsored by the Peking University to develop and validate ocular disease detection algorithms.<sup>(11)</sup> Collected by Shangong Medical Technology Co., Ltd., the ODIR dataset comprises de-identified data from 5,000 patients across 487 hospitals in 26 Chinese cities.<sup>(11)</sup> This dataset, one of the most extensive of its kind on Kaggle, contains color fundus photographs of both left and right eyes, paired with diagnostic keywords assigned by ophthalmologists.<sup>(11)</sup> For this study, all images were resized to a standardized 224 x 224 pixel resolution.<sup>(11)</sup> The ODIR dataset categorizes fundus images into eight classes, seven representing specific diseases: normal (N), myopia (M), hypertension (H), diabetes (D), cataract (C), glaucoma (G), and age-related macular degeneration (A). The eighth category (O) encompasses other diseases or abnormalities.<sup>(11)</sup>

To test the Gobvision AI tool, we randomly selected 115 images from patients diagnosed with cataract and 115 from patients without the disease, all uploaded directly to the web application available at <https://www.gobvisionai.com/>. The results were documented in an Excel spreadsheet. The cataract images were not graded by severity and were treated as binary (cataract versus non-cataract). Future work should include stratification by severity levels to improve clinical relevance.

### Gobvision Artificial Intelligence platform and model training

The Gobvision AI tool, based on the MobileNet-V2 architecture, employs convolutional neural networks (CNNs) for efficient image classification. This web-based platform allows ophthalmologists to easily analyze medical images with AI, without requiring advanced programming skills (Figure 1). Chosen for its affordability and wide availability, Gobvision AI supports the practical integration of AI technology in clinical settings. The AI models were trained using retinography images with default parameters of 50 epochs, a batch size of 16, and a learning rate of 0.001, optimizing the system for reliable diagnostic use. Importantly, the model was not previously trained with images from the ODIR database to avoid bias and better reflect real-world conditions.<sup>(11)</sup>



**Figure 1.** Interface of the Gobvision AI Tool.

## Statistical analysis

The statistical analysis conducted in this study involved several key performance metrics to evaluate the accuracy and reliability of the deep learning model for cataract diagnosis. The overall accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to assess the model's diagnostic performance.

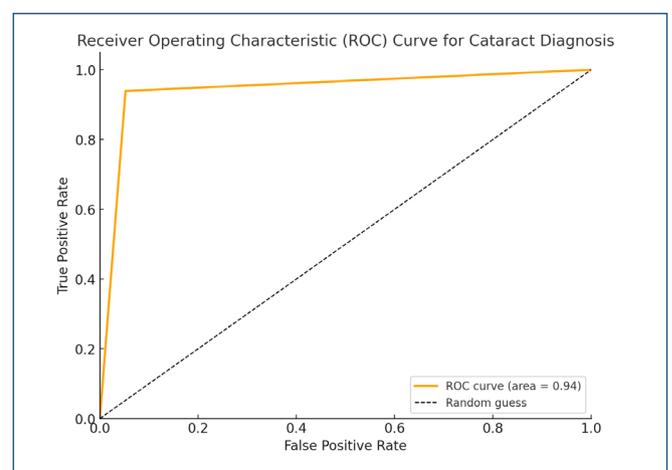
The accuracy was determined by calculating the proportion of correctly classified cases (both cataract and non-cataract) relative to the total number of cases, reported with a 95% confidence interval (CI). Sensitivity and specificity were used to measure the model's ability to correctly identify true positive cases (cataract eyes) and true negative cases (non-cataract eyes), respectively. The PPV and NPV were calculated to further evaluate the model's performance, focusing on its reliability in predicting the presence and absence of cataract.

Additionally, the area under the receiver operating characteristic curve (AUC) was computed to assess the model's overall discriminative ability. An AUC score close to 1 indicates excellent diagnostic power. The Cohen's Kappa coefficient was calculated to assess the level of agreement between the model's predictions and the clinical diagnoses, with a Kappa value close to 1 representing near-perfect agreement. Statistical analysis was conducted using the DataTab software.<sup>(12)</sup>

## RESULTS

The deep learning model for cataract diagnosis was evaluated in a sample of 230 eyes, equally divided between those with cataract and without cataract. The model achieved an overall accuracy of 94.35% (95%CI:

89.85%-98.85%), with sensitivity measured at 93.91% (95%CI: 88.45%-99.37%) and specificity at 94.78% (95%CI: 89.99%-98.06%). The ROC curve (Figure 2) provides a graphical representation of the model's diagnostic performance, with an area under the curve (AUC) of 0.94. The PPV was 94.74% (95%CI: 89.49%-99.99%), and the NPV was 93.97% (95%CI: 88.47%-99.46%). Additionally, the F1-score was calculated at 0.94, and Cohen's Kappa coefficient was 0.89 (95%CI: 0.80-0.98), quantifying the agreement between the model's predictions and the reference standard labels from the ODIR dataset. Retinography images of four eyes classified differently from their reference labels by the model are shown in Figure 3.

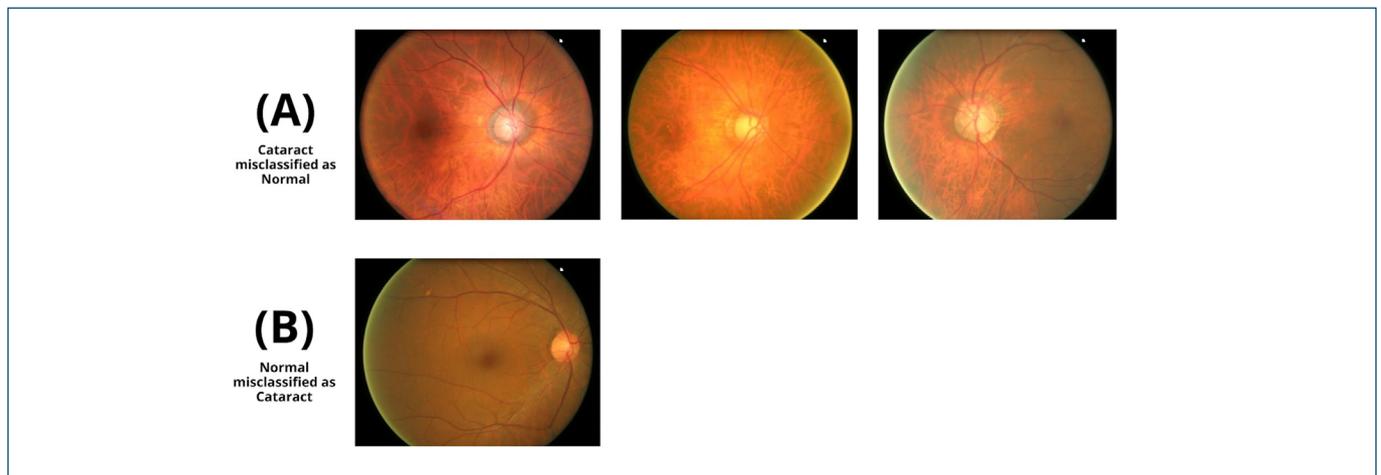


ROC: Receiver Operating Characteristic.

**Figure 2.** Receiver Operating Characteristic curve chart.

## DISCUSSION

The application of AI and deep learning models in cataract detection has shown potential to enhance diagnostic



**Figure 3.** Retinography of four eyes misclassified by the deep learning tool. (A) Two cataract eyes misclassified as non-cataract. (B) Two non-cataract eyes misclassified as cataract.

accuracy, efficiency, and accessibility, potentially complementing traditional methods.<sup>(13-21)</sup> While slit-lamp examination remains the gold standard, it is time-consuming and reliant on specialized clinical expertise.<sup>(12-25)</sup> AI tools could potentially analyze various imaging modalities, including slit-lamp images, anterior segment photos, optical coherence tomography (OCT), and retinal fundus images, for cataract diagnosis, offering a faster initial assessment.<sup>(12-25)</sup> In this study, we evaluated a widely available web-based AI tool that diagnoses cataract using retinal fundus images. Retinography is a relatively cost-effective and commonly used examination, suggesting a potential avenue for wider cataract screening, particularly in resource-limited settings.<sup>(12)</sup>

Mobile platforms and AI tools are also expanding access to cataract screening in areas with limited ophthalmologist availability.<sup>(12-25)</sup> For example, the mobile app e-Paarvai extends cataract detection capabilities to underserved areas, achieving a sensitivity of 96% but with a relatively low specificity of 25%, resulting in an overall accuracy of 88%.<sup>(17)</sup> Its performance in detecting mature cataract was notably lower, with only 22% accuracy.<sup>(17)</sup> While mobile platforms provide greater reach, the accuracy of detection varies significantly depending on the model and the type of cataract being evaluated.<sup>(17)</sup> On the other hand, AI models trained on more detailed slit-lamp video data and retinal photographs have demonstrated higher diagnostic accuracy.<sup>(18)</sup> For instance, an AI model for nuclear cataract diagnosis from slit-lamp videos achieved an area under the curve (AUC) ranging from 0.923 to 0.967 depending on cataract grade, with a diagnostic accuracy of 94.1%.<sup>(18)</sup> Similarly, a deep learning-based model using retinal photographs reached an AUC of 96.6% in internal testing, highlighting the robustness of AI for identifying

visually significant cataract in more controlled environments.<sup>(22)</sup>

In a related study, Dong et al. employed a combination of deep learning and machine learning algorithms to classify cataract severity in 5,495 fundus images, achieving an accuracy of 94.07% for cataract detection and 90.82% for severity grading.<sup>(22)</sup> Ran et al. used a Deep Convolutional Neural Network (CNN) for feature extraction and Random Forest for prediction, reaching an impressive AUC of 97.04% and sensitivity of 97.26%.<sup>(23)</sup> Similarly, Pratap and Kokil applied pre-trained CNN and SVM for cataract detection and severity classification, reporting 100% accuracy in cataract detection but emphasizing the limitations of testing solely on an internal dataset.<sup>(24)</sup> Zhang et al. developed a CNN-based system using 4,004 fundus images, with preprocessing using a green channel filter, achieving an AUC of 93.52% for cataract detection and 86.69% for severity grading.<sup>(25)</sup> Finally, Li et al. combined ResNet-18 and ResNet-50 for cataract detection and severity grading, reaching an AUC of 97.2% for detection, though discrepancies in the saliency maps suggested room for improvement in feature identification.<sup>(26)</sup> Unlike these studies, our work evaluated the accuracy of an AI model using an external dataset, without training the model on any part of that dataset, providing a more robust and generalizable assessment of the AI's real-world performance.

In our study, we evaluated the Gobvision AI tool, based on the MobileNet-V2 architecture, which demonstrated high accuracy in diagnosing cataract. The Gobvision AI tool achieved an accuracy of 94.35%, a sensitivity of 93.91%, and a specificity of 94.78%. These results align with similar AI models, reinforcing the effectiveness of convolutional neural networks (CNNs) in cataract detection. A previous

study assessed the performance of the VGG-19 deep learning model on the publicly available ODIR dataset, reporting an accuracy of 0.94 and an F1-score of 0.95 for cataract diagnosis, which are comparable to the results obtained in our study.<sup>(27)</sup> These findings suggest that AI models could potentially serve as a valuable tool in identifying cataract cases. The analysis of the errors made by the AI indicates that false positives may be associated with underlying diseases that can alter the transparency of the ocular media or even artifacts, as previously described in the literature. Conversely, false negatives are often linked to early-stage cataract, which tend to have a smaller impact on the transparency of the ocular media.

This study demonstrates the potential of AI for cataract detection, but several limitations warrant consideration. While the AI model was promising in identifying the presence or absence of cataract, its generalizability is a concern. The ODIR dataset, sourced from 487 hospitals across 26 cities in China, may not adequately represent the diversity found in broader patient populations.<sup>(10)</sup> The absence of detailed demographic information in the ODIR dataset limits a comprehensive assessment of potential biases related to age, ethnicity, and systemic comorbidities. Moreover, since the dataset comprises exclusively Chinese patients, there is a risk that the model's performance may not generalize across diverse ethnic and geographic populations. To enhance external validity and ensure broader applicability, future studies should prioritize validation using multi-ethnic and demographically heterogeneous cohorts.<sup>(10)</sup>

Furthermore, the study did not evaluate the severity of cataract, focusing only on their presence or absence. Incorporating a grading system like the Lens Opacities Classification System (LOCS III) would allow for a more nuanced assessment of the AI model's performance across different cataract types and severities.<sup>(28)</sup> Finally, the "black box" nature of the AI model presents a challenge for clinical adoption.<sup>(29,30)</sup>

Enhancing the interpretability of the model's decision-making process could improve clinician trust and facilitate its integration into existing clinical workflows. Future research should prioritize using diverse datasets, incorporating clinical data such as best-corrected visual acuity, utilizing standardized grading systems like LOCS III, and potentially including anterior segment OCT imaging for a more comprehensive evaluation. Addressing these limitations will be crucial for advancing the development and clinical implementation of reliable AI-based tools for cataract diagnosis.

Future validation using independent datasets from other institutions or populations is necessary to confirm the model's generalizability. The model currently analyzes color fundus images resized to 224 x 224 pixels; thus, images must meet this resolution and quality standard. A more thorough evaluation of compatibility with other imaging formats would also be beneficial.

## CONCLUSION

The Gobvision AI tool demonstrated high accuracy, sensitivity and specificity in detecting cataracts using fundus images from the public ODIR dataset. These results highlight the potential of Gobvision Artificial Intelligence as an efficient screening tool, especially in regions with limited access to ophthalmologists, contributing to early cataract detection and reducing delays in treatment.

Although the study evidenced the effectiveness of the model under specific conditions, limitations such as the restricted representativeness of the dataset used and the absence of cataract severity analysis indicate the need for further research. Future studies exploring more diverse populations and incorporating complementary clinical data, such as best-corrected visual acuity and anterior segment imaging, are essential to validate and expand the clinical applicability of the model.

By integrating deep learning technology into health-care systems, tools like Gobvision Artificial Intelligence can revolutionize ophthalmological diagnostics, fostering greater equity in eye health access on a global scale. This study underscores the importance of innovative approaches to addressing public health challenges and points to promising directions for the development of Artificial Intelligence-based solutions.

## AUTHORS' CONTRIBUTION

Substantial contribution to conception and design: Matheus Gobira; Mauro Cesar Gobira Guimaraes Filho; Acquisition of data: Matheus Gobira; Carolina Oliveira de Ávila; Analysis and interpretation of data: Matheus Gobira; Mauro Cesar Gobira Guimaraes Filho; Carolina Oliveira de Ávila; Drafting of the manuscript: Matheus Gobira; Carolina Oliveira de Ávila; Critical revision of the manuscript for important intellectual content: Mauro Cesar Gobira Guimaraes Filho; Carolina Oliveira de Ávila; Have given final approval of the submitted manuscript (mandatory participation for all authors): Matheus Gobira; Mauro Cesar Gobira Guimaraes Filho; Carolina Oliveira de Ávila.

Statistical analysis: Matheus Gobira; Carolina Oliveira de Ávila.

Research group leadership and supervision: Mauro Cesar Gobira Guimaraes Filho.

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