Healthcare Chatbot for slowing the Progression in Chronic Kidney Disease Stage 3 patients

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Abstract*— Chronic kidney disease (CKD) is a significant global health problem characterized by the continuous deterioration of kidney function. It has been found that patients with stage 3 chronic kidney disease are at risk of progressing to end-stage kidney disease. This situation requires close medical attention to slow down kidney deterioration in these patients. To achieve this, a health chatbot system specifically designed for stage 3 CKD patients has been developed. The chatbot serves as a virtual representative of hospital staff, processing user messages based on medical knowledge stored in the system's database and responding in a chat format within the LINE application. Additionally, the chatbot's algorithm, which boasts very high accuracy, is vital for medical diagnosis. This research aims at the investigate of three techniques: Dialog flow, Gemini, and GPT3.5. These are powerful and widely used technique in natural language processing (NLP). We conducted a health chatbot in the outpatient department of internal medicine at Burapha University Hospital, Chon-buri Province, Thailand. The study sample consisted of 50 patients with stage 3 chronic kidney disease. These patients were divided into two groups: experimental group: 25 patients and control group: 25 patients. We classified the medical knowledge of chronic kidney based on insights from qualified medical experts which included 120 distinct sentences in the Thai language. Finally, the effectiveness of dialog flow, Gemini, and GPT3.5 in predicting CKD based on knowledge sentences was modeled. Our experiments compared the accuracies of Dialog flow, Gemini, and GPT3.5, which were found to be 88%, 75.61%, and 41.46%, respectively. As a result, Dialog flow outperformed the other methods.

Keywords—Chronic Kidney Disease, Chatbots, Natural Language Processing.

I. INTRODUCTION

Chronic kidney disease (CKD) is a significant public health issue globally, including in Thailand. It affects more than 10 percent of the global population, equating to over 800 million people [1]. CKD is the 12th leading cause of premature death worldwide, resulting in 1.2 million deaths annually [2]. Thailand ranks third in ASEAN for CKD prevalence, following Malaysia and Singapore. Currently, 17.5 percent of the Thai population, or approximately 11.6 million people, suffer from CKD [3]. The trend shows an increasing number of CKD-related deaths, with 10,758 deaths recorded in 2020 (Non-Communicable Diseases Division, Ministry of Public Health, 2022).

Studies on the global prevalence of CKD reveal that most patients are in stage 3. Specifically, 84 percent are in stage 3a and 16 percent in stage 3b [4]. This aligns with data from CKD patients seeking hospital services from 2017-2021, where stage 3 CKD was the most prevalent, accounting for 38.14-41.47 percent of all CKD patients. In 2022, stage 3 CKD patients remained the largest group, approximately 41.42 percent (Ministry of Public Health, 2022).

In the early stages (1-2) of CKD, patients often exhibit no symptoms or very mild ones, as the kidneys can still compensate for their reduced function. However, in stage 3, the kidney function deteriorates significantly, making it easier to diagnose and leading to a higher prevalence of stage 3 CKD patients (Senanayake et al., 2017). These statistics highlight the growing trend of CKD and emphasize the need for medical professionals to focus particularly on stage 3 CKD patients.

Current literature shows extensive development of programs designed to slow kidney deterioration. A systematic review by [5] analyzed 26 studies worldwide on lifestyle modifications for chronic kidney disease (CKD) patients, aimed at slowing kidney deterioration. Additionally, a review of 10 studies from Thailand focusing on stage 3 CKD patients revealed common elements in effective behavior-promoting programs, which include: Education, Self-Management Skills Training, Empowering Patients, Motivational Conversations, and Social Support.

Most of these programs are implemented over a 12-week period. The outcomes of these programs indicate significant improvements in the health behaviors of participants, leading to slowed kidney deterioration. Specifically, the patients showed better adherence to health-promoting behaviors such as dietary adjustments, regular exercise, and stress management.

Due to the nature of managing stage 3 chronic kidney disease (CKD), the focus is on palliative care to prevent progression to more advanced stages. Patients are scheduled for periodic outpatient visits to hospitals for treatment follow-ups. This limited contact time often results in insufficient self-management information being conveyed to patients. Studies have shown that patients receiving outpatient services often get minimal information from healthcare personnel.

The advancements in technology have significantly altered the way people live and communicate. Technology has become integral to daily life, leading to the development of health innovations that enhance patient access to healthcare services.

Currently, a survey shows that 77.8% of the Thai population has internet access. Furthermore, 86.18% of internet users in Thailand use social networks for consultations and e-health services. The most popular social networks among Thais aged 16-64 include: Facebook, LINE Application, and Facebook Messenger.

These platforms provide a valuable opportunity to deliver healthcare information and services more effectively and efficiently. Given the limited time patients have during hospital visits, leveraging technology and social networks can bridge the gap in self-management education for stage 3 CKD patients. By using popular platforms like Facebook, LINE application, and Facebook Messenger, healthcare providers can offer continuous support and information, helping patients manage their condition better, and potentially slowing the progression of CKD.

Chen and team [6] conducted a study focused on developing an AI-based chat system to support chronic kidney disease (CKD) patient care. The primary objective was to collect necessary information to create a health education support program tailored for CKD patients. The study included 55 participants (35 males and 20 females), and data from these participants were used to refine the program's design. The variables measured included age, gender, marital status, education level, duration of CKD, number of comorbidities, and body mass index (BMI).

Key findings from the study indicated significant improvements in participants' basic knowledge about CKD (t_{54}=3.46; p=.001), body care, dietary habits, and medication use. However, there were no significant differences noted in CKD prevention practices. A subgroup analysis showed that outcomes for male participants were consistent with the overall sample, but this was not the case for female participants.

Patil, Sneha, Varshini, Joshi, and Kavya [7] conducted research to design a chatbot that provides health care services by leveraging the expertise of medical specialists. The chatbot is capable of receiving user queries about symptoms or illnesses and offering advice or treatment recommendations. For the chatbot's development, Python and Natural Language Processing (NLP) were used to understand user questions, while Machine Learning was utilized to improve the chatbot's responses over time.

In summary, the chatbot effectively provided disease-related advice and information, benefiting users by offering valuable guidance. The study concluded that health care chatbots are efficient tools for delivering health care services and information about diseases. These tools can be implemented in current health care settings to assist patients in obtaining advice or information about their health conditions. The purpose of this research is to apply clinical decision-making strategies by using chatbot system in attempt to enhance the management and care of patients with chronic kidney disease by leveraging modern communication technologies and providing both users and healthcare professionals with a comprehensive, accessible, and user-friendly platform in Thai language context.

II. BACKGROUND

A. Natural Language Processing

Natural Language Processing is a field at the intersection of computer science, artificial intelligence, and linguistics [8]. That deals with understanding and processing information which comes from natural language or the language that humans use in their daily lives. With various technologies and algorithms allow computers to understand and respond to natural language information. It focuses on processing large amounts of data in the form of human language to enable computers to understand and work with data efficiently in various situations related to natural language. Some NLP uses Machine Learning techniques to work, including Deep Learning and not Deep Learning, and some do not use Machine Learning to work (such as using Rule-Based Chatbot) [9]. Natural Language Processing is a rapidly evolving field with immense potential. Advances in machine learning, particularly deep learning, have significantly improved the performance of NLP systems.

B. Chronic kidney disease

Chronic kidney disease is a disease of “silent killer” as the patients in early stages typically do not exhibit physical symptoms while those in stage 3 may present some symptoms causing them to visit the physicians. Although CKD cannot be cured, its progression can be amplified by changing the patient's health behaviors. Kidney Disease: Improving Global Outcomes (2022) is a global organization that develops and implements guidelines based on evidence-based clinical practice for kidney disease and advocates for structured self-management interventions for individuals with CKD. However, the literature reviews indicate that patients with CKD frequently have inappropriate behaviors to delay kidney deterioration. In Thailand, challenges such as limited patient visit times and insufficient information about lifestyle modifications make it difficult to encourage adherence of self-management programs. Healthcare professionals recognize the importance of these issues and are striving to develop new innovations to engage patients with CKD in self-management behaviors for slowing kidney deterioration. This includes addressing their questions and concerns, providing feedback on inappropriate behaviors, offering ongoing counseling, and highlighting improvements in clinical outcomes to reinforce motivation for behavior changes.

III. CHATBOT MODELS FOR HEALTHCARE TO CHRONIC KIDNEY DISEASE

A. Chatbot concept

A chatbot is a computer program that can automatically respond and interact like a real human, available 24/7. Chatbots can be categorized into different types based on their design and the purposes they serve. There are two main types: Rule-Based Chatbot (Script Bot) and conversational AI Chatbot. The first type of chatbot operates and provides results based on predefined rules and keywords. If the user makes a typo or asks a question that does not match the set keywords, then the chatbot will not be able to provide the correct answer. Therefore, it is necessary to define multiple commands to cover all possible questions. Next, conversational AI Chatbot, this type of chatbot combines Machine Learning and Natural Language Processing (NLP). It uses Natural Language Understanding (NLU) to interact with users more naturally [10]. The responses are similar to real human conversations and more aligned with user needs. For example, if a user types

"หวัดดี," "สวัสดี," or "ดีจ้า," which all mean "hello," the chatbot can understand that they are the same.

Figure 1, the system architecture of a healthcare application chatbot. When the user types in a question through the UI, the message will be sent to the chatbot application, which will prepare the received data before further processing to display the answer User [11] as follows.

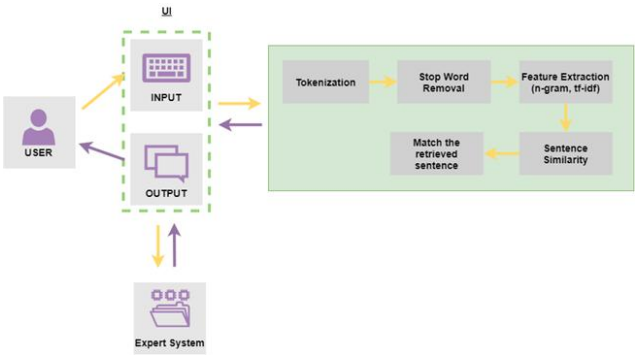


Fig. 1. The system architecture of a healthcare application chatbot

The process of dividing sentences into words (Word) or search words (Keyword) involves collecting actual information related to the patients and incorporating empirical evidence of the symptoms experienced by the patients (Real-World Evidence) in order to search for results or symptoms. Patients are currently experiencing the application of Tokenization to make the search or matching of search terms and connections more accurate. When applied to nursing knowledge for kidney patients, it also ensures the data is assembled to correctly link events and outcomes for patient referrals. This allows the Tokenization engine process to be associated with information contained in the body of knowledge, unlike other matching algorithms. For example, a user types text = "โรคไตเรื้อรังคืออะไร". The word tokenize function will separate the sentence to ['โรคไต', 'คือ', 'อะไร'] (see in Fig 2).

function word Tokenization **returns** A list of tokens (words)
inputs: *texts*, a set of string of Thai text data, each with input each of sentences
steps :
1) Dictionary loading: Load a dictionary of Thai word
2) Forward Maximum Matching: Start from the beginning of the text and match he longest possible word in the dictionary.
3) Backward Maximum Matching: Optionally, apply a backward matching algorithm and combine results with forward matching.
return Tokens: the list of tokens.

Fig. 2. The tokenization algorithm applied in Thai language dataset

Additionally, verbiage or common words that occur frequently in sentences are removed from sentences to isolate important keywords. And it is also used to remove unimportant or meaningless words. This reduces processing time or processing complexity.

B. *Structure of knowledge for healthcare to Chronic*

We classified the knowledge domain for chronic kidney that was established based on the experience of the experts who are medical staff and diagnosis the chorionic kidney's patients. The structure of knowledge for healthcare to chronic Kidney including kidney function and changes in chronic kidney disease, medical management, nutritional management, lifestyle and behavioral management, education and social support and monitoring and evaluation (Fig 3).

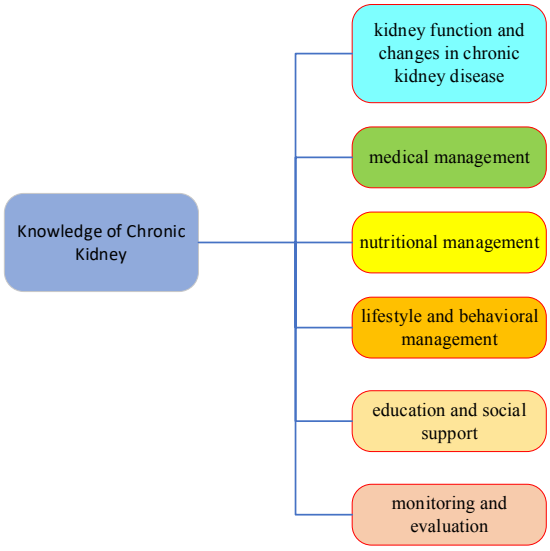


Fig. 3. The structure of knowledge for chronic kidney

IV. Model Evalution

A. *Data source*

This research was conducted in the outpatient department of internal medicine at Burapha University Hospital, Chonburi Province, Thailand. This hospital is a tertiary care facility with a capacity of 500 beds. The study sample consisted of 50 patients with stage 3 chronic kidney disease (CKD), characterized by a rapid decline in kidney function. These patients were divided into two groups: Experimental Group: 25 patients and Control Group: 25 patients. This division aims to evaluate the effectiveness of a specific intervention by comparing the outcomes between the experimental group receiving the healthcare chatbot intervention for slowing the progression of Chronic Kidney Disease and the control group receiving standard care or no intervention.

The participants in this study were patients receiving services at the outpatient department of internal medicine at Burapha University Hospital, meeting the following criteria: 1) Diagnosed with stage 3 chronic kidney disease (CKD) by a physician. 2) Consistently recorded an estimated glomerular filtration rate (eGFR) between 30-59 milliliters per minute per 1.73 square meters for at least three months.

B. *Experimental Results in Chatbot techniques*

In this paper, the researcher used three chatbot techniques: Dialog flow technique; Gemini technique; and GPT3.5 for chatbot algorithm. we evaluated the chatbot system's performance using a Confusion Matrix (see in Fig 4-6). The testing involved 120 question sentences that include user and knowledge of chronic kidney disease, and the experimental results are as follows in Table 1.

Fig. 4. Confusion matrix of Dialog flow Technique

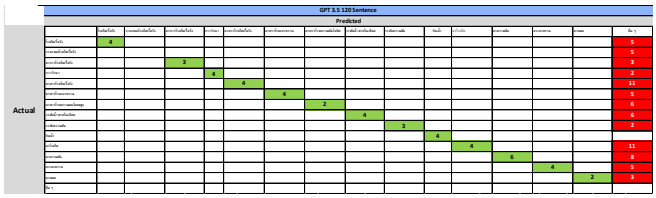


Fig. 5. Confusion matrix of Gemini Technique

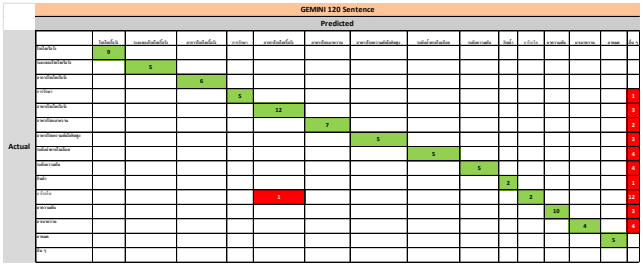


Fig. 6. Confusion matrix of GPT3.5 Technique

TABLE I. COMPARED BETWEEN 3 TECHNIQUES IN CHATBOT ALGORITHM

Technique	Accuracy	Precision	Recall
Dialog flow	88	89	95
Gemini	75.61	76.86	97.89
GPT 3.5	41.46	45.28	77.42

The Thai and English languages differ significantly in various aspects, including their linguistic structures, writing systems, phonology, and grammar. Here's a comparative overview of these differences: Phonetics and Phonology, Writing Systems, Grammar, Sentence Structure and Syntax, and Cultural and Contextual Elements. So, it relies on alphabetic characters and a more rigid grammatical structure. Understanding these differences is crucial for effective communication and translation between the two languages.

Therefore, both Dialog flow and Gemini offer powerful tools for building conversational interfaces, but they cater to slightly different needs. Dialog flow is ideal for structured, intent-based interactions and integrates smoothly with Google services, making it suitable for developers looking for ease of use and quick deployment. Gemini excels in more flexible, open-ended interactions and provides advanced language capabilities, making it a better choice for applications requiring nuanced and complex conversational AI. So, the result of Dialog flow show that is most suitable for generating the chatbot in Thai language context for predictive analysis in CKD. that are valid for suggestion to patients and significantly favorable to decision-making, monitor and evaluations by a medical practitioner.

C. *The system of Chatbot for slowing chronic kidney disease*

The system consists of two main components that work together to provide ser-vices to users. Here are the details: 1. Front-End/Client Side This part is directly accessible and interactive for users. The main components include LINE Applica-tion, Dialog Flow, Various Algorithms 2. Back-End/Server Side This part operates behind the scenes to support the front-end application. The main components include NoSQL Database Server (see in Fig 7).

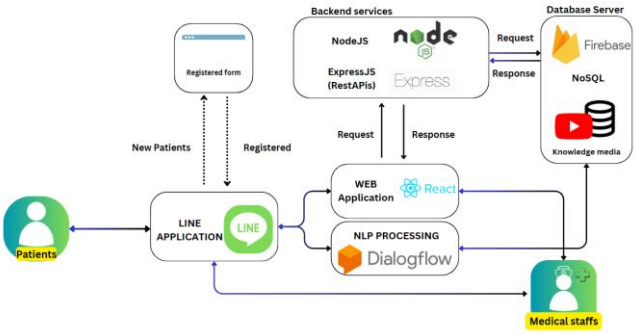


Fig. 7. System overview of slowing chronic kidney disease

V. EVALUATION AND APPLICATION

A chatbot system that provides care and answers questions regarding chronic kidney disease (CKD) for users. The system will be deployed on the LINE application, accessible via smartphones running on iOS and Android, and will also include a web interface for healthcare professionals accessible through a web browser.

Chatbot program consists of registration form, chatbot, knowledge of media, frequency of question, health form, and staff contact (see in Fig 8-9).

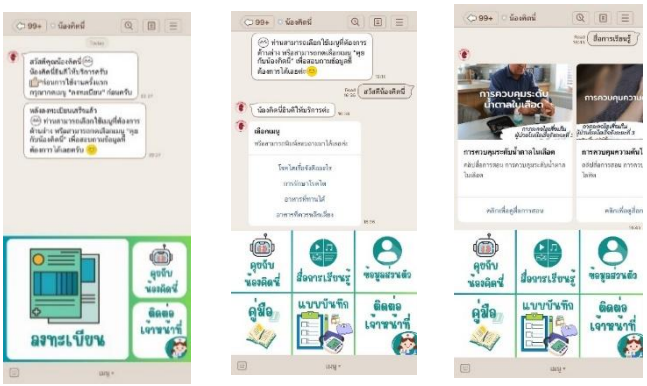
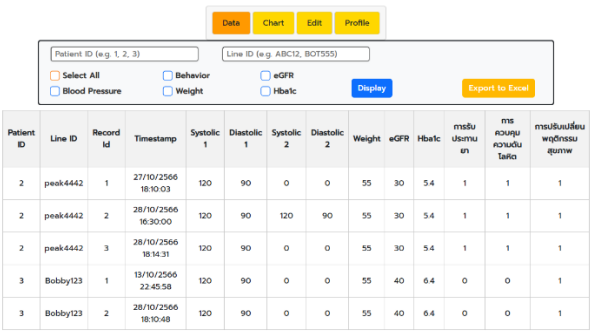


Fig. 8. Chatbot Chronic kidney disease

Fig. 9. Example of a health form in chatbot system

For web applications, it is back-end for health professionals. The purpose of this system is to apply clinical decision-making strategies by using automated reasoning an attempt to diagnose and follow-up chronic kidney disease from the patient data in Electronic Healthcare Records (EHRs) that consists of registration for medical staff, patient history, Blood Pressure, Weight, Behavior graph, eGFR graph, and Hba1c graph (see in Fig 10-13). This may potentially facilitate clinicians in predicting future patients.



Patient ID	Line ID	Record Id	Timestamp	Systolic 1	Diastolic 1	Systolic 2	Diastolic 2	Weight	eGFR	Hba1c	การรับประทานยา	การควบคุมความดันโลหิต	การปรับเปลี่ยนพฤติกรรมสุขภาพ
2	peak4442	1	27/10/2566 18:10:03	120	90	0	0	55	30	5.4	1	1	1
2	peak4442	2	28/10/2566 16:30:00	120	90	120	90	55	30	5.4	1	1	1
2	peak4442	3	28/10/2566 18:14:31	120	90	0	0	55	30	5.4	1	1	1
3	Bobby123	1	13/10/2566 22:45:58	120	90	0	0	55	40	6.4	0	0	1
3	Bobby123	2	28/10/2566 18:10:48	120	90	0	0	55	40	6.4	0	0	1

Fig. 10. Historical data of patients with chronic kidney disease (CKD)

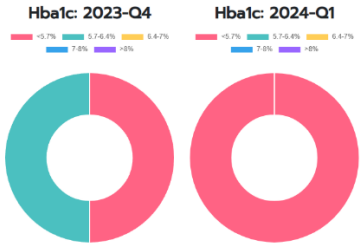


Fig. 11. An overview graph of Hba1c levels for patients with CKD

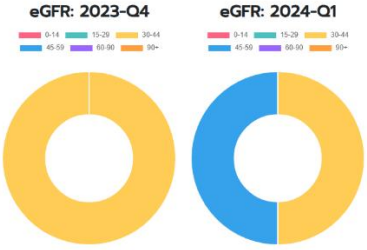


Fig. 12. An overview graph of the Glomerular Filtration Rate (GFR) for patients with CKD

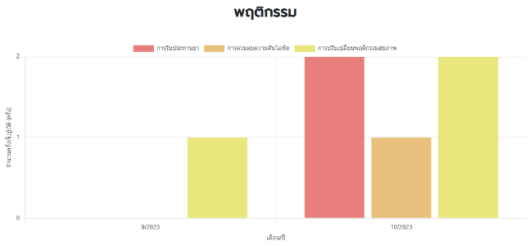


Fig. 13. An overview graph of behaviors related to CKD management

The survey results indicate a generally high level of satisfaction among users of the chatbot system. The participants of survey including Male 11(44%) and Female 14 (56%). Key strengths include its ease of use, accuracy, and usefulness of the information provided. However, there may be areas where improvements can be made, such as response timeliness and addressing specific user needs (see in Table 2).

TABLE II. USER SATISFACTION WITH THE CHATBOT SYSTEM

Topic	score
Ease of Use	4.25
Accuracy of Responses	3.55
Usefulness of Information	4.35
Timeliness of Responses	3.5

VI. Conclusion and Future Work

In this paper, the researcher used three chatbot techniques: Dialog flow technique; Gemini technique; and GPT3.5 for chatbot algorithm. The testing involved 120 question sentences that include user and knowledge of chronic kidney dis-ease in Thai language. The Thai and English languages differ significantly in various aspects, including their linguistic structures, writing systems, phonology, and grammar. The results of Dialog flow and Gemini show that while both are tools for building conversational interfaces, but they cater to slightly different needs. Dialog flow is ideal for structured, intent-based interactions and integrates smoothly with Google services, making it suitable for developers looking for ease of use and quick deployment. Gemini excels in more flexible, open-ended interactions and provides advanced language capabilities, making it a better choice for applications requiring nuanced and complex conversational AI. This confirmed that Dialog flow technique is most suitable for generating the Thai language context for predictive analysis in chronic kidney disease.

Consequently, NLP allows the disclosure of some unknown or unexpressed knowledge during prediction procedure, which is beneficial for decision-making in medical practice and provide useful suggestions and warnings to patient. In future, we will use more knowledge sentences to predict in NLP algorithm and compare to other techniques.

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References

[1] C. P. Kovesdy, "Epidemiology of chronic kidney disease: an update 2022," (in eng), *Kidney Int Suppl (2011),* vol. 12, no. 1, pp. 7-11, Apr 2022, doi: 10.1016/j.kisu.2021.11.003.

[2] E. F. Carney, "The impact of chronic kidney disease on global health," *Nature Reviews Nephrology,* vol. 16, no. 5, pp. 251-251, 2020/05/01 2020, doi: 10.1038/s41581-020-0268-7.

[3] T. Kanjanabuch and K. Takkavatakarn, "Global Dialysis Perspective: Thailand," *Kidney360,* vol. 1, no. 7, pp. 671-675, 2020, doi: 10.34067/kid.0000762020.

[4] N. R. Hill *et al.*, "Global Prevalence of Chronic Kidney Disease – A Systematic Review and Meta-Analysis," *PLOS ONE,* vol. 11, no. 7, p. e0158765, 2016, doi: 10.1371/journal.pone.0158765.

[5] N. Evangelidis, J. Craig, A. Bauman, K. Manera, V. Saglimbene, and A. Tong, "Lifestyle behaviour change for preventing the progression of chronic kidney disease: a systematic review," *BMJ open,* vol. 9, no. 10, p. e031625, 2019.

[6] N.-J. Chen *et al.*, "User evaluation of a chat-based instant messaging support health education program for patients with chronic kidney disease: preliminary findings of a formative study," *JMIR Formative Research,* vol. 7, no. 1, p. e45484, 2023.

[7] S. M. Patil, S. Sneha, S. Varshini, U. Joshi, and M. Kavya, "Design & implementation of healthcare chatbot using artificial intelligence," *INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) RTCSIT,* vol. 10, no. 12, 2022.

[8] J. O'Connor and I. McDermott, *Principles of NLP: What it is, how it works*. Singing Dragon, 2013.

[9] R. Kumar and M. M. Ali, "A review on chatbot design and implementation techniques," *Int. J. Eng. Technol,* vol. 7, no. 11, pp. 2791-2800, 2020.

[10] E. Adamopoulou and L. Moussiades, "An overview of chatbot technology," in *IFIP international conference on artificial intelligence applications and innovations*, 2020: Springer, pp. 373-383.

[11] L. Athota, V. K. Shukla, N. Pandey, and A. Rana, "Chatbot for healthcare system using artificial intelligence," in *2020 8th International conference on reliability, infocom technologies and optimization (trends and future directions)(ICRITO)*, 2020: IEEE, pp. 619-622.