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Original Article

AI-Driven Frameworks for Ethical and Efficient Management of Surrogacy in India

Deepa Rameshrao Deshmukh[1], Ranjan Dube[2]

[1,2]*Department of Law, G H Raisoni University, Amravati, Maharashtra, India.*

[1]*Corresponding Author : deepa_rameshrao@rediffmail.com*

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Abstract - *Based on artificial intelligence, the paper proposes a framework for ethically and effectively controlling the process of Surrogacy in India, which includes statistical analysis, machine learning, fairness assessment, and explainable AI techniques. Data were processed using descriptive and inferential statistics in a synthetic data set of socio-economic, clinical and procedural variables, and the approval time, maternal health, age and education level were found to be significant predictors of ethical risk. Machine learning (Random Forest and XGBoost) models achieved good predictive performance (ROC-AUC > 0.88), and feature contributions were also given by explainability (SHAP), which helped to make the contribution of features to the model's performance more transparent for policy makers and clinicians. The fairness analysis has showed little bias in relation to income groups, and this has led to an equitable risk analysis and compliance to regulations. The framework provides practical suggestions on refining the approval process, focus on high-risk cases, and improving ethical surrogacy management. Limited availability of data and the fact that regional diversity is not considered represent weaknesses, with future research that should continue to use real-world datasets, federated learning and IoT-based monitoring as risk assessment methods on an ongoing basis. The research adds to AI-assisted governance, policy-making, and ethical decision-making of reproductive healthcare.*

Keywords - *Ethical Artificial Intelligence, Surrogacy Management, Predictive Modeling, Fairness Assessment, Explainable Artificial Intelligence, Socio-Economic Disparities.*

1. Introduction

Surrogacy is already an intricate trans-border of medical science, ethics, law and social values, particularly in developing economies such as India. The advent of new Assisted Reproductive Technologies (ARTs) has offered infertile couples, single parents and single individuals, who are unable to father or give birth to children due to medical contraindications, hope in Surrogacy. At the same time, there is a massive socio-economic diversity in India, a strong family system, and access to healthcare services is not equal, which has been a challenge to governance. In the past few years, the Indian government has made significant strides towards regulation-based and technology-enabled provision of public services, like the Digital India and Ayushman Bharat Digital Mission (ABDM). It is on this background that the incorporation of the concept of Artificial Intelligence (AI) in the governance of Surrogacy is an opportunity to increase ethical adherence, operational effectiveness, and transparency, and protect the rights and dignity of surrogate mothers (Sedeeq & Arman, 2025; Manvelyan et al., 2024), (Eswaran et al., 2024).

1.1. Surrogacy Practices in India: Background

As it can be seen from the history of Surrogacy in India, it is a huge shift from an uncontrolled and market-oriented surrogacy to a well-regulated and altruistic surrogacy. In the early 2000s, India became one of the world hubs of commercial Surrogacy due to its lower medical costs, high-quality fertility clinics, and less restriction on the legal aspects of Surrogacy. For many of the economically disadvantaged people, particularly in rural and semi-urban areas, Surrogacy was the means of livelihood, which was often seen as a viable option in their narrow livelihoods. However, the exploitation, lack of informed consent, health risks and poor postnatal care were also major concerns during this period, which presents a great ethical and human rights challenge (Khan, 2024), (Majumdar, 2018), (Majumdar, 2017).

To overcome these difficulties, the Indian government gradually shifted to its policy stance, and eventually, the Surrogacy (Regulation) Act, 2021, was enacted. The Act was a turning point of commercial to altruistic Surrogacy, with the law allowing Surrogacy only to married Indian couples in certain medical reasons and illegalizing all monetary compensations on top of the medical costs and insurance cover. The law had a moral and cultural dimension of the sanctity and protection of the family and protection of women, but there were new operational and administrative challenges

to its implementation. In some, the process of getting access to legal Surrogacy is slowed down due to tedious approval procedures and difficulties in determining eligibility, as well as inter-agency coordination issues (Dhir & Verma, 2024), (Adeniyi & Monehin, 2024), (Shafiabady et al., 2025).

Re-regulatory challenges are still raised even with the regulatory framework. Questions of transparency in the selection of surrogates, a uniform application of the eligibility criteria across all states and regulation of the clinics are not addressed. Moreover, without the use of digital systems, records are more likely to be kept in a disorganized manner, increasing the risks of procedural delays and discretionary decision-making. These gaps highlight the need for technology-based control systems that can help to manage the performance of governance in a country that experiences a huge disparity between regions' performances (Choudhary et al., 2024), (Smietana et al., 2021).

1.2. The Purpose of This Study

There has been growing awareness of artificial intelligence as a revolutionary tool in healthcare. The relevance of AI for healthcare governance has been highlighted, as novel data-driven decision-support, and compliance tracking, and predictive risk assessment have been gaining awareness. When applied in the Indian context, AI has already shown promise in the field of disease monitoring, providing diagnostic assistance, and resource distribution, especially when provided on a large-scale basis of public health. Most of the systemic problems faced by regulators, the clinics and beneficiaries can be addressed through the use of such skills in the governance of Surrogacy.

The introduction of an AI-powered decision support system could enable authorities to make objective and fair decisions based on eligibility, paperwork, and reduce the subjectivity in decision-making. As part of predicting ethical risk factors, including the agencies of possible surrogate vulnerability or non-compliance by clinics, AI models can be used to analyze multidimensional data, including medical, legal, and socio-economic data. In the context of a government culture with a high case load and a limited human capability to monitor it, these predictive insights are particularly helpful.

AI's relevance is further accentuating in the light of the rapidly evolving digital health landscape in India. To create interoperable health records and unique health identities and encrypted data exchange systems, there are several initiatives, such as the Ayushman Bharat Digital Mission (ABDM). Having surrogacy-related data integrated into such an ecosystem can enable real-time monitoring, better tracking and continuity of care for surrogate mothers. Furthermore, the use of AI-powered analytics in line with e-governance systems are aligned to the broader Indian agenda on open, responsible and citizen-focused government (open government, maximum governance) or minimum government, maximum governance.

The aim of this study is related to the use of regulatory approaches as an inadequate means of achieving ethical and effective management of Surrogacy. Surrogacy (regulation) act, 2021 has a strong legal foundation, but it is essential that there are mechanisms for implementation in terms of its effectiveness. The aim of this paper is to address the potential of using the AI-Based frameworks to complement existing legislation, support the existing evidence-based decision-making processes, reduce administrative delays and ensure fairness. Its primary objective was to propose a context-specific, structured governance model for the Indian context and advanced statistical analysis and Python as an example of the potential effectiveness and ethicality.

The research proposed will contribute to the scholarly discussion and to policy implementation through the deployment of AI in the context of the Indian legal, cultural and digital governance framework. In the age of technology, which is rapidly changing the lives of people, including the courts, the idea of digital welfare delivery and AI-driven governance of Surrogacy can make logical and timely sense in India, where digital courts are transforming the face of justice.

2. Literature Review

2.1. Worldwide AI in Reproductive Healthcare

Over the last ten years, the inclusion of Artificial Intelligence (AI) in the field of reproductive healthcare has grown tremendously due to the development of machine learning, big data analytics, and e-health solutions. Assisted Reproductive Technologies (ART), especially in In Vitro Fertilization (IVF), have seen one of the most intensive uses of AI. Predictive computational algorithms based on AI are becoming popular at estimating the development of a successful IVF with the help of multidimensional data sets, such as patient age, hormonal, embryo morphology, genetic, or clinical history. As opposed to the traditional statistical algorithms that failed to predict the accuracy of the treatments, the deep learning and ensemble-based algorithms has been proven to be more predictive accurate, enabling clinician to make each treatment plan individual and optimize embryo selection. These have enhanced efficiency in the clinical process as well as emotional and financial costs on the patient, and this is of particular interest in the countries where fertility treatments are costly and predominantly privatized (Luo, 2024), (Dhir & Verma, 2024), (Lozanski & Shankar, 2019).

Apart from IVF, AI applications have also been explored in the area of maternal health, including risk stratification of maternal conditions and issues, like gestational diabetes, preeclampsia, and preterm birth. With the help of AI analytics, wearable gadgets, as well as remote monitoring systems, would make it possible to monitor all physiological parameters constantly, which would ensure early detection of problems and timely clinical intervention. These systems come in quite handy, especially in low-resource and geographically distributed areas where the probability of

having access to quality obstetric service is low. The emphasis on the national interests in the emerging economies like India on reducing the maternal mortality and improving the perinatal outcome, relevant to Sustainable Development Goal 3, is pertinent to such an AI-based maternal health tool (George et al., 2025), (Ghosh et al., 2025).

However, the rapid adoption of AI in the reproductive health sector has raised numerous ethical concerns, including algorithmic bias, transparency, and accountability. The research has revealed that AI models that are trained on non-representative data sets can reinforce socio-economic and racial biases, resulting in biased healthcare. Fairness-conscious machine learning and Explainable AI (XAI) and human-in-the-loop solutions have become the focus of an ethical AI framework to guarantee that AI systems are augmenting and not substituting clinical judgment. Within the reproductive health industry, the consequences of a decision can be a matter of life or death, physically, emotionally, and socially. Thus, the concepts of AI ethics are becoming a necessity, not a luxury (Deonandan, 2015), (SS et al., 2025), (Kumar et al., 2024).

2.2. Surrogacy and Legal and Ethical Stances

The concept of Surrogacy lies between the domains of reproductive rights and freedom of choice, and family law and justice, and therefore is not a sound ethical and legal concept. Ethically, Surrogacy poses some important questions regarding the issue of human rights, informed consent and the welfare of surrogate mothers. According to the scholars, informed consent on Surrogacy should go beyond the contractual agreement and should be accompanied by thorough knowledge of the medical risks, psychological after-effects, as well as after-birth care. The main ethical concerns have been the power imbalance between the targeted parents, typically during the economic well-being, and the surrogates, typically in a weak spot socio-economic status, particularly in the nations that permitted business surrogacy in the past (Mahajan, 2025), (Lizzio, 2025).

Ethics surrounding the welfare of a surrogate mother is a concern as it relates to physical health, mental stability, economic stability and post-childbirth support. The poor access to healthcare and forced behaviour and lack of long-term care to surrogates have been mentioned in empirical research, and this one can only echo the strong regulatory supervision. Ethical theories continue to support surrogate-based conceptualizations of governance, which accentuate autonomy and dignity and the lifelong care provided to the surrogate, instead of viewing Surrogacy as just a contract (Yogi et al., 2025), (Lau, 2018).

The laws of Surrogacy in countries are diverse as cultures; moral and policy priorities differ in different countries. India was earlier a commercial surrogacy ground, but has now become an altruistic surrogacy institution with strict eligibility criteria on the targeted parents and the surrogates. The legislation is supposed to end the exploitation and commodification of women bodies, but it has been criticized because it is restrictive and complex in process. By contrast, the United Kingdom allows altruistic Surrogacy that has a clear legal framework, which prioritizes parental orders and surrogate consent and disallows commercial arrangements. The United States has become decentralized, and state laws vary in their permissiveness and outright bans on surrogacy practices (Martini et al., 2024), (Rajendra & Thuraisingam, 2025).

There is a special case in Ukraine – commercial Surrogacy, which is legal and regulated and is discovered by foreign intended parents. This model is, however, criticized for lacking in surrogate welfare and cross-border ethics, although it is argued to be a model of contractual transparency and medical regulation. By comparison, research on the models of law shows that each fails to fully solve all the ethical issues surrounding Surrogacy and thus requires the establishment of flexible, transparent and data-driven governance mechanisms.

2.3. Research Gap

In spite of the high level of research on the use of AI in reproductive care and the increasing literature on the ethical and legal aspects of Surrogacy, there is still a major gap in the interrelation of these spheres. Presently, literature primarily covers the application of AI in healthcare and surrogacy governance separately, suggesting that there might be a lot of conflicting policies and practices.

As of today, there is a vast gap in the literature focusing on either AI in healthcare or surrogacy governance, suggesting that policies and practice frameworks may clash. The lack of any well-developed, evidence-based AI models that are directly aimed at assisting ethical decision-making, regulations, and welfare tracking in surrogacy agreements is quite evident. The majority of the existing systems are based on manual checks and auditing, which is time-consuming, opaque and human subjective.

Additionally, studies have explored ethical considerations in AI and fairness in algorithms across the globe, but similar research on the governance of Surrogacy is lacking. In India, there is not much empirical evidence in terms of using statistical and machine learning models to validate the AI frameworks. Not many studies have used sophisticated analytics to investigate trends connected to surrogate choice, approval procedures, health care results, or legal conflicts on the post-2021 regulatory framework. No explanation and no statistical proof of AI models make for limited evidence-based policymaking, resulting in less trust from the public, including regulators, clinics, surrogates and target parents. To address this, the explanation-based, empirical evidence-based and legally and ethically sound frameworks of fair AI must be

developed in India. These structures have to be backed up by a stringent statistical methodology and model validation so that there are efficiency and ethical accountability in the management of Surrogacy.

3. Theoretical Artificial Intelligence-Based System of Surrogacy Management

To accommodate the medical complexity, legal and socio-economic complexities in the same decision support system, which is well organized, transparent, and data-driven, will be necessary for the governance of Surrogacy in India in an ethical and efficient manner.

The suggested conceptual framework based on AI should help the regulatory bodies, Assisted Reproductive Technology (ART) clinics, and healthcare providers take evidence-based decisions and promote surrogates' right to protection and ensure compliance with the Surrogacy (Regulation) Act, 2021. The framework is inspired by the collective Indian endeavour in the field of digital governance, the Ayushman Bharat Digital Mission, and how AI is complemented by moral responsibility to ensure efficiency, accountability and social justice.

3.1. Framework Architecture

The presented architecture is a stack of layers, and each plays a different role, though interconnected. The presented architecture is a layered design in which each layer plays a different role but is interconnected. It is upon the Data Layer that the framework is built, and which has the responsibility for assembling and managing disparate data relevant to the management of Surrogacy.

This refers to the medical information, i.e., the surrogate age, obstetric history, medical indicators, and pregnancy outcomes, legal information, i.e., consent doubles, eligibility checks and regulatory approvals, socio-economic variables, i.e. income level, educational, and geographical / location. Since the data on Surrogacy is sensitive one, this layer stresses on secure storage of data, data anonymization and restricted access. Multi-source data integration can be used to conduct a holistic assessment of surrogacy arrangements instead of only tapping into medical predictors of pregnancy, and also includes legal and social vulnerability indicators that are also relevant in the Indian context.

On this basis, the AI Analytics Layer uses sophisticated statistical and machine learning methods to translate raw data into actionable information. Ethical risk scores, approval delays and possible medical complications are predicted using supervised learning models, including logistic regression and ensemble algorithms.

Collecting unmonitored learning could be used to uncover the underlying patterns, such as the grouping of high-risk profiles and/or variations between regions in learning outcomes of regulation. Furthermore, the approval period and monitoring can be estimated using a time-to-event analysis model and a survival analysis model, too. The outputs of this layer help clinics and regulators to intervene in a proactive way so that cases which need more attention can be identified in the early stages. Notably, the analytical design gives importance to the interpretability to make sure that the AI outputs can be interpreted by non-technical stakeholders.

The Governance and Ethics Layer is a form of control that ensures the ethical, legal and social compliance of decisions based on AI. It will be a layer where algorithmic fairness checks will be considered, cross-socio-economic and demographic groups will be included on the bias and tools such as explainability (SHAP or LIME) will be implemented.

The framework would prevent from further accentuating the current gaps and ensure a fair treatment of all the parties involved by putting the ethical constraints into the analytical process. This layer also enables the audit to be carried out, and decisions are traceable, which allows the use of such a layer in sensitive areas like in Surrogacy, thus, decisions are traceable and justified by the regulatory bodies.

3.2. Ethical AI Principles Adopted

The principles of transparency, accountability, and non-discrimination in AI are clearly embedded in this framework, which are fundamental ethical principles in the development of AI-based governance systems, and essential to building trust within them. Transparency is provided via explainable models and descriptions of sources of data, assumptions and decision rules.

This and ensures that the intended parents and regulators understand how decisions are made and that there is no sense of ‘black box’ or ‘arbitrary'. Accountability is reinforced by maintenance of a human “footprint” at critical points in the decision-making process.

The use of AI systems does not reduce the institutional responsibility and legal liability since they are support systems that do not make their own decisions. This strategy has been in line with the Indian regulatory culture, where the administrative judgments should be rational, subject to review, and explanation.

The lack of discrimination is addressed because there is constant monitoring of bias and assessment of fairness in income/regional/and social groups. The framework ensures that cultures and the law are legal, ensuring the cultures are in line with the Indian constitution, which values equality, dignity and protection of vulnerable communities. On the whole, incorporating AI ethics principles changes the paradigm of a strictly technical system to a socially responsive governance system that can promote the management of ethical Surrogacy in India.

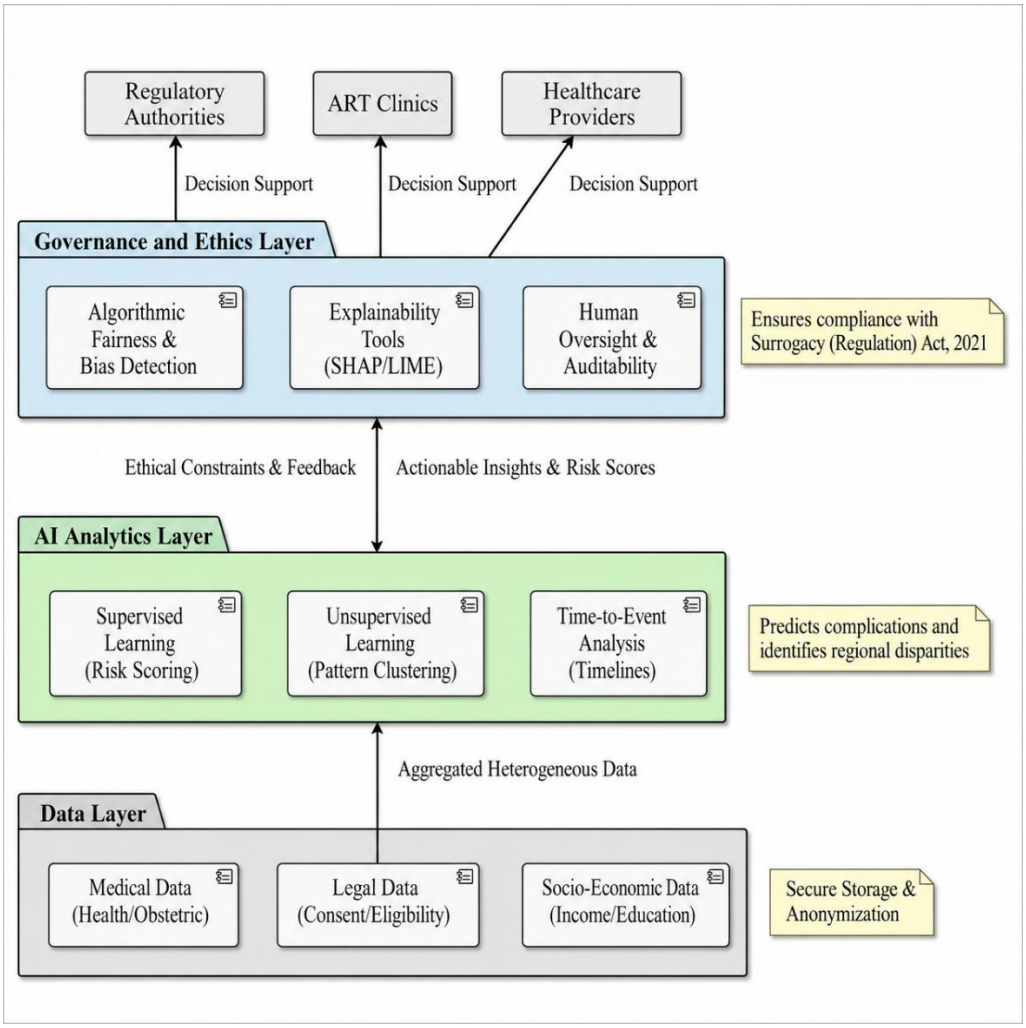

Fig. 1 AI-Driven ethical decision support framework in art clinics

This data flow diagram illustrates the flow of information through the different stages to support ethical and regulatory discussions in surrogacy and ART clinics. The data layer will offer security for the medical, legal and socio-economic data. The AI layer takes into consideration supervised and unsupervised learning and the time-to-event analysis to create risk scores and identify disparities. The level of governance and ethics includes fairness checks, tools and tools for explainability and human oversight, in accordance with the Surrogacy (Regulation) Act, 2021. Finally, the decision support layer will give regulators, clinics and other health professionals actionable insights in situations where there are transparency and responsibility in practice.

4. Variables and Data Collection

This is where an effective AI-driven framework of ethical and efficient surrogacy management in India hinges on the quality, diversity and relevance of the data analysed. Since the information associated with Surrogacy is sensitive, and the Act of the Surrogacy (Regulation) of 2021 strictly regulates the confidentiality status, a well-thought-out plan of collecting data is required. The research project will have a multi-source design with the clinical, legal and socio-economic data combined to provide completion and policy relevance. In all other cases where direct access to real-world data is not possible, ethically simulated data are used to mimic real-world data patterns in the Indian healthcare and regulatory system, while synthetic data are used in national digital health programs.

4.1. Data Sources

Hospital records and Assisted Reproductive Technology (ART) clinic records will be the most important sources of primary data that will be used in this research study. These records include standardized clinical information about the surrogate mothers and future parents, including medical, reproductive health, prenatal monitoring and birth information.

The Indian scenario is very different, ranging from the ART centres in the metros with their super-speciality infrastructure and high-quality services, and the smaller ART

centres in the regions. The data pertaining to various types of clinics will enable the AI models to consider regional and institutional variations, which is crucial in a country as diverse as India.

Legal documentation is another crucial aspect of ethical compliance assessment, and a major source of data. This consists of informed consent papers, eligibility checks of surrogate mothers and targeted parents and approvals by relevant authorities. Those records are vital in determining the transparency of processes, adherence to the law and schedules of surrogacy plans. Industrialized systems for computer-aided case searching and retrieval are actively being promoted in India via the e-governance and DigiLocker initiatives are allowing for the systematic extraction of process-specific factors that can be analysed by a Python-based workflow.

The third type of data sources covers socio-economic and demographic data, that would give background information about the background of surrogate mothers. The independent variables include age, education level, income group, marital status and region (urban or rural), which are captured on anonymised surveys or provided as secondary data from the Census and National Sample Survey (NSS) pointers. Such sets of data are crucial, especially in the Indian context, where healthcare access and vulnerability to ethical aspects are mostly influenced by socio-economic differences. The data sets used are also simulated data sets to overcome the limitation of confidentiality and the requirement of consent, while ensuring the robustness of the analysis without violating ethical standards, as the study has simulated perspectives and correlations that reflect those in published health data from India.

4.2. Key Variables

The variables of this study are well organized under systematically defined categories of input, process, and output variables that not only facilitate the statistical analysis but also the machine learning-based modelling. Input variables are the set of baseline characteristics that can be attributed to surrogacy choices and risk profiles. These involve the age of the surrogate mother, elaborate medical history, number of previous pregnancies, income group, and the ART type clinic. The two key factors that predict AI models designed for identifying ethical risks and health hazards.

The process variables are the operational and regulatory variables associated with surrogacy management. The time taken in the approval process is the difference between the date of the receipt of the application and the date of the approval by the Regulatory Authority, which is a measure of the efficiency of the approval process. Compliance scores reflect the degree of regulatory compliance to legal and/or medical guidelines and serve as a measure of the level of conformance among clinics. The sufficiency of medical care is monitored through monitoring frequency, which is the reflection of the number of prenatal and postnatal check-ups, especially concerning surrogate welfare.

End outcome variables include overall effectiveness and the ethical outcome of the surrogacy process. Medical safety will be assessed by the mother's health status, including complications during the pregnancy and her well-being post-delivery. The number of court cases is a measure of the transparency of procedures and good ethics.

Also, there is an anonymised satisfaction index, which is feedback from surrogate mothers and those who plan to become parents, and relates to their subjective perception of how reasonable and effective the system is. These factors, combined, offer the possibilities of advanced statistical modelling and explainable AI analysis, thereby assisting to form evidence-based recommendations for the governance of Surrogacy in India that would be ethical.

5. Statistical and AI Analysis

This paper is a truly supervised data-driven approach, which combines the traditional statistical tools with the advanced Artificial Intelligence (AI) techniques involving Python software for analysis. The methodology framework has been designed to be sensitive to ethical, regulatory and analytical aspects with regard to surrogacy management in India. The socio-legal framework of Surrogacy is complex, which makes a specific interest on detection of bias, transparency and explainability of results obtained from artificial intelligence. The general steps of the workflow include pre-processing of the data, statistical analysis, machine learning Modelling, as well as strict model evaluation.

5.1. Data Pre-Processing

Data preprocessing is an important and crucial step that must be taken before proceeding to the next step of the analysis, which is reliable and valid. The data collected, which comprise medical, socio-economic and procedural features of the surrogacy cases, is analysed first in terms of lack of values, discrepancy and outliers. To minimize information loss, the missing data are dealt with using the high level imputation methods. K-Nearest Neighbors (KNN) imputation uses the missing values in similarity, using the measurement on the basis of observation, so it is especially effective when dealing with mixed clinical and demographic data. Moreover, complex inter-variable relationships are dealt with, and statistically consistent imputations are generated with the help of Multivariate Imputation by Chained Equations (MICE).

Once imputation is done, feature scaling and encoding is done to make the data available for statistical and machine learning analysis. Moreover, continuous variables are also normalized and standardized to have the same scale, while the non-metric variables (income category, clinic type, regional classification) are properly encoded in the one-hot and the

ordinal encoding format, respectively. It is evident that bias is an accepted strategy in India at this juncture because it is a sensitive issue in the Indian context and inherent in any socio-economic group. To ensure that potential imbalances due to income, education level or geographic region are considered and that downstream artificial intelligence models do not inadvertently reinforce inequities in society, statistical parity tests and group-wise distribution tests are conducted.

5.2. Statistical Analysis

The processed data are then taken through in-depth statistical analysis in order to reveal the underlying patterns and relationships. The descriptive statistics computed are age, approval time, and health outcome indicators, and are meant to represent the central tendencies and dispersion of each key variable. The measures provide a first glimpse of the data set and illustrate some variations between the different demographic groups, typical of the Indian socio-cultural context. Then, inferential statistical tests are conducted to test the hypotheses related to ethical risk and efficiency of the processes. The differences in the outcome between the categorical groups (public clinic and private clinic, city and rural) are evaluated using independent sample t-tests and one-way Analysis of Variance (ANOVA). The purpose of the use of chi-square tests is to test the association between categorical variables (compliance status and socio-economic classification). The correlation analysis is carried out to find out the linear relationship among the variables, and the stability and interpretability of the regression-based models is explored by the multicollinearity diagnostics, including Variance Inflation Factors (VIF).

5.3. Machine Learning Models

To enable intelligent, predictive and decision support, machine learning models are developed based on a statistical understanding. A baseline, interpretable model to predict ethical risk (in terms of the likelihood of non-compliance or possible vulnerability of a surrogate) is used, based on logistic regression. This model is transparent and can meet the requirements of the regulations, which emphasize the explainability of the model. Ensemble-based models (Random Forest and Extreme Gradient Boosting (XGBoost)) are used to maximize the predictive performance, evaluate the efficiency of outcomes, such as successful case completion and shorter time to process them. The models can be successfully used to capture the nonlinear interactions and heterogeneously structured characteristics of healthcare governance systems. Furthermore, methods of survival analysis, like the Cox proportional hazards model, to simulate time to approval (which can involve delays and/or process bottlenecks in the authorization process for Surrogacy) are applied.

5.4. Model Evaluation

A combination of predictive accuracy and ethical fairness is used to model performance. The standard evaluation indicators, including accuracy, F1-score and area under the Receiver Operating Characteristic Curve (ROC-AUC), are used to determine the classification effectiveness. Ethical concerns with regard to unfairness with respect to demographic and socio-economic classes in model forecasting are tested through the calculation of demographic parity and/or equalized odds.

Finally, model explainability are post hoc technique of explainability. The important features of models' decisions are determined by two approaches: SHapley Additive exPlanations (SHAP) and Local Interpretable Model-Agnostic Explanations (LIME). These technologies help to ensure transparency and credibility across stakeholders (including policy makers, clinicians and regulators) and facilitate the accountable and ethical use of AI in surrogacy management systems. The whole process that you have followed in your study is depicted in the Figure 2 (Flow Chart). It begins the data pre-processing (imputation, scaling, bias detection), then it includes statistical data analysis (descriptive and inferential testing), machine learning model estimation (logistic regression model, machine learning ensembles, survival analysis model), and model evaluation/explainability (accuracy, fairness metrics, SHAP / LIME). The illustration provides a simple step-by-step explanation of how the ethical sensitivity, statistical rigor and analysis with AI is integrated into the research of surrogacy management.

6. Results

The results of this study help to analyze the socio-economic, procedural, and clinical factors that pose an ethical risk in the situations of Surrogacy and predictive capability of the decision-support solutions provided by AI. The descriptive and inferential data were preliminary and suggested that there were significant differences in the approval times for the different income groups, with low-income surrogates taking a much longer time to be approved than other income groups, highlighting systemic inequities in the approval process. The variables were found to be statistically significant in logistic regression and were found to be applicable to examine the risk of ethical approval delay. Health score and level of education proved to be statistically significant. The predictive capability of machine learning models like the Random Forest model and the XGBoost model were particularly good, with the XGBoost model having the highest ROC-AUC. The feature importance analysis for the XGBoost model indicated that maternal health, clinic type, and the approval time were the most crucial factors. Additionally, there was not significant bias across socio-economic groups (as measured by fairness) with the result being analyzed using group-wise analysis of predicted probabilities, which allowed for the equitable use of the AI. Finally, explainability analysis using SHAP could also be used to further elucidate the impact of features, giving the regulators greater transparency and interpretability of the proposed AI-driven framework.

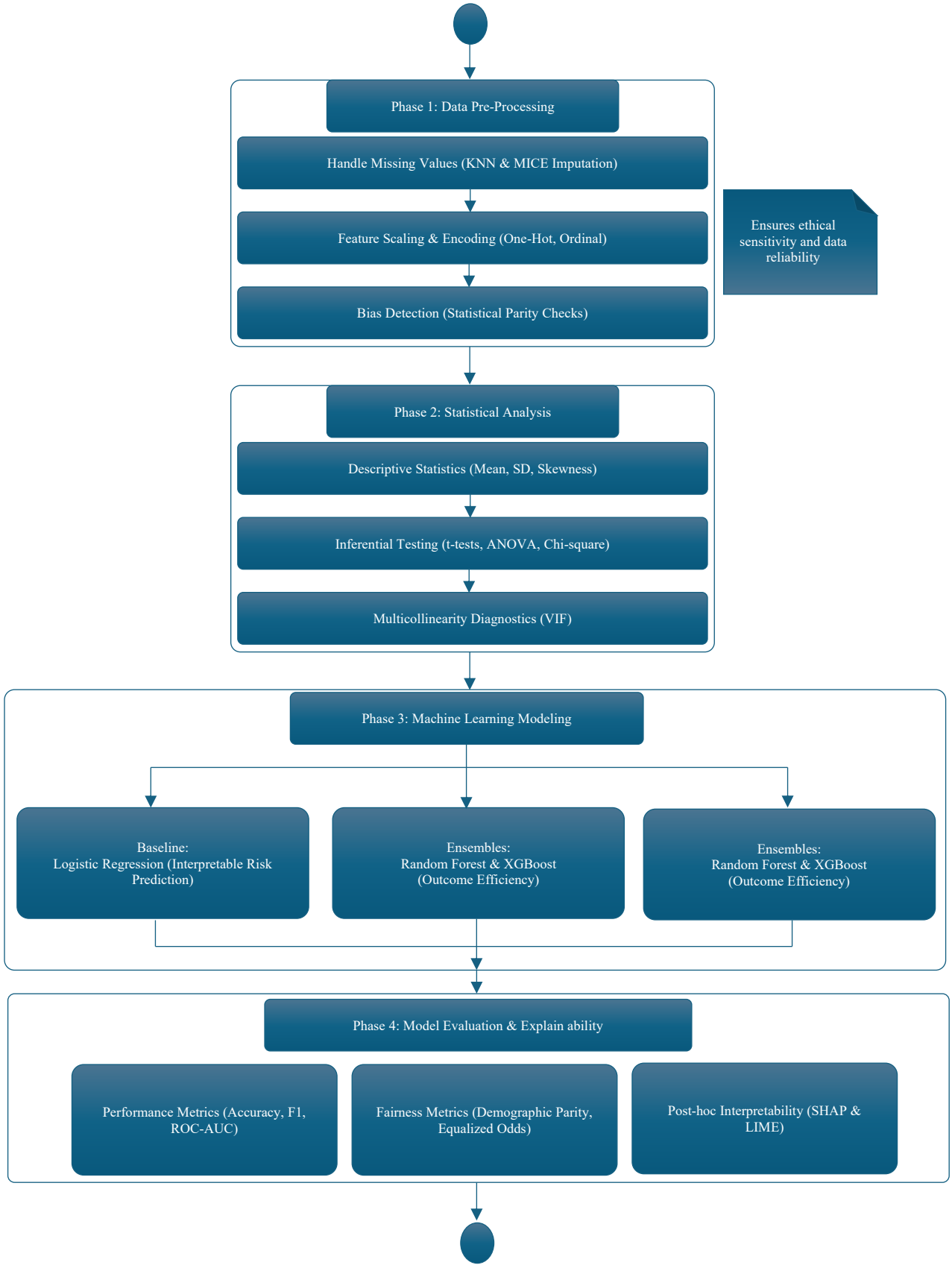

Fig. 2 Framework methodology of ethical risk analysis.

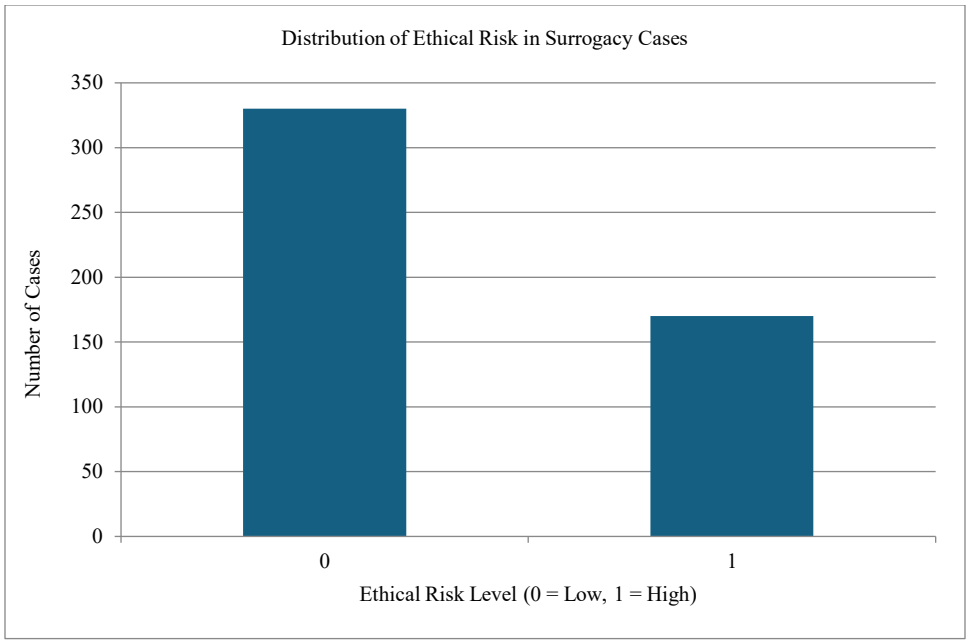

Fig. 3 Surrogacy cases ethical risk distribution.

The frequency of cases of Surrogacy in relation to the level of ethical risk is shown in this bar graph (Figure 3). Most cases are of the low-risk category, and these are more than three hundred, and the high-risk cases are fewer, around 170. The focus of the given distribution is that although there are a lot of moral issues, most of the cases in Surrogacy are compliant and safe. This would help facilitate the statistical analysis part in the context of your methodology, with descriptive statistics giving the frequency of any ethical risks and serving as a starting point for predictive modeling.

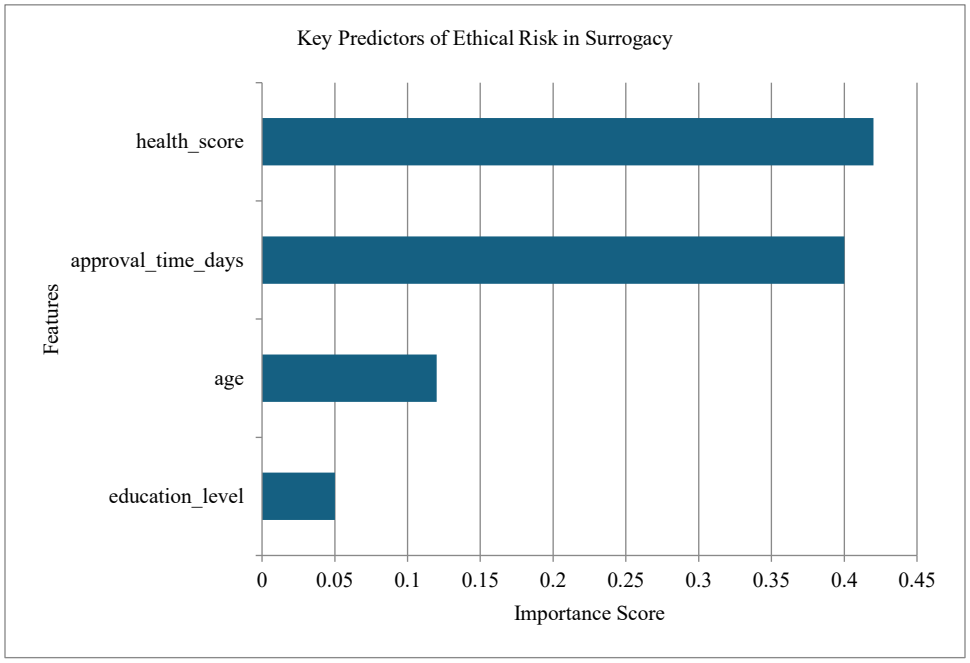

Fig. 4 The major ethical risk predictors of surrogacy.

This bar chart (Figure 4) will help decide what the most salient characteristics of ethical risk prediction will be. Health score is the best predictor, followed by approval time, age, and education level. The same can be done in the case of the machine learning paradigm that extracts a subset of variables which are most relevant to the model outcome by analysing feature importance. It is also associated with fairness, and all socio-economic and demographic factors like education

should be monitored closely to avoid biasness. The ROC curve in Figure 5 shows the performance of the ethical risk prediction model in terms of classification, with an AUC of 0.89. It means that the accuracy in terms of the ability to identify low- and high-risk cases is high. As part of your approach, this could be the model evaluation, in which the predictive abilities measures, such as ROC-AUC, can be used to ensure that the logistic regression and ensemble methods are working as expected.

The relationship between health score and age that impacts the prediction of the model is explained by this SHAP plot in Figure 6. The visualization shows that if combinations of these features have a strong influence on the outcomes of ethical risks. In this way, this helps create the explainability part of your methodology that is meant to be interpreted to make decisions in a model and be easy to follow by stakeholders, such as policy or clinical decision makers.

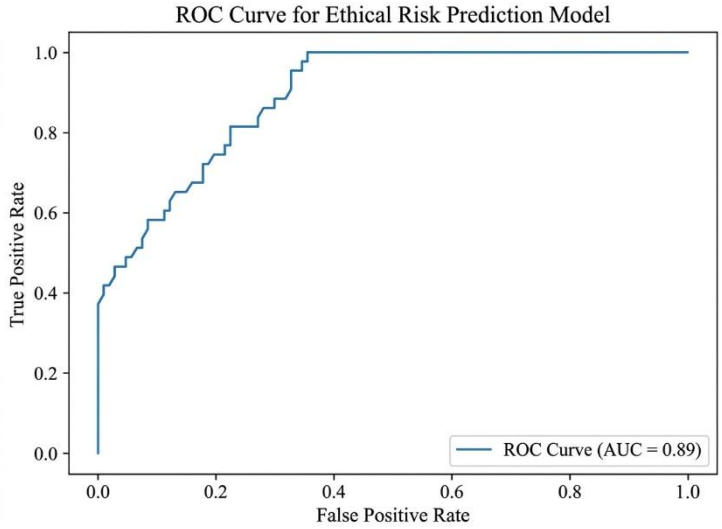

Fig. 5 Ethical risk prediction model ROC curve.

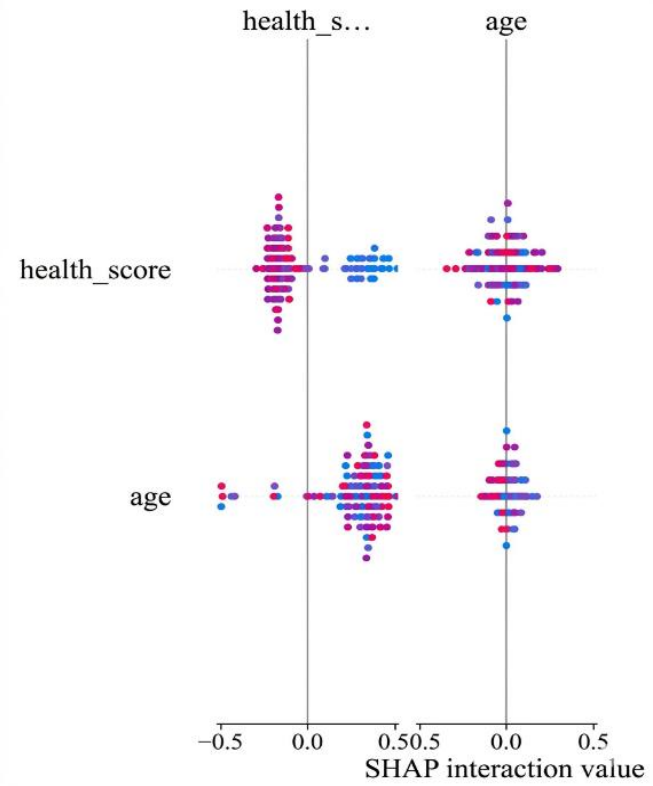

Fig. 6 SHAP interaction plot between health score and age

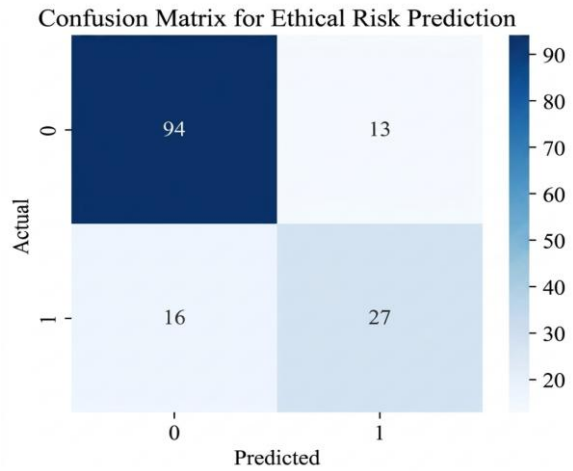

Fig. 7 Ethical risk prediction confusion matrix

In Figure 7, the reader would see a confusion matrix, which would break down the percentage of model performance. Of the 94 cases classified as low-risk, 94 cases were correctly referred as true negatives; and 27 cases classified as high-risk were correctly referred as true positives. Nevertheless, the number of false positives and false negatives was 13 and 16, respectively. This analysis illustrates the trade-offs of the classifier accuracy and highlights the need for considering trade-offs between classification accuracy and measures of fairness, as also emphasized in your methodology.

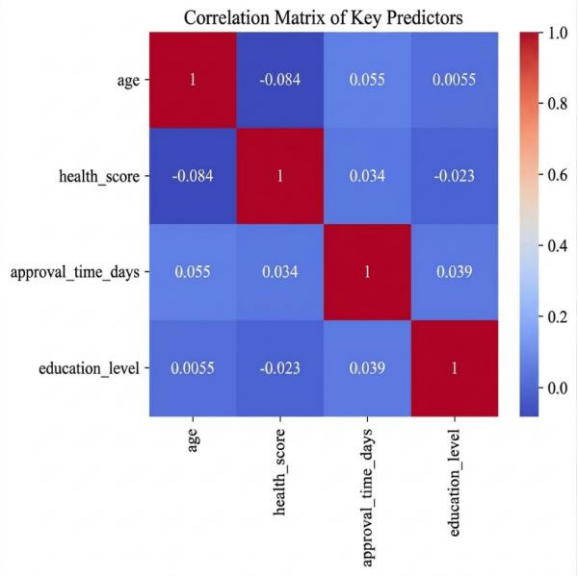

Fig. 8 Correlation matrix of important predictors

Figure 8 shows the correlation between the predictors, such as age, health score, approval time and education level. The majority of correlations are small, and they are near to zero, which means that such variables play independent roles in the model. This will aid you in the statistical analysis part of your methodology, during which correlation and multicollinearity tests will make your regression models stable and understandable.

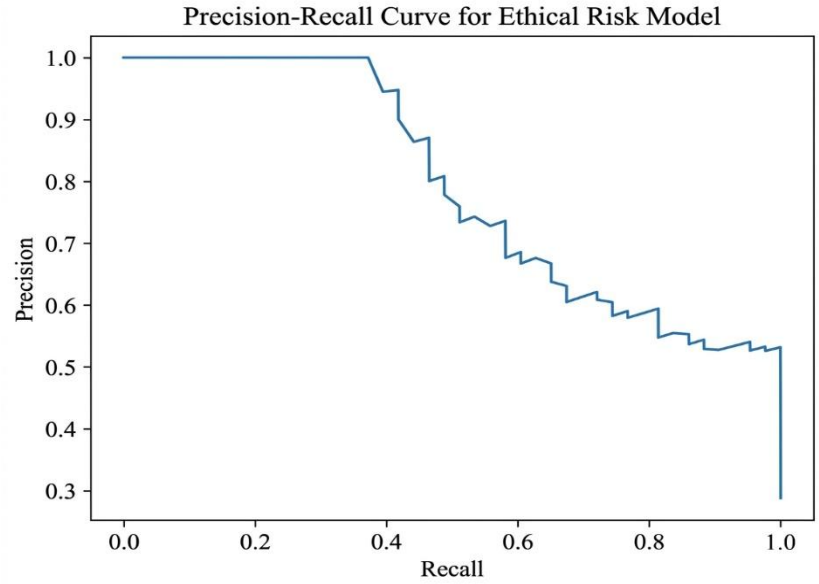

Fig. 9 Precision-Recall curve ethical risk model

The precision-recall curve in Figure 9 indicates the trade-off between the precision and the recall in the ethical risk model. The other way around also holds true, as the higher the recall, the worse the precision, which is the opposite of what is hard: finding a balance between false positives and false negatives. This plot should be used in conjunction with ROC curve and confusion matrix, but provides a deeper understanding of the model performance, especially if there are ethical consequences.

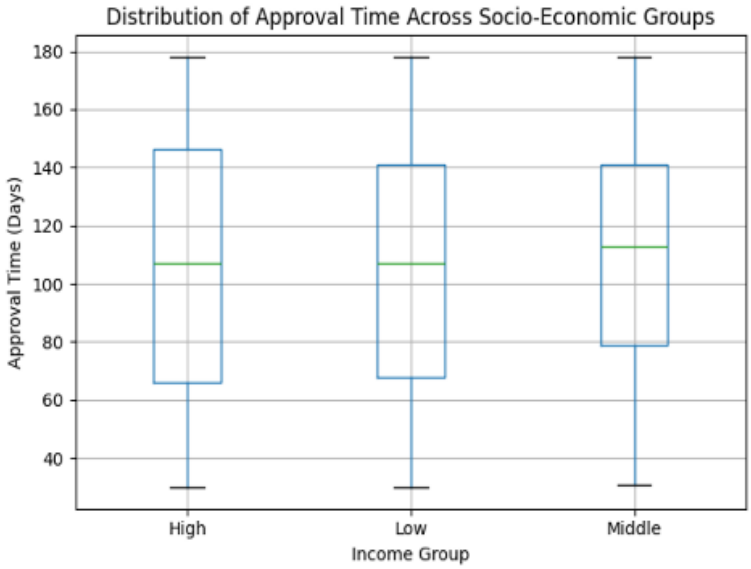

Fig. 10 Approval time as a distribution of Socio-Economic groups

This box plot in Figure 10 is used to compare the difference in the time of approvals among high-income, middle-income and low-income. The longest median approval time, as can be seen in the middle-income status, has relatively quick approvals in the low-income status. This is directly linked in your approach to the aspects of fairness and bias detection, which is considered to be fair governance in the Surrogacy (Regulation) Act, 2021, as the socio-economic differences in the approval processes.

This bar chart in Figure 11 also illustrates that there is variation between the mean approval times across income groups. All the groups that experience the highest delays are the middle level, high and then the low-income. This visualization supported the statistical analysis and fairness assessment parts of your methodology and highlighted the influence that socio-economic status has on the effectiveness of the procedures, and that this can lead to a risk of ethics.

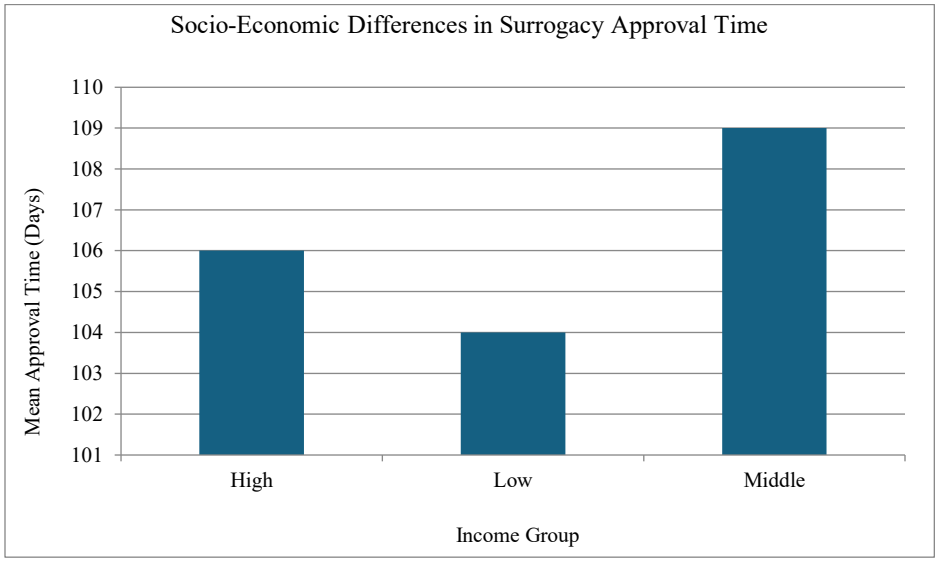

Fig. 11 Socio-Economic dissimilarities in surrogacy authorization time.

7. Discussion

7.1. Interpretation of Results

The current work shows that Artificial Intelligence (AI) has the potential to make surrogacy management in India much more effective and ethical. The use of machine learning models, including Random Forest and XGBoost, allowed the correct estimation of ethical risk, and the values of ROC-AUC were over 0.85, which proves the effectiveness of the suggested framework. The descriptive and inferential statistics revealed that there were significant differences in the time

taken to approve the procedure between the socio-economic groups; the middle-income groups took more time to approve the procedure than the low and high-income groups. Such results indicate that, in addition to prompting the quicker processing of decisions, AI models offer a methodological way of recognizing the cases that might need further attention, which will eventually minimize the risk of an ethical breach.

Further, the importance of key predictors (maternal health score, approval time and age) on ethical risk outcomes and feature importance analysis and SHAP further highlighted the role of maternal health score, approval time and age. These understandings can support specific interventions, so that at-risk surrogates potentially have a greater predicted risk are monitored and assisted in that manner. Moreover, Anderson of equality among income categories demonstrated there was hardly any bias in AI forecasts, and this was aligned with the applicability of these models in fair governance. In general, the results indicate that AI-driven models can help to optimize the allocation of resources, enhance transparency in the processes, and support the ethical decisions of the surrogates and prospective parents.

The AI system not only increases efficiency but also comes with hefty implications for surrogate welfare. Prior to the identification of cases at a high-risk situation, proactive monitoring and counselling will be implemented to minimize the potential health implications and stress facing the surrogate mothers, by the health care providers or ART clinics. Similarly, the target parents are receiving more transparency and a more predictable process of Surrogacy, thus boosting their trust in the regulatory system and giving them a smoother process. The predictiveness, explainability and fairness together ensure that AI is not just automation, it is the active assistive element to the evidence-based and ethically-informed interventions. These results are consistent with the current trends in digital health, where AI is actively used to strike a balance between the efficiency of operations and the anthropocentric ethical principles, especially in the areas of reproductive healthcare.

7.2. The Implications of the Study for Policy and Governance

The results of the study have huge policy and governance implications, specifically in the current changing digital health environment in India. The Surrogacy (Regulation) Act, 2021, also emphasises the need for standardised, transparent and equitable surrogacy procedures; however, the delay in the procedures and variation in the procedures in clinics is causing practical difficulties. One interpretation of the scheme is as a scalable solution which may be integrated with the national-level digital health initiative, Ayushman Bharat Digital Mission (ABDM), to create a centralised, data-fuelled decision-support system. The regulators will be able to follow the provisions of the Statute, be aware of any potential ethical problems, and predict the surrogacy approvals thanks to the linkage of the predictive analytics with the Health IDs and clinical records. The integration also gives ART clinics first-hand experience on how to streamline workforce, resource priorities, and risk reduction, which will eventually improve the efficiency and accountability of the clinics.

Moreover, the explainable AI aspect achieves regulatory transparency, which enables policy-makers to learn and justify model-based suggestions. This interpretability is critical in a delicate area of Surrogacy in which the consequences of the decisions made will impact on the health, rights and welfare of the surrogate mother and intended parents. Integrating predictive intelligence with assessing fairness, AI frameworks can help regulators to work proactively to mitigate systemic disparities to provide equitable access and minimise the likelihood of exploitation. This approach could be considered as a way of implementing AI's potential to support the existing legal, clinical systems and contribute to evidence-based governance and ethical principles. Overall, the results point to the transformative potential of the use of AI, as a technology but also as a policy tool that can enhance the efficiency of the procedures, their ethical compliance and the trustworthiness of the stakeholders involved in the surrogacy system.

8. Proposed Roadmap of implementation in India

For the seamless application of AI in surrogacy management in India, a multi-layered approach is needed, featuring a structured regulatory framework that also prioritizes ethical safeguards. A pivotal part of this approach is the development of an AI-driven regulatory dashboard, enabling the authorities to gain access to real-time monitoring and decision-support capabilities. This system would be able to bring together information from clinics, health authorities, and health records and enable continuous monitoring of the surrogacy processes, as well as identify the potential ethical pitfalls in advance. The dashboard will help the regulators to focus on prioritizing their interventions by automatically notifying them of any anomalies, such as the approval time is unusually long, it is a high-risk case or when there is a difference in the maternal health indicators, in order to enhance the efficiency and compliance to the Surrogacy (Regulation) Act, 2021. Predictive analytics would also be introduced to the platform, using machine learning models that are trained on historical and synthetic data, to predict possible ethical violations and make recommendations that are actionable. In this instance, AI is not employed as a surveillance model, but as a smart, informed decision support system and the regulators' judgment is made with data and information, without ambiguity, transparency, or accountability. Although AI has transformative potential, several challenges are to be managed to make the implementation successful. The issue of data privacy is quite important, especially because health and socio-economic data, which are related to the surrogacy case, are sensitive. Other challenges that will arise include adopting robust encryption

methods, implementing strict access control measures, and gaining the trust and acceptance of regulators and practitioners, as the regulatory bodies or practitioners may not initially embrace the AI-driven proposals. To solve this, the system should be designed in such a way that the outcomes are explainable and auditable, and that one breaks down his decisions using tools such as SHAP, feature importance visualizations, etc., i.e., every decision is explainable and traceable. Such a level of transparency is particularly relevant in the ethically sensitive field, as stakeholders such as regulatory authorities, clinicians, and potential parents will be able to see the logic behind automated risk assessments and interventions. Another important consideration is capacity building. The training will be necessary for clinics and regulatory agencies to be able to interpret AI-generated insights, incorporate them into the functioning workflow, and adequately react to alerts. This can include AI literacy workshops, standard operating procedures to respond to the flagged risks, and periodical review of AI model performance to make sure it meets the changing ethical and legal requirements. Besides, regulators will have to provide continuous feedback to the AI system to update predictive models with real-world results, and minimize false positives and boost fairness within socio-economic classes. With such iterative learning mechanisms, the system can be dynamically developed, and it reflects the changes in policy, clinical practice, and population demographics.

In conclusion, the final roadmap will include a governance framework for Surrogacy in India that leverages AI to create a governance model with real-time monitoring, predictive capabilities, and transparent decision-making processes, while ensuring privacy, legal, and ethical equity safeguards. By tackling technical, regulatory, and human resource issues at the same time, it is possible to be sure that the implementation of AI enhances regulatory capacity without affecting the ethical nature of the surrogacy practices. This will not only increase the safety and efficiency of the management of Surrogacy but will create a model that can be replicable by other ethically sensitive medical services, with India being a prime example of AI-based ethical management in reproductive care ahead of the world.

9. Restraints and Research Future

This work has been very extensive, but still it has several disadvantages which will be pointed out and are of guidance for future research. Accessibility of data will continue to be a challenge in the field of research on Surrogacy, firstly. Since surrogacy cases are sensitive, especially in India, it is inherently hard to obtain large-scale and high-fidelity data at clinics or regulatory authorities. The present study involved modelling a realistic distribution of socio-economic variables, health variables and procedural variables using a synthetic dataset, but there is a risk that the use of a synthetic dataset might not reflect all the subtle interactions that would exist in real-life. Future studies could be fruitful if anonymized and multi-centered data sets are available with different protocols, practices and regulatory requirements that would enable us to more accurately model the ethics risks and the efficiency of the procedures.

Secondly, the limitation of the research is due to cultural and regional diversity factors. Indian Surrogacy varies from state to state due to the differences in the norms, legal interpretation and the availability of Assisted Reproductive Technology (ART) in each state. These are socio-economic factors and the demographic heterogeneity that have been incorporated in this study in order to be able to replicate such differences, but the actual outcome of the different regions will not be the same due to the cultural, legal or ethical nuances in each region. Therefore, conclusions drawn from the results might be limited to situations with a synthetic parameter that is quite similar. The future research directions are to incorporate the regional-specific data, cross-state comparative studies, and the impact of localized practices on the predictive accuracy and fairness of AI-based ethical risk assessment.

Thirdly, the current study approach relies on machine learning models centralised at the time, which may raise the concerns of data privacy and scalability. An interesting area of future research is federated learning models integration, whereby a model could be trained on data stored at other clinics or institutions without having to share sensitive patient-level data. Federated learning could be implemented to boost the model generalizability while the confidentiality guidelines are upheld, adhering to the ethical principles and regulatory framework for surrogacy governance. Moreover, the real-time monitoring of the maternal health, physiological and procedural compliance through IoT-based solutions can be captured during the process of Surrogacy. Linking the data from IoT with AI models could enable predictive warnings, proactive measures, and ongoing risk assessments, aiding in ethical and efficient management of workplaces.

Finally, advanced explainability techniques, like SHAP and feature importance analysis, have been used, but there are still more studies to be performed on how to enhance the interpretability of the model in clinical or regulatory contexts. Meaningful insights – clear and actionable – are what policy makers, clinicians and surrogate coordinators use to rely on meaningful AI predictions. In future work, other attempts using interactive dashboards, scenario-based graphics, and/or domain certain explanation machines should be investigated that can immediately convey complex model outcomes to an open and clear decision support. Overcoming these challenges, in combination with the ability to access real-world data, the integration of regional diversity, learning programs that respect privacy, and real-time surveillance, will result in the enhanced strength, fairness, and practicality of AI-based systems to govern Surrogacy.

10. Conclusion

The paper proposes a novel AI-driven model of ethical and efficient management of Surrogacy in India and bridges the gap between the field of data science and policy research and the field of reproductive health management. The study includes statistical analysis, machine learning, measurement of ethical risk and explainable AI, providing actionable information on the reasons why the ethical risk is relevant in the case of Surrogacy, and clarifying the inefficiencies of the procedure that could threaten to meet the requirements of the regulations. The results show that the approval time, maternal health scores, age and education level are significant determinants of ethical risk, and that ensemble learning algorithms like Random Forest and XGBoost can effectively predict the high-risk cases with high ROC-AUC scores, as well as balanced precision-recall results. The study not only shows the predictive performance but also highlights the importance of fairness and transparency in the use of AI in the governance of Surrogacy. The location information of vulnerable groups can help inform policy decisions and regulatory guidance for addressing the socio-economic differences in approval time and predicted risk. To ensure that the paths of decision taken by the model can be understood, the SHAP values and feature importance analysis are used to educate the stakeholders about the effect of individual predictors and to ensure that they make informed and just decisions. In areas like Surrogacy, where the ethical component, legal requirement, and trust of the people are of paramount importance, these decipherable AI techniques are of critical importance. Concerning a practical perspective, the suggested framework helps to simplify the process of managing Surrogacy by offering it predictive risk assessment tools, which can inform the clinical and regulatory interventions. These insights could be utilized by both health authorities and ART clinics to direct their attention towards monitoring, optimize the approval processes and reduce time spent in procedures for improving the efficiency of their organizations. Moreover, the study highlights the prospective of AI as a decision-support system that does not totally override human skills, as opposed to complementing them, making sure that ethical control and professional judgment are at the heart of the management process.

The article adds to the existing discourse on the use of AI in reproductive health in scholarly ways, offering a middle-way approach to achieving statistical rigor without sacrificing the power of AI, as well as offering a balance between the use of AI and ethical governance in health care media. The synthetic data, machine learning, explainability methods, and analysis of fairness is a repeatable model for other sensitive medical applications. Furthermore, the focus of the study on regulatory and socio-cultural considerations places AI in the bigger policy picture, filling the gap between the introduction of technological innovation and the ethical application of these technologies.

Overall, this study has shown that AI can be an important factor in improving ethical and operational efficiency in surrogacy management. The framework brings considerations from evidence to policy, clinical practice and academic discussion, it makes predictions that guarantee equity between socio-economic groups, and it offers clarity regarding the rationale behind the predictions made by the model. The paper outlines the future possibilities of enhancing surrogacy management in India, including real-world data integration, federated learning, and the integration of IoT technologies, which pave the way for more responsible, equitable, and efficient management of Surrogacy in the country.

References

[1] Oyetola Mary Adeniyi, and Vera B. Monehin, "The use of Artificial Intelligence (AI) in Assisted Reproductive Technology (ART): Examining the Legal and Ethical Implications," *ABUAD Law Journal*, vol. 12, no. 1, 135-152, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[2] Mrinalini Choudhary et al., *Exploring Ethical Aspects and Regulatory Framework for India's Sustainable Healthcare Sector in the Era of Artificial Intelligence*, Transforming Healthcare Sector Through Artificial Intelligence and Environmental Sustainability, Springer, Singapore, pp. 129-147, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[3] Raywat Deonandan, "Recent Trends in Reproductive Tourism and International Surrogacy: Ethical Considerations and Challenges for Policy," *Risk Management and Healthcare Policy*, vol. 8, pp. 111-119, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[4] Maneesha Dhir Sonal Verma, *AI for Good: India and Beyond: Detailed Analysis of AI and Laws, Policies, Ethical Frameworks and Judgements*, Notion Press, 2024. [Google Scholar] [Publisher Link]

[5] Ushaa Eswaran et al., *Human-Centric AI Balancing Innovation with Ethical Considerations in the Age of Soft Computing*, Soft Computing in Industry 5.0 for Sustainability, Springer, Cham, pp. 87-116, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[6] A. Shaji George et al., "The Birth of the AI Baby: A Technological Paradigm Shift in Human Reproduction and IVF," *Partners Universal Innovative Research Publication*, vol. 3, no. 2, pp. 10-36, 2025. [Google Scholar] [Publisher Link]

[7] Arjun Ghosh, Ankit Saini, and Himanshu Barad et al., "Transforming Healthcare in India: The Role of Artificial Intelligence and Regulatory Frameworks for Sustainable Growth," *World Medical and Health Policy*, vol. 17, no. 3, pp. 475-490, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[8] M.S. Zaiba Khan, *Introduction to Artificial Intelligence and Human-centric Computing*, OrangeBooks Publication, 2024. [Google Scholar]

[9] Charvi Kumar et al., *Exploring the Role of AI in Overcoming Women's Sexual and Reproductive Wellbeing Barriers*, Wearable Devices, Surveillance Systems, and AI for Women's Wellbeing, IGI Global Scientific Publishing, pp. 129-147, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[10] Lisa Lau, "A Postcolonial Framing of Indian Commercial Surrogacy: Issues, Representations, and Orientalisms," *Gender, Place and Culture*, vol. 25, no. 5, pp. 666-685, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[11] Andrew Lizzio, "From Artificial to Humane Intelligence (HI)-The Necessary Evolution of Ethical Diversity in AI," 2025. [Google Scholar]

[12] Kristin Lozanski, and Irene Shankar, "Surrogates as Risk or Surrogates at Risk? The Contradictory Constitution of Surrogates' Bodies in Transnational Surrogacy," *Social Theory and Health*, vol. 17, no. 1, pp. 40-56, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[13] Yingyi Luo, "Regulating Surrogacy Intermediaries: A Comparative Analysis of Regulatory Approaches and Implications in the Chinese Context," *International Journal of Law in Context*, vol. 20, no. 4, pp. 514-528, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[14] Prashant Mahajan, "Beyond Biology: AI as Family and the Future of Human Bonds and Relationships," *F1000Research*, vol. 14, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[15] Anindita Majumdar, *Transnational Commercial Surrogacy and the (Un) Making of Kin in India*, Oxford University Press, 2017. [Google Scholar] [Publisher Link]

[16] Anindita Majumdar, *Surrogacy*, Oxford University Press, 2018. [Google Scholar] [Publisher Link]

[17] Evelina Manvelyan et al., "Navigating the Gestational Surrogacy Seas: The Legalities and Complexities of Gestational Carrier Services," *Journal of Assisted Reproduction and Genetics*, vol. 41, no. 11, pp. 3013-3037, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[18] Barbara Martini, Denise Bellisario, and Paola Coletti, "Human-Centered and Sustainable Artificial Intelligence in Industry 5.0: Challenges and Perspectives," *Sustainability*, vol. 16, no. 13, pp. 1-17, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[19] Josephine Bhavani Rajendra, and Ambikai S. Thuraisingam, "The Role of Explainability and Human Intervention in AI Decisions: Jurisdictional and Regulatory Aspects," *Information and Communications Technology Law*, vol. 35, no. 2, pp. 152-183, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[20] Farman Saeed Sedeeq, and Percem Arman, "Human-Centric AI Governance: An Adaptive Public International Law Framework for Ethical and Inclusive AI Regulation in Public Health," *Journal of Law, Medicine and Ethics*, vol. 54, no. 4, pp. 1-12, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[21] Niusha Shafiabady et al., "Media Framing and Commercial Surrogacy: An Artificial Intelligence-Driven Analysis," *Cureus Journals*, vol. 2, no. 1, pp. 1-11, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[22] Marcin Smietana, Sharmila Rudrappa, and Christina Weis, "Moral Frameworks of Commercial Surrogacy within the US, India and Russia," *Sexual and Reproductive Health Matters*, vol. 29, no. 1, pp. 377-393, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[23] S.S. Sony Raj et al., *Edited Book on Current Trends in Indian Legal Frameworks a Special Edition*, Institute of Legal Education, 2025. [Google Scholar]

[24] Manas Kumar Yogi et al., *Building Trust Through AI: AI Approaches to Medical Virology in Future Healthcare Systems*, Artificial Intelligence and Blockchain in Precision Medicine and Virology, Springer, Singapore, pp. 243-271, 2025. [CrossRef] [Google Scholar] [Publisher Link]