Cogitare Enfermagem

TECHNOLOGICA INNOVATION

EXPERT SYSTEM MODELING FOR THE MULTIDIMENSIONAL EVALUATION OF AGED PEOPLE

HIGHLIGHTS

1. A technological solution based on artificial intelligence.
2. Operationalization of the Multidimensional Evaluation of Aged People in Primary Health Care.
3. Identification of the geriatric-gerontological needs and generation of the Singular Therapeutic Plan.
4. Management of the diverse information related to aged people's health.

Fernanda Matoso Siqueira[1]
Edna Aparecida Barbosa de Castro[1]
Dárliton Barbosa Feres Carvalho[2]
Gabriel Santos Trindade[2]
Gylce Eloisa Cabreira Panitz Cruz[2]
Érica Toledo de Mendonça[3]
Ricardo Bezerra Cavalcante[1]

ABSTRACT

Objective: to describe the modeling of an Expert System for the Multidimensional Evaluation of aged people. **Method:** the study was carried out from April 2021 to September 2022 by researchers from universities in the inland of Minas Gerais - Brazil. The following stages were conducted: literature review; survey of the System requirements; modeling; and implementation. **Results:** the System makes it possible to assess the physical, psychosocial and functional aspects; it identifies the geriatric-gerontological needs and classifies them according to severity levels, in addition to offering suggestions for therapeutic interventions. The diverse information generated can be shared through instant messengers via apps, providing the basis for the development of a monitoring panel for aged people assisted in the municipality. **Conclusion:** the System presents itself as a technological solution given the importance of the multidimensional evaluation of aged people within the scope of care for this population segment and the lack of technological solutions to carry out the assessment.

DESCRIPTORS: Older Adult; Geriatric Evaluation; Information Technology; Artificial Intelligence; Primary Health Care.

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[1]Universidade Federal de Juiz de Fora, Programa de Pós-Graduação em Enfermagem, Juiz de Fora, MG, Brasil.
[2]Universidade Federal de São João Del-Rei, Departamento de Ciência da Computação, São João del-Rei, MG, Brasil.
[3]Universidade Federal de Viçosa, Curso de Enfermagem, Viçosa, MG, Brasil.

INTRODUCTION

Brazil is heading towards an increase in longevity of its population, in line with the world scenario. In 2010, the proportion of aged Brazilians was 7.3%, and may reach 40.3% by 2100. The sociodemographic changes that have taken place in recent decades, such as reduction in infant mortality, decline in the fertility rate and change in the epidemiological profile, justify this population configuration[1].

Variations in the age structure of society lead to a new care perspective, given the prevalence of chronic degenerative diseases in this population group, which leads to higher health expenses and increased consumption of services[2]. As a result, there is a need to restructure health networks to meet emerging demands with quality, resoluteness and cost savings[3]. The Unified Health System (*Sistema Único de Saúde*, SUS) should organize itself to assess aged people, identifying vulnerabilities and risks of compromised functionality to preserve quality of life, in an aging perspective that does not associate presence of diseases with absence of health[4].

It is in this context that the Multidimensional Evaluation of Aged People (MEAP) or Comprehensive Geriatric Evaluation (CGE) emerges, structuring and organizing care for older adults and allowing for an expanded and comprehensive understanding of the individual, considering multiple dimensions (clinical, psychosocial and functional) that can affect their functionality, in addition to enabling the formulation of a Singular Therapeutic Project (STP) that guides interventions to the agents involved in the care provided[3].

In this sense, the incorporation of technologies in institutions and services emerges as an important factor for the qualification of the assistance provided, as systematized programs have been developed to manage diverse information that forms the basis for planning interventions[5]. As a set of technologies, Artificial Intelligence (AI) seeks to understand and design systems that have intelligence properties, thus having the ability to transform health systems in order to achieve universal coverage with improved efficiency, effectiveness, equality and response from the services[6].

Within the techniques to automate intelligent behavior, there is the Expert System (ES), a category covered by Knowledge-Based Systems (KBS). ESs are developed from the knowledge of a human expert within the knowledge area of the system proposed, so that the computational program solves complex problems from procedures, rules and strategies[7].

In Primary Health Care (PHC) in Brazil, information management has been carried out through the Electronic Citizen Record (ECR), developed by the Ministry of Health, or through software produced/acquired by municipalities; however, neither MEAP or AI are incorporated into its constructs. In the current information technology era, technological solutions emerge as promising possibilities for recording, storing and retrieving diverse information and anticipating interventions for health promotion, disease prevention and rehabilitation.

Given the problem, the objective is to describe the modeling of an Expert System for the Multidimensional Evaluation of aged people.

METHOD

This is the description of the modeling of a technological solution capable of carrying out the MEAP covering the clinical, psychosocial and functional dimensions and suggesting the STP with interventions focused on older adults' health. The intention is to incorporate

technology into the work process of PHC teams, contributing to comprehensive health care for aged people in the state of Minas Gerais.

The following stages were conducted to achieve the objective proposed: 1) Literature review; 2) Survey of the requirements for the ES; 3) Knowledge-based ES modeling; and 4) ES implementation.

The current study was carried out from April 2021 to September 2022. It comprises research phase 1 aiming to develop and validate an Intelligent System for the multidimensional evaluation of aged people, conducted by a group of researchers from partner universities in the inland of Minas Gerais. Conduction of the first and second stages involved an MSc student and professors in the Nursing field, and the third and fourth stages were developed in partnership with researchers in the Computer Science field, an undergraduate student and a professor.

The literature review was conducted by means of a scoping review based on the *Joanna Briggs Institute* (JBI) methodology, with the objective of mapping the scientific publications available in the national and international literature regarding MEAP in the PHC context. The dimensions that make up the evaluation, the measuring instruments used in each dimension and how information technologies are used to carry out MEAPs in PHC were investigated. Figure 1 presents a summary of the main results extracted from this research.

This first stage took place so that the diverse evidence available in the scientific literature could be collected to comprise the System's content, through a state-of-the-art mapping of the MEAP theme. The protocol for this review was registered in the *Open Science Framework* platform, at https://osf.io/btm7e, DOI: 10.17605/OSF.IO/BTM7E.

The theoretical framework of Functional Health Patterns by *Marjore Gordon*[8] was also used in the first stage, providing a structure that has been widely used in clinical practice, research and education, capable of guiding a comprehensive evaluation of a patient's health in a unified, holistic and comprehensive way. It consists of Eleven Standards, namely: Health Perception-Health Maintenance; Nutrition-Metabolic; Eliminations; Activity-Exercise; Sleep-Rest; Coping-Stress; Self-Concept/Self-Perception; Cognitive-Perceptual; Relationship-Role; Sexuality-Reproductive; and Value Belief, which describe the professional's perception of other people's health status and portray risks[8].

The second stage provided the survey of requirements for the ES design. Initially, from the literature review carried out, the measuring instruments, tools, scales, tests and questions that should be applied in the evaluation of each dimension were selected. It was decided to use instruments already validated or cross-culturally adapted in studies, easy to apply and available in the public domain. The authors of the selected instruments, whose presence in the public domain was not certain, were contacted via email and authorized their use for the ES.

In the third stage, there was multidisciplinary integration among the Nursing specialists who conceived the ES and Computer Science professionals who programmed the technology, so that basic information could be passed on for operationalization of the System and its general objectives, for subsequent interpretation and analysis. Meetings were held among the professionals to create a cooperative construction on how to solve problems based on experts' knowledge expressed in natural language.

For ES modeling, the techniques for knowledge representation and the proposed inference process were defined. First, all the necessary characteristics for the ES were registered in a computer program and later on linked to the diverse information they represent, so that weights could be assigned to each of them. A logical system based on binary rules of the "IF-" <condition> "THEN-" <consequence> type was used, considering input data in decision-making for the formation of possible diagnoses, called "geriatric-gerontological needs" in this study.

In the fourth and last stage, implementation of the System was carried out, using programming languages to create a web-centered information system, that is, a *Progessive Web App* (PWA). The choice to develop a PWA system comes from the fact that the web is a convergent accessibility technology through the Internet, with use priority by mobile devices (smartphones), although it is also accessible through the Internet by desktop computers. Figure 1 represents the functionalities of the ES proposed through a use case diagram.

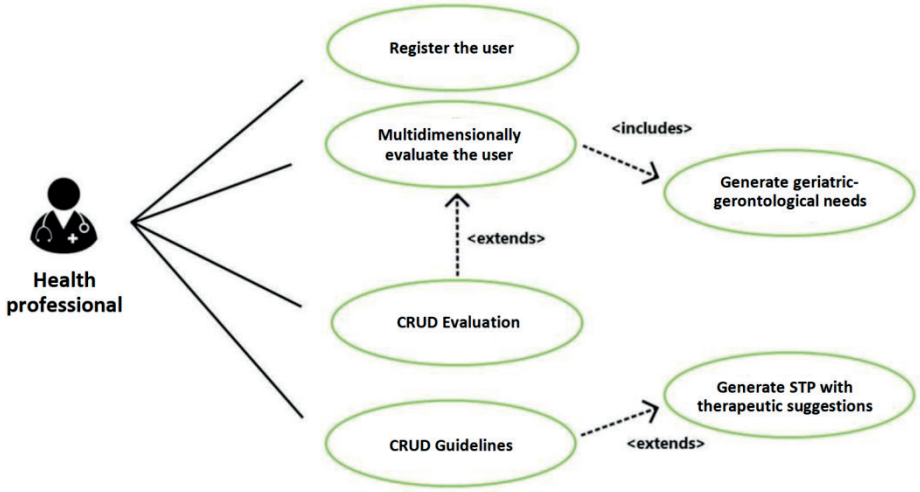

Figure 1 - Modeling of the requirements for the ES and use case diagram. Juiz de Fora, MG, Brazil, 2023

Source: The authors (2023).

RESULTS

Based on the scoping review, the first stage of this study, a total sample of 19 studies with multiple designs was included for analysis. As a result, the three dimensions that make up the evaluation (clinical, psychosocial and functional) are verified; as well as various instruments developed that can be applied to Primary Care; two types of information technologies used to instrumentalize the evaluation; and relevant findings on the MEAP practice in PHC. Prevalent domains present in the instruments were verified, with those included in the System being relevant when the intention is to specifically evaluate the aged population.

After collecting the diverse evidence available to comprise the System's content, the survey of requirements for the ES design continued, and the measuring instruments, tools, scales, tests and questions that should be used in the evaluation of each dimension, the main geriatric-gerontological risks generated from the weaknesses found in the evaluation and the therapeutic suggestions according to the needs raised were defined.

In the integration between the experts, the System requirements were passed on to be interpreted and analyzed, so that the binary rules of the "IF-" <condition> "THEN-" <consequence> type could be applied. Please see the examples below:

Example 01: IF <Timed up and go test performance time greater than 35 seconds>

THEN <high risk for falls>.

Example 02: IF <more than six points on the Geriatric Depression Scale>

THEN <suspected depression>.

Example 03: IF <unsafe environment>

THEN <therapeutic suggestions for risk of falls related to the environmental evaluation>.

Once the inference rules were defined, the web-centered system was created from the programming languages. Subsequently, the functionalities of the technology will be presented with screen prints generated on the Website itself, showing the stages to be followed by the professional to perform the MEAP.

The first screen of the System presents the login and password bars for access, which can also be registered in "*Registrar*" ("Register") and, if the password is forgotten, it is possible to recover it through the email informed in the registration form.

After the professional accesses the System with their login and password, the screen has shortcuts that make it possible to add new clients and search for those already registered by name. The "*Relatar erros*" ("Report errors") and "FAQ" tabs consist of assistance and support means through direct contact with the developer in case of questions while handling the website.

By clicking on the "*Avaliação com novo cadastro*" ("Evaluation with new registration") icon, the individual characterization is initiated, with gaps for filling in basic information about their socioeconomic profile, current and past health history, family history and other health-associated factors, shown in Figure 2. Such information can be edited later.

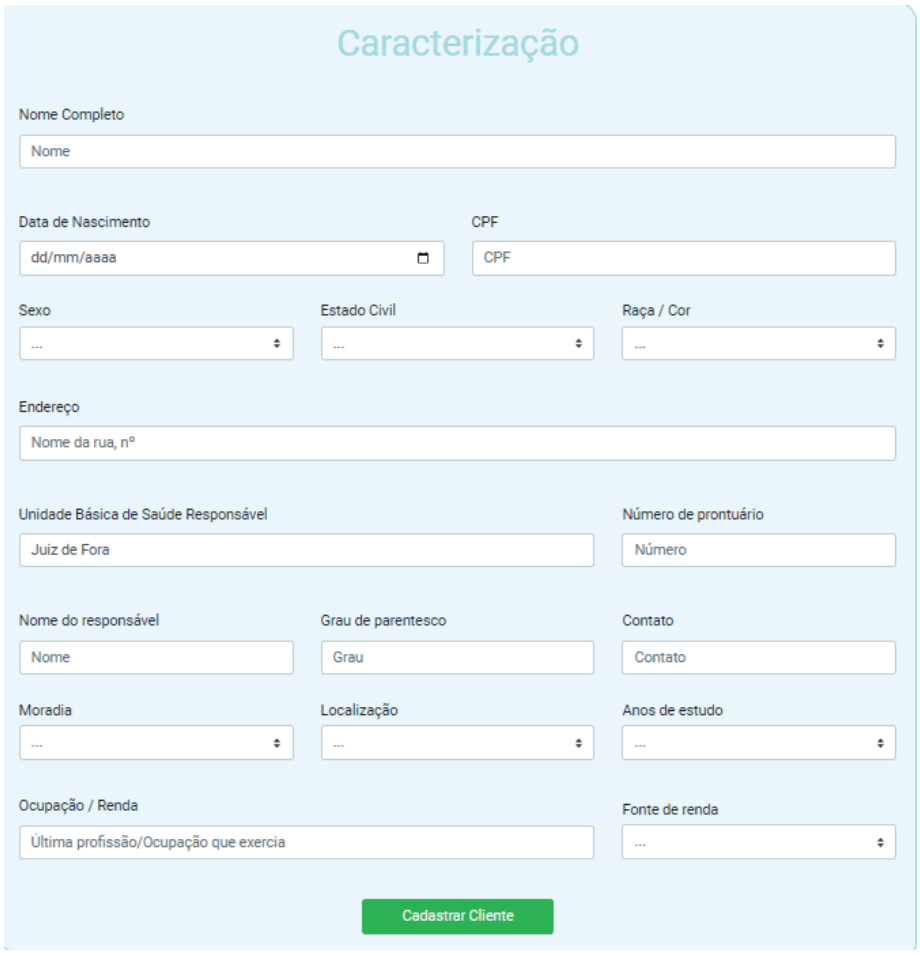

Figure 2 - Characterization of the aged person. Juiz de Fora, MG, Brazil, 2023

Source: The authors (2023).

After completing the registration, the professional can proceed to the multidimensional evaluation with questions, questionnaires and scales considering the physical, psychosocial and functional aspects, as shown in Figure 3. A hypothetical name (José Maria da Silva) was registered as example.

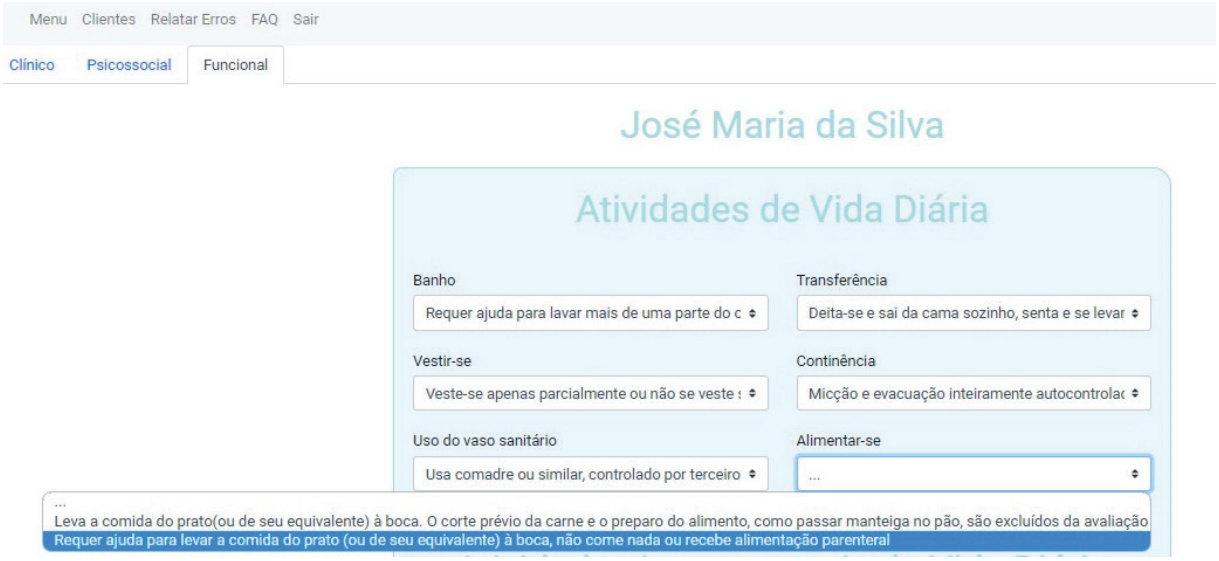

Figure 3 - Multidimensional evaluation (Functional evaluation screen). Juiz de Fora, MG, Brazil, 2023

Source: The authors (2023).

The System identifies the geriatric-gerontological needs according to the evaluations carried out, and classifies them according to severity levels in color gradations to alert the professional about the areas where they need to prioritize the intervention, as follows: green - no need for attention ; yellow – moderate attention; red – maximum attention, as shown in Figure 4, exemplifying some tests performed within the functional dimension.

Figure 4 - Geriatric-gerontological needs. Juiz de Fora, MG, Brazil, 2023

Source: The authors (2023).

After completing this stage, the System offers suggestions for therapeutic interventions through the generation of the STP, which will support the professional's decision-making according to the needs raised by the aged person. Decision support for the professional comes from the knowledge base integrated into the system, which will indicate individual and specific recommendations for the individual evaluated. Figure 5 exemplifies therapeutic suggestions when suspected depression is identified.

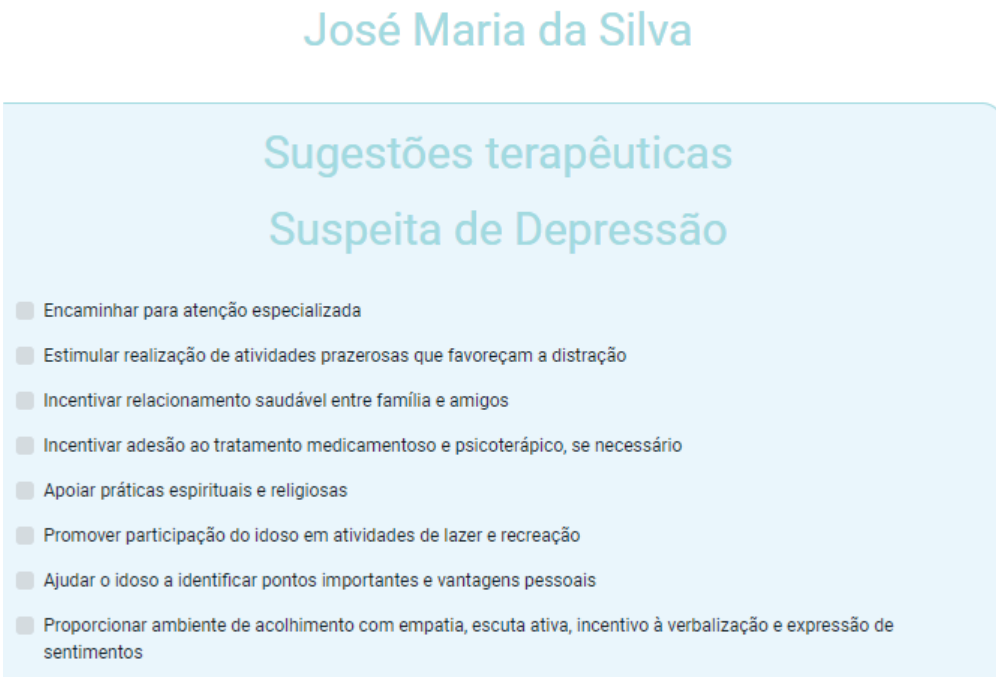

Figure 5 - STP example. Juiz de Fora, MG, Brazil, 2023

Source: The authors (2023).

The diverse information generated can be shared through instant messages via apps commonly used by users, such as *WhatsApp*, through an integration between apps and the system. Subsequently, a monitoring and control panel for the aged people assisted in the municipality can be developed with diverse information, reports and indicators generated from this information.

DISCUSSION

The growing adoption of Artificial Intelligence Health Technologies (AIHTs) can be an alternative to face the health challenges of the 21st century, as they allow improvements in workflows and support clinical decision-making[9]. A number of countries have invested significantly in the advancement of AI and, with that, it is expected that health teams will be impacted by the innovations launched[10].

Frequently described as the new electricity[10], Artificial Intelligence has been used to organize care processes and assist people dependent on care or their caregivers through screening, monitoring or classifying health activities and data[11].

In environments with limited resources, AI can be considered a promise capable of transforming the provision of health services; mass use of smartphones, for example, associated with supportive technologies, constitutes an opportunity to improve the health outcomes of low-income countries. ESs can be used to support diagnosis and choose treatment plans, as exemplified by the modeling described above, or to act in place of a human expert if one is not readily available[12].

From the intradisciplinarity perspective, a number of studies suggest that the main objective of applying AI in Nursing has been the proposal of solutions for monitoring or classifying activity and health. Apps have also been developed to support care coordination or communication, detect, classify and prevent falls, as well as to recognize, classify and reduce alarms and predict and classify pressure injuries[11]. In the medical field, AI has been applied to diagnose and treat diseases[13]: some examples are ES to diagnose and classify arrhythmias and ischemic heartbeats[14] and a web-based system to diagnose strabismus based on input data and weights of the variables[15].

The System described has innovative potential given that it is capable of carrying out the MEAP and suggesting the STP, proposing interventions focused on the individual health of older adults and their family context. In addition to that, it can produce learning algorithms based on the data collected from using the system, with a method to enable automated improvements in the professional decision-making support model. The diverse information shared through instant messaging with users, family members and caregivers makes care possible and eases therapeutic communication. All of this can prevent undesirable outcomes, monitor older adults' health and suggest more effective interventions, contributing to Older Adults' Comprehensive Health Care in Brazil[3].

Through the system's monitoring panel, it will be possible for the health manager and professionals to view the mapping of aged people in the territory, those who are in a vulnerable situation and the classification of frailty levels, in addition to screening and locating frail older adults and those with a potential to develop frailty.

It is worth noting that the technology is not intended to replace the professional's perspective and clinical judgment in user care, but to be used as a resource to support decision-making, thus promoting improvement in care quality.

Regarding the study difficulties, it is noted that the first stage required more time to be completed, given the large number of publications found on the theme to be analyzed and sorted. In the third stage, countless meetings were necessary between professionals

in the Nursing and Computer Science areas so that the knowledge representation was passed on and became adequate to what was intended to be built.

As study limitations, the product developed is a simple example of AI technology (Expert System). Other technologies might be incorporated, originating more powerful and complex hybrid AI systems, such as Machine Learning and Neural Networks, allowing support for decision-making with superior performance. Added to this is the possibility of creating an app in the Android and IOS versions to offer more access options to the system developed.

FINAL CONSIDERATIONS

The System consists of a technological solution for PHC professionals to operationalize the Multidimensional Evaluation of Aged People, given the importance of MEAP in the scope of care for this population group that is on the rise, as well as the lack of technological solutions for MEAP. Among various objectives, the debate around the incorporation of technologies in health is broadened to manage the diverse information produced, within a perspective of improving the response capacity of health systems.

The System will enable agility in the collection, analysis and dissemination of information, systematizing management of the information arising from the assistance process in comprehensive care for older adults' health.

It is noted that the technology produced is a first version that can be improved and validated by experts in the field and by professionals who will use it, consisting of the second stage of this study. It is also intended to develop the monitoring panel that will contribute to improving the quality of health care and of the information generated in the Primary Care level of the SUS. Aged people can be continuously monitored regarding functional capacity and stratification of the frailty and vulnerability levels, facilitating the process of prioritizing home visits. Risk prediction will contribute to monitoring and preventing unfavorable outcomes in the assistance provided to older adults.

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Corresponding author:
Ricardo Bezerra Cavalcante
Universidade Federal de Juiz de Fora
Rua São Mateus 1278, apt 306, Juiz de Fora, MG
E-mail: ricardo.cavalcante@ufjf.br

Role of Authors:
Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - **Siqueira FM, Castro EAB de, Carvalho DBF, Trindade GS, Mendonça ET de, Cavalcante RB**; Drafting the work or revising it critically for important intellectual content - **Siqueira FM, Cavalcante RB**; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - **Siqueira FM, Cavalcante RB**. All authors approved the final version of the text.

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