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# Prevalence of Metabolic Syndrome and its associated risk factors among Passo do Lontra community at the Brazilian Pantanal

**Prevalencia del Síndrome Metabólico y sus factores de riesgo asociados en la comunidad de Passo do Lontra en el Pantanal Brasileño**

**Prevalência da Síndrome Metabólica e seus fatores de risco associados na comunidade Passo do Lontra no Pantanal Brasileiro**

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**Abstract**

The metabolic syndrome (MetS) is a complex of risk factors for cardiovascular disease and its incidence has increased globally, causing this condition to be currently a global public health problem. It was estimated that 20 to 35% of the world's population has MetS. However, the global prevalence ratios vary enormously, due mainly to social and economic discrepancies. Despite the importance of MetS in the context of metabolic and cardiovascular disease, studies that described the prevalence of MetS and its determinants among rural and vulnerable populations worldwide. In this study, we aimed to determine the MetS prevalence and associated risk factors in a riverside population living in Pantanal biome from Mato Grosso do Sul in Brazil, that has difficulties in accessing health services. This investigation is a retrospective cross-sectional study conducted from March 2010 to July 2016 in adult individuals (aged 18 years or older)) from riverside community of Passo do Lontra. MetS was defined according to NCEP/ATP III, 2001criteria. A total of 81 adult individuals, being 36 (44.4%) females and 45 (55.6%) males were enrolled. The overall MetS prevalence was 40.7% (33/81) with no gender difference. About the risk factors analysis, higher levels of BMI, uric acid, non-HDL, VLDL cholesterol and obesity among adults led to higher chances of developing the syndrome. These

findings provide important evidence on the MetS prevalence as a public health problem, particularly for obese, dyslipidemic and hyperuricemic individuals. Our results reinforce an alarming public health trend.
**Keywords:** Metabolic syndrome; Abdominal obesity; Dyslipidemias; Hypertension.

**Resumen**
El síndrome metabólico (SMet) es un complejo de factores de riesgo de enfermedad cardiovascular y su incidencia ha aumentado a nivel mundial, provocando que esta condición sea actualmente un problema de salud pública mundial. Se estimó que del 20 al 35% de la población mundial tiene MetS. Sin embargo, las razones de prevalencia global varían enormemente, debido principalmente a discrepancias sociales y económicas. A pesar de la importancia del MetS en el contexto de las enfermedades metabólicas y cardiovasculares, pocos estudios han descrito la prevalencia del MetS y sus determinantes entre las poblaciones rurales y vulnerables de todo el mundo aún son limitados. En este estudio, nuestro objetivo fue determinar la prevalencia de MetS y los factores de riesgo asociados en una población ribereña que vive en el bioma Pantanal de Mato Grosso do Sul en Brasil, que tiene dificultades para acceder a los servicios de salud. Esta investigación es un estudio transversal retrospectivo realizado entre marzo de 2010 y julio de 2016 en individuos adultos (mayores de 18 años) de la comunidad ribereña de Passo do Lontra. MetS se definió de acuerdo con los criterios de NCEP/ATP III, 2001. Se inscribieron un total de 81 individuos adultos, siendo 36 (44,4%) mujeres y 45 (55,6%) hombres. La prevalencia general de MetS fue del 40,7% (33/81) sin diferencia de género. En cuanto al análisis de los factores de riesgo, los adultos obesos, con IMC alto, o aquellos adultos que presentaban niveles elevados de ácido úrico, colesterol no HDL y VLDL, tenían mayores posibilidades de desarrollar el síndrome. Estos hallazgos proporcionan evidencia importante sobre la prevalencia de MetS como un problema de salud pública, particularmente para personas obesas, dislipidémicas e hiperuricémicas. Nuestros resultados refuerzan una tendencia alarmante de salud pública.
**Palabras clave:** Síndrome metabólico; Obesidad abdominal; Dislipidemias; Hipertensión.

**Resumo**
A síndrome metabólica (SM) é um complexo de fatores de risco para doenças cardiovasculares e sua incidência tem aumentado globalmente, fazendo com que essa condição seja atualmente um problema de saúde pública mundial. Estima-se que 20 a 35% da população mundial tenha MetS. No entanto, as taxas de prevalência globais variam enormemente, devido principalmente a discrepâncias sociais e econômicas. Apesar da importância da SM no contexto das doenças metabólicas e cardiovasculares, poucos estudos descrevem a prevalência da SM e seus determinantes entre populações rurais e vulneráveis no mundo todo. Neste estudo, objetivou-se determinar a prevalência de SM e fatores de risco associados em uma população ribeirinha residente no bioma Pantanal de Mato Grosso do Sul no Brasil, que tem dificuldades de acesso aos serviços de saúde. Esta investigação é um estudo transversal retrospectivo realizado no período de março de 2010 a julho de 2016 em indivíduos adultos (18 anos ou mais) da comunidade ribeirinha do Passo do Lontra. A SM foi definida de acordo com os critérios do NCEP/ATP III, 2001. Foram cadastrados 81 indivíduos adultos, sendo 36 (44,4%) do sexo feminino e 45 (55,6%) do sexo masculino. A prevalência geral de SM foi de 40,7% (33/81) sem diferença de gênero. Sobre a análise dos fatores de risco, níveis elevados de IMC, ácido úrico, colesterol não HDL, VLDL e obesidade levaram a maiores chances de desenvolver a síndrome. Esses achados fornecem evidências importantes sobre a prevalência da SM como problema de saúde pública, principalmente para indivíduos obesos, dislipidêmicos e hiperuricêmicos. Nossos resultados reforçam uma tendência alarmante de saúde pública.
**Palavras-chave:** Síndrome metabólica; Obesidade abdominal; Dislipidemia; Hipertensão.

## 1. Introduction

Metabolic syndrome (MetS) is a cluster of metabolic conditions, that lead to increase of cardiovascular disease (CVD), stroke and type 2 diabetes mellitus (T2DM). The most widely accepted definition of MetS is given by the World Health Organization (WHO), the European Group for the Study of Insulin Resistance (EGIR), and the National Cholesterol Education Program – Third Adult Treatment Panel (NCEP ATP III) and given as concomitant occurrence of at least three out of five abnormalities: abdominal obesity, hyperglycemia (insulin resistance), hypertriglyceridemia, low HDL-cholesterol and hypertension (NCEP, 2001; WHO, 1999).

The MetS occurrence has a multifactorial nature, having aspects linked to genetic (endogenous) and also environmental (exogenous) factors, such as habits related to lifestyle, physical activity, food and nutritional quality (Tureck, 2015). Studies show that the incidence of MetS tends to increase with age, because physiological changes that come from aging have common points in biochemical changes of MetS (Stout, et al., 2017). The MetS occurrence has been increasing not only due to the extension of life, but also due to the greater demand and supply of industrial foods, together with the reduction in physical activity, which favor the development of CVD (Battelli, et al., 2019). Overall, MetS is closely linked to overweight, obesity and

inactivity. Studies strengthen the significant association between remaining or becoming physically inactive and a greater chance of developing metabolic syndrome (Santos, et al., 2020).

During the past several decades, MetS prevalence has markedly increased worldwide (Borch-Johnsen, 2007). The estimated prevalence vary widely based on the criteria used for the definition of MetS and according to lifestyle of populations (Nsiah et al., 2015). However, it was estimated that 20 to 35% of the world's population has MetS (O'Neill & O'Driscoll, 2015; Saklayen, 2018). For example, in the United States nearly 35% of all adults and 50% of those aged 60 years or older were estimated to have the metabolic syndrome (Aguilar, et al., 2015); while in Chinese adults the MetS prevalence is 14.03% (Xu, et al., 2020). The MetS prevalence in the Brazilian adult's population range of 29.6 to 38.4% (de Carvalho, et al., 2003; Oliveira, et al., 2020). However, these ratios vary enormously between the Brazilian states, due mainly to social and economic discrepancies. In addition, data on MetS prevalence among rural and vulnerable populations in Brazil are still limited. Passo do Lontra is a small community of approximately 264 inhabitants, located in a region belonging to the Brazilian Pantanal biome that has difficulties in accessing health services. The community is located on the banks of the Miranda River and the Pantanal Park Road, far 315 km away from Campo Grande, capital of the Mato Grosso do Sul state, Brazil. The riverside community is composed of people with low income, who provide low-cost services to the owners of inns and fishing ranches. Moreover, about 69% of the residents in this community have an incomplete primary education, which reflects in low levels of basic education (Ribeiro, 2018; Costa, et al., 2017).

Overall, it has been observed that rural communities have a high incidence of MetS, a fact associated with the incorporation of higher consumption of high-calorie foods and lower levels of physical activity (Echavarría-Pinto, et al., 2006; Grandinetti, et al., 2005). Thus, epidemiological and situational diagnosis is important for primary health care, as it serves as a basis for the development of preventive measures. In this way, we aimed to determine the MetS prevalence and associated risk factors in a riverside population living in Pantanal biome from Mato Grosso do Sul, Brazil. Furthermore, we performed subgroup analyses stratified by gender or anthropometric and laboratory parameters to clarify the MetS association with each component.

## 2. Materials and Methods

### *Study Design*

This investigation was a retrospective cross-sectional study conducted from March 2010 to July 2016 at the ''Base de Estudos do Pantanal—BEP'' [Pantanal Study Base], located in the Passo do Lontra community at the Brazilian Pantanal in Mato Grosso do Sul state [19º34'37″S e 57º00'42″ W]. This study was approved by the ethics committee of the HUMAP hospital from the Universidade Federal de Mato Grosso do Sul – UFMS (CAAE: 69793917.0.0000.0021).

### *Data source and study population*

This study included data from individuals above 18 years old without missing information on record health database of a university project, which is developments by UFMS professors, researchers and academic students, and that aim to ensure essential healthcare to vulnerable communities. Indigenous or quilombolas individuals (people from the remaining quilombos regions, which were communities formed by runaway slaves at the time of slavery in Brazil) were excluded from the study. Collected data were grouped in a Microsoft Excel file, without identifying patient names.

### *Anthropometric and laboratorial measurements*

The anthropometric data collected consisted in patient´s height, body weight, waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP) and BMI, which were obtained by a trained nurse team. As for the laboratory data collected, laboratory data were fasting plasma glucose (FPG), triglycerides (TG), HDL-cholesterol, Total cholesterol, non-

HDL cholesterol, LDL-cholesterol, VLDL-cholesterol and uric acid (UA) were analyzed from venous blood sampling after overnight fasting.

Patient´s weight and height, the body mass index (BMI) was calculated using the ratio between body weight in kilograms and height expressed in meters squared ($kg/m^2$), based on the procedures of the World Health Organization (WHO, 1995). Healthy, overweight and obesity groups were classified according to WHO BMI criteria, using BMI cut-off values: (i) healthy BMI < 25 $kg/m^2$; (ii) overweight BMI between 25 to 29.9 $kg/m^2$; and (iii) obese BMI ≥ 30 $kg/m^2$. At the same time, obesity is frequently subdivided into three main categories, based on one's BMI: (i) class 1: BMI of 30 to < 34.9; (ii) class 2: BMI of 35 to < 39.9; and (iii) class 3: BMI > 40 (Weir & Jan, 2021).

### *Metabolic syndrome definition*

MetS was defined as the concomitant presentation of at least three of MetS parameters, defined by the National Cholesterol Education Program/Adult Treatment Panel (NCEP/ATP III, 2001): (i) abdominal obesity as measured by WC (cut-offs male ≥ 102 cm, female ≥ 88 cm); elevated TG (≥150 mg/dl or statins use); (iii) low HDL-c levels (< 40 mg/dl or use of medication); elevated blood pressure or hypertension (HNT) (systolic/diastolic ≥130/85 mmHg or use of antihypertensive medication); and (v) elevated FPG (>100 mg/dl or use of hypoglycemic agents).

### *Statistical analysis*

Results are presented as n (%) or mean and standard deviation (SD). The association analysis between categorical variables with the presence or absence of MetS was performed using the chi-square test or Fisher's test. The comparison among quantitative variables (total cholesterol, LDL cholesterol, non-HDL cholesterol, VLDL cholesterol and BMI) and the presence or absence of MetS was performed using the student's t-test or Mann-Whitney U test. For these variables, the Shapiro-Wilk normality test was applied. The other results of the evaluated variables were presented descriptively in the form of tables. Linear regression was used to check whether the MetS trend is significant. To analyze the non-parametric correlation between UA and quantitative variables (BMI, body weight, total-cholesterol, VLDL-cholesterol, HDL-cholesterol, FPG, WC, TG, SBP, DBP, LDL-cholesterol and non-HDL cholesterol) we used the correlation Spearman, to help us understand how the variability of one can affect the other. The data was analyzed using Jamovi statistical program, version 1.6 for Windows, considering a significance level of $p \leq 0.05$.

## 3. Results

A total of 81 adult individuals, being 36 (44.4%) females and 45 (55.6%) males were enrolled in this study, which was equivalent to about 30% (81/264) from Passo do Lontra community live-in at the Brazilian Pantanal. The characteristics of adults who participated in the regular health check-up between 2010 to 2016 are presented in Table 1. The overall MetS prevalence in the studied population was 40.7% (33/81) of the adults. According to the number of diagnostic components of MetS, only 14.8% of total adult individuals had zero components, and 3.7% had all five components. Among those with MetS diagnosis, the majority (91%) presented 3 or 4 components simultaneously (Table 1). Among anthropometric and laboratory measurements, the majority presented mean above the cut-off values, such as FPG, TG, female WC, SBP, total cholesterol and BMI values.

**Table 1** – Characteristics of study population, Passo do Lontra, MS, Brazil, 2010 to 2016.

| **Characteristics** | **Values** |
|---|---|
| Number of enrolled individuals | 81 |
| **Gender** | **% (n)** |
| Female | 44.4 (36) |
| Male | 55.6 (45) |
| **MetS diagnosis** | **% (n)** |
| MetS (-) | 59.3 (48) |
| MetS(+) | 40.7 (33) |
| **Number of MetS components** | **% (n)** |
| 3 | 55.5 (17) |
| 4 | 39.4 (13) |
| 5 | 9.1 (3) |
| **Anthropometric and laboratory measurements** | |
| **MetS parameters** (cut-off values) | **mean ± SD** |
| Fasting Plasma Glucose (FPG) (>100 mg/dL) | 103 ± 42.3 |
| Triglycerides (TG) (> 150 mg/dL) | 157 ± 108 |
| HDL cholesterol (< 40 mg/dL) | 50.3 ± 52 |
| WC - female (≥88 cm) | 93.4± 12 |
| WC - male (≥ 102 cm) | 94.6 ± 14 |
| SBP (≥ 130 mmHg) | 132.1 ± 24.6 |
| DBP (≥ 85 mmHg) | 84.1 ± 13.8 |
| **Other parameters** (cut-off values) | **mean ± SD** |
| Total cholesterol (> 190 mg/dL) | 195 ± 48.4 |
| Non-HDL cholesterol (>160 mg/dL) | 78 ± 25.9 |
| LDL cholesterol (>130 mg/dL) | 117 ± 43.9 |
| Uric acid - female (>6 mg/dL) | 4.65 ± 1.31 |
| Uric acid - male ( > 7 mg/dL) | 5.84 ± 1.42 |
| BMI (>25 kg/m$^2$) | 28.5 ± 6.14 |

WC: waist circumference; BMI: body mass index. Source: Authores

Table 2 summarizes the association results between MetS (+) prevalence and categorical variables. There was no difference in MetS (+) prevalence between gender (p-value = 0.288). However, according to WHO BMI criteria, there was a significant association between obesity and MetS (+) (p-value <0.001). There was also a significant association between the obesity levels and MetS (p-value 0.034).

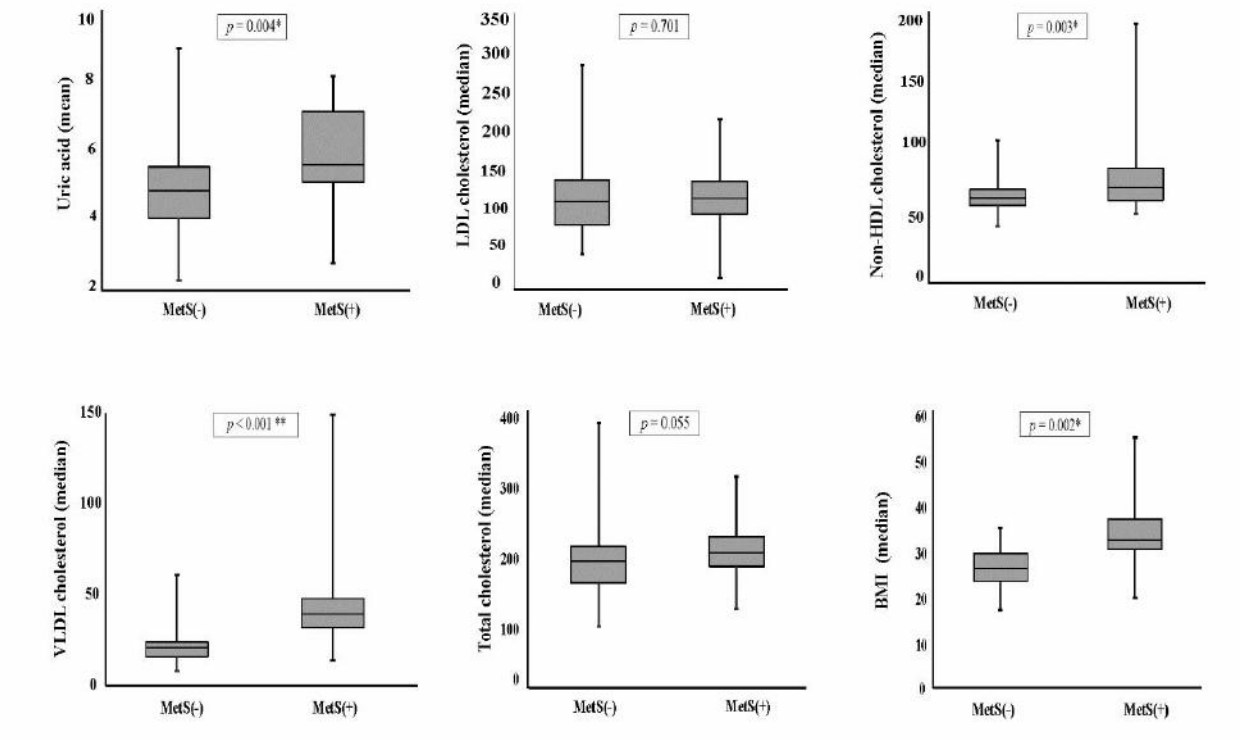
**Table 2** - Categorical variable comparisons according MetS status, Passo do Lontra, MS, Brazil, 2010 to 2016.

| | MetS (-) % (n) | MetS (+) % (n) | *p-value* |
|---|---|---|---|
| **Gender** | | | |
| Female | 52.8 (19) | 47.2 (17) | 0.288 |
| Male | 64.4 (29) | 35.6 (16) | |
| **WHO BMI criteria** | | | |
| Healthy | 95.5 (21) | 4.5 (1) | <0.001* |
| Overweight | 60.6 (20) | 39.4 (13) | |
| Obese | 26.9 (7) | 73.1 (19) | |
| **WHO classification of obesity levels** | | | |
| Class I | 46.7 (7) | 53.3 (8) | 0.034* |
| Class II | 0 (0) | 100 (7) | |
| Class III | 0 (0) | 100 (4) | |

*Statistically significant (p-value < 0.05) using chi-square or Fisher's exact test. Source: Authores.

In addition, when comparing quantitative variables between adult individuals with or without MetS (Figure 1), the results revealed a significant increase between in the levels of uric acid, non-HDL cholesterol, VLDL cholesterol and BMI. In contrast, there were no differences between LDL and total-cholesterol in the studied group.

**Figure 1** – Graphical representation of quantitative variables between adult individuals with or without MetS.




*$p$-value < 0.05 and **$p$-value ≤ 0.001 for statistically significant. Source: Authores.

In a correlation analysis, UA was significantly and positively correlated with BMI ($\rho$=0.417, p<0.001), body weight ($\rho$=0.509, p<0.001), VLDL-cholesterol ($\rho$=0.44, p<0.001), WC ($\rho$=0.405, p<0.001), TG ($\rho$=0.435, p<0.001), SBP ($\rho$=0.252, p=0.02), and non-HDL cholesterol ($\rho$=0.288, p=0.009) (data not shown).

## 4. Discussion

The overall MetS prevalence found in the studied population was 40.7%. This ratio was higher than those in previous reports (range from 29.6 to 38.4%) for the average Brazilian adult population (de Carvalho, et al., 2003; Oliveira, et al., 2020). The MetS prevalence in this study was also higher than the one found in populations in other Latin American countries (Márquez-Sandoval, et al., 2011), such as Colombia, Venezuela, Peru and Mexico; in addition, it was also higher than the global estimate (20 to 35%) (O'Neill & O'Driscoll, 2015; Saklayen, 2018). It is important to highlight the high MetS prevalence and obesity found in the riverside population studied. When emphasizing the most vulnerable populations, it is know that from the view point of health care coverage, these people are more likely to have more chronic conditions (Blanquet, et al., 2019), such as diabetes and hypertension, as well as MetS components and the metabolic syndrome itself, corroborating our findings.

Overweight and obesity are associated with metabolic syndrome and abdominal obesity, thereby increasing the risk of type 2 diabetes mellitus and cardiovascular diseases (Sattar, et al., 2003). Here, we showed that MetS and its components were significantly more frequent among obese than healthy, mainly to II and III classes of obesity. Brazil has demonstrated growing estimates of obesity and overweight, which, consequently, can increase the risks of MetS development (Kelly, et al., 2008; Saklayen, 2018; Tzika & Dreker, 2018).

Studies have highlighted the association between MetS with greater risks for CVD (Hadaegh, et al., 2012; Ladla, et al., 2021). A study by Agarwal et al. (2012) in an elderly population in the USA found a 1.71-times increase in the risk of cardiovascular disease for those with metabolic syndrome. Changes in the lipid profile are a major risk factor for the CVD development of cardiovascular and cerebrovascular diseases, such as atherosclerosis, brain stroke and acute myocardial infarction. Our results suggest that; non-HDL and VLDL cholesterol increases were associated to MetS. This is probably due to the poor diet and lack of physical activity of the Passo do Lontra community.

MetS is often characterized by oxidative stress, a condition that results from the imbalance between the production and inactivation of reactive oxygen species (ROS) (Roberts & Sindhu, 2009). Oxidative stress is thought to play a major role in the pathogenesis of a variety of human diseases, including atherosclerosis, diabetes, hypertension, aging, Alzheimer's disease, kidney disease and cancer (Roberts & Sindhu, 2009; Halliwell & Gutteridge, 2015). In addition, the obesity and its comorbidities have been associated with oxidative stress (Boesing, et al., 2010; Halliwell & Gutteridge, 2015).

Uric acid is responsible for 60% of the plasma elimination of ROS (Simão, et al., 2008; Parisotto, et al., 2014). Our data showed an association between increased uric acid values and MetS, which suggests that the increase in AU could be a compensatory mechanism for ROS neutralization in MetS, which on the other hand may contribute to the pathogenic process of MetS.

Another risk factor that we would like to highlight is elevated uric acid. Under normal conditions, UA is the main antioxidant in plasma. However, when there is an increase in their circulating levels, cardiometabolic diseases may develop (Lee, et al., 2020). In our study, the majority of MetS (+) adults presented hyperuricemia compared to Mets (-) status. Studies have called attention that hyperuricemia could be not only a consequence of insulin resistance states but also a significant predictor of the development of metabolic syndrome (Borges et al., 2010). Therefore, serum UA had been suggested as an independent risk factor for MetS (Yoo, et al., 2005; Özalp, et al., 2019; Ciarla, et al., 2014; Wang, et al., 2018; Maloberti, et al., 2020; Magalhães, et al., 2021).

## 5. Conclusion

Our findings revealed a high prevalence of MetS in adults from Passo do Lontra community, with no distinction between genders. It was also demonstrated that the MetS presence is associated with the emergence of other disorders, such as increased UA, BMI and non-HDL and VLDL cholesterols, important risk factors for the CVD emergence. The retrospective design and the relatively small population of this study make the findings difficult to interpret. However, this is the first study reporting the MetS prevalence in a riverside and vulnerable population in Brazil. Therefore, our results provide important evidence on the MetS prevalence as a public health problem, particularly for obese, dyslipidemic and hyperuricemic individuals that live in areas with difficulties in accessing health services. Our results reinforce the urgency on health care to prioritize the most vulnerable population.

### Author Contributions

RFAZ, WFOF, APAS and SSW conceptualized and designed the study. RFAZ, WFOF, VAO and APAS worked on data acquisition. RFAZ, KM, VAO, EBP, ASS and SSW analyzed and interpreted the data. ASS and ECAB performed the statistical analysis. RFAZ, KM, ECAB and SSW drafted the manuscript. WFOF, APAS and EBP critically revised the manuscript.

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### Conflict of interests

The authors have declared that no competing interests exist

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