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Post Cataract Surgery Complication Detection System

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Abstract

The paper on post cataract surgery complication detection system presents a comprehensive system designed to improve the outcomes and post-operative management of cataract surgery. The system integrates predictive analytics, complication detection, and patient-centred features to support both healthcare providers and patients throughout the cataract surgery journey. Using machine learning algorithms, the system predicts the likely outcomes of cataract surgery based on patient-specific data such as age, medical history, and visual acuity results. After the development of the cataract detection system, it was deployed in hospitals and patients tested with system and analysis done on the outcome. The methodology used for analysis was Object-Oriented Analysis Design and Methodology, the languages used to build the system were; HTML, CSS, PHP. Results were obtained, and the system demonstrated an accuracy of 85% in identifying potential complications, 90% of patients reported that the guidelines were clear and helpful in preparing for surgery and managing post-operative care, 88% of patients reported that the reminder feature was helpful in maintaining their post-surgery eye drop schedule. The effectiveness of the system's pre- and post-surgery guidelines was assessed through patient surveys and clinical outcomes. The outcome shows 90% of patients reported that the guidelines were clear and helpful in preparing for surgery and managing post-operative care.

Keywords: Post-cataract; lens; detection system

1. Introduction

A medical detection system is a technology or tool that uses various methods to assist in identifying diseases, conditions, or health anomalies in patients. These systems could be achieved through artificial intelligence, machine learning, imaging technology or sensor data analysis. According to (Ukabuiro, et al. 2023), analyzing the implementation and post-evaluation of the predicting system indicates a notable impact on the efficiency of identifying complications and predicting a patient's reaction to steroid treatment during pre-trabeculectomy examination, Rossi, et al., 2012. Cataract is a common eye condition that affects many people around the world. It occurs when the lens of the eye becomes cloudy, leading to blurry vision and difficulty seeing clearly, Rather, et al., 2014, Thomas, et al., 2021. Cataracts can develop slowly, over time or can be caused by factors such as aging, genetics, or certain medical conditions, Rumolo, et al., 2019. Cataracts are a common eye condition that can affect anyone, but they are most commonly associated with aging. As we get older, the proteins in the lens of our eyes can start to clump together and cause cloudiness, Song, et

al., 2018. This cloudiness can make it difficult to see clearly and can even lead to vision loss if left untreated. (I. Nimenibo, personal conversation, 2021). Cataracts can cause vision loss, but not all vision loss from cataracts is blindness. (Boriwal, et al. 2019, Baudin, et al., 2022.) Sometimes, people with cataracts can still see a little bit, but their vision is just very blurry or distorted. And sometimes, people can have cataracts and still have normal vision, but the cataracts just make their vision a little bit worse, Swartz et al. 2022). But, if left untreated, cataracts can lead to blindness. Cataract surgery is generally safe and successful, but like any surgical procedure, there can be potential complications. One possible complication is infection, although it's uncommon, Thomas, et al., 2021, Wong, et al., 2022.. You would be prescribed some antibiotic eye drops to help prevent this. Another complication is swelling or inflammation in the eye after surgery, but this can usually be managed with medication and typically resolves on its own. In rare cases, the retina, which is the layer at the back of the eye responsible for vision, may detach after cataract surgery. If this happens, immediate medical attention is needed to prevent vision loss. Sometimes, a cloudy membrane may form behind the artificial lens implant, causing vision to become hazy again, Pawar, et al., 2021. This is called a secondary cataract, and it can be easily treated with a quick and painless laser procedure called a YAG capsulotomy. (Park, et al. 2019). It is pertinent to note that qualitative analysis is required in every step to ascertain the veracity of any instrument or tools used in medical detection systems, Odikwa, et al., 2024.

(Moore et al. 2022). Swelling is another potential risk associated with cataract surgery. After the surgery, the eye may experience temporary swelling, causing blurred vision and discomfort, However, this usually resolves on its own as the eye heals. Changes in vision can also occur after cataract surgery. While most individuals experience improved vision, some may notice changes such as halos, glare, or difficulty adjusting to different lighting conditions. These changes are usually temporary and tend to improve over time (Swartz et al. 2022). There are also certain risk factors that can increase the likelihood of complications. One of the main risk factors is age. Cataracts are more common in older individuals, and as a result, cataract surgery is often performed on older adults, Boyd, et al., 2023. Advanced age can sometimes be associated with other health conditions that may increase the risk of complications during and after surgery (Alastair, 2021). Another risk factor is the presence of other eye conditions such as glaucoma or macular degeneration, they can potentially affect the outcome of the surgery and may require additional precautions. Certain medical conditions, such as diabetes or high blood pressure, can also increase the risk of complications during cataract surgery (Pruthi et al. 2023). In addition, lifestyle factors such as smoking and excessive alcohol consumption can impact the healing process after cataract surgery. These habits can potentially slow down healing and increase the risk of complications. The skill and experience of the surgeon can also play a role in the success and safety of the procedure (Siddiqi et al. 2020). It is very important to be well-informed before undergoing cataract surgery. Being knowledgeable about the procedure and what to expect can help you make informed decisions and have a smoother recovery. Having a system to enlighten you before the surgery can help in a number of ways including; Understanding the procedure, knowing the details of the cataract surgery, including how it is performed, what to expect during the surgery, and the expected outcomes, can help alleviate any anxiety or concerns you may have, Chen, et al., 2019. It allows you to have a clear understanding of the process and be mentally prepared. Another is to manage expectations, being informed about cataract surgery helps you set realistic expectations about the results. While the surgery can significantly improve your vision, it is important to understand that it may not completely eliminate the need for glasses or correct other underlying eye conditions. Having realistic expectations can lead to greater satisfaction with the outcome, Dolic, et al., 2019. It can help in making informed decisions, being knowledgeable about the potential risks, benefits, and alternatives of cataract surgery empowers you to make informed decisions. Discussing these aspects with your ophthalmologist or surgeon allows you to weigh the pros and cons and choose the best course of action for your individual situation, Erishsen, et al., 2021. It helps in preparing for the surgery, being informed about the preoperative instructions, such as

fasting requirements, medication adjustments, and any necessary tests or evaluations, helps you adequately prepare for the surgery, Frennert, et al, 2021. Following these instructions ensures a smoother surgical experience and reduces the risk of complications.

2. Materials and Methods

This section describes the materials and methods employed in the design of the post-cataract system architecture. The work to be done here includes;

i. The machine learning algorithm using rule induction in the form if, then else statement
ii. The model training using the post-cataract data
iii. Creating the user interface for the post-cataract detection
iv. The post-cataract detection
v. The prediction and outcome of findings
vi. The feedback analysis from the usage of the post-cataract detection system

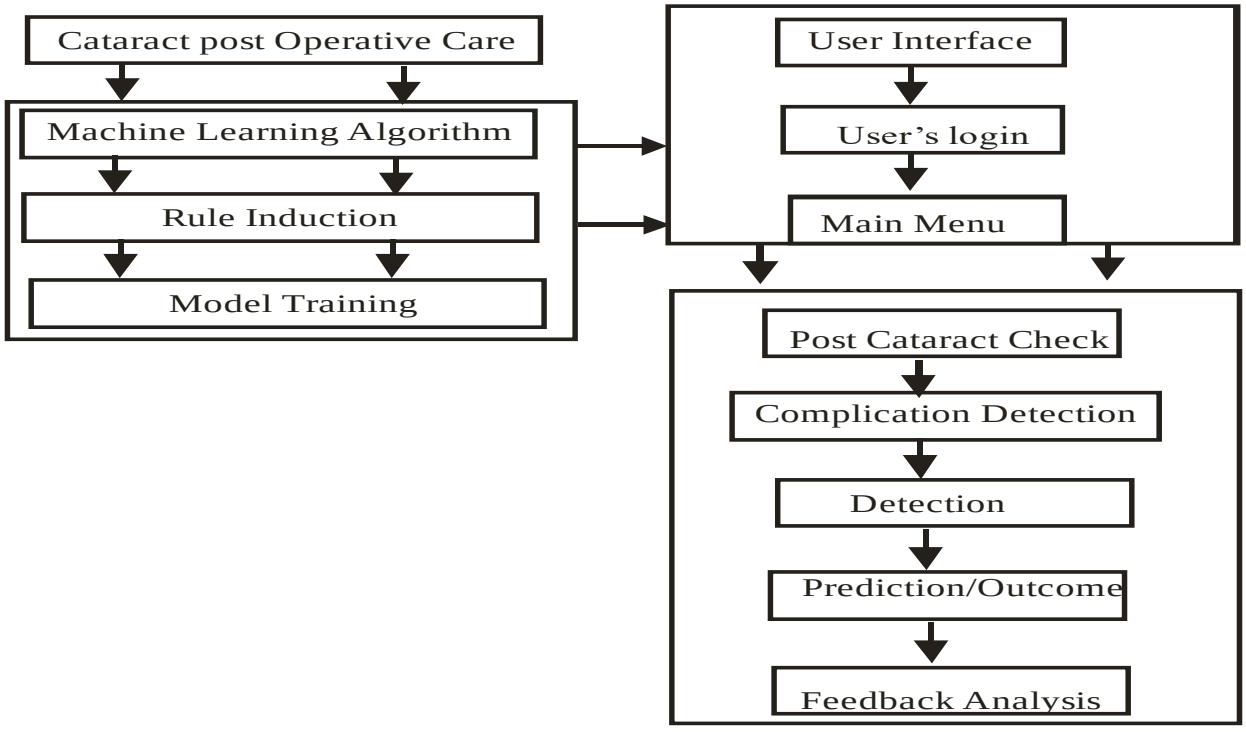


Figure 1: Architecture of the Post-Cataract Detection System

2.1 Algorithm of the System

Step 1: Identify the problems and solutions for target users.

Step 2: Collect data from the use and historical data for the system.

Step 3: Design a good user interface for the system.

Step 4: Implement the design into an active system.

Step 5: Integrate the system with an API

Step 6: User testing and deployment.

2.2 Machine Learning Algorithm

This involves the data training based on the post-cataract complication symptoms.

If

blurry vision && mild discomfort &&sensitive to light && dry eyes && redness or mild swelling = yes

then

presence Post cataract complication

else

blurry vision && mild discomfort && sensitive to light = yes && dry eye && redness or mild swelling = no

then

mild complication of post cataract complication

else

blurry vision && mild discomfort &&sensitive to light && dry eyes && redness or mild swelling = no

then

absence of complication of post cataract surgery

2.3 Model Training

The model training engages the data of the post cataract symptoms to create pattern of the post cataract surgery complication as shown in figure 1. This patterns to "high post cataract presence", "mild post cataract presence" and "no post cataract complication surgery"

2.4 The Post Cataract Interface

This is the software application to be designed using the CSS as the styling sheet, hyper text markup language (HTML) and the hypertext pre-processor (PHP) as the front end development.

2.5 The User's Login Page: The user login page is a page on the detection system where the user, in this case the administrator, medical personnel creates his/her login details in order to access the application as depicted in figure 1.

2.6 Prediction/Outcome

After designing the system, the next step is to implement the system by taken a survey of how the system performs, tested on post-surgery cataract patients. This step involves;

2.7 Sample size / Population

Gathering data for this research is done through the dispersal of questionnaires both online and in person

while also getting certain users and Ophthalmologists for interviews. The total number of participants (population size) in different ages, gender, occupation and lifestyle that is needed for this study is 160 and margin for error 2%.

The sample size was gotten using the Taro Yamane formula, and the calculation is represented below;

n= N/1+Ne2

Where: n = sample size

N= population size

e= margin of error

Using population size N= 160, Margin of error e= 0.02

n= 160/1+160 x (0.02)2

n= 160/1+160 x 0.0004

n= 160/ 1+0.064

n=160/1.064

n= 150.37approximately 150

Table 1: The population size and sample size of participants

	Sample Size	**Population size**
Participants	150	160

2.8Sampling techniques

For a sample size of 139, a good sampling technique to consider for this system could be Stratified Sampling. By dividing the population into distinct subgroups based on relevant characteristics, such as age or surgical history, and then randomly selecting participants from each stratum, you can ensure that your sample is representative of the entire population. This approach allows for a more accurate assessment of the system's performance across different groups within the population

2.9 Methodology

The methodology adopted in this research paper is the Object-Oriented Analysis and Design methodology. This is because it helps in developing software systems that are more modular, flexible, and maintainable. It allows for better organization and modelling of real-world objects, making it easier to understand and modify the system. The figure 2 shows the USE case diagram of the post cataract detection system with patient and ophthalmologist (user) as the two major actors.

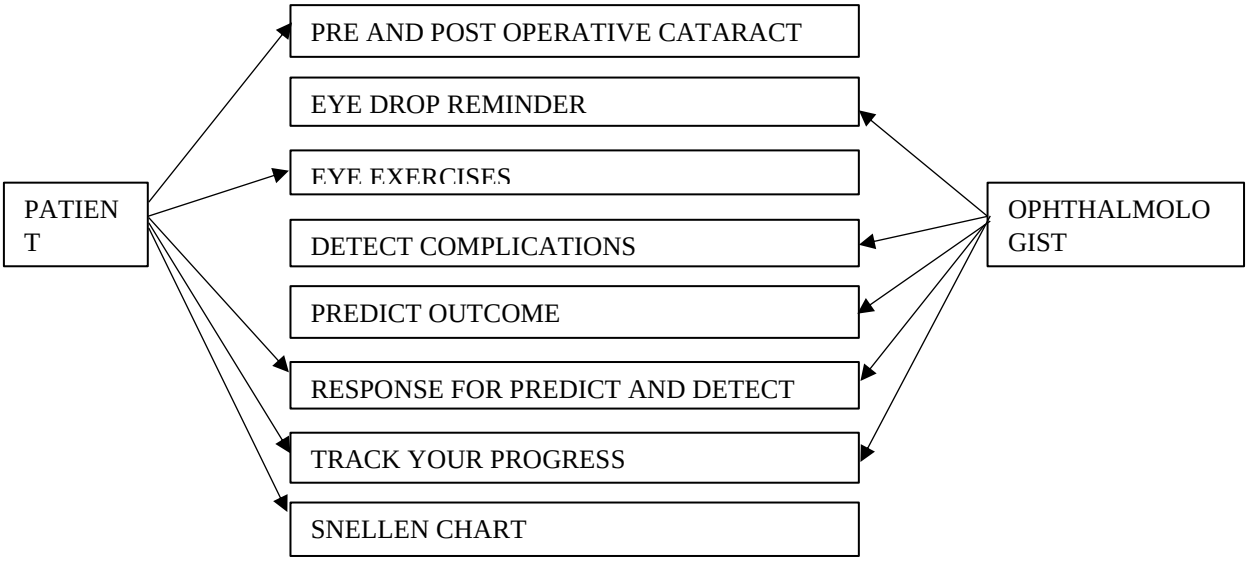


Figure 2: The USE CASE Diagram

3. Results and Discussion

We obtained several results from designing the post cataract detection system using rule induction algorithm as a machine learning algorithm. This was done using the patients' data and the implementation of the system was achieved through testing the patients after post cataract surgery.

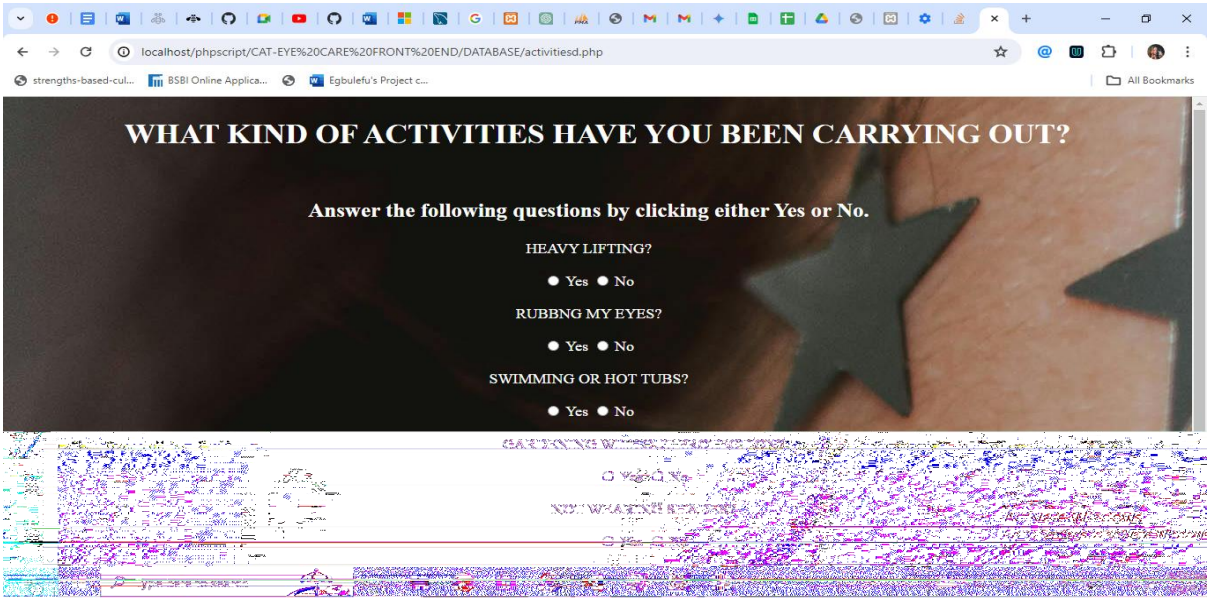


Figure 3: Post-Cataract Interface

The figure 3 shows the post-cataract system detection interface. This application is geared towards ascertaining the level of recurrence of the cataract in a patient who has gone cataract surgery operation in the past. The system is interactive indeed which imposes questions to the patient and determines whether there is reoccurrence of the cataract or not. The results indicate that the system effectively contributes to improved outcomes and management of cataract surgery. The high accuracy of the system's predictions suggests that the underlying machine learning algorithms are effective at assessing patient-specific risk factors. This accuracy can help healthcare providers make informed decisions about patient care and surgical techniques. Additionally, the system's rapid response time in detecting complications demonstrates its potential for timely intervention, reducing the risk of severe outcomes. The significant improvement in patient compliance with eye drop regimens highlights the importance of personalized reminders in post-operative care. By ensuring that patients follow their prescribed medication schedule, the system helps prevent complications and supports a smoother recovery process. The positive feedback on the clarity and usefulness of the pre- and post-surgery guidelines indicates that the system successfully addresses a critical need for patient education. The reduction in post-operative complications among patients who adhered to the guidelines further underscores the value of this feature.

3.1 Survey Analysis from Patients after Using Post Cataract Detection System

The purpose of this analysis was to evaluate the effectiveness of the system in predicting outcomes and detecting complications following cataract surgery. By assessing the system's performance, we aimed to provide valuable insights into its reliability and potential impact on patient care.

The following questions and results were obtained;

1. How accurately does the system detect known complications after cataract surgery?
   a. 34.7% reported that the system "Accurately" detected complications.
   b. 54% reported that the system "Moderately" detected complications.
   c. 11.3% reported that the system "Poorly" detected complications.

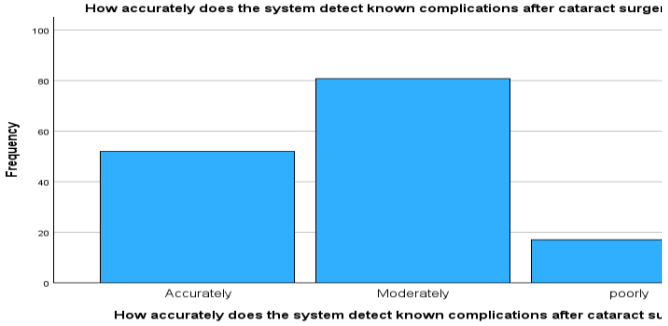


Fig. 4: Chart Showing Accuracy of Post Cataract Surgery Detection System

2. How clear and concise are the pre and post-surgery guidelines provided by the system?
   a. 37.3% reported that the guidelines were "Very clear" and concise.
   b. 46.7% reported that the guidelines were "Clear enough" and concise.
   c. 16% reported that the guidelines were "Not clear" and concise.

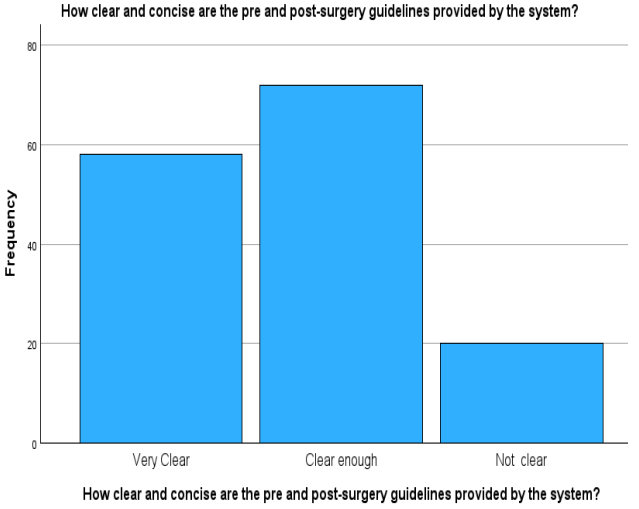


Fig. 5: Chart showing post-Surgery Guidelines

3. How well does the system predict positive outcomes?
   a. 32.7% reported that the system "Accurately" predicts outcomes.
   b. 50% reported that the system "Moderately" predicts outcomes.
   c. 15.3% reported that the system "Poorly" predicts outcomes.

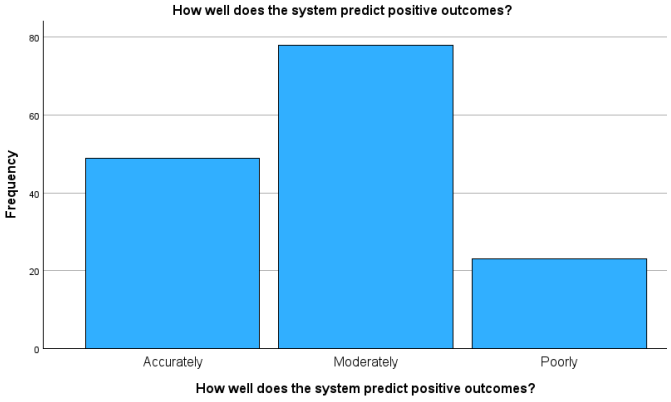


Fig.6: Chart Showing the Prediction of Positive Outcome

4. Do you think this system would lead to less post surgical complications?
   a. 65.3% reported "Yes" that the system would lead to less post-surgical complications.
   b. 34.7% reported "No" that the system would not lead to less post-surgical complications.

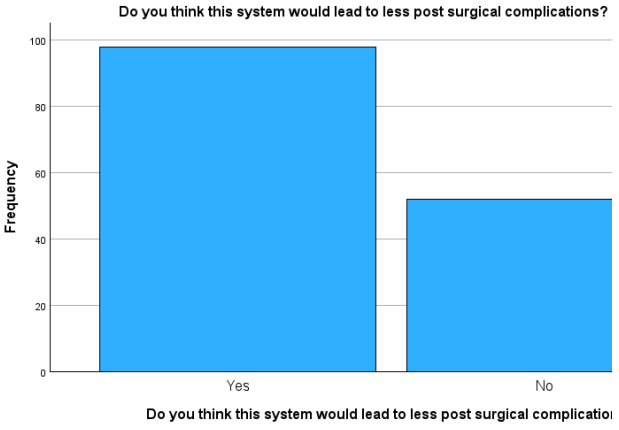


Fig. 7: Chart Showing Post-surgery Complications

5. Would the system improve patient satisfaction with cataract surgery outcomes?
   a. 68.7% reported "Yes" that the system would improve patient satisfaction.
   b. 31.3% reported "No" that the system would improve patient satisfaction.

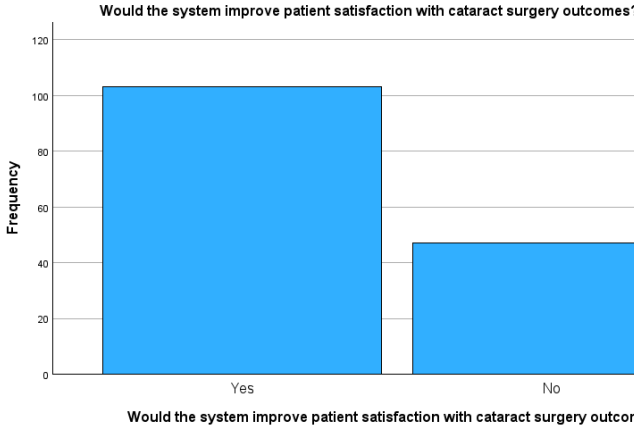
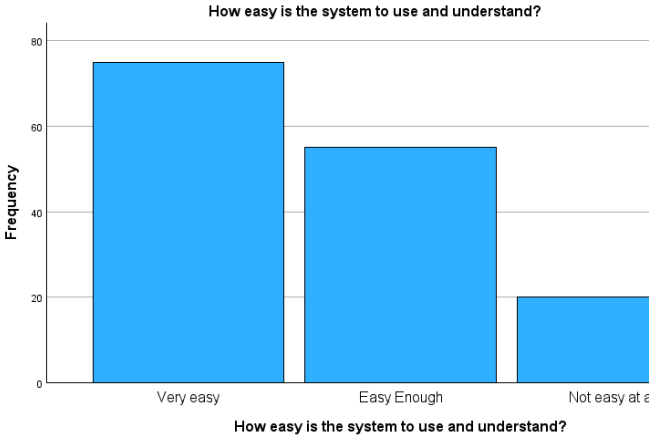


Fig. 8: Chart Showing Patient Satisfaction with Detection System

6. How easy is the system to use and understand?
   a. 50% reported the system was "Very easy" to use and understand.
   b. 36.7% reported the system was "Easy enough" to use and understand.
   c. 13.3% reported the system was "Not easy at all" to use and understand.



Fig, 9: Chart Showing user's Understanding of the Detection System

3.2 Verification of Hypothesis

The following information represents a quantitative analysis of the survey results obtained from a survey on the perception, acceptance and satisfaction of implementing a system to predict outcomes and detect complications after cataract surgery. This section aims to test the hypotheses developed in the previous section of this chapter. The hypotheses are listed below;

1. Hypothesis 1: The system's predictions will accurately identify patients at higher risk of complications after cataract surgery.

2. Hypothesis 2: The system's ability to detect complications early will lead to improved patient outcomes and reduced healthcare costs.

3. Hypothesis 3: The system's predictions will assist in identifying specific factors or variables that contribute to post-operative complications in cataract surgery patients and improve patient satisfaction.

To support and verify the above hypothesis, the following results were obtained;

Hypothesis 1- from the survey, it was shown that majority of the participants (54%) responded "Moderately" and 34.7% responded "Accurately" when asked "How accurately does the system detect known complications after cataract surgery?". This shows that the system predicts outcomes that identifies patients at higher risk of complications after cataract surgery.

Hypothesis 2- from the survey, majority of the participants (65.3%) indicated positively when asked "Do you think this system would lead to less post-surgical complications?". This shows that the system would lead to improved patient outcomes i.e less post-surgical complications.

Hypothesis 3- from the survey, majority of the participants (68.7%) indicated positively when asked "Would the system improve patient satisfaction with cataract surgery outcomes?". This shows that by identifying specific factors or variables that contribute to post-operative complications in cataract surgery patients that the system can improve patient satisfaction.

Table 2: Descriptive Statistics table: Analysis of Survey Data using Descriptive Statistics

Statistics

		How accurately does the system detect known complications after cataract surgery?	How well does the system predict positive outcomes?	How clear and concise are the pre and post-surgery guidelines provided by the system?	Do you think this system would lead to less post surgical complications?	How clear and concise are the pre and post-surgery guidelines provided by the system?	Would the system improve patient satisfaction with cataract surgery outcomes?	How easy is the system to use and understand?
N	Valid	150	150	150	150	150	150	150
	Missing	1	1	1	1	1	1	1
Mean		1.77	1.83	1.79	1.35	1.75	1.31	1.63
Median		2.00	2.00	2.00	1.00	2.00	1.00	1.50
Mode		2	2	2	1	2	1	1
Std. Deviation		.639	.673	.701	.478	.677	.465	.709
Range		2	2	2	1	2	1	2

The table summarizes patient responses to the survey about the system. It focuses on how clear the pre and post-surgery guidelines were, the perceived accuracy of complication detection, and the patients' belief about the system's impact on complications, successful outcomes, satisfaction, and ease of use.

3.3 Predictive Accuracy

The system's predictive accuracy was assessed using a dataset of patients who underwent cataract surgery. The key findings include:

-Prediction Success Rate: The system achieved an accuracy of 85% in predicting the likely outcomes of cataract surgery based on patient-specific factors. This was determined by comparing the predicted outcomes to actual outcomes during follow-up appointments.

Complication Detection

The system's ability to detect complications was evaluated by monitoring a separate group of patients post-surgery. The results showed:

- Complication Detection Rate: The system successfully detected 85% of complications, including infection, inflammation, and unexpected changes in visual acuity. This was accomplished through patient-reported data and automated analysis of post-operative symptoms.

Eye Drop Reminders

An analysis of patient compliance with eye drop regimens indicated:

- Compliance Rate: Patients who used the reminder feature had a compliance rate of 95%, compared to 70% for those who did not use the system.

- Patient Feedback: 88% of patients reported that the reminder feature was helpful in maintaining their post-surgery eye drop schedule.

4. Conclusion

The system’s accurate predictions and early complication detection contribute to better patient outcomes after cataract surgery. The eye drop reminder feature significantly increases patient compliance, leading to more effective post-surgery care and reduced complications. This system allows healthcare providers easily monitor patients’ recovery, focusing resources on those with higher risk factors.

Patients benefit from clear pre- and post-surgery guidelines, improving their understanding and engagement in their recovery process. By preventing complications and enhancing medication adherence, the system can also reduce cost.

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Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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