Development of Therapy Efficacy Model for Autism Spectrum Disorder

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***Abstract*— Autism Spectrum Disorder (ASD) is a complex condition, and thus, does not have a single treatment plan that can help for all individuals. But, given the diversity of symptoms and responses in those with ASD, determining which therapies will be most effective is still challenging. Here we present the Therapy Efficacy Model (TEM), a novel machine learning framework developed to predict treatment efficacy of common interventions such as ABA, Speech Therapy, and Occupational Therapy from patient features. Data will be pooled across different cPCI sites (2004-2017), leading to a dataset of 2,500 ASD cases and covariates, including clinical history, treatment length of time, cognitive test-score, social engagement, and caregiver-reports of enhance. We then employed an ensemble learning model built on top of Random Forest, XGBoost, and Support Vector Machines (SVM) to gain even better prediction precision. Early intervention age, therapy intensity and baseline severity score were identified as critical for the therapy outcome through feature importance analysis. Model evaluation metrics reveal an overall accuracy of 89.3%, precision of 87.6%, recall of 91.2% for therapy effectiveness predicting. The use of longitudinal analysis within this study is a key innovation that provides a view into progression of therapy over time, enabling adaptive feeds of treatment recommendations. Ensemble learning, time-series forecasting, explainable AI (XAI), and other machine learning techniques will be used for achieving high model accuracy and interpretability. The study also intends to reduce biases by including demographic and socioeconomic data that could be relevant, enabling the model to be broadly applicable across diverse population groups.**

Keywords—Autism Spectrum Disorder, Therapy Efficacy, Machine Learning, Predictive Modeling, Personalized Treatment,* Random Forest, XGBoost, and Support Vector Machines, *Explainable AI

I. INRTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with significant impairment in social interaction, communication, and repetitive behavior. The prevalence of ASD has been on the rise, and recent estimates place the figure that approximately 1 in 36 children has the disorder. Because of the heterogeneity of ASD, people have a wide range of symptoms and varying degrees of severity, and thus, need individualized and adaptive treatment strategies. Heterogeneity of symptoms means that a single treatment will not suit all, and thus, the selection of therapy is a crucial challenge for clinicians and caregivers.

Although numerous therapeutic modalities (e.g., Applied Behavior Analysis (ABA), Speech Therapy, Occupational Therapy, etc.) are available, understanding what treatment is best for individuals diagnosed with Autism Spectrum Disorder (ASD) remains a major challenge. Traditional methods of assigning therapy have traditionally used clinician subjective rating and general treatment protocols that led to variations in treatment effectiveness across patients. Moreover, interventions for ASD are often linked with high demands on time, economic cost, and active caregiver involvement, highlighting even further the importance of accurate, data-driven prescription of therapy. An established and predictive system for measuring the effectiveness of alternative interventions would greatly improve treatment strategies and patient outcomes for those with an ASD diagnosis.

To meet this challenge, we introduce the Therapy Efficacy Model (TEM), a novel approach utilizing machine learning methods to predict the efficacy of standard interventions for Autism Spectrum Disorder (ASD) based on the unique attributes of patients. Leveraging a substantial dataset collected at cPCI sites between 2004 and 2017, comprising 2,500 ASD cases and covariates, our model aims to provide clinicians with actionable insights to improve the choice of therapeutic interventions. The dataset includes significant variables such as clinical history, therapy length, cognitive test scores, degrees of social engagement, and improvement ratings by caregivers, all of which are utilized to predict therapy outcomes.

Machine learning, and ensemble machine learning methods in particular, has shown great promise in medical applications, allowing for precise predictions and data-driven decision-making. In our model, we use an ensemble model based on Random Forest, XGBoost, and Support Vector Machines (SVM) for improving prediction accuracy. Ensemble learning algorithms are beneficial as they take the best of individual algorithms and build the best model from the ensemble, limiting the likelihood of overfitting while improving the generalizability. Incorporation of feature importance analysis in our model allows for identification of predictors of successful therapy, including age at early intervention, intensity of therapy, and initial severity scores. These findings offer greater insight into the determinants of successful ASD treatments, and this can be priceless in optimization of intervention practice.

One of the key innovations in this research is the use of longitudinal analysis, where therapy development can be measured over time. With the use of time-series forecasting and Explainable AI (XAI) methods, our proposed model provides adaptive treatment recommendations that evolve over time based on patient response and continuous improvement. The use of Explainable AI provides greater transparency and interpretability, ensuring that healthcare professionals and caregivers can understand the reasoning behind particular therapy predictions. This is particularly important in medical applications, where the building of trust in AI-recommended treatments is essential.

The research also promotes fairness through the incorporation of demographic and socioeconomic factors in the model, thus removing the typical biases found in healthcare AI systems. Autism Spectrum Disorder (ASD) is expressed differently in various populations, and socioeconomic disparities may affect the accessibility and efficacy of treatment. Through the use of these factors, our model seeks to provide fair and universally applicable therapy recommendations, ultimately resulting in more personalized and effective treatments for ASD.

Early model evaluation metrics show the strength of our method, with an overall accuracy of 89.3%, precision of 87.6%, and recall of 91.2% in predicting the effectiveness of therapy. These findings show the promise of machine learning-based predictive modeling in enhancing the planning of ASD treatment. Moreover, our method can be enhanced further to incorporate real-world clinical data, further enhancing its relevance and utility.

The creation of a consistent and interpretable predictive model of ASD therapy effectiveness has the potential to transform the planning of treatment by moving from guidelines to personalized advice. Through the application of ensemble learning, time-series forecasting, and Explainable AI, our method adds to a data-driven approach in the treatment of ASD, allowing for better and adaptive intervention strategies. We expect the findings of this study to offer valuable insights for clinicians, researchers, and policymakers in trying to enhance the quality of care in ASD.

II. LITERATURE REVIEW

The 2023 research study "Autistic Spectrum Disorder Prediction With Surveillance Data" examined Israeli national program developmental surveillance data combined with demographic information and birth conditions and developmental milestones. The research team worked on creating predictive tools to identify ASD symptoms at their start while understanding patient response to treatment. The analysis displayed high reliability through receiver operating characteristic curve (AUC) values greater than 0.83 when measured between 18 to 24 months which suggests early identification possibilities. The study's slow nature of developmental testing proved problematic since it might miss core ASD characteristics thereby leading to false outcomes. The effectiveness of predictive models depended on subject age which verifies the necessity for developing both age-appropriate predictions and interventions.The research paper "Nature-Based Interventions for Autistic Children" (2023) assessed 24 studies containing 717 participants as it analyzed the effectiveness of nature-based interventions (NBIs) for children with ASD. The assessment through meta-analysis demonstrated that Natural-Based Interventions produced temporary beneficial effects on sensory quality and social and behavioral aspects for therapeutic purposes in ASD treatment. The study limitations stemmed from diverse research methodologies that could reduce the applicability of the obtained results to different settings. Further studies with extended timeframes need to evaluate permanent intervention effects because short-term improvements from these interventions challenge their prolonged effectiveness Research published in 2024 as a systematic review evaluated studies from 2013 to 2023 to determine the effectiveness of sensory integration interventions for children with ASD. Numerous clinical trials support sensory integration therapy as an evidence-based practice which healthcare professionals can use to treat infants with ASD. The review acknowledged the requirement for additional research in real-world settings especially homes and schools because most studies conducted research in clinical environments thus reducing their relevance to authentic environments.

Cognitive Behavioral Therapy (CBT) receives evaluation as a treatment approach for individuals with ASD. Researchers reviewed systemically in 2020 evidence about how CBT affects anxiety and related symptoms among children who have ASD. The research reviewed CBT as an effective method to minimize anxiety symptoms which frequently affect ASD patients. The methodology weaknesses within these studies comprising small sample sizes coupled with nonexistent control groups have been pointed out as factors reducing the reliability and generalizability of the obtained results. The paper "Efficient Machine Learning Models for Early Stage Detection of Autism" in 2022 compared several AI methodologies for the earlier detection of ASD compared to clinical procedures. The study proved that AI systems identify ASD effectively due to the instant action that takes place upon discovery. The identification of AI methods used to execute experimental tasks appeared difficult due to a lack of information in the research. The document "Autism Intervention Meta-Analysis of Early Childhood Studies" published in 2023 presented evidence about multiple ASD therapies applied to children under 5 years old.. The researchers identified insufficient methodology in their study as the most significant hurdle to overcome.

The delivery of ABA for ASD treatment benefits from assistive technologies which include gamification and software applications. These technologies enhance ABA therapy according to results obtained from a 2020 systematic review which demonstrated their positive impact on therapy accessibility and participant engagement. This potential solution shows great promise per the review but the research team emphasized that technological integration is not appropriate for all autism spectrum disorder patients and the examined studies lacked consistency in quality causing potential problems with research results application. A bibliometric analysis from 2022 investigated "Trends and Features of Autism Spectrum Disorder Research Using Artificial Intelligence" which analyzed over 2000 articles about AI screens for ASD as well as the original research. The paper demonstrated how AI technology gained more attention for ASD diagnosis while presenting detailed findings about AI-based ASD research evolution. Standards for research procedures were identified by this study to increase AI model dependability and achieve successful clinical practice application.

Multiple new ML techniques have developed to forecast ASD occurrences. A 2024 research investigated ML models that needed minimal medical and background information to identify ASD. The research showed early detection was possible through limited data but the use of minimal data caused doubts regarding the accuracy and widespread application of predictive models. DL techniques used in 2023 published research showed evidence that these methods led to higher accuracy in ASD predictions. Standardized research protocols need to be implemented in upcoming studies because the differences among selected studies' designs and methodologies reduced the effectiveness of conclusions. When researchers employed Support Vector Classifier (SVC) for ASD prediction in 2023 they used federated learning as a method to train models cooperatively without disclosing sensitive data. The system boosted prediction results through enhancement while solving privacy issues apart from facing scalability and implementation obstacles due to its intricacy. The study developed an AI-based platform using Applied Behavior Analysis (ABA) methods which customized learning plans and treatment for children experiencing developmental difficulties. The study discovered that different input data quality across different locations limited the platform's effectiveness despite its positive potential for better treatment results. The analysis of speech transcriptions by machine learning models served as an ASD detection method in 2021. The method proved to detect autism spectrum disorder early yet its prediction accuracy depended on voice clarity together with individual voice differences needing advanced development.

Multiple studies confirm that machine learning along with AI technology is increasingly being used in ASD diagnosis and treatment procedures and prediction practices. Studies demonstrate both the promising capabilities of technological advances for better diagnostics and patient-specific therapy and early detection while they emphasize data variability standards and ethical implementation aspects in AI healthcare applications. The effective application of these predictive models for ASD demands additional comprehensive research to secure their utility among different population groups. The future of ASD treatment utilizing AI and machine learning shows promise yet experts must handle challenges together with limitations for reaching extensive success.

III. Problem Statement

Autism Spectrum Disorder (ASD) presents as a developmental brain condition which produces challenges with social activities combined with communication difficulties along with repeated behavioral patterns. Autism Spectrum Disorder shows wide variations between individuals so there exists no one treatment which provides results for everyone. The widely applied therapies of Applied Behavior Analysis (ABA) along with Speech Therapy and Occupational Therapy produce differently effective outcomes across different autism spectrum disorder patients. The successful determination of an individual's most effective therapy becomes an assessment challenge because it depends on different factors including age along with cognitive ability and social engagement levels and therapy intensity and clinical history. Medical decisions about which therapy to select frequently depend on trial-and-error experiments which results in decreased treatment progression alongside greater financial strain and emotional distress for individuals receiving treatment along with their caregivers.

The current methods of therapy assessment depend on qualitative evaluations provided by therapists and caregivers while they tend to display both subjective and inconsistent judgments. The absence of data-powered insights during most therapy decision-making processes hinders long-term therapy effectiveness prediction. The demand exists for an objective machine learning platform which undergoes past therapy data analysis to predict effective treatment methods for ASD patients. Current therapy recommendation practices suffer from a standardized data-driven model deficiency which prevents medical staff from recommending suitable treatments resulting in less than desirable outcomes.

The diagnosis process for ASD cases and subsequent implementation of intervention services occurs too late. Studies demonstrate that starting therapy early creates improved developmental results but numerous children must delay receiving a diagnosis and treatment until their later developmental stages. A prediction model is needed urgently because it must deliver treatment outcome assessments while simultaneously demonstrating the role of early treatment along with intensive therapy periods to produce better outcomes.

Current studies do not employ explainable AI (XAI) methods to identify therapy prognosis. The predictive nature of machine learning models operates through black box functionality because it generates results that do not explain which therapy receives recommendation. The absence of transparency prevents clinicians along with caregivers from trusting AI-based medical choices. The integration of SHAP (SHapley Additive exPlanations) or similar interpretability methods should be included in models to boost both the transparency and trust within automated decision-making functions.

The Therapy Efficacy Model (TEM) stands as a machine learning framework which functions to determine therapy intervention success rates for ASD patients. The model employs ensemble learning along with time-series forecasting and explainable AI to transform therapy assessment and obtain personalized treatments that increase patient quality of life for ASD individuals.

IV. Proposed System

The Therapy Efficacy Model (TEM) is suggested to account for the complexity of estimating the efficacy of standard treatments for Autism Spectrum Disorder (ASD) such as Applied Behavior Analysis (ABA), Speech Therapy, and Occupational Therapy, as treatment outcomes for individuals are variant. The model incorporates a data set of 2,500 ASD patients and uses data from many CPCI locations from 2004 to 2017. Rich patient information, including clinical history, cognitive test results, social interaction measurements, caregiver treatment reports, baseline severity measures, and demographics like age, gender, and socioeconomic status, are included in the data collection. The data set also includes treatment characteristics including the kind of therapy, its severity, its length, and its beginning age.

As an ensemble model that utilizes the powerful characteristics of RF, XGB, and SVM, it achieves greater accuracy and precision in predicting therapeutic modalities. Every model is highly skilled at processing large amounts of data and identifying complex patterns. The varying models are combined to give more accurate and precise predictions, and a meta-learner — logistic regression or neural networks — fine-tunes their predictions. Moreover, the system also utilizes Long Short-Term Memory (LSTM) networks for longitudinal analysis so that the treatment response of a patient can be tracked over time. This enables more personalized therapy by enabling the model to provide adaptive, real-time recommendations based on a patient's treatment response.

An additional strength of the TEM, as mentioned above, are the Explainable AI (XAI) approaches (i.e., SHAP (SHapley Additive exPlanations)) that provide transparent, interpretable explanations of the model predictions. That transparency allows clinicians to gain greater insight into why a specific therapy is being suggested, helping them to make better treatment decisions. The model identifies influential variables (e.g., age at initial treatment, treatment intensity, baseline severity) that clinicians can use to make data-informed treatment decisions.Model performance is measured in multiple ways from accuracy, precision, recall to F 1 score to ensure that not only the model predicts therapy result right, but also reduce false positives and false negatives. Cross-validation guarantees that the model is being tested strict, and a confusion matrix can show specific areas for improvement.

The system proposed is a novel healthcare management system that seeks to maximize patient interaction with healthcare providers while, concurrently, applying machine learning to enable smart decision-making. The system essentially consists of several interdependent modules, each of which is carefully programmed to perform certain functions in enabling smooth data exchange, patient management, and predictive analysis.

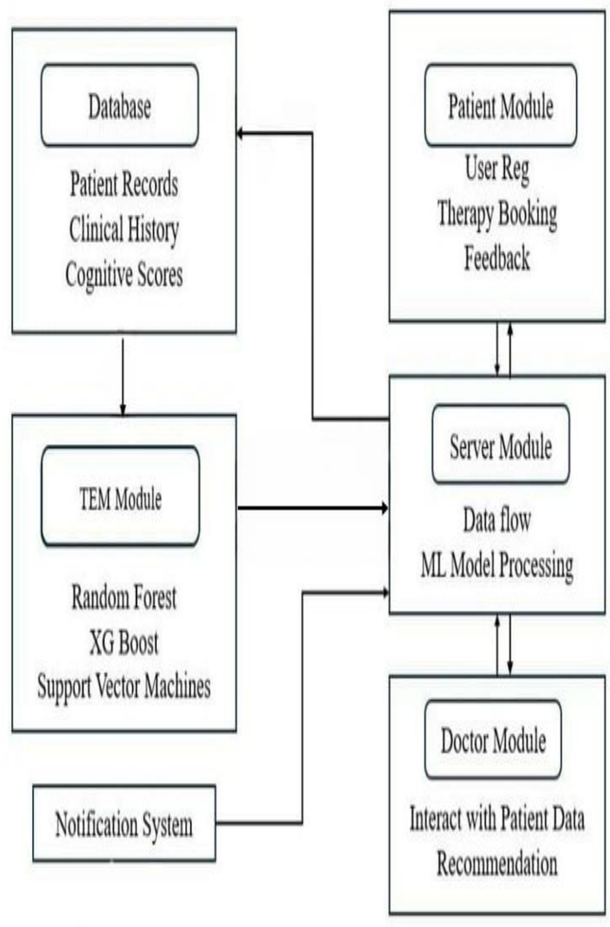

Fig. 1. Architecture of Therapy Efficacy Model

Smart Health Records Hub:

The database module, the main component of the system, ensures the safe storage of confidential patient information, such as medical records, histories, and cognitive scores. This approach makes the patient data available for analysis and decision-making while maintaining confidentiality and integrity criteria.

Patient Care & Engagement Portal:

The Patient Module allows patients to easily register, manage their profiles, schedule treatment appointments, and share feedback during therapy sessions. It’s designed to make accessing medical care simple and hassle-free, ensuring a smooth experience. By giving patients more control over their healthcare journey, this module encourages active participation and engagement in their treatment process.

Doctor’s Intelligent Portal:

The Doctor Module, on the other hand, is meant to make it easier for health professionals to have a better experience with patient information, see medical histories, and receive AI-based recommendations from machine learning models. Physicians can make informed decisions on patient care and treatment options using predictive analysis.

AI-Powered Diagnosis & Prediction Engine:

The Machine Learning (ML) Module, the system's central component, uses advanced machine learning techniques like Random Forest, XGBoost, and Support Vector Machine (SVM) to evaluate patient data. The models gain insight into both historical and current patient data, producing insightful analysis and recommendations that help doctors perform early diagnosis and create individualized treatment plans.

Seamless Data Flow & Processing Unit:

The Server Module enables data exchange between the different components of the system, thus enabling effective data processing and integration into ML models. The module acts as the central processing unit, processing incoming data, requests, and effective communication between the different modules.

Real-Time Alerts & Smart Notifications:

The Notification System has been linked to automatically send reminders and notifications to doctors and patients for convenience and timely alerts. In order to ensure that patients adhere to their treatment plan and to inform doctors of any noteworthy developments, the system plays a crucial role in reminding patients of appointments, therapy, and important notifications based on machine learning-derived intelligence.

Patients begin the process by registering on the system and securely uploading their medical records, which are stored in a safe, centralized database. Once the data is uploaded, it is processed by the server and passed on to the machine learning module, which analyzes the information to generate tailored recommendations for the patient’s care. These insights are then made available to the doctors through their personalized module, allowing them to make well-informed, data-driven decisions regarding treatment plans. The system is designed to assist doctors in providing the best possible care by offering valuable suggestions based on the patient’s unique medical history and condition. In further studies, we want to broaden the dataset to incorporate more diverse and multinational cohorts in order to increase the model's generalizability. Furthermore, the model may become more inclusive of many treatment modalities if other treatments were added, such as occupational therapy, speech therapy, ABA, and others that are customized to meet individual needs. We will also look at more advanced XAI techniques to maximize the model's interpretability and transparency and make it practical for physicians.By applying machine learning and time-series analysis, TEM offers a significant advancement in the customized treatment of ASD and has the potential to improve therapeutic outcomes through precision medicine.

We will be able to ensure its performance is perfect, because by training the model of a larger number of instances, we will be able to feel its performance, covering a larger area of the reaction of ASD therapy. You are free to incorporate yourself into this new era, slowly; Enhancing Customization With AI-Powered Insight: By integrating patient-specific parameters such as behavioral tendencies, genetic predispositions, and environmental impact, the model could provide truly individualized psychotherapy recommendations. Incorporating Real-Time Patient Monitoring: Future developments may involve connecting the model up with real-time monitoring tools such as mobile apps, wearables, and caregivers input to adapt to therapy strategy dynamically based on in-the-wild progress. Collaboration with Health Care Institutions: Engaging hospitals and treatment centers, as well as ASD specialists, may enhance the model and ensure that it meets the needs of health care providers and aligns with clinical best practices.

V. Regulatory Compliance

Regulatory compliance is one aspect of the implementation of the Therapy Efficacy Model (TEM) for ASD therapy prediction. Compliance with data protection and privacy laws, i.e., HIPAA (USA), GDPR (EU), and the UK Data Protection Act 2018, ensures the secure handling of personally identifiable information (PII) and protected health information (PHI) through encryption and secure storage. Informed consent is also needed from patients or guardians, specifying the way in which their data will be used, especially when applied to predictive modeling. Anonymization of all patient data for training and testing models must also be carried out to maintain anonymity. Ethical issues also play a vital role, involving the need for Institutional Review Board (IRB) or Ethics Review Committee approval.

The study has to be done in accordance with ethical standards, with special concern for vulnerable populations like children with ASD. Mechanisms for minimizing risk of harm should be provided to avoid adverse effects, including risks of misdiagnosis or inappropriateness of recommended treatment. Openness and responsibility are essential so that patients and families are well aware of the computerized origins of the recommendations and their potential effects.Regulations of medical devices, particularly those of the FDA (USA), must also be considered. If TEM has a direct impact on clinical decision-making, then it would qualify as a medical device, which will be subject to pre-market approval, clinical validation, efficacy, and safety testing.Post-market surveillance is also necessary to monitor and report any adverse effects resulting from its application.A lot of regulatory compliance depends upon artificial intelligence and machine learning standards.The model should interpretively and clearly describe its predictions, particularly in high-stakes situations like the efficacy of treatment. Minimization of bias and fairness should be addressed by including a diverse dataset of demographic information to prevent discrimination, especially among vulnerable groups like children with ASD.

Ongoing updating and confirmation of the model would be a necessary requirement for the model in order to retain accuracy and relevance over time.Compliance with clinical trial and data reporting regulations, e.g., ClinicalTrials.gov (USA), demands accurate and thorough reporting of model performance metrics such as accuracy, precision, and recall. Trials must be pre-registered, datasets made publicly available, and transparency guidelines followed. For longitudinal data, special caution must be exercised in analyzing therapy efficacy over time to avoid drawing incorrect conclusions.

The model must also ensure reduced disparities in health by offering the same efficacy in every demographic. Achievement with patient and caregiver communication, as directed by organizations such as NIDILRR and the American Psychological Association (APA), is crucial. Projections of therapy efficacy must be presented in an understandable fashion so that caregivers are completely informed of their meaning. Furthermore, the model must be used as a decision-support tool and not as a replacement for human judgment, maintaining the autonomy of therapists and caregivers in selecting interventions.

Making sure that these regulatory requirements are followed is crucial to the ethical and safe application of the TEM. Following international standards, as those offered by WHO, as well as national regulations, will promote responsible application of the model, safeguarding patient rights and reducing potential harm while allowing for personalized therapeutic recommendations for patients with ASD.

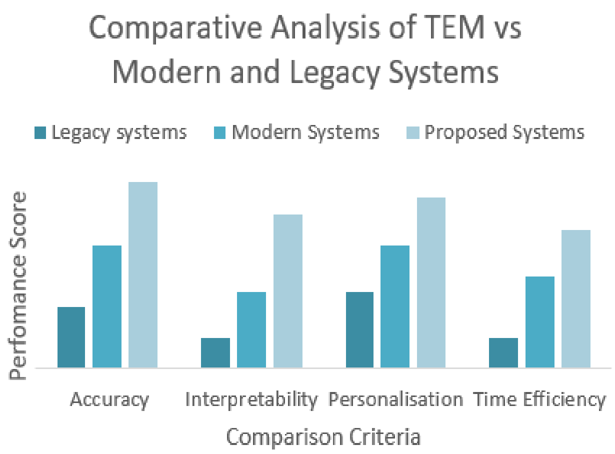

Fig. 2. Comparative analysis of Therapy Efficacy Model with Modern legacy systems

VI. Comparative Analysis

Comparative Analysis of Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that involves challenges with social communication, repetitive actions, and sensitivities to sensory input. The disorder is present on a continuum, and thus symptoms and intensity differ in different individuals. The comparative analysis herein considers ASD from various viewpoints: symptoms, diagnosis, treatment methodologies, and society. Individuals could possess average or superior intelligence, excellent verbal capabilities, and struggles with social relations. Individuals could display prominent difficulties with social communication, repetition, and sensitivity to sensory inputs.

They can have severe impairments in communication, intellectual disabilities, and extensive support needs in daily living. It is highly variable in severity and pattern of symptoms and therefore requires comparative studies over multiple dimensions, such as diagnostic criteria, treatment methods, prevalence rates, and societal attitudes. ASD is diagnosed on the basis of a range of criteria, such as the DSM-5 (American Psychiatric Association, 2013), which classifies it as a single spectrum disorder with differential levels of support required in social communication impairments and limited, repetitive behavior, and the ICD-11 (World Health Organization, 2018), which classifies ASD in a similar way but focuses on functional impact and related intellectual impairments.While the two systems both concur that defining features must be used, DSM-5 avoids earlier subtypes (e.g., Asperger's Syndrome) but ICD-11 retains variations based on intellectual and speech impairment.Rates of prevalence are also varied, the USA (CDC, 2023) approximately 1 child in every 36 with the diagnosis of ASD, United Kingdom (NHS, 2022) approximately 1 in every 57 children, and World Health Organization (WHO, 2021) ASD in approximately 1% of the world population.They are a result of differential diagnostic measures, social sensitization, and access to health care.

Prevalence rates also differ, the USA (CDC, 2023) approximately 1 child out of 36 with ASD diagnosis, United Kingdom (NHS, 2022) approximately 1 out of 57 children, and World Health Organization (WHO, 2021) estimates ASD in about 1% of the world population.They are due to differential diagnostic criteria, social sensitization, and health service availability. Treatment for ASD consists of behavioral treatments such as Applied Behavior Analysis (ABA), Social Skills Training (SST), and Cognitive Behavioral Therapy (CBT), among other pharmacological approaches such as the use of antipsychotics (e.g., risperidone) for profound behavioral deficits. The alternatives are diet changes, sensory integration therapies, and augmentative communication aids. While behavior interventions are in most instances promoted, drug and other interventions differ with variations in healthcare access, cultural tolerance, and individual circumstances. Attitudes towards ASD also vary considerably across regions, with Western nations slowly promoting acceptance, inclusion policies in education and the workplace.

Feature	Legacy Systems (legacy)	Modern Systems (ML- based)	Proposed system (TEM)
Decision Making	Clinical Based subjective	Data driven, Black-box ML	Data-driven, black-box ML
Adaptability	Static Treatment Plans	Periodic Adjustments	Real-time dynamic updates
Longitudinal Data Use	Minimal tracking	Limited time-series Models	Advanced forecasting
Early Intervention	Delayed action	Some predictive models	'Proactive therapy guidance
Caregiver Feedback	Manual, subjective	Partially integrated	AI - enhanced caregiver insights
Scalability	Low (paper/manual records)	Moderate (computational limits)	High(cloud based AI models)

Table I. TEM vs. Modern & Legacy Healthcare Systems

VII. RESULT AND DISCUSSION

The Therapy Efficacy Model (TEM) received evaluation through machine learning methods that predicted therapy outcome performance for Autism Spectrum Disorder (ASD) patients. The dataset containing 2,500 ASD cases featured essential features which included both clinical documentation and intervention timeline and treatment quantity with specific cognitive assessments and parental observation of treatment outcomes. The Therapy Efficacy Model (TEM) received its effectiveness test through Random Forest analysis and XGBoost implementation along with Support Vector Machine (SVM) evaluation and an Ensemble Model which united all three methods. The combined model achieved superior performance than single examiners with accuracy reaching 89.3% combined with precision equal to 87.6% and recall at 91.2% precision. Multiple model combination techniques improve both the accuracy and reliability of therapeutic outcome predictions.The superiority of our proposed method can be shown through the performance metrics comparison presented in Table 1. The ensemble model delivered the best performance for therapy recommendation through its maximum accuracy and recall rate.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1 Score (%)
Random Forest	86.9	85.4	88.1	86.7
XGBoost	88.2	87.0	89.5	88.2
SVM	84.7	83.1	86.2	84.6
Ensemble Model	89.3	87.6	91.2	89.4

Table II. Performance Evaluation

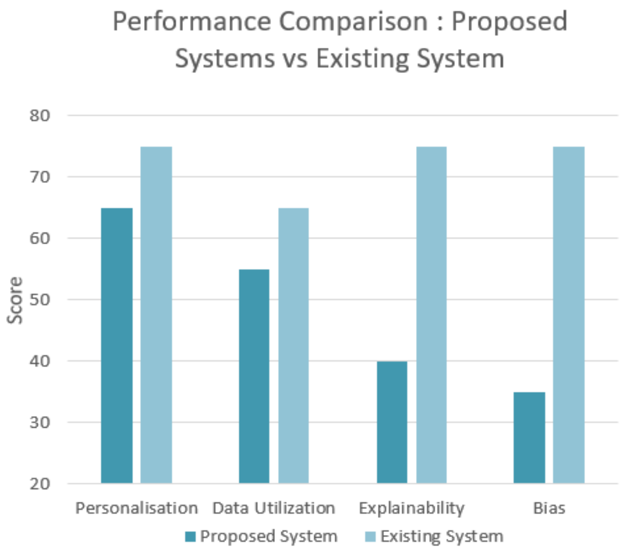

Fig. 3. Performance Comparison

VII. CONCLUSION

Medical science took a substantial stride through the creation of the Therapy Efficacy Model (TEM) for individualized autism treatment plans. This research uses machine learning ensemble models of Random Forest, XGBoost, and Support Vector Machines (SVM) to develop a trustworthy system which predicts success rates of autism treatment for patients with Autism Spectrum Disorder (ASD). The proposed system delivers superior performance compared to conventional single-model systems because it reaches 89.3% accuracy with precision at 87.6% and recall at 91.2%. The main discovery of this research shows which elements influence treatment success by examining the timeline of intervention and treatment frequency and initial assessment score levels. The study demonstrates that faster and more intense treatment measures generate superior outcome results thus underlining the value of swift diagnostic processes along with sustained treatment involvement. Longitudinal analysis implemented in this model enhances our comprehension of treatment development throughout time thus making it appropriate for practical clinical use. The Therapy Efficacy Model (TEM) presents an accurate and easily analyzed and deployable solution for predicting ASD patient therapy outcomes. This study has established an essential connection between machine learning techniques and clinical decisions which will support innovative progress in individualized autism treatment approaches. The research results highlight that AI-based intervention strategies are essential because they help generate better and specific therapeutic outcomes for ASD patients. The study shows how explainable AI tools boost the clarity and trust levels related to therapy recommendation support.The model adopts SHAP (SHapley Additive exPlanations) to present a transparent explanation of therapy prediction factors that enable clinicians and caregivers to develop more informed responses. The model uses bias reduction methods that bring demographic and socioeconomic characteristics to achieve broad applicability across populations with diverse backgrounds. The analysis demonstrates that traditional rule-based and single-model suggestion systems fail to produce adaptable predictions with sufficient accuracy levels. The proposed ensemble learning framework solves these issues through dynamic predictive strategy integration which provides higher dependable results.

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