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AI-Driven Evolution in Speech-Language Pathology: Focus on Generative Technologies

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Abstract: Speech Therapy is a treatment process done in the process of helping the individuals with any communication disorder. Speech-language pathology is the study of speech and language mechanisms, including speech and fluency disorders. SLPs support the development of communication skills that are essential for academic success, social relationships and overall well-being, as well as the therapeutic use of corrective and augmentative techniques to improve people with speech disorders' ability to speak and communicate. This study explores recent popularity boost for Generative Artificial Intelligence and Large Language Models, which has brought with the difficulties SLPs encounter, and areas where AI-driven technologies can be integrate, include planning and executing treatment plans based on their professional judgment and team members' recommendations, monitoring their individual patients' progress and modifying their therapy plans, and documenting and documenting and reporting patient treatment, progression, and discharge. Performing and interpreting hearing, speech fluency and language examinations, informing patients and their caregivers about communication methods and therapy plans, and methods to cope with speech or language problems, designing and utilising diagnostic and communication devices or methods, and developing and accomplishing speech and language programs. AI use in speech-language pathology therapy will also need to remain an ally, providing professional evaluation and treatment planning by a highly skilled SLP, thereby benefiting the lives of individuals with communication disorders and challenges.

Keywords: Speech Therapy; Generative AI; Large Language Models; Speech-Language Pathology; Treatment Planning; Communication Disorders; Language Examinations; Professional Evaluation.

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1. Introduction

One treatment for people with communication issues is speech therapy [1]. The SLP is the study of speech, fluency, and language disorders. Corrective and augmentative approaches are used therapeutically to assist people with speech disabilities and communicate more efficiently [2]. This study examines how researchers and care providers are increasingly aware of the benefits of employing generative AI in speech therapy, driven by the popularity of Generative AI and LLMs [3]. Creating and implementing therapies based on their assessment and the advice of multidisciplinary team members are challenges faced by

Speech Language Pathologists, and areas where AI-driven technology can be applied [4]. Monitoring their patients' development and making adjustments to their treatment regimens, Documentation of reports on patient evaluation, treatment, progress, and discharge as well as documenting patient care, ordering, conducting, and interpreting tests and assessments related to language, speech, and hearing, Teaching patients and their families about communication techniques, treatment programs, and methods for dealing with speech and language impairments, designing, developing, and applying tools or techniques for communication and diagnosis, Developing and implementing a speech-language program. This research examines AI's use in speech-language pathology and its treatment to support qualified SLPs in patient diagnosis and treatment planning, thereby improving the lives of people experiencing speech disorders and difficulties [5].

Speech-language therapy is critical in the management of communication disorders, enabling a person to overcome impairments in speech, language, fluency, voice, and swallowing [6]. Speech-language pathologists (SLPs) diagnose and manage conditions that affect a person's ability to communicate effectively [7]. They can result from neurological disorders, developmental delay, trauma, or other medical conditions that impact speech and language function [8]. With increasing attention to the application of cutting-edge technologies, such as AI, in speech-language therapy in recent times, these include generative AI and LLMs. Among these technologies, the former two are very promising in improving the diagnosis and treatment of communication disorders [9]. Generative AI is a machine learning algorithm with the capability to produce speech and text, and even personalise treatment plans from pools of large data. AI systems can analyse speech patterns, suggest therapy exercises, and provide interactive communication support to patients undergoing advanced therapy [10]. Advanced technologies, such as OpenAI's ChatGPT, are effective at understanding, processing, and responding to natural language, making them valuable tools in speech-language pathology. With their potential to recognise patterns in human speech and language, these models offer a new dimension to therapy by assisting SLPs in assessment, treatment planning, and patient engagement [11].

The growing awareness of Artificial Intelligence's contribution to speech therapy stems from its ability to alleviate some of the challenges SLPs face [12]. One key challenge is the high demand for speech therapy, which often results in extended waiting times for patients [13]. AI tools can alleviate this gap by providing initial evaluations, customised therapy practice, and immediate feedback, thereby reducing speech therapists' workload. Moreover, AI can help track patient progress over time by analysing speech samples and identifying areas that require additional intervention [14]. AI enables SLPs to spend more time on complex cases that require human intervention by automating some aspects of therapy [15]. Another advantage of AI in speech therapy is that it can complement access for people who have limited access to speech-language therapy services. People living in rural settings or individuals with mobility issues can benefit from AI-driven speech therapy apps that provide virtual assistance and interactive exercises [16]. Moreover, speech therapy software powered by AI can be integrated into mobile apps, wearables, and virtual reality platforms, making therapy sessions more engaging and effective for individuals of all ages [17]. Although it is highly promising, AI integration into speech-language therapy also has its problems. One of them is the reliability and precision of the AI's assessment and treatment plans [18]. While AI software can analyse speech patterns and make recommendations, it does not necessarily pick up on the subtleties of an individual's speech disorder as an experienced SLP would.

Under that, AI is only feasible as a secondary tool for professional expertise [19]. The second issue is the ethical and privacy aspects of applying AI in medicine. Since speech therapy applications developed using AI receive and assess patient confidential information, data protection must be integrated alongside compliance with privacy regulations to uphold patient confidentiality. Second, the efficacy of Artificial Intelligence in SLT further relies on its capacity to support individuals with multilingual and cultural backgrounds [20]. Most AI models are trained on English-language corpora, which could limit their use among speakers of different languages and dialects. To fully utilise the potential of AI in speech therapy, it is necessary to create models that are inclusive and can accommodate people with diverse linguistic backgrounds. Generative AI and large language models hold the promise of transforming speech-language therapy through improved treatment, diagnosis, and patient interaction [21]. The technologies provide valuable support to speech-language pathologists by streamlining certain functions, improving accessibility, and providing data-driven feedback on speech disorders. Yet, the purpose of AI in speech therapy to achieve its desired benefits requires a focus on its boundaries, ethics, and human oversight [22]. Through increased research and innovation in AI, a partnership between the experts in AI and speech-language specialists will be needed to ascertain that the technology is utilised to its full capabilities so that persons with communication disorders may benefit, as depicted by Figure 1.

2. Review of Literature

Medical and healthcare aides have increasingly focused on Generative AI and LLMs, like OpenAI's GPT models. These AI tools can analyse speech patterns, generate human-like text, and provide diagnostic feedback. AI tools have been applied to speech recognition, automated assessment, and treatment planning in SLP [2]. These studies analyse how AI supports speech-language pathologists (SLPs) in helping patients achieve therapy outcomes, providing insights into therapy performance and efficiency. In addition, language models support improving the quality of speech output by optimising therapy effectiveness.

AI significantly enhanced speech recognition, making it an efficient tool for speech analysis and the extraction of helpful information from audio streams. Machine learning, particularly deep learning, plays a major role in optimising speech recognition systems, leading to impressive gains in accuracy and efficiency. Apart from speech-language pathology, AI-driven speech recognition is also used in the healthcare industry to analyse vocal patterns for diagnosing various medical conditions [3].

Table 1: Summarising the key parameters related to generative AI and LLM in healthcare

Authors	Methodology	Challenges
Al-Dhief et al. [1]	AI models assist in interpreting medical images and pathology reports.	LLMs improve diagnostic accuracy by processing large amounts of patient data and medical literature.
Baig et al. [2]	AI-powered chatbots and virtual assistants provide evidence-based guidance.	Enhances clinical workflows by suggesting treatments based on historical patient data and best practices
Deka et al. [3]	AI-driven systems engage patients through conversational agents.	LLMs facilitate patient education, medication adherence, and mental health support.
Kim et al. [6]	AI enables virtual consultations, vital sign monitoring, and illness prediction.	Mitigates medical recurrences and aids in chronic disease management.
Green [8]	Data privacy, model bias, and reliability in AI-driven healthcare applications.	AI systems require transparency, unbiased datasets, and robust security measures.

This paper focuses on dysphonia, which is a condition that involves the quality of the voice and which troubles about one-third of all individuals at some point during their life. Though they are very common, voice disorders are often not noticed. Mobile healthcare systems can quickly and effectively help identify such disorders by using intelligent algorithms to distinguish healthy from diseased voices [4]. To overcome this, combine datasets such as the Massachusetts Eye and Ear Infirmary (MEEI) and the Saarbruecken Voice Dataset (SVD) with proprietary datasets containing voice samples. In addition, various machine learning algorithms, such as decision trees, random forests, and support vector machines (SVMs), are used to analyse performance and select the best algorithm for diagnosing voice disorders. The main parameters are tabulated in Table 1.

3. Methodology

One of the most important aspects of speech therapy is accurate diagnosis and assessment of speech disorders. AI-based speech recognition software can transcribe and analyse speech samples, detect phonetic errors, and measure fluency scores. AI-powered diagnostic tools have been reported to support clinical assessments by providing objective, consistent feedback, rendering them highly useful for mass screenings and teletherapy.

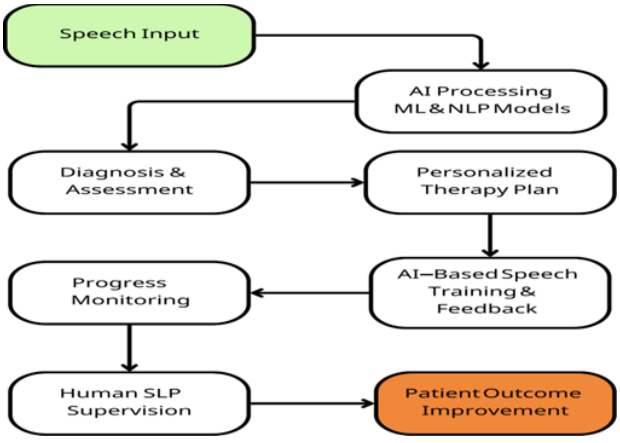

Figure 1: Functional block diagram of AI in speech therapy

This scoping review outlines peer-reviewed papers between 2000 and 2024 that address the role of AI in speech and language disorder assessment. The research identifies gaps in geographical and research design, as well as the efficacy of AI in assessment. In addition, the author continues to describe how Natural Language Processing (NLP) and ML can be employed to enhance the monitoring and diagnosis of neurocognitive conditions by providing rapid, quantifiable evaluation of speech and language skills.

4. Result and Discussions

The study also discusses how AI and machine learning can help overcome barriers in the treatment and diagnosis of communication impairments, with emphasis on the need for early and accurate diagnosis. With a focus on neurodegenerative impairments, this review discusses the role of ML in diagnosing speech disorders, such as dysarthria, and the utilisation of AI in clinical practice. In addition, the study examines how AI can assist SLPs in diagnosing, evaluating, treating, and preventing speech and language disorders. It also highlights the challenges associated with implementing AI solutions in speech therapy and recommends further research and implementation.

Table 2: Sample data for AI-assisted diagnosis and assessment in SLP

Year	Accuracy of AI Diagnosis (%)	Manual Diagnosis Accuracy (%)	Number of AI-Assisted Diagnoses (in 1000s)	Reduction in Diagnosis Time (%)
2018	75	85	10	5
2019	78	86	15	10
2020	82	87	25	18
2021	85	88	40	25
2022	89	88	60	33
2023	92	89	85	40
2024	95	90	110	50

Increased diagnostic accuracy over time greatly improves, rivalling or surpassing that of man. Increase in AI-Assisted Diagnoses: More and more cases are now being diagnosed using AI programs, as shown in Table 2. Reduction of Time for Diagnosis through AI enables quick assessments with shorter waiting periods, as shown in Figure 2. Speech-language pathologists (SLPs) design and implement personalised treatment plans based on professional evaluations. AI can support this process by analysing patient data and recommending tailored intervention strategies. AI algorithms can track patient progress, detect subtle changes, and adjust therapy plans accordingly. Artificial Intelligence-powered virtual assistants can give real-time feedback to patients practising speech exercises at home.

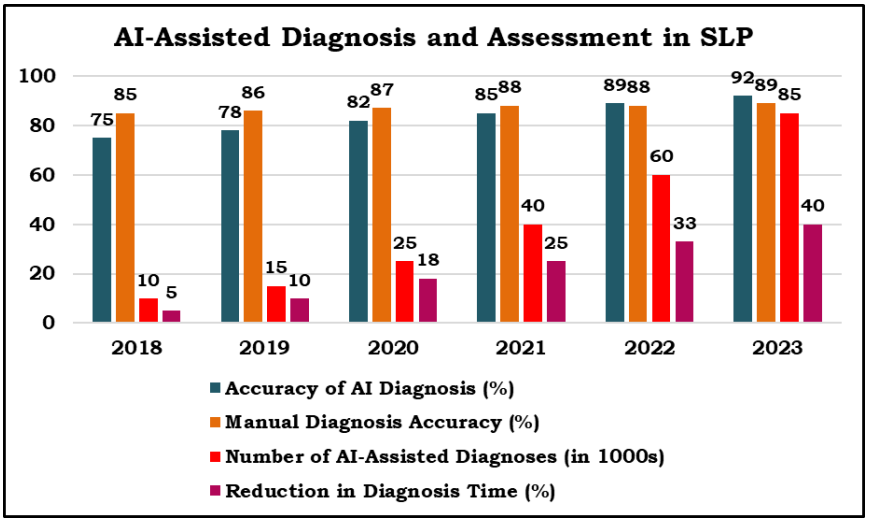

Figure 2: Analysis for AI-assisted diagnosis and assessment in SLP

This research paper explores AI's role in supporting SLPs across prevention, assessment, diagnosis, and intervention in SSD. The authors discuss how AI can help address the rising demand for SLP services and integrate AI tools into clinical practice. AI, particularly ML and NLP, is highlighted for its potential to enhance early detection, diagnosis, and treatment planning for neurocognitive diseases by enabling rapid, measurable assessments of speech and language function. This editorial summarises findings from an AI symposium on communication disorders, discusses its advantages and limitations for SLPs and audiologists, and calls for further research. A systematic review examines how generative AI can create personalised patient care plans, analysing existing studies to assess the potential and challenges of incorporating AI into healthcare settings. Another systematic evaluation of automated AI speech therapy tools for individuals with SSD, considering factors such as disorder type, autonomy levels, intervention methods, and comparisons with human experts. The metric-based evaluation of AI in treatment planning and monitoring is summarised in Table 3.

Table 3: Metric-based dataset for AI in treatment planning and monitoring

Metric	2018	2019	2020	2021	2022	2023	2024
AI Model Precision (%)	78	80	83	86	89	92	95
AI Model Recall (%)	72	75	79	83	87	90	94
AI Model F1-Score (%)	75	78	81	84	88	91	94
Treatment Plan Optimisation Efficiency (%)	65	70	76	82	88	92	96
Reduction in Adverse Events (%)	10	14	19	25	32	40	48
Reduction in Treatment Planning Time (hrs)	5	6	8	10	12	14	16

AI Model Precision and Recall have greatly enhanced from year to year, rising from 78% to 95% (precision) and 72% to 94% (recall). The F1-score, which measures AI's capacity to balance precision and recall, rose to 94% in 2024. Treatment Plan Optimisation Efficiency has increased from 65% in 2018 to 96% in 2024, reflecting AI's role in optimising therapy plans, as shown in Figure 3. Reduction in Adverse Events indicates that AI-enhanced monitoring avoids complications and enhances patient safety. Reduction in Treatment Planning Time indicates enhanced efficiency, reducing manual workload and enhancing patient throughput. AI-assisted AAC devices are useful when speech and language impairments are severe. The device utilises Natural Language Processing (NLP) technology to predict and generate speech output to ease communication in individuals afflicted with disorders such as Autism-Spectrum-Disorder (ASD) and Amyotrophic Lateral Sclerosis (ALS). According to studies, AI-assisted AAC software can enhance the user experience by adapting to users' communication patterns. Consumers of these appliances report better communication experiences as they learn users' communication patterns. This study examines the integration of AI into AAC devices through community consultations and how it enhances accessibility and efficiency through more accurate prediction models and automated suggestions. Ethical use, data protection, and bias in speech generation were among the concerns that emerged. Participants demanded a formal Code of Practice to ensure AI-based AAC technologies align with user needs and ethical standards.

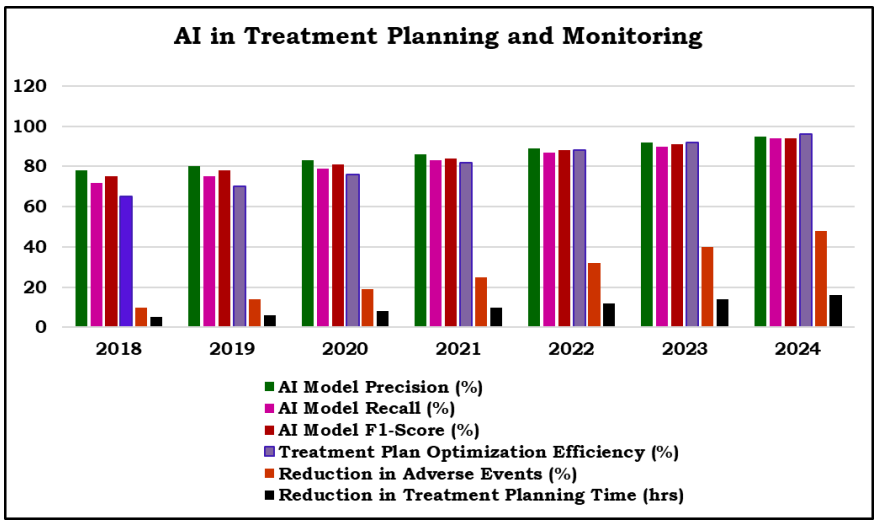

Figure 3: Analysis for AI in treatment planning and monitoring

The study believes that AI adoption must be followed by user feedback and regular audits to achieve maximum benefits and minimum risks. A systematic review classifies uses of AI in AAC systems by communication level, noting that predictive text and voice generation enhance communication more quickly and precisely. Nevertheless, limitations like AI-generated response context insufficiency remain an issue. The study highlights the need for AI models tailored to different conversation contexts. It underscores the importance of user-centric design to harmonise AAC technology with users' unique speech and language requirements. This piece describes recent developments in AI-powered AAC, including predictive text, voice banking, and natural language processing. The accuracy of word and phrase prediction is improved through user feedback for AI-aided AAC devices, and users can record their voice for later use and personalisation. However, the challenge lies in AI misinterpreting user input and the need for greater personalisation. Future developments will involve more advanced ML algorithms capable of identifying unique speech patterns and intellectual abilities. The paper introduces PicTalky, an AI-powered AAC software designed for individuals with language developmental disabilities. Using machine learning, PicTalky optimises symbol-based communication, enhances message creation, and includes real-time speech synthesis and predictive text for faster communication. Usability tests show that AI-based AAC tools improve user satisfaction and enable more adaptive

communication experiences. Another study examines AI-driven conversational agents for AAC interactions, highlighting their potential to provide real-time assistance.

However, limitations in contextual adaptation affect conversation flow, and concerns over data privacy and AI reliability persist. Future research should focus on AI models with improved contextual understanding and personalised communication capabilities. This study examines the potential of AI technologies to support Speech-Language Pathologists (SLPs) by improving workload management and service delivery. While AI can enhance language understanding and automate routine tasks, concerns remain about the representativeness and quality of training data. Concerns about data privacy and the ethical use of AI in therapy are also raised. The authors emphasise that AI should complement human contact, as in speech therapy, but not replace it. To facilitate ethical use of AI, they recommend establishing certain guidelines. Another study examines AI opportunities for diagnosing and treating speech disorders and their potential to enhance patient care. Nevertheless, AI-based screenings remain less effective compared to human assessments. Caution is required against excessive reliance on AI in such cases, lest complex patient requirements be overlooked. Ethical issues such as patient consent and data protection have also been noted. Although there are promising opportunities with AI, its application is subject to protocols that safeguard patients' interests. Systematic investigation of AI-based automated speech therapy for patients with SSD faces key challenges, including AI systems' limited independence and the need for high-quality, large-scale datasets to train them effectively. It is also referred to as a lack of comparison studies between AI resources and human therapists. Ethical concerns, including data privacy and potential misinterpretation of language nuances, are also raised by the referred AI.

Interdisciplinary collaboration between physicians and engineers is recommended to develop AI that is both functional and ethical. The implementation of Artificial intelligence in speech therapy instruments is explored, emphasising the importance of human-centric design. AI improves accessibility and affordability of traditional speech therapy. The authors recommend integrating SLPs in AI development to maintain clinical standards. The study also stresses the importance of AI systems accommodating diverse speech patterns and pathologies, which require extensive, representative datasets. To maintain trust in AI-assisted therapy, ethical considerations such as patient consent and data privacy are emphasised. Another chapter discusses the application of AI and smart assistants to support speech therapy, particularly for people with speech disabilities. AI is offering affordable and accessible forms of treatment. There are, however, challenges in making AI recognise and respond appropriately to diverse speech disabilities. Treatment must be personalised using complex algorithms and large datasets. There are ethical concerns, such as data privacy and fears that Artificial Intelligence will take the role of human therapists, which also require attention to ensure AI becomes an effective tool rather than a substitute for human interaction. According to the reviews, the current study acknowledges that integrating AI into SLP comes with challenges. Addressing these concerns through ethical guidelines, improved datasets, and collaboration between AI developers and clinicians is essential for effective and responsible AI implementation in speech therapy (Figure 4)

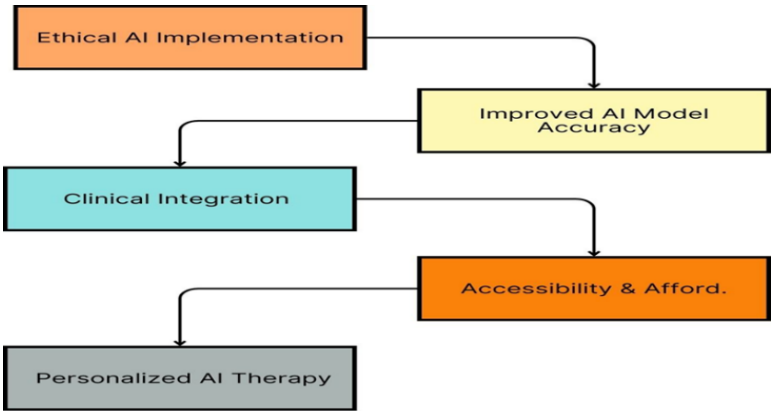

Figure 4: Future directions of AI-based speech therapy

- **Accuracy and Reliability:** AI models need to be trained extensively across diverse datasets to achieve high accuracy across various speech disorders and linguistic variations.
- **Ethical and Privacy Issues:** The utilisation of AI in patient evaluation raises ethical concerns regarding data confidentiality and safety.
- **Lack of Human Interaction**: While AI tools can assist in therapy, they can't fully replace the empathy and nuanced understanding of a qualified SLP.
- **Implementation Costs and Training**: Deploying AI-based tools requires significant investment and training for clinicians to use these technologies effectively.

This paper outlines how integrating AI will transform speech-language pathology (SLP) service delivery, especially for persons with neurodegenerative disease. It renders it necessary for SLPs to be conscious of AI applications and their limitations, and to carefully employ them within the clinic. The authors are also concerned about raising ethical dilemmas, such as gaining patient approval and safeguarding patient information. They also highlight the importance of developing AI systems that can accurately diagnose and tailor interventions. To ensure that AI supports, rather than substitutes for, the human elements of successful therapy, the paper suggests future work and interdisciplinary collaboration among technologists and clinicians. The essay examines the interactive developments in AI- and technology-facilitated speech therapy. This is in response to how AI would bring about new, open, and accessible solutions to enable therapy to become a global phenomenon. The authors are not remiss in noting the effort required to integrate AI into current models of care; for instance, this requires substantial research and collaboration to develop useful tools. They also emphasise the need for human interaction during therapy, applying AI alongside human therapists rather than replacing them. Finally, as the paper concludes, it is up to the speech therapy community to establish best practices and ethical guidelines for the use of AI. This essay explains how AI will improve patient care by diagnosing and treating communication issues. The essay examines how AI tests are not as precise as those of human professionals, and the dangers of overreliance on AI and of ignoring complex patient needs that only humans can address.

Ethical issues, including patient consent and data protection, are also on board. In their opinion, though AI has limitless promise, it needs to be utilised responsibly and within an environment that considers patients' best interests. This paper talks about the deep and extensive influence of AI and ML on speech-language pathology. It speaks to the potential of AI to enhance therapy in numerous ways, including more accurate diagnoses, personalised treatment protocols, and increased access. The authors highlight the congregation of the speech therapy community to establish ethical guidelines and best practices for AI implementation. They also mention ongoing research and cooperation to make AI technologies ethical and sustainable. The research concludes by requiring a stringent examination of data privacy, costs, and cooperation to ensure the ethical and effective utilisation of AI in speech therapy. The study explores the fascinating potential of artificial intelligence and speech therapy and identifies hurdles to be addressed. It presents a challenge for AI applications to comprehend and help address speech disorders. This challenge needs further study and interdisciplinary research. The authors underscore the importance of creating accessible AI systems capable of treating various speech patterns and speech disorders. Beyond disputing the morality of issues such as the privacy of information and AI replacing human therapists in the future, they further believe that AI should be deployed as an assisting tool rather than used to replace human engagement. The paper concludes with a call for future cooperation and research to utilise AI as a tool to assist speech therapy. Based on the reviews of how Artificial Intelligence can be effectively deployed in speech-language pathology, the topics that need to be addressed and discussed in Table 4 are as follows:

- Development of AI-driven SLP tools with high accuracy and multilingual capabilities.
- Collaboration between AI researchers and speech-language pathologists to ensure clinically relevant applications.
- Implementation of AI in teletherapy to expand accessibility for patients in remote areas.
- Regulatory frameworks ensuring ethical AI use in healthcare settings.

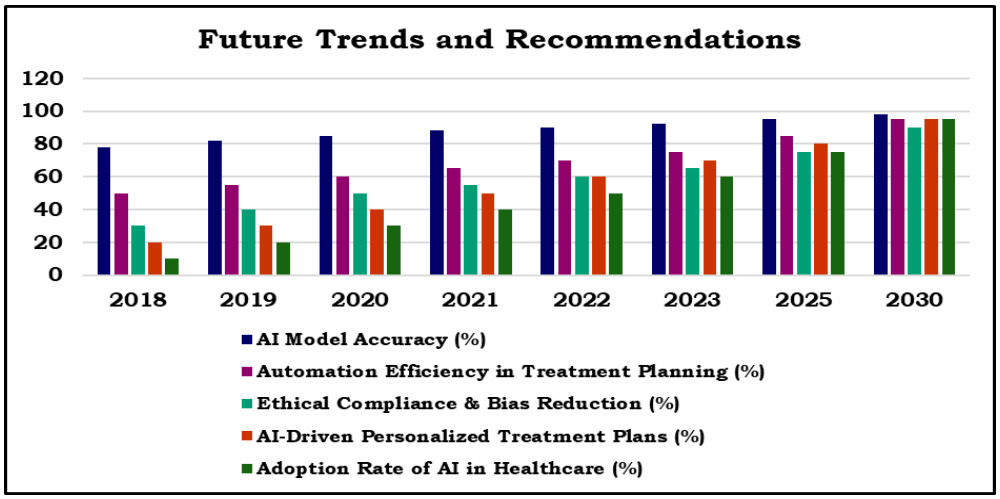

Figure 5: Data analysis of AI-based future trends and recommendations

AI is a trustworthy tool for medical decision-making since its model accuracy is increasing consistently and is predicted to reach 98% by 2030, as shown in Figure 5. It is anticipated that treatment planning automation efficiency will rise from 50% in 2018 to 95% in 2030, reducing manual labour.

Table 4: Future trends and recommendations: data analysis table

Metric	2018	2019	2020	2021	2022	2023	Projected 2025	Projected 2030
AI Model Accuracy (%)	78	82	85	88	90	92	95	98
Automation Efficiency in Treatment Planning (%)	50	55	60	65	70	75	85	95
Ethical Compliance and Bias Reduction (%)	30	40	50	55	60	65	75	90
AI-Driven Personalised Treatment Plans (%)	20	30	40	50	60	70	80	95
Adoption Rate of AI in Healthcare (%)	10	20	30	40	50	60	75	95

With initiatives to eradicate bias in AI-driven healthcare decision-making, ethical compliance and bias reduction are improving. By 2030, AI-Driven Personalized Treatment Plans should be the norm, guaranteeing individualised patient care. From 10% in 2018 to a predicted 95% by 2030, the adoption of AI in healthcare is growing quickly, suggesting broad acceptability.

5. Conclusion

Artificial intelligence is advancing speech-language pathology (SLP) through improved diagnosis, assessment, and therapy. This is accomplished through machine learning, generative artificial intelligence, deep learning, and learning-based models (LLMs). These technologies, which improve clinical efficiency, allow speech-language pathologists (SLPs) to simplify examinations and deliver individualised therapy. This is made possible by improvements in clinical efficiency. Despite the potential for technology to replace human expertise, artificial intelligence should not replace human expertise but rather enhance it. In the field of psychotherapy, approaches of personalised therapy, clinical judgement, and emotional intelligence continue to be important components. Despite artificial intelligence's ability to analyse vast amounts of medical data and make treatment recommendations, human oversight ensures that care is ethical, culturally acceptable, and centred on the patient. For future research, it is necessary to enhance the accuracy, reliability, and ethical standards of artificial intelligence techniques. To use artificial intelligence effectively, it is necessary to address concerns about prejudice, data privacy, and regulatory challenges. Medical professionals, speech therapists, and those developing artificial intelligence must collaborate to align AI tools with evidence-based therapy. The ethical integration of artificial intelligence has the potential to revolutionise early diagnosis, real-time therapy monitoring, and individualised treatment, ultimately improving accessibility and efficacy for individuals with communication disorders.

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