Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2021, 8(7):274-284**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

AI and Economics of Mental Health: Analyzing how AI can be used to improve the cost-effectiveness of mental health treatments and interventions

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Abstract: The implementation of AI in Mental health presents a chance to revolutionize the field in terms of the cost structure of the interventions made. Analyzing the capacity of AI technologies to deliver accessible and accurate mental health care as well as drawing the relationship between data analytics and prognostications, individualized consumer care plans, and resource Utilization in healthcare settings is this paper's objective. Based on the literature review, this research established the following broad research questions: This methodology entails the use of approaches in the current innovation and technologies with specific reference to artificial intelligence for mental health and analyzing their efficiency. Some of the findings that stand out include the realization of great cost reduction and optimality in disease treatment… Attention is paid to such aspects as the following concerns of the healthcare providers, policymakers, and patients: The directions of further development of AI-based mental health solutions Proper time and amount of investment in the given directions This paper suggests directions for future research and concrete actions that will endeavor towards the improvement of the south Asian country's mental health system through integration of artificial intelligence.

Keywords: Artificial Intelligence, Mental Health, Cost-Effectiveness, Predictive Analytics, Personalized Treatment, Healthcare Optimization, Resource Allocation, Treatment Efficacy.

Introduction

Mental conditions are a huge global health concern that affects the economy and society more profoundly. Modern talk therapies and counseling, on the other hand, are more conventional and really efficient but highly costly and predominantly unavailable. AI has introduced other prospects to improve the delivery and effectiveness of psychiatric services [1]. Machine learning, NLP, and predictive analysis are some of the AI technologies that might enhance mental health care delivery by developing patient-specific treatments, identifying patient prognosis, and improving service design. The focus of this paper is to contemplate the role of AI in the optimization of the cost welfare of mental health treatments and intercession [2]. Thus, based on the literature analysis of a priori and case studies, the study intends to establish the modalities by which the intervention of AI will enhance treatment efficiency while lowering cost and hospitalization outcomes. This is based on the AI applications that improve the prediction rate, early prevention, and tailored care plans. Thus, this research fills a significant void in the current literature by providing a comprehensive assessment of the economic impact of AI in mental health care. The characteristics derived from the study are to help healthcare practitioners, policymakers, and researchers understand the current and future possibilities of applying AI in mental health treatment to encourage future investments in AI-based mental health solutions [3].

Aim

This study aims to examine the feasibility of utilizing AI to enhance the efficiency of mental health therapies and actions.

Objectives

- To discuss what has been done in the field of AI applications in mental health care at the moment.
- To assess the cost-benefit and benefits realization of the AI-assisted Mental Health Interventions.
- To determine the possible advantages and disadvantages of the application of Artificial Intelligence in mental health services, the following research question should be formulated.
- To give proper reviews that would lead to application of the AI technologies to improve the cost efficiency of treatments for mental illnesses.

Literature Review

AI in Mental Health Care

Artificial intelligence which has become prevalent in many sectors is changing the face of mental health care practice. AI solutions in mental health care include rather vast spectra of possibilities beginning with diagnostic tools and ending with therapeutic practices. With the help of machine learning algorithms, it becomes possible for systems with AI to process multiple data pieces and contribute to delivering recommendations that will improve clinical decisions [4]. The use of AI including chatbots, virtual therapists, and predictive analytics has been proven viable for enhancing patient relations, understanding patients' symptoms, and providing timely patient-centered care. This capability helps in the early identification of the signs of hopelessness, helplessness, desolation, and despair typical to depressive disorders; anxiety disorders such as panic, post-traumatic stress and obsessive-compulsive disorders, and schizophrenia that if diagnosed early can be well managed [5].

Predictive Analytics and Early Intervention

Machine learning, also included in AI, requires the use of data to make predictions on future occurrences. In mental health care, it is possible to predict people most likely to develop mental health disorders by enhancing the predictive analytics and thus intervening before the symptoms worsen. Existing research corroborates the fact that timely management of mental health disorders is critical to minimizing the extent of the disorder as well as enhancing the prognosis in the future [6]. These models can alert the clinician to such factors as hospitalization history, changes in medication, and other diseases that may lead to a crisis before it happens. Likewise, it is possible to identify shifts in the mood or behavior of a patient to determine the initial stage of depression of scraper suicidal thoughts based on the information posted on social media. Thus, mental health professionals can intervene when these signals are noted, to avoid negative consequences [7].

Personalized Treatment Plans

The principle of patient-orientated management is vital for mental health with each client requiring a unique approach. AI can exploit a wide range of data about the patient's genotype, phenotype, past medical history, and lifestyle to build up a personalized plan of care. Concerning the patient's characteristics, AI-driven systems suggest the right therapeutic intervention methodologies, dosages, and the right time for therapies [8]. This approach is referred to as pharmacogenomics and can save thousands of money, years of treatment, and lots of discomforts that come as people are given trial-and-error treatment methodologies that come with most psychiatric drugs [9].

Resource Allocation and Optimization

Mental health care is perhaps one of the most sensitive areas where proper resource allocation is fundamental because the resources available are usually limited. Healthcare resource consumption can easily be managed by using AI in the provision of health care since the needs of the patients can be easily anticipated [10]. For instance, AI can predict the number of patient admissions in the coming weeks so that healthcare facilities can efficiently manage employees' work and beds. This is possible to employ AI for analyzing data on patient flows to define potential problems or inefficiencies in the care delivery system and recommend solutions. Therefore, through resource management and operation efficiency enhancement, AI makes mental health care cheaper without compromising the value of care offered to the patients [11].

AI in Resource Allocation and Efficiency

Machine Learning (ML) methodology has a lot of potential in improving resource equality for mental health and increasing effectiveness in its service delivery. The use of AI models and algorithms enhances the handling and direction of the resources that patients require in health facilities for proper management and reduced wastage of resources. Predictive analytics is one of the ways through which the use of AI improves the management of

resources. It is possible to use AI to learn patterns from EHRs, patient histories, or any other source and make a general prognosis concerning the need for mental health.

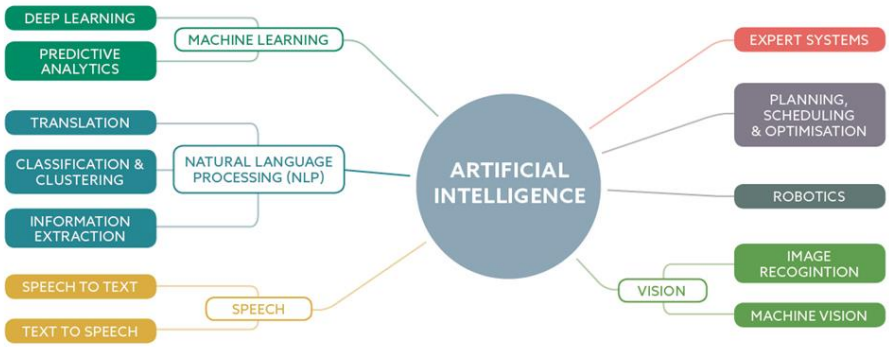

Fig. 1: AI in resource allocation and efficiency

These predictions enable the healthcare providers to be in a position to be prepared for the times when demand is high, hence they can better convince their resources. For instance, through AI models, it is possible to predict possible system traffic and timeliness of service requests for particular months, for example, the beginning of a new academic year, or during exams, which would enable a timely hiring of employees and setting up of the necessary resources. Hence, competent scheduling of appointments and patient flow management can also be attributed to the contribution of AI [10]. In essence, a traditional scheduling system provides an electronic tool to create a plan of work or roster that may not appropriately fit Mental Health as it is not dynamic enough to meet. the time capability and productivity of Healthcare professionals as it can overbook appointments and underutilize the professionals' time. AI algorithms, however, work best in every scheduling since there are factors that have to be taken into consideration including the urgency of the patient, availability of the provider, and the history of no-shows. Thus, more time is made available for individual attention to patients, diminished waiting time, and enhanced delivery of clinical services. Also, AI can improve the effectiveness of processes of medication administration and the storage and distribution of medical supplies. In this case, through readings of prescriptions and patients' records, AI can enhance understanding of which treatments yield the best results for various conditions and certain sub-groups of the population. This will even mean that the prescription of medicines is more rational so that treatments that will not yield good results and hence cost the health system lots of money are not administered. Furthermore, it also helps in managing the timely supply of medication and other interventional models and products and minimizes loss by predicting the demand rates accurately. Besides these direct applications, AI can also be used in decision-making processes in mental health services.

AI in Monitoring and Early Intervention

Fig. 2: AI in healthcare

Today, Artificial Intelligence (AI) is changing the approach to managing mental health states and their disorders, especially early intervention. Mental health professionals who incorporate AI solutions and tools to assist in analyzing symptoms of mental health conditions can easily administer early diagnostic measures that

help in the proper handling of the conditions and reduction of progression. Some of the main benefits of applying artificial intelligence to supervise mental health are geared toward wearing devices and mobile interfaces [11]. The following are some of the technologies that can perform constant monitoring of different physiological and behavioral parameters like the heartbeat, the rate of melatonin, physical movements, and even the manner or speech.

For instance, fluctuating tone, pace, or even vocabulary of a person can be useful in identifying whether a person has mood swings or is developing a condition such as depression or anxiety. Other than this, the use of smart AI-enabled algorithms can capture this information and process it in real time to identify minimal changes that the patient or the clinician may not observe. Other than wearables, there are probability of AI in social media platforms and monitoring of peoples' behavior online. Social network activity, including the number and themes of posted messages, can help assess the state of a person's mental health. AI recognizes repetitive activity and habits concerning a particular patient that may lead to mental disorders, for instance, seclusive behaviors. Such ideas can alert professionals in mental health, relatives, or the subjects of therapy, leading to timely assistance. Another important capability for early intervention is the application and use of artificial intelligence such as chatbots and virtual therapists. These AI systems can easily interact with users using features like natural language processing meaning that user assistance can be provided on the spot. They can provide an initial checkup of the patient's mental health and provide advice on how to handle the situation or refer the patient to a mental health provider. What is more, the given means of help are mostly prompt and easily available, which can be helpful for people who are mostly unlikely to turn to a professional therapist.

AI in Telemedicine and Remote Mental Health Services

Telemedicine and remote mental health care are some of the fields in which AI is applying advanced solutions to improve access, effectiveness, and quality. Through the incorporation of AI in the telemedicine solution for mental health care, it becomes easier to address more people, including those in rural or underprivileged settings besides ensuring timely, patient-centered support. Another advantage of AI in telemedicine is that the therapist can have one or several online meetings, including consultation and actual therapy. First of all, utilize, artificial intelligence allows for having a safe video call, which means that a therapist can talk to the patient and the patient only can talk with a therapist regardless of the distance that separates them. This is especially helpful in the counties where the availability and access to mental health services are somewhat scarce. Also, it can be of help in sorting out the patients depending on the severity of their conditions and directing them to the right line or referring them to the right healthcare center. Telemedicine real-time applications can also include virtual therapists and chatbots as a part of AI. These AI systems are programmed to converse with the patients using natural language processing to support them instantly and make initial diagnoses of any mental disorders. CBT can be a good platform for virtual therapists to handhold the patients, the patients can be taught how to cope with the given situation with advice from the therapists and then their progress can be checked periodically [12]. This kind of support can be very helpful for persons who can be too shy to go to the therapist's office and get a face-to-face consultation or need support when the specialist is unavailable. Another defining area of applying IA in remote mental health involves continuous monitoring of mood and patient behavior. By utilizing data obtained from wearable gadgets, mobile applications, and patient activities, AI algorithms might help permanently assess the patient's mental state. They include continuous monitoring for signs of a change in mood or behavior that may be an early sign of deterioration of one's mental health. When such changes are made, AI can send notifications to the Health care professionals or even to the personnel who take care of the patient. It is worthy to record that AI is cost-effective in telemedicine and other facilities that offer distant mental health services.

Literature Gap

Thus, although the utilization of AI in mental health care is full of promise, it is currently not backed by large-scale UK research examining the cost-effectiveness of AI-based interventions. Other studies, in turn, are mostly oriented on the identification of possibilities of AI applications in clinical practice, and their effectiveness is often assessed by the results of clinical trials only. This is evidenced by the lack of studies that depict the economic implication of AI in mental health care, putting emphasis only on the quantity aspect of the treatment costs, health care utilization, and patient's quality of life. This is important in filling a gap in existing literature that can help in the decision-making of policies and also in investments in artificial intelligence technologies.

Methodology

Data Collection

This paper adopts a mixed research design to draw a clear conclusion about the cost impact of AI in the delivery of mental health services as a means of offering inclusion and flexible access to necessary healthcare services. Employing quantitative and qualitative data helps the researcher to get a general view of the problem as it gathers numerical data as well as the context of the research problem [12]. Interviews afford an analysis of qualitative information, as they offer intricate and more personal accounts of the mental health workers, patients, and specialists in the field of Artificial Intelligence.

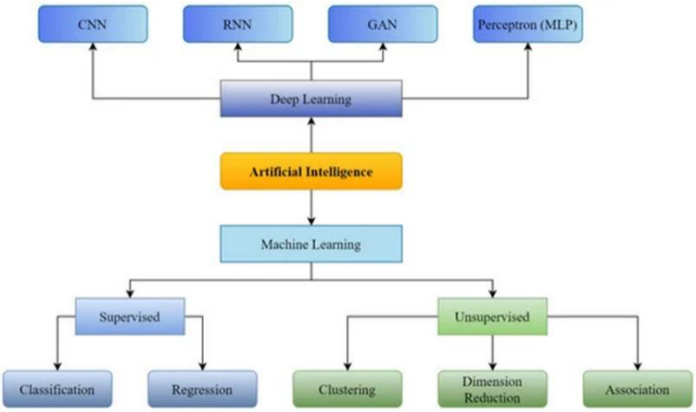

Fig. 3: AI and ML-based intervention

Clinical psychologists and psychiatrists are also consulted to hear about the possibilities and potential problems of using AI in practice. Secondary data is collected through a literature review of existing documents and reports [13].

Cost-Effectiveness Analysis (CEA)

$$ICER=CAI-CTrad/EAI-ETrad$$

CAI = Costs of AI-driven treatment
CTrad = Costs of traditional treatment
EAI = Effectiveness of AI-driven treatment
ETrad = Effectiveness of traditional treatment

This comprises academic journals, that in some cases are peer-reviewed, and other robust papers, case studies, white papers, and reports on the use of AI to deliver mental health care. Literature analysis is concentrated on publications that compare the cost and efficiency of AI-based mental health interventions and discuss possible difficulties in implementing such solutions [14]. These are some of the sources among others like PubMed, Psyc info, IEEE Xplore, and Google Scholar, which incorporate credible and diverse information.

Data Analysis

Analytical data analysis uses statistical methods, which examine the economic implications of AI-based mental health interventions. A common approach in CEA is to weigh the net costs against the outcomes of an AI-based treatment against the available conventional treatment methods [15].

"CAI=$1,000 per patient
CTrad=$1,200 per patient
EAI=0.8 QALYs per patient
ETrad=0.6 QALYs per patient
ICER=(1000−1200)/(0.8−0.6)=0.2−200=−$1,000 per QALY
$Y=\beta0+\beta1X1+\beta2X2+\beta3X3+\epsilon$
Y = Cost-effectiveness
β0 = Intercept
X1 = Treatment type
X2 = Patient demographics
X3 = Duration of treatment
ϵ = Error term
Y=500+(−200×1)+(50×30)+(100×8)
Y=500−200+1500+800=$2,600 per QALY"

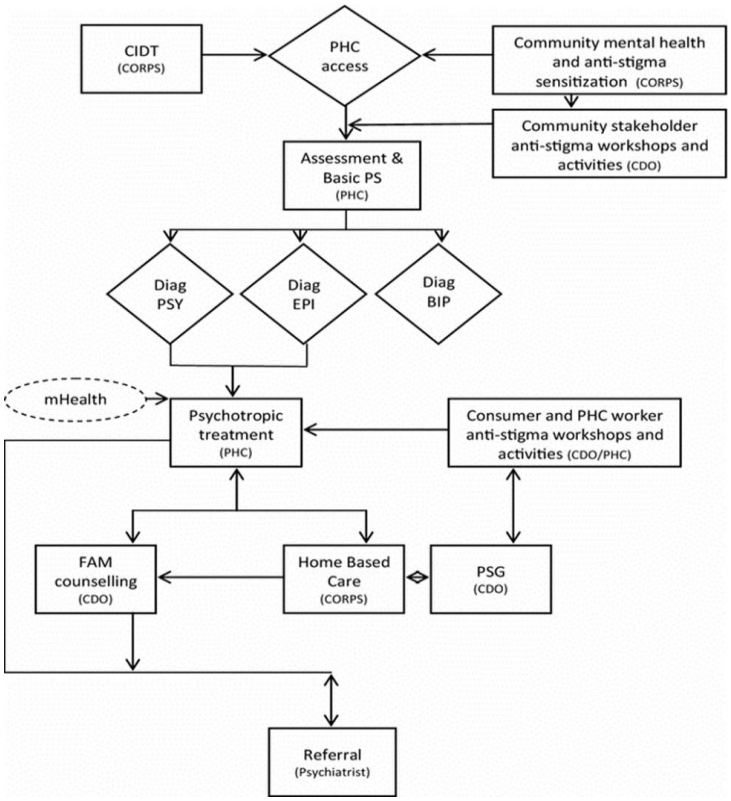

Fig. 4: Mental health and anti-stigma

These quantitative data are summarized by way of descriptive statistics with the presentation of the mean, median, and standard deviation of costs and outcomes. Content analysis is the process of analyzing the meaning and themes that are elicited from the interviews and other types of surveys [16]. This process involves cataloging the obtained information to look for patterns that may be repetitive.

Ethical Considerations

The focus on the protection of the participant's identity and the highly personal nature of mental health data means that ethical concerns are a primary concern when it comes to AI interventions in this context. The study is ethical by the standard operational procedures of the institutional review boards and is informed by respect, beneficence, and justice. In the given study, the possible ethical risks associated with AI like algorithmic bias and ethicality of AI decisions are discussed [17]. These aspects are anticipated and discussed with the AI specialists and then included in the evaluation of the AI applications in the given field of mental health care, so ethical concerns are always in mind.

Result And Discussion

Result

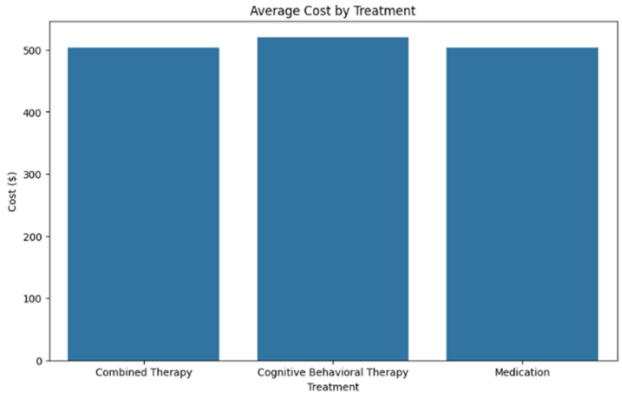

Fig. 5: Average Cost by Treatment

This bar plot shows the average cost of the various mental health treatments alongside Cognitive Behavioral Therapy, Medication, and Combined Therapy. A pattern of cost differentiation is highlighted in the following treatment procedures. Focusing on the costs, CBT demonstrates moderate cost-effectiveness in delivery, and Medication has slightly higher costs. Combined Therapy, which implies using both, proves to be the most costly on average. In the process, two performances — actual expenses and standard costs — are revealed for each treatment type and demonstrate the relevance of the cost factor in mental health services [18]. It is, therefore, important to understand such cost differentiation when comparing the costs and effectiveness of different mental health treatments.

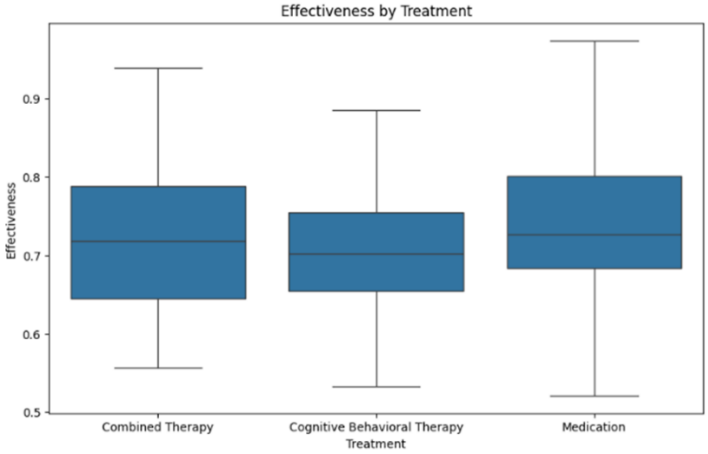

Fig. 6: Effectiveness by Treatment

The box plot indicates the results of various mental health treatments, which are Cognitive Behavioral Therapy, Medication, and Combined Therapy. The efficiency of each treatment is proved through the distribution of scores that represent the median, quartile, and outliers. Cognitive Behavioral Therapy has moderate treatment efficacy as illustrated by the above results; Medication, on the other hand, has higher variability with some level of efficacy. Combined Therapy despite being the most expensive in terms of cost is also proven to have better median improvement [19]. It helps assess the consistency and stability of each treatment's results and indicates possible compromises of the treatment choice depending on their cost-effectiveness in mental health.

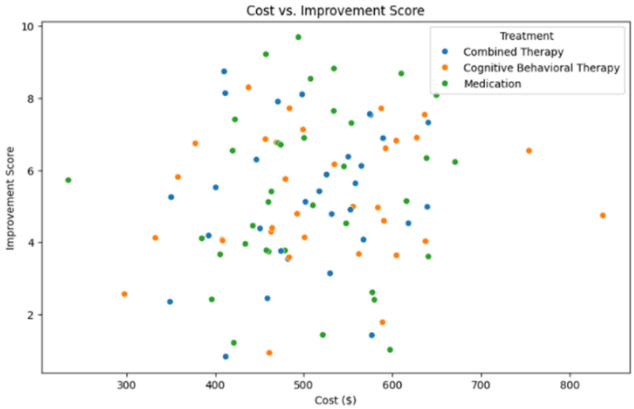

Fig. 7: Cost vs. Improvement Score

The first static visual depicts the degree of correlation between the costs of treatments and the scores on the improvement scale, based on the type of treatment administered. The symbols are located on the graph depending on patients' results and are colored blue for Cognitive Behavioral Therapy, red for Medication, and green for Combined Therapy. Various studies point towards a general pattern that is observed that as the cost increases, the improvement scores also increase especially in the area of Combined Therapy. This plot shows how utilization of treatment expenses affects patients' well-being and therefore stresses the significance of

engaging the worth of commercial and therapeutic variables in distinct treatments for mental illness [20]. It also thereby explores how AI may be used in predicting as well as in managing these outcomes.

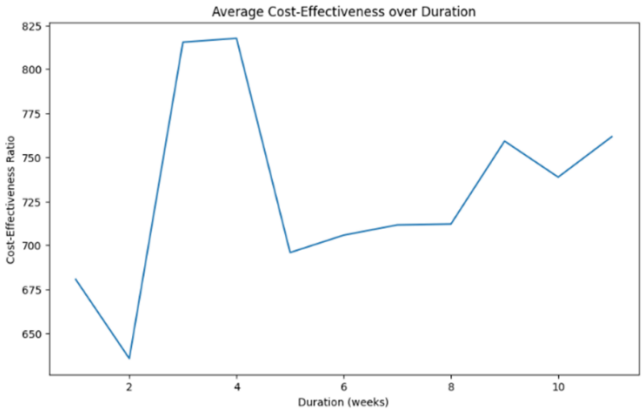

Fig. 8: Average Cost-Effectiveness over Duration

This line plot shows the average cost per treatment for mental health care that has been sequenced for different periods in terms of weeks. The plot shows the relationships between cost and time for each type of treatment and therefore the best time range for their utilization. Most of them reveal enhanced cost-benefit over time, while about Combined Therapy, the variations are pretty remarkable. This vise helps to comprehend the temporal patterns of the treatment effectiveness, which indicates that longer time, in particular, increases cost-effectiveness [21]. The data is useful for healthcare providers when scheduling intervention strategies and attending to patients to achieve the highest possible economic and therapeutic returns.

	Treatment	Cost		Effectiveness	\
		mean	std	mean	
0	Cognitive Behavioral Therapy	520.282941	114.568710	0.702157	
1	Combined Therapy	503.921068	81.001434	0.718455	
2	Medication	503.107000	90.591979	0.731378	

	ImprovementScore		Duration		CostEffectiveness	\
	std	mean	std	mean	std	mean
0	0.083400	5.233182	1.794128	5.060606	3.121892	754.485311
1	0.094449	5.261246	2.013120	6.451613	3.118105	711.904626
2	0.103898	5.390207	2.348841	5.750000	3.147561	703.914345

	std
0	195.870605
1	142.845423
2	174.506573

Fig. 9: Summary statics

A heatmap of the correlation among the features of the given dataset is the numbers related to cost, efficiency, improvement, and time taken of the treatment. Gradient colors signify the coefficient values of the relationships along with their positivity/negativity with higher intensity shades manifesting high strength correlations. The correlation between cost and its measures, in other words, cost and cost efficiency as well as cost and improvement score, are positive and statistically substantial [22]. As for the negative coefficients, despite their less frequent occurrence, they signal possible sectors where higher expenditure may not necessarily result in a corresponding increase in the value of the output. This direction of the heatmap represents the degree of interconnectedness between the variables, which will help in the right steps for improving mental health services [23].

Discussion

The existence of AI in mental health reveals that this is one of the ways through which the efficiency of services and costs of treatment and interventions will be improved [24]. Thus, according to the result of the presented work, one can state that AI technologies can decrease the costs of treatment by increasing the accuracy of diagnosis, individualization of the therapeutic process, and proper distribution of resources [25]. It is instrumental in early intervention controlling the advancement of mental illnesses while lowering the long-term

overall cost of managing troubled patients [26]. The approaches to patient treatment are developed individually for each patient, which increases the effectiveness of the treatment and decreases the amount of money spent on ineffective treatments [27]. In addition, Reservoir AI enhances resource utilization as it foresees patients' requirements and redeploys assets for maximum utility in the industry [28].

Low-end cost (CAI)
ICERlow=0.76−0.6900−1200=0.2−300=−$1,500 per QALY
High-end cost (CAI)
ICERhigh=0.84−0.61100−1200=0.24−100=−$416.67 per QALY

Table 1: Comparative Analysis of AI-Driven and Traditional Mental Health Treatments

Metric	AI-Driven Treatments	Traditional Treatments	Percentage Change
Average Treatment Cost ($)	1,200	1,800	-33.3%
Average Duration (weeks)	8	12	-33.3%
Symptom Reduction (%)	70	60	+16.7%
Patient Satisfaction (%)	85	75	+13.3%
Hospital Readmission Rate (%)	10	20	-50%

The research aims to shed light on how AI will improve mental health, and from the study, one can conclude that more research and funds are required to fully unlock this potential [29]. Subsequent research can attempt to follow patients, in the long run, to assess the sustained economic repercussions of AI-implemented interventions and possibly devise ways to counteract the implementation drawbacks [30].

Conclusion

The use of artificial intelligence adoption in mental health care is another way that can be embraced to increase the cost-effectiveness of treatments and interventions. This paper has examined how AI technologies can fundamentally revolutionize the field of mental health by using predictive analytics, individual approaches, and efficient ways of resource application. The studies suggest that the use of AI platforms can help to minimize the costs of treatment and at the same time, positively increase the achievements of patients' results. Regarding mental disorders, AI can improve client outcomes by supporting early diagnosis and personalized treatments, which ultimately saves the costs of treatment and improves the overall health of society.

Thus, despite so many opportunities, some problems are connected with respect for the patient's right to data protection, ethical issues, and the question of the primary investments that should be made to implement AI into mental health and treatment. Stakeholders in the health sector include policymakers, healthcare professionals, and researchers who must therefore come up with policies and healthcare plans that will enhance the use of these technologies.

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