EDUCATIONAL STRATEGIES IN QUILOMBOLA COMMUNITIES: USE OF BAYESIAN NETWORKS FOR HEALTH RISK ASSESSMENT

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ABSTRACT

This study reports experiences in health education in two quilombola communities in Rio Grande do Sul, highlighting the use of Bayesian networks (RB) to assess the risks of type 2 diabetes mellitus (DM2) and systemic arterial hypertension (SAH). It was conducted as a cross-sectional and observational study, using the methodology of problematization, with stages that included observation, definition of key points, theorizing, hypothesis and practical application. The modeling of the quality of life was carried out using the Netica software, with the implementation of Bayesian networks (RBs), allowing the insertion of probabilities of occurrence of the variables through the network nodes. The profile of the 34 participants revealed a predominance of women (79.4%), aged between 30 and 59 years (55.9%) and with a mean body mass index (BMI) of 32.5 kg/m². Among them, 51.5% had a diagnosis of SAH and 23.5% of DM2. Inadequate diet was observed, with high sugar consumption (38.2%) and low use of whole foods (3.0%). The RBs had a sensitivity of 71.42% for DM2 and 76.47% for SAH, and specificity of 77.7% and 88.23%, respectively, demonstrating high precision. The modeling also identified a significant association between the risks of the diseases with factors such as BMI, age, family history and glucose. Educational strategies contributed to preventing complications and promoting quality of life, while MB proved to be promising tools for diagnosis and health education. The study reinforces the importance of inclusive public policies aimed at quilombola communities.

Keywords: Bayesian network. Type 2 diabetes mellitus. Systemic Arterial Hypertension. Problematization Methodology.

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INTRODUCTION

The number of adults with diabetes in the world has exceeded 800 million, more than quadrupling since 1990. According to the analysis of the NCD Risk Factor Collaboration (NCD-RisC), supported by the World Health Organization (WHO), this increase reflects the impact of obesity, promoted by unhealthy foods, sedentary lifestyle, and economic inequalities. Between 1990 and 2022, the global prevalence of the disease doubled, from 7% to 14%, with low- and middle-income countries facing the greatest growth and difficulties in accessing treatment. The study reinforces the urgency of action to curb rising rates and reduce care gaps (Zhou, 2024).

Type 2 diabetes mellitus (T2DM) is a metabolic syndrome characterized by chronic hyperglycemia, resulting from insulin deficiency, resistance to insulin action, or both. Insulin, produced by the pancreas, regulates glucose metabolism and, its lack or inefficiency, can cause difficulty in metabolizing sugar, leading to a persistent increase in its levels in the blood. DM2, responsible for 90% of cases, combines insulin resistance and inadequate secretion of the hormone. Its main symptoms include recurrent infections, blurred vision, difficulty in wound healing, tingling in the feet, and boils. Treatment consists of lifestyle changes, such as a balanced diet, physical activity, and the use of medications, aiming to keep blood glucose controlled and prevent serious complications, such as damage to nerves, eyes, kidneys, and the cardiovascular system (Ministry of Health, 2024).

The increasing incidence of these diseases, especially in developing countries, poses a challenge for health systems, due to the negative impact on quality of life, costs associated with treatment, and chronic complications (SMS, 2018). These conditions pose public health problems due to their high prevalence and complications.

Risk factors for DM2 are variables such as age, sex, ethnicity, family history of DM2, obesity, sedentary lifestyle, gestational diabetes, macrosomia, hypertension, reduction in high-density lipoprotein (HDL) cholesterol, increased triglyceride levels, cardiovascular diseases, polycystic ovary syndrome, high blood glucose in previous tests, impaired glucose tolerance, and glycated hemoglobin ≥5, 7% (ADA, 2013).

Obesity is pointed out as one of the main risk factors for DM2. It is estimated that between 80 and 90% of individuals affected by the disease are obese and the risk is directly associated with increased body mass index (BMI) (Martínez-Castelao et al., (2015).

Around 1972, the evidence-based medicine (EBM) movement emerged, created by Archie Cochrane, defined as the judicious and thoughtful use of the best evidence in decision-making about patient care, uniting evidence from research with clinical experience (Sackett, 1996). EBM is essential in the control of chronic non-communicable diseases

(NCDs), it allows clinical decisions to be made, increasing the quality of care by promoting the personalization of treatment and adapting interventions to the individual needs of patients.

With the incorporation of artificial intelligence (AI) techniques, it has become possible to use EBM to assess and reduce uncertainty in medical decision-making, with AI being a widely accepted area of research for medical applications. Among these applications, Bayesian networks (RB) stand out, used as an aid to medical diagnosis. Defined as probabilistic networks composed of a graphical structure and an associated probability distribution. Mathematically, a RB can be represented by B = (Pc, G), where G is a directed acyclic graph and Pc is the conditional probabilities associated with each probabilistic variable represented on a node of the graph. In this way, RBs establish a connection between EBM and AI, as they are applied in causal probabilistic calculations to describe evidence-based medical practices (Pearl, 2000).

NCDs, such as DM2 and systemic arterial hypertension (SAH), represent serious public health problems in Brazil and worldwide, highlighting the need for strategies for prevention and early diagnosis of these conditions. Data from the Surveillance of Risk and Protective Factors for NCDs (Vigitel) show that DM2 affects 21.6% of Brazilians over 65 years of age, while in the age group of 18 to 24 years the prevalence is 0.6%. In the case of SAH, its average prevalence in Brazilian adults is 32%, reaching more than 50% in individuals between 60 and 69 years of age and up to 75% in elderly people over 70 years of age. In view of this scenario, the application of technologies such as MB emerges as a strategy to assess risks and promote health education. These tools make it possible to identify risk patterns and communicate information in an accessible way, and are especially relevant in vulnerable communities, such as quilombolas, where access to health services is limited.

Thus, the objective of this study was to investigate the use of RBs in health education with a focus on the risk assessment of DM2 and SAH, contributing to the promotion of educational strategies in vulnerable communities.

THEORETICAL FRAMEWORK

The prevalence of T2DM in Central and South America is estimated at 26.4 million people, with a projection of growth to 40 million by 2030. In developed countries, such as the USA and European nations, the increase will occur mainly in the older age groups due to the increase in life expectancy. In developing countries, prevalence is expected to grow

at all ages, with a threefold increase predicted for people aged 45 to 64 years and a double increase in the 20-44 age group and over 65 years (IDF, 2024).

The study conducted by Zhou (2024), highlights significant differences in T2DM rates, with prevalences in adults aged 18 years and older reaching about 20% in the WHO Southeast Asia and Eastern Mediterranean regions. These areas, along with the African Region, have the lowest rates of treatment coverage, with less than 40% of adults using glucose control medications. The study also shows that, in the Americas, 112 million adults (13% of the adult population) are living with diabetes; This is almost four times the number of adults with diabetes in 1990 (30 million adults, 7% of the adult population). In the Caribbean, the prevalence is even higher, reaching 20% of the adult population.

In Brazil, data from the Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey (Vigitel) show that DM2 increases according to the age of the population: 21.6% of Brazilians over 65 years of age and 0.6% of those aged between 18 and 24 years are people with diabetes (Brasil, 2012). Regarding the regional results of the survey, the capital with the highest number of people with diabetes was Fortaleza, with 7.3% of occurrences. Vitória had the second highest index (7.1%), followed by Porto Alegre, with 6.3%. The lowest rates were recorded in Palmas (2.7%), Goiânia (4.1%) and Manaus (4.2%) (Brasil, 2015).

The results in the control of DM2 depend on a combination of factors and conditions that enable the adequate follow-up of these patients. The main goals of health interventions for T2DM include glycemic control and, in the long term, the reduction of complications and mortality. In this context, implementing structured educational interventions with health professionals is important to address these health challenges (Brasil, 2013).

SAH is a multifactorial clinical condition characterized by high and sustained levels of blood pressure (BP ≥140 x 90 mmHg). In Brazil, its prevalence varies between 22% and 44% for adults (32% on average), reaching more than 50% for individuals aged 60 to 69 years and 75% in individuals over 70 years of age (SBC, 2010).

The average prevalence of self-reported SAH in the population over 18 years of age, according to data from the Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey Vigitel is 22.7%, being higher in women (25.4%) than in men (19.5%) (Basil, 2012). The frequency of SAH became more common with age, with a predominance in females, reaching more than 50% in the age group of 55 years or older. Among women, the inverse association between education level and the diagnosis of the disease stands out. While 34.4% of women with up to 8 years of schooling reported a diagnosis of SAH, the same condition was observed in only 14.2% of women with 12 or more years of

schooling. For men, the diagnosis of the disease was less frequent in those who had studied for 9 to 11 years (Gomes; Silva; Santos, 2010).

Health education, supported by the use of RB, allows for an accurate assessment of the risk of developing DM2 and SAH, promoting effective interventions for the prevention of these diseases.

A RB is a graphical model that represents probabilistic relationships between variables of interest (Nassar, 2024). They have a one-graph architecture, where the nodes represent the variables (input and output) that interrelate and represent the reasoning structure of an expert in an application domain. The nodes are connected by arcs, directed in the direction of the exit node to the input node, and for each arc the values of the conditional probability that represent the rules of the type "If output then input" must be estimated. Thus, a RB is made up of two parts: the qualitative part, which are the nodes of the network; and quantitative, the probabilities of occurrence. RBs are systems from the area of AI, based on conditional probability, used to relate variables and arrive at percentage results with confidence levels. From the interposition of existing information, it can present results ranging from 0 to 100% depending on the existence of a causal relationship (Luger, 2004).

Because it is based on probability theory, probabilistic reasoning is one of the main advantages of RBs). This approach allows rational decisions to be made even in the face of uncertainty, when there is not enough or complete information to prove that a particular action will be successful. The ability to represent uncertainties in a structured way makes RBs a useful tool in areas such as diagnosis, planning, and machine learning, where knowledge is often partial or ambiguous. Also known as causal networks, RBs have their origin in probability theory and are characterized by a formalism that represents knowledge in the domain, and also by the uncertainties associated with this domain, through Bayes' theorem (TB). Physicians, when formulating their diagnostic hypotheses, prescribing a treatment to their patients, intuitively use TB. By assuming a random sampling of events, bayes' theory supports the calculation of more complex probabilities, based on previously known results (Navar et al., 2015).

Problematization provides the opportunity for reflection mediated by the teacher on interaction activities, being a key element for the personal satisfaction of students and for the improvement of quality of life. The problematization methodology aims to prepare students for a conscious and transformative action in their communities. It promotes a dynamic relationship between theory and practice, encouraging students to reflect on the complexity of social phenomena and to develop critical thinking (Bergel, 1998).

The problematization methodology, which is based on the Arco de Maguerez, is a valuable pedagogical resource in health education, especially in contexts that demand in-depth understanding, such as teaching about diabetes mellitus (DM). This approach encourages students to become protagonists of their learning, promoting a horizontal relationship between educators and students, where both actively participate in the educational process (Dias; Saints; Lopes, 2022).

METHODOLOGY

This is a cross-sectional and observational study carried out in the quilombola communities of Mormaça and Arvinha in the municipality of Sertão/RS. 34 quilombolas participated in the research. Health education was formalized through the problematization methodology, which aims to prepare students for conscious and transformative action in their communities, using the Manguerez arch, structured in five stages: (1) observe the cultural context of the communities, highlighting the risks of NCDs, such as DM2 and SAH, to which the quilombola population is exposed; (2) identify key points to inform about SAH and DM2, including nutritional and physical activity guidelines; (3) promote conversation circles to identify possible suspicions of these pathologies; (4) develop solutions to the problem, ensuring the active participation of the communities and (5) develop activities aligned with the local reality, strengthening learning (Villardi; Cyrino; Berbel, 2015).

To model the probabilities associated with clinical variables such as BMI, sedentary lifestyle, heredity (1st degree), triglycerides, tingling of the feet and legs, cholesterol, high blood pressure, fatigue, blurred vision, gestational diabetes, excessive thirst, intake of vegetables and legumes, stress, neck and chest pain, dizziness, headaches, fluid retention and sociodemographic (such as age), the Netica software was used for the implementation of the RBs (Nassar, 2024).

The team was composed of 12 members, including six volunteer students, a physical activity specialist, three collaborating medical professors, two nurses and the project's coordinating teacher. Five workshops were held: in the first, there was a conversation circle with explanations about DM2 and SAH; in the second, the participants were instructed about the importance of physical activity and performed practical exercises; in the third, the focus was on healthy nutrition, with a demonstration of practical recipes for diabetics and hypertensives, accompanied by a tasting of low-calorie foods; in the fourth workshop, BMI, blood glucose and blood pressure measurements were carried out and, in the fifth workshop, interviews were conducted for data collection, aimed at quantifying the

epidemiological profile. Finally, two Bayesian networks were implemented: one for the diagnosis of DM2 and the other for the diagnosis of SAH.

This study is an excerpt from the research project on the theme "Epidemiological Profile of DM2 and SAH in the quilombola communities of Mormaça and Arvinha/RS". The project was approved by the Human Research Ethics Committee of UFFS, under opinion No. 1.857.616 (CAAE 62073016.1.0000.5564), carried out in accordance with Resolution 466/2012 of the National Health Council.

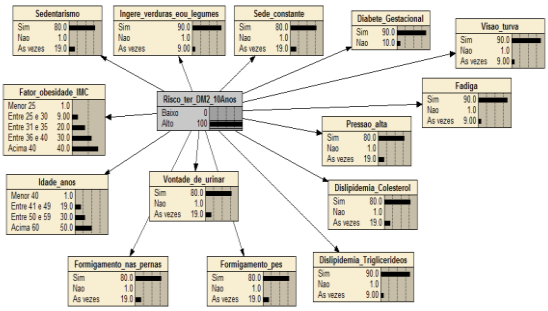
RESULTS

The profile of the 34 participants was predominantly composed of women (79.4%), between 30 and 59 years old (55.9%), with a mean BMI of 32.5 kg/m². Of the total, 51.5% had a medical diagnosis of SAH and 23.5% of DM2. Regarding eating habits, it was found that 44.1% had their meals watching television, using the computer and/or cell phone and, it was observed, that the interviewees consumed at least two meals a day, with lunch being the most prevalent (100%) and dinner (97.0%).

In addition, the most frequent dietary pattern observed was the daily consumption of beans (67.7%) and foods prepared with sugar (38.2%). The consumption of fresh fruits occurred three times a week (54.6%), as well as vegetables (45.8%), hamburgers and/or sausages (54.5%) and instant noodles/snacks/cookies (48.5%). Only 3.0% of the interviewees used whole foods in their diet.

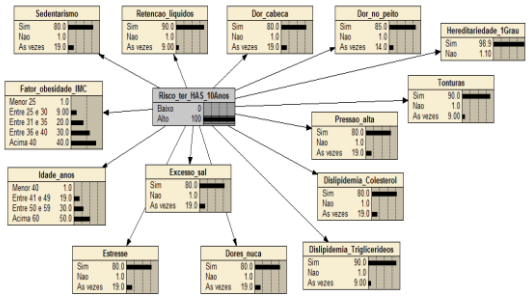
In order to provide guidance on quality of life in quilombola communities, with the use of educational strategies, two RBs were constructed, as illustrated in figure 1 with the Abductive Reasoning of DM2 and in figure 2 based on the abductive reasoning of SAH, based on the knowledge of physicians specialized in helping to diagnose DM2 and SAH.

Figure 1. T2D Abductive Reasoning



Source: Prepared by the authors

Figure 2. Abductive Reasoning HAS



Source: Prepared by the authors

The implemented RBs show the risk of developing T2DM and SAH. The nodes represent the qualitative variables of the study while the probabilities of occurrence represent the quantitative events. In these models, the probabilities of occurrence of each event (abductive reasoning) were computed, according to bibliographic references and the common sense of physicians, in this way, MB will be learning knowledge and informing a low or high risk of patients contracting DM2 and SAH.

After the compilation and selection of the nodes, the entire RB is affected and, in this way, it is recalculated, that is, based on the variables selected in the RB models, it was possible to predict the existence of evidence of the occurrence of DM2 or SAH.

In this study, which evaluated the risk of occurrence of DM2 and SAH and their association with clinical and sociodemographic variables using RBs, the diagnostic tests demonstrated a sensitivity of 71.42% and 76.47% for detecting DM2 and SAH, respectively, in sick patients, and a specificity of 77.7% and 88.23% for excluding the diagnosis of DM2 and SAH in healthy patients.

The RBs demonstrated an efficiency of 82.35% in the data analyzed, proving to be a promising tool for the diagnosis of DM2 and SAH, with great potential for medical education by allowing probabilistic inferences. A significant association was observed between the risk of developing DM2 and SAH with clinical variables, such as body mass index, physical activity, family history, glucose and triglyceride levels, in addition to the sociodemographic variable age.

DISCUSSION

The authors Lourenço et al. (2022) highlighted that effective management of chronic diseases requires a comprehensive approach, including lifestyle modifications and educational initiatives, considering health education as an essential pillar to improve outcomes and prevent disease, especially when applied in primary health care structures. In this context, the results of this research corroborate this perspective, demonstrating that

educational interventions in quilombola communities were relevant in promoting the prevention of complications associated with DM2 and SAH. These educational actions encouraged the adoption of healthy habits, such as a balanced diet and regular physical activity, thus contributing to the improvement of quality of life and the reduction of risks related to these diseases.

According to Santer, Leite and Lima (2021), older adults with better dietary quality tend to consume a higher proportion of processed foods, especially rice (97%), meat (94%), beans (91%) and salad (91%). In contrast, in this study, it was observed that the most frequent dietary pattern among the participants involved the daily consumption of beans (67.7%) and foods prepared with sugar (38.2%), while the use of whole foods was recorded by only 3.0% of the interviewees. These findings suggest that, although beans continue to be a common food in the diet of the elderly, there is a significant prevalence of food choices with greater processing and added sugar, which may impact the nutritional quality of the diet. This suggests that health professionals should focus on promoting nutrition education that emphasizes the benefits of whole and minimally processed foods.

Queiroz et al. (2021) highlight conversation circles as an effective strategy for health education, especially for the elderly, also emphasizing the importance of continuous monitoring in chronic diseases. Similarly, our study applied the theory of problematization in five stages, involving the observation of the cultural context of quilombola communities, the promotion of conversation circles to inform about chronic diseases such as DM2 and SAH, in addition to offering nutritional and physical activity guidance. These actions aim to strengthen learning and promote the active participation of communities.

In the study by Souza (2018), the implementation of a ontology-based BR in the health area showed satisfactory validation, with about 80% accuracy both in the evaluation of specialists and in the validation of real clinical cases, using the Netica software. Similarly, our study, also implemented with Netica software, obtained an efficiency of 82.35% in the data analyzed, demonstrating the potential of RBs as an effective tool to aid in the diagnosis of DM2 and SAH, in addition to their great potential for medical education, allowing probabilistic inferences.

Kong et al. (2024) implemented a RB model that was effective in its predictive capabilities, with high sensitivity and specificity, with a value greater than 0.8. The study identified several factors that influence T2D, such as age, education level, family history, lifestyle choices, including exercise and diet. The results indicated that populations in rural areas are at higher risk of developing T2D due to factors such as lower educational levels and limited access to health care. These results are in agreement with the results found in

the present study, reinforcing that understanding these relationships can help health professionals to target risk factors in education and prevention programs.

The main limitations of the study include the small sample size, with only 34 participants, which may restrict the generalization of the results to other populations. This limitation can impair the sensitivity and specificity of the RBs, since their performance varies according to the quality and quantity of data used. Suggestions for future research could replicate the study in other communities, both vulnerable and urban, to identify regional variations in the impact of RBs. Another suggestion is the incorporation of new variables, such as social determinants of health and psychosocial factors, to refine the models used.

CONCLUSIONS

From this study, it was observed that the educational strategies were relevant to the extent that they contributed to help in the prevention and occurrence of complications of DM2 and SAH in the quilombola communities. They were important as they contributed with new teachings about the manifestations of these diseases and how to acquire a better quality of life, through a healthy diet and the practice of physical exercises. It was concluded that public health policies should seek equity through inclusive care for special groups, especially in quilombola communities.

The practical implications of this research range from individual patient care to broader public health strategies, highlighting the relevance of predictive modeling to predict future behaviors and the effective management of NCDs. It is essential that patients with NCDs are aware of the risks related to their health problem. The information generated from the implemented RBs demonstrated great potential for use in health education. The results presented show the need to implement more effective actions in the educational area, contributing to health promotion and disease prevention.

This study shows the relevance of continuous educational interventions as a strategy for the prevention of NCDs. The RBs offered valuable insights that can be used to develop more effective health education programs. The results of this study are not restricted only to the context of quilombola communities, but may be applicable to other populations with similar characteristics, contributing to the improvement of quality of life and reduction of the risks associated with DM2 and SAH.

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