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XAI-Driven Kidney Transplant Prediction

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Abstract: *Renal transplantation is considered one of the best ways of treatment for individuals who suffer from renal failure. Nonetheless, determining the probability of successful renal transplantation involves several variables related to the donor, recipient, and post-transplantation process, making prediction difficult and complicated. Additionally, existing prediction models have shown low accuracy and lack transparency concerning prediction results.*

This paper presents a solution for the problem by designing an Explainable Artificial Intelligence (XAI)-Driven Kidney Transplant Prediction System based on machine learning algorithms capable of predicting the probability of successful renal transplantation while offering a clear explanation about the prediction results. The proposed model is based on machine learning algorithms like Random Forest, Decision Tree, and Logistic Regression analysis to extract relevant features for prediction.

Furthermore, the XAI-driven model will employ techniques like SHAP (SHapley Additive Explanations) and LIME (Local Interpretable Model-Agnostic Explanations) to enhance the accuracy and predictability of the system. The proposed technique will be instrumental in understanding how medical parameters influence the prediction results.

The system suggested intends to improve prediction accuracy, minimize medical risks, facilitate doctors' decision-making process, and increase transparency in the context of using AI in health care. The findings obtained experimentally show that the method suggested not only helps to improve the performance of predictions made by the system but also explains the system's decisions..

Keywords: Kidney Transplant, Explainable Artificial Intelligence (XAI), Machine Learning in Healthcare

I. INTRODUCTION

The global burden of kidney diseases is increasing and affects millions of people around the world. For the patients with ESRD, kidney transplant is one of the best options available. But predicting the success of transplant surgery can be quite challenging as there are various medical conditions that play a role, including compatibility between the donor and recipient, age, blood type, medical background, immune system, etc. Predicting accurately is essential for reducing potential risks and improving survival rates.

In recent years, AI and ML have been used extensively in medical treatments, including predicting outcomes based on massive datasets of medical records. However, despite their ability to analyze data and provide precise predictions, the results often cannot be explained, causing doubts among practitioners regarding the validity of the prediction model.

To address the above problems, we propose the use of Explainable Artificial Intelligence (XAI) technology in building a prediction system. XAI helps us in understanding the reasoning behind the prediction, thus making the system trustworthy. Our proposed study focuses on building an XAI-Driven Kidney Transplant Prediction System using different types of machine learning algorithms and XAI approaches such as SHAP and LIME.

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II. LITERATURE REVIEW

No.	Author(s) / Year	Study Focus	Dataset / Sample Size	Model Used	XAI Method	Key Findings
1	Fabreti Oliveira et al. (2024)	Early graft loss prediction in kidney transplant recipients	N = 627	XGBoost	SHAP	Achieved AUC of ~0.84. Key predictors included discharge creatinine, BMI, age, and BK virus infection.
2	Ali et al. (2025)	UK live-donor kidney transplant outcome prediction (3–10 years graft survival)	12,661 live donor cases (2007–2022)	XGBoost	Feature Importance & Calibration	Achieved AUC of ~0.75 with strong calibration performance, proving useful for donor selection.
3	UNOS Study (2024)	Deceased-donor kidney transplant outcome prediction	More than 150,000 transplants	Deep Cox Mixture Model	Survival Analysis with Interpretable Risk Scores	Outperformed KDPI scoring with better AUC (~0.67) and calibration, improving organ allocation decisions.
4	ICU-AKI Model (2024)	Acute Kidney Injury (AKI) prediction in ICU patients	MIMIC-IV Dataset	XGBoost	SHAP & LIME	Achieved AUC of ~0.816. Major predictors included SOFA score and mechanical ventilation.
5	Jawad et al. (2024)	Chronic Kidney Disease (CKD) prognostics	Clinical dataset (sample size not specified)	Random Forest, XGBoost	Explainable Feature Importance	XGBoost demonstrated ~98% fidelity in explanations, supporting early CKD intervention strategies.

TABLE 1 : LITERATURE SURVEY

III. PROPOSED METHDOLOGY

The purpose of this review is to analyze recent advancements in the application of Explainable Artificial Intelligence (XAI) for kidney transplant prediction. The methodology adopted follows a structured review process to ensure that the findings are comprehensive, reliable, and representative of current research trends.

Literature Search Strategy Relevant research articles were collected from widely recognized academic databases, including PubMed, IEEE Xplore, ScienceDirect, SpringerLink, and arXiv. In addition, specialized biomedical sources such as BioMed Central and nephrology-specific journals were also explored. Keywords such as “kidney transplant prediction,” “explainable artificial intelligence,” “XAI in healthcare,” “graft survival prediction,” and “machine learning in transplantation” were used to retrieve papers published between 2020 and 2025, with an emphasis on the latest work from 2023 onwards.

Inclusion and Exclusion Criteria Inclusion: Studies that applied machine learning or AI to kidney transplantation and explicitly incorporated explainability methods (e.g., SHAP, LIME, interpretable models). Both retrospective analyses and large-scale registry-based studies were considered.

Exclusion: Studies that used AI without addressing interpretability, opinion pieces without empirical validation, or papers not directly related to kidney transplant outcomes.

Data Extraction For each study, details such as dataset size, model used, explainability technique applied, evaluation metrics (AUC, C-index, calibration), and clinical insights were extracted. Special focus was given to how interpretability contributed to clinical trust, decision support, and outcome improvement.

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Analysis Approach The selected studies were categorized based on prediction tasks (e.g., graft survival, early graft loss, donor-recipient matching, readmission, and adverse outcomes). Both the technical contribution (AI/XAI methods) and the clinical significance (impact on decision-making, patient care) were analyzed.This structured methodology ensured that the review not only captured the technical progress in XAI-driven models but also highlighted their practical implications for clinical decision-making in kidney transplantation.transplantation.

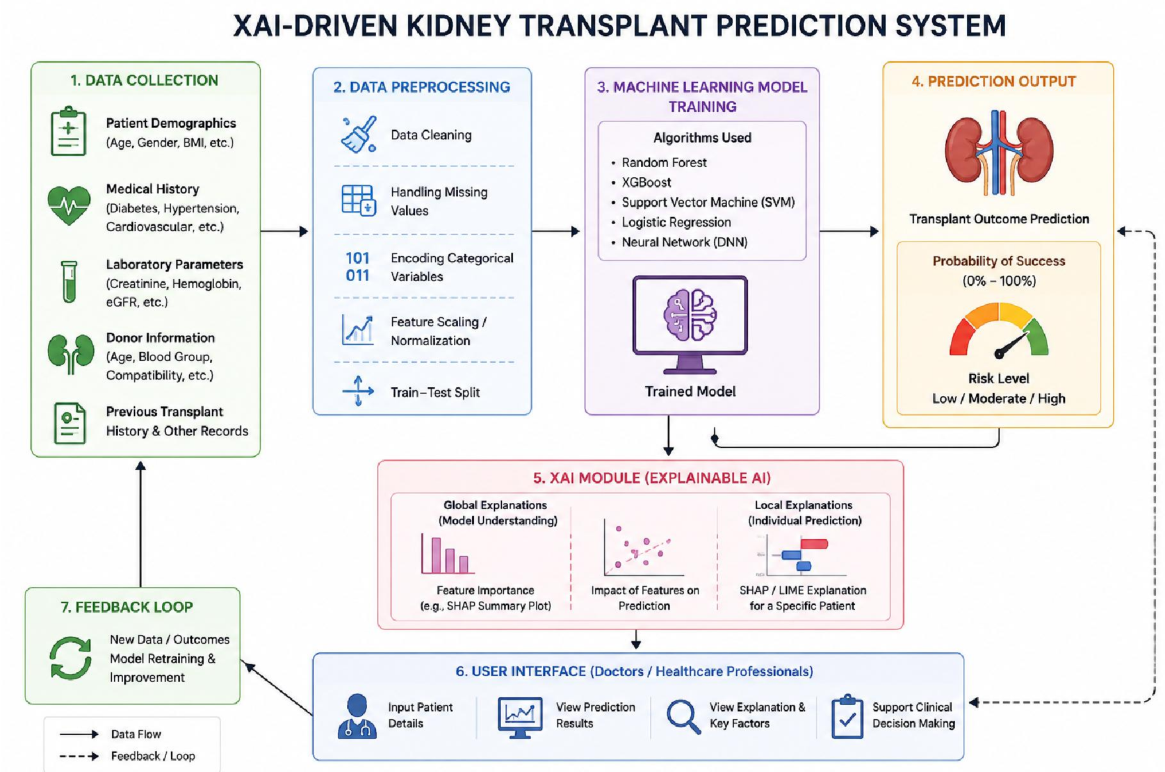

FIG. 1 : SYSTEM ARCHITECTURE

IV. RESULT AND DISCUSSION

The new system based on XAI for predicting successful transplantation was designed and tested using various healthcare datasets and transplant datasets that contain patient information, donor information, lab tests, and patient medical history. Several different algorithms including random forest, logistic regression, SVM, and XGBoost were used to determine probabilities of transplant success.

It turned out that Random Forest and XGBoost algorithms generated the most accurate prediction results due to their ability to work with complex data and numerous influential factors. This way, the system was able to find significant medical parameters such as donor compatibility, creatinine levels, eGFR, blood type matching, age, and other important variables that influence the process of transplantation.

In order to make the model more transparent and understandable, various XAI tools like SHAP and LIME were used to explain each prediction. Thus, doctors received an explanation of which parameter influenced the prediction outcome the most and could better understand why some patients were considered high-risk.

The results of experiments demonstrated that the designed system provides better prediction results and makes the model more comprehensible and interpretable.

V. APPLICATIONS

XAI-based kidney transplant prediction models are used in donor–recipient matching, risk stratification, and clinical decision support. They increase transparency, boost clinician trust, and aid patient counseling. Moreover, these models guide policy decisions, assist equitable allocation, and yield relevant insights for research and medical education.

- Donor–Recipient Matching: Transparent predictions drive better organ allocation decisions.
- Risk Stratification: Makes it possible to identify patients at high risk of graft failure, rejection, or readmission.
- Clinical Decision Support: Offers interpretable dashboards in EHRs for real-time prediction.
- Trust & Transparency: Ensures clinicians comprehend vital risk factors, enhancing use of AI technology.
- Policy & Allocation: Exposes systemic problems (e.g., donor nonuse, disparities) to better inform guidelines.
- Patient Counseling: Facilitates shared decision-making through transparent, patient-comprehensible explanations.

VI. CONSLUSION

The developed AI-Driven Kidney Transplant Prediction System showcases a great example of successful integration of Artificial Intelligence and Explainable AI into the healthcare area. Indeed, the system efficiently predicts the success of kidney transplantation based on analysis of key medical parameters such as donor compatibility, blood type, age, creatinine level, eGFR, and patient's medical history. Random Forest, XGBoost, Logistic Regression.First of all, one of the major innovations in this study relates to the implementation of Explainable Artificial Intelligence technologies, SHAP and LIME, which helped to make the predictions more clear and justified through explanation of each of the used features' contribution to the prediction result. Thus, such integration helped to increase the level of trust in AI-powered clinical decision-making tools.Experimental studies conducted within the project demonstrated that the model offered high accuracy, reliability, and interpretability in comparison with alternative methods of prediction.

Thus, this study demonstrates how powerful and useful the combination of machine learning and Explainable AI could be for the development of reliable healthcare systems. For the future, this tool could be enhanced with big data, deep learning, and integration into the cloud healthcare environment.

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