Development of a chatbot prototype to assess arteriovenous fistula maturation

Desenvolvimento de protótipo de *chatbot* para avaliação da maturação da fístula arteriovenosa

Desarrollo de prototipo de chatbot para la evaluación de maduración de la fístula arteriovenosa

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Abstract

Objective: To describe the development and characteristics of a chatbot prototype intended for data collection and recording for arteriovenous fistula maturation assessment by nurses.

Methods: This is a methodological study applied to the construction of a chatbot conducted in the following phases: knowledge base construction; virtual assistant type selection; content scripting; dialogue creation in the chatbot; and dialogue review.

Results: The knowledge base of a chatbot, called "FAViana", was built from the content of a fistula maturation assessment protocol applying inspection, palpation and auscultation. Content scripting provided the basis for simulating a dialogue structured in a questionnaire on Google Forms®, which was transformed into a conversation using the Chat Forms® add-on. "FAViana" characteristics were aligned with the first step of the Nursing Process for documenting assessment data and abnormalities of AVF maturation and providing support for abnormal data interpretation, indicating the likely complication and suggesting recommendations on the possible complication.

Conclusion: A chatbot prototype could provide an innovative alternative for the Nursing Process implementation in assisting nephrological patients.

Resumo

Objetivo: Descrever o desenvolvimento e as características de um protótipo de *chatbot* destinado à coleta e ao registro de dados de avaliação da maturação da fístula arteriovenosa pelo enfermeiro.

Métodos: Estudo metodológico aplicado para a construção de um *chatbot* conduzido nas seguintes fases: construção da base de conhecimento; seleção do tipo de assistente virtual; roteirização do conteúdo; criação do diálogo no *chatbot*; e revisão do diálogo.

Resultados: Foi construída a base de conhecimento de um *chatbot*, denominado de "FAViana", a partir do conteúdo de um protocolo de avaliação da maturação da fístula aplicando-se a inspeção, palpação e ausculta. A roteirização do conteúdo deu base para a simulação de um diálogo estruturado em questionário no Google Forms® que foi transformado em conversação por meio do complemento *Chat Forms*®. As características do "FAViana" foram alinhadas à primeira etapa do processo de enfermagem para documentação dos dados da avaliação e anormalidades da maturação da FAV e ao oferecimento de suporte para a interpretação dos dados anormais, indicando a provável complicação e sugerindo recomendações sobre a possível complicação.

Conclusão: O protótipo do *chatbot* poderá fornecer uma alternativa inovadora para a implementação do processo de enfermagem na assistência a pacientes nefrológicos.

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Resumen

Objetivo: Describir el desarrollo y las características de un prototipo de *chatbot* destinado a la recopilación y al registro de datos de evaluación de la maduración de la fístula arteriovenosa por enfermeros.

Métodos: Estudio metodológico aplicado para la elaboración de un *chatbot* conducido en las siguientes etapas: construcción de la base de conocimiento; selección del tipo de asistente virtual; elaboración del guion del contenido; creación del diálogo en el *chatbot*; y revisión del diálogo.

Resultados: Se construyó la base del conocimiento de un *chatbot*, denominado "FAViana", a partir del contenido de un protocolo de evaluación de la maduración de la fístula, en que se aplica la inspección, palpación y auscultación. La producción del guion del contenido estableció la base para la simulación de un diálogo estructurado en un cuestionario de Google Forms® que fue transformado en una conversación por medio del complemento *Chat Forms*®. Las características de "FAViana" fueron elaboradas de acuerdo con la primera etapa del proceso de enfermería para la documentación de los datos de la evaluación y de anomalías de la maduración de la FAV y con el ofrecimiento de asistencia para la interpretación de los datos anormales, indicando la complicación probable y sugiriendo recomendaciones sobre la posible complicación.

Conclusión: El prototipo del *chatbot* podrá servir como una alternativa innovadora para la implementación del proceso de enfermería en la atención a pacientes nefrológicos.

Introduction

Arteriovenous fistula (AVF) is an autogenous anastomosis between an artery and a vein that generates a continuous blood flow, increasing the volume of blood diverted to the vein, making the venous segment capable of withstanding repeated punctures of dialysis therapy in patients with kidney disease who require constant hemodialysis sessions.[1,2] In the process of AVF maturation, it is usually up to nurses to take actions and interventions such as the correct instruction of patients and the thorough access assessment, which involves scientific knowledge of the maturation steps.[3] Assessment requires obtaining information that has clinical relevance for clinical judgment.

In the Nursing Process, information is obtained in a systematic, deliberate and continuous way about human responses of health and disease processes by nurses so that they are compatible with an accurate clinical judgment.[4] Authors of a scoping review for mapping published evidence on AVF maturation clinical assessment identified that nurses or nursing staff were the most common evaluators of this process.[5] This gives relevance to recognize the importance of nursing assessment.

One of the authors of this article produced an assessment protocol for AVF maturation based on the Nursing Process and nursing theories, in a master's study that has not yet been published. This protocol is directed to a more comprehensive nursing fistula assessment. Despite the potential advantages of this broadening of perspective and the standardization of assessment procedures by a protocol, its informa-tion may still be complex and filling out forms may be extensive in daily practice. Hence, collecting and interpreting data can be discouraging or impractical for professionals.

Challenges of this nature may require the production of technological alternatives that reduce the burden of human cognitive effort without losing the quality required for the production of high standards of care and preservation of essential information for clinical documentation. Developers of clinical judgment and decision support technologies sometimes migrate content from clinical protocols to systems that use electronic data recording for the benefits of structuring, storing, and retrieving data. However, in this process, problems occur in the man/machine relationship, such as incorrect data entry, the absence of feedback to users, and too much information on the screen or information irrelevant to the practice.[6]

Computer program-type chatbots as a resource stands out, with the potential to improve human-machine interaction, reduce human cognitive effort, approaching the use of natural human language in the communication of human beings with computational systems and occurring through messages based on in automatic tasks.[7] Such computer programs act as cognitive systems, being able to help people in information processing and decision making, having the benefit of being available 24 hours a day to offer support.[8,9] In health, its capabilities can be useful in care, especially in supporting information acquisition, answering questions, making recommendations or directing users to other online resources.[10,11]

Although there are researches on chatbots linked to treatments or experiences of health users,[12-15] the development of conversational agents aimed at nursing assessment in the field of nephrology still remains as an innovative theme, as well as which attributes could be contemplated in their development,[7,14] using data from a structured knowledge base from a nursing protocol. Thus, the objective was to describe the development and characteristics of a chatbot prototype intended for data collection and recording for assessing AVF maturation by nurses.

Methods

This is a methodological study for developing a chatbot prototype, carried out in five steps: (1) choice of knowledge base; (2) selection of virtual assistant type with definition of attributes; (3) content scripting; (4) creation of dialogue in the chatbot; and (5) dialogue review. All these methodological steps were based on typical development project activities, involving planning, engineering, execution and review.[7,14-16] The developers were three authors of this article, namely: undergraduate nursing student with a scientific initiation scholarship (developer 1), master's degree in nursing (developer 2) and PhD in nursing and academic advisor (developer 3). The team was engaged for five months of 2020 in the chatbot development steps. The chatbot developers used the knowledge base on AVF maturation, obtained from a scoping review,[5] incorporated into a nursing protocol to assess AVF maturation for hemodialysis. This protocol was elaborated in research developed at the academic master's level. This application prototyping research did not involve participants other than the authors of this study in a team of developers. Therefore, submission to a Research Ethics Committee was waived.

Results

In the first step, for choosing the knowledge base, the developers chose to select the "Nursing Protocol for the AVF Maturation Assessment for Hemodialysis", for being based on evidence obtained by an updated scoping review and being based on the Nursing Process and on a nursing theory, the Self-Care Deficit Theory. Although the protocol contained content and assessment structure, the developers were faced with the lack of a corpus of human-machine interaction dialogue that could serve as a knowledge base. Thus, the developers chose to use a simplified solution: creating a flowchart with information from a standardized clinical data collection to assess AVF maturation. This flowchart supported the construction of a form with 21 questions. Developers 1 and 3 chose Google Forms® to elaborate the questions and select the type of answer to be offered by users. The choice referred to the easy access, wide use and free use of Google Forms˚. When selecting the virtual assistant type, the closed properties of the knowledge base and the data collection form guided the choice of the chatbot-type virtual assistant without using artificial intelligence. The development team sought free options in Google Forms' own add-on library to generate the chatbot, ensuring the possibility of editing pre-structured dialogs. Chat Forms® was the add-on that seemed to also meet the desired attributes of training and diagnostics, coaching, dialogue management and textual communication.

For the scripting step, developers 1 and 3 built the sequence and dialogue structure of the user-chatbot conversation, following an initial version of the data collection form built by developer 2 for clinical assessment purposes, without, however, constituting the dialogue interaction in human language necessary for a virtual assistant. In the fourth step, developer 1 edited the standardized structure to insert elements that mimicked human conversation, such as inserting a motivational segment: "are you ready for some questions?". An in-house test was carried out with members of the development team to verify semantic content coherence, accuracy and adequacy of the dialogue structure in terms of cordiality and fluidity. In the chatbot dialog review, a new version of the dialog structure was generated, with completion

simulated by developers 1 and 2, independently. After that, adjustments were made to fit content and chatbot dialogue from editing directly in Chat Forms®. Regarding the more specific characteristics of the chatbot, the developers gave it a name that could indicate both its purpose and indicate an anthropomorphism with a name similar to that of human beings. Thus, the chatbot was named FAViana (Figure 1).
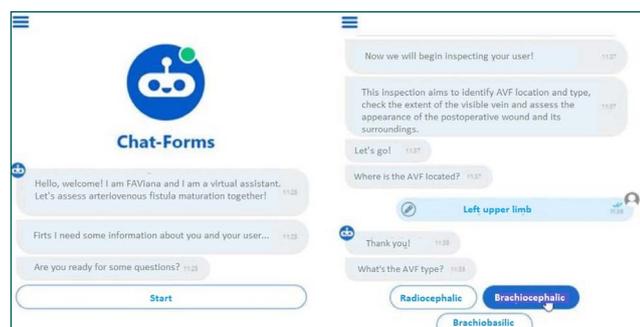
Figure 1. Representation of the robot-human interaction initial screen, indicating the emphasis on aspects of anthropomorphism in language and appearance

The chatbot developers were guided by conducting the work taking into account the categories of primary attributes: health goal, dialog type, agent type and communication model; and secondary attributes: behavior, purpose, graphic presentation, form of communication, memory, language, learning ability, form of information presentation, ability to observe user behavior and integration with information systems. Chart 1 presents the characterization of primary and secondary attributes.

A chatbot was built with two main health goals. The first development purpose refers to training for collecting and documenting assessment data that characterize AVF maturation and any abnormalities that have been verified during inspection, palpation and auscultation that indicate conditions of complications in the process. The second purpose is to provide support for the interpretation of abnormal data that were selected, indicating the probable complication and to suggest recommendations against this for a choice by professionals. To conduct data

Chart 1. Attributes considered in chatbot development

Categories or attribute nodes	Chatbot attributes
Health goal	Training and diagnosis (support in identifying complications).
Dialog type	Dialog management, in particular the collection of structured data.
Agent type	Coach oriented to guide nurses in AVF nursing assessment.
Communication model	Text mostly. Complementary image.
Behavior	Dynamic, showing up to help as soon as nurses start assessment.
Purpose	Specialist, addressing AVF maturation assessment.
Graphic presentation	With avatar, indicating a robot figure provided by the application.
Form of communication	Sociable, including user motivational statements.
Memory	Without memory, answers to questions are offered in the pre-established context of scripted dialogue content.
Language	Monoglot, interacting exclusively in Portuguese.
Learning ability	Without learning capability, regardless of the number of interactions, content remains unchanged.
Ability to observe user behavior	Proactive, providing help with additional knowledge required for the task.
Integration with information systems	Non-integrated, no access to database information other than that provided at its creation.

AVF: arteriovenous fistula

collection, FAViana asks the questions guided by the procedures established in the knowledge base protocol. Assessment is structured in three phases: AVF inspection, palpation and auscultation. The beginning of robot-human interaction is characterized by a chatbot presentation and by professionals collecting data about users who underwent the AVF procedure. Data entry from the nursing assessment itself into the chatbot begins by presenting the questions related to inspection. In this phase, the questions refer to AVF characterization in terms of location, type, visible vein extension, aspect of surgical wound and its surroundings. During palpation, the data collected by the chatbot are pulse amplitude perception, diameter estimation, vein depth and AVF thrill tactile perception. Data input from the auscultation phase refers to hearing AVF murmur in terms of the presence or absence of hearing, continuity and discontinuity of the sound and the frequency (high or low) of hearing the murmur. For each phase of the assessment process (inspection, palpation and auscultation), FAViana asks a question about the observed abnormalities and offers a set of possibilities for selection (Figure 2). Subsequently, it suggests the complicating condition that would be more likely to be interpreted as associated with those abnormal data, such as AVF venous segment stenosis (Figure 3).
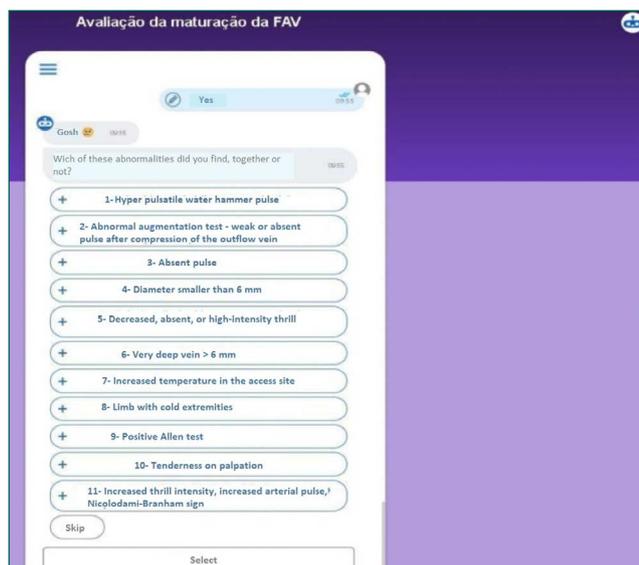
Figure 2. Abnormalities presented to the examiner in the palpation step
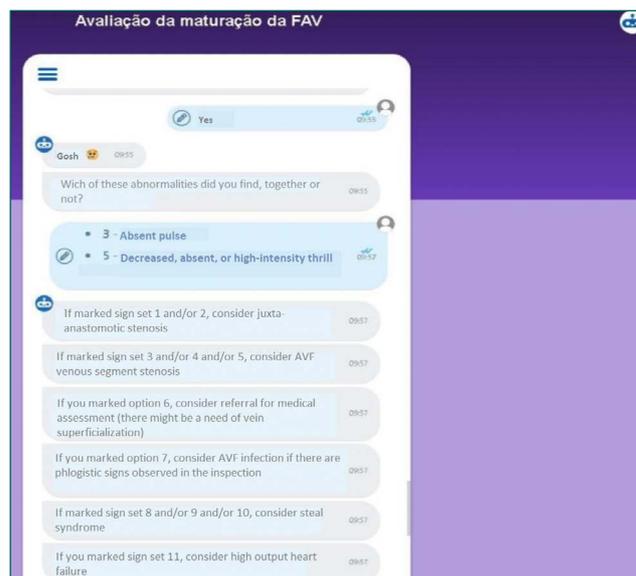
Figure 3. Interpretation of the probable complication of AVF maturation due to the abnormalities pointed out by the examiner during the palpation step

Discussion

The main limitation of results is the impossibility of investigating the chatbot's interaction with users in a dynamic information base, which would provide elements of human interpretation, later serving as support for better clinical judgment based on diagnoses, results and nursing interventions contained in the assessment protocol of AVF maturation. However, due to the chatbot's simplification characteristics, this limit may be circumstantial and supplanted in future versions, possibly with the incorporation of artificial intelligence.

The performance scenario of nurses providing direct care to nephrological patients produces high levels of work demands,[17] and this can affect nursing assessment accuracy, which ultimately requires the optimal use of support technologies. A chatbot can be a suitable support alternative when producing a structured dialogue and providing elements of already available information that can free human memory from the effort of storage and retrieval, for instance. In this perspective, nursing informatics is in full development, providing useful applications for nursing care, including the implementation of clinical decision support systems.[18]

Intelligent virtual assistants can support decision-making by leveraging a database and the computing power of artificial intelligence (AI). However, chatbots that have a structured knowledge base are only as intelligent as they can access it. Thus, as relevant as having an adequate dialogue structure is producing and organizing an adequate knowledge base.

Sometimes, given the amount of data available in the clinical context and the required processing speed, nurses may not be able to fully understand patients' health issues, which would limit their ability to make accurate decisions.[19] Thus, predictive algorithms for identifying nursing diagnoses proved capable of achieving high accuracy, reducing the time spent on decision-making by nurses.[20]

Presumably, for the nursing team, the collection of information and immediate decision-making in time-poor contexts could potentially be improved with structured technologies of computational capabilities. Intelligent assistants can assist in the mentioned processes.

However, even simpler chatbots without their own memory attributes can be useful when a knowledge base is clearly structured. For FAViana,

an extensive scoping review and the different recommendations of AVF maturation assessment protocol limited the possibilities of dispersion in its construction. Hence, deviations from the object of interest were avoided, in this case, data collection/AVF maturation assessment process, as well as ensuring an information base supported by research evidence, which is a relevant factor for the health area.

Chatbots have been used to support patient relationship building in a variety of tasks, such as assisting with exercise sessions for elderly or rehabilitation patients, as a distraction tool for pain management, for conversation and relationship facilitation, conducting interviews and providing patient education.[18] It has also been used in the area of women's and children's health by educating women about breastfeeding and child health promotion.[21,22] Still, chatbots can be targeted for use as "Conversational Recommender Systems". Recommender systems are mechanisms capable of analyzing and understanding the behavior of users of a given platform to make relevant and personalized recommendations.[23]

The FAViana chatbot was designed to produce recommendations based on the AVF assessment protocol during the conversation process. Recommender systems can provide clinical decision support, nursing education, clinical quality control and, as was the case with FAViana, serve as an add-on to existing practice guidelines.[24] In its design, FAViana was developed to have attributes of sociable and motivating communication, which can facilitate the creation of a better machine-human interface. Recent studies have pointed out that chatbots can attract users more than classic format questionnaires due to an association with the idea of entertainment, socialization and relational factors between conversational assistant and users.[25,26] Anthropomorphic characteristics incorporated into FAViana, such as visual traits similar to that of a human and a name, tend to trigger humanity heuristics.[27]

Although the chatbot developed is limited in the attributes of learning and memory capacity, the robustness in its specialized purpose can be guaranteed by clinical knowledge base based on research evidence and the anchoring in the Nursing Process's logic. Associated with sociable communication, such attributes can facilitate its use by nurses who need to monitor AVF maturation, minimizing the difficulty of dealing with the complete extension of the protocol. In general, the incorporation of these technologies in nursing is welcome, considering the trend towards the discontinuity of traditional methods of manual recording and the ever-increasing demands on the set of terms that form the standardized language systems that are used in the Nursing Process development. Even if chatbots along with innovation bring benefits, it is assumed that their use will not replace the fundamental role of person-centered nursing care, since robots have limitations in recognizing individual needs and response mechanisms that are configured as particularities of care.[19] Given this perspective, developers can use person-centered care models as a reference in the construction of virtual assistants or chatbots. In the case of FAViana, person-oriented perspective was guaranteed directly by the communication attribute and by the human naming given to the application. Indirectly, a chatbot was developed on a clinical knowledge base that used a nursing theory as a reference.

Conclusion

It was possible to present the description of the development and characteristics of a chatbot prototype for AVF assessment. Due to its attributes, FAViana tends to facilitate the follow-up process carried out by nurses in the postoperative period of patients with AVF, such as coaching with training attributes and support for the diagnosis of complications. It is assumed that, through an interactive and sociable man-machine dialogue and depending on the knowledge base used in its development, the demands of practice based on research evidence would be preserved. FAViana can provide an innovative alternative for imple-

menting the Nursing Process in the care of nephrological patients.

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Collaborations

Silva ABB, Correia BR, Zaccaro KRL, Campos JF, Souto JSS, Adba YB and Brandão MAG contributed with project design, data analysis and interpretation, article writing, relevant critical review of intellectual content and approval of the final version to be published.

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