

# Nutritional and Metabolic Diseases: Profile and Financial Impact of Hospitalizations in the Brazilian National Health System

Isabelle Aguiar Carvalho Andrade<sup>1</sup>, Anna Júlia Leles Mendes<sup>1</sup>, Bruna Brito Silva Gonçalves<sup>1</sup>, Ítalo Luiz Azevedo Santos<sup>1</sup>, Luís Gustavo Antunes Miranda<sup>1</sup>, Matheus Mendes dos Santos Ferreira<sup>1</sup>, Karina Andrade de Prince<sup>2</sup>

<sup>1</sup>Medical Student at FIPMoc University Center - UNIFIPMOC, Montes Claros, Minas Gerais, Brazil.

<sup>2</sup>PhD in Biosciences and Biotechnology Applied to Pharmacy and professor at the University Center FIPMOC - UNIFIPMOC, Montes Claros, Minas Gerais, Brazil.

Email address: <sup>1</sup>bell\_aguiar15@outlook.com <sup>2</sup>karina.prince@professor.unifipmoc.com.br

**Abstract**—Metabolic diseases are associated with oxidative stress and inflammation in the body, altering human physiological functions. Nutritional diseases, on the other hand, are defined as the absence of balance between intake and utilization of nutrients by the body. Both groups of diseases are associated with lifestyle, characterized by inadequate dietary intake, intestinal dysbiosis, and sedentary behavior. The objective of this study is to analyze the profile and financial impact of hospitalizations for nutritional and metabolic diseases in the Brazilian National Health System (SUS) between 2017 and 2021. This is a documental, observational, retrospective study with quantitative design, which evaluated the sociodemographic, clinical profile and the financial impact of hospitalizations for metabolic disorders on the Unified Health System (SUS) in the period from January 2017 to December 2021 in all regions of Brazil. The variables studied include sociodemographic (gender, age group and color/race) and clinical (number of hospitalizations, prevalence of hospitalizations according to regions, regime and character of hospitalizations, average length of stay, deaths, mortality rate and hospital expenditures). In general, the Southeast region had the most hospitalizations and the highest mortality rate, followed by the Northeast. The disease with the highest number of hospitalizations was Diabetes Mellitus in all regions with 130,767 procedures. The total amount spent by SUS for the three diseases (Obesity, Malnutrition, and Diabetes Mellitus) in the country was 932,166,082.2 Reais in this period. It was observed that nutritional and metabolic diseases represent a large portion of the hospitalization rates in the Brazilian Unified Health System (SUS), generating high expenditures for the public budget. With the increasing prevalence of these diseases and the reduction of investments in public health, it is necessary to reflect on effective interventions to reduce the development of complications from these conditions.

**Keywords**—Diabetes mellitus; Hyperlipidemia; Malnutrition; Nutritional and metabolic disease; Obesity.

## I. INTRODUCTION

Metabolic diseases are disorders developed by the dysregulation of the complex network of cellular pathways, on which perform the connection and biomolecular interaction that aim to maintain life [1]. Nutritional diseases, on the other hand, are defined by the absence of balance between intake and utilization of nutrients by the body [2]. Both groups of diseases are characterized by having association with contemporary

lifestyle, by inadequate dietary intake, intestinal dysbiosis and insufficient practice of physical exercises [1, 3, 4].

In addition, metabolic disturbances are associated with oxidative stress and inflammation in the body, which accelerates the aging process [5]. Moreover, the oxidative stress promoted by the nutritional state generates an increase in lipid peroxidation products and a reduction in the antioxidant system, resulting in a situation of chronic inflammation [6]. They are responsible for promoting a diversity of alterations in human physiological functions, including cardiovascular, pulmonary, renal, visual, immunological, and cognitive dysfunction [7, 8, 9, 10].

Both groups of diseases are characterized by complex metabolic changes and negative impacts on human health in view of the strong relationship with cardiovascular diseases [11]. Furthermore, it is worth noting the association of the increased prevalence of obesity and overweight in children and adolescents in the country with the emergence of these disorders, which generates repercussions both in youth and adulthood [12]. Thus, the increase in these diseases has impacted the quality of life of the general population and generated concern in public agencies of nutrition and health [13].

Therefore, state policies need to act on risk factors such as diabetes mellitus, malnutrition, dyslipidemia and obesity with a holistic change in the global food system to reduce morbidity and mortality from these diseases [14]. Knowing that there is a significant financial cost of public health with hospitalizations, the need arose to develop a research that will serve as a source of information for new studies related to the topic. There are still limitations as to the number of studies related to the regions of Brazil. Like so, it is important that the sociodemographic and clinical profile of nutritional and metabolic diseases in the country be seen, in order for a resolute intervention directed to the population at higher risk, seeking to reduce expenses, hospitalizations, functional impairments, and mortality in the economically active population. With this, it becomes necessary to analyze the profile and financial impact of

hospitalizations for nutritional and metabolic diseases in the Brazilian National Health System from 2017 to 2021.

Diabetes Mellitus is a diverse group of metabolic changes that correspond to a classic finding of hyperglycemia in which can be consequences polyuria, weight loss, polydipsia, fatigue and even ketoacidosis and increased vulnerability to infections [15]. There are several forms of diabetes, the most important being type 1 diabetes that occurs from the absolute lack of insulin due to autoimmunity and type 2 related to insulin resistance and hyperglycemia [16].

Diabetes Mellitus type 1 and 2 are very common chronic diseases that lead to great losses both in terms of patients' health and health care costs [17]. This comorbidity has emerged as a serious health issue health since 2015. Estimates showed that more than 8% of the adult population was affected and, in the future, it is estimated that this number will exceed 10%, most of which corresponds to Diabetes Mellitus type 2 with more than 90% of cases [18].

Malnutrition is defined by inadequate intake or absorption of one or more nutrients and is related to the impairment of adverse health conditions, with organic repercussions, reducing the quality of life of the individual [19]. This is a serious public health issue considered, worldwide, one of the most frequent problems in the elderly population, commonly found in underdeveloped countries and also in developed. [20]

Dyslipidemias are modulated by genetic and environmental factors that can alter the values of Total Cholesterol (TC), Triglycerides (TG), Low Density Lipoprotein Cholesterol (LDL) and High-Density Lipoprotein Cholesterol (HDL) [21]. Increased TC and LDL, as well as decreased HDL contribute to the development of Coronary Artery Disease (CAD), atherosclerosis, and High Blood Pressure (HBP), and can occur from a young age, worsening during adulthood [22].

The categorization of obesity to World Health Organization (WHO) takes into account Body Mass Index (BMI). This division was separated into 3 subtypes: grade I obesity (30 to 34.9kg/m<sup>2</sup>), grade II obesity (35 to 39.9kg/m<sup>2</sup>) and grade III obesity (40kg/m<sup>2</sup> or more). However, the increase in BMI can occur due to several factors, including increased muscle mass. The phenotype of each patient presents different metabolic and/or inflammatory alterations, being a risk factor for other pathologies in a different way, and among the phenotypes mentioned, visceral fat increase is the main subtype associated with other Chronic Noncommunicable Diseases [23].

## II. OBJECTIVE

The main objective of this study is to analyze the profile and financial impact of hospitalizations for nutritional and metabolic diseases in the Brazilian National Health System from 2017 to 2021.

## III. METHODS

This is a retrospective, descriptive, quantitative, documentary-based study, with comparative-statistical procedure. It had as research universe the database of the Hospital Information System of the Unified Health System (SIH/SUS), referring to the sociodemographic and clinical profile and the financial impact of hospitalizations due to

metabolic disorders in the Unified Health System (SUS) in the period between 2017 and 2021. The data was obtained from the SIH/SUS, made available by the Department of Informatics of the Unified Health System (DATASUS), at the electronic address (<http://www2.datasus.gov.br>).

The hospitalizations were selected from the tenth version of the International Classification of Diseases (ICD 10), which was developed by the World Health Organization (WHO) to monitor the incidence and prevalence of diseases through a universal standardization by codes, composed of letters and numbers, of diseases and public health problems.

Data collection occurred in the month of September 2022 through the use of the Health Information Program (TABNET). The tabulation of the SIH/SUS records for the research included: sociodemographic variables (gender, age group, and ethnicity) and clinical variables (number of hospitalizations, mortality rate per year and according to the regions of the country, metabolic disorders according to the ICD-10 morbidity list, total and mean value of hospitalizations, mean length of stay).

A descriptive analysis of the variables was performed, with frequency, percentage and average number of cases recorded. Microsoft Office Excel® software and the Statistical Package for the Social Sciences® (SPSS) program for Windows®, version 25 (Chicago, IL, USA), were used for data management and analysis.

Considering that the research was based on data made available electronically by the Ministry of Health, which are in the public domain, and due to the fact that there is confidentiality about the identification information inherent to the human beings involved, this study does not require the review and approval of the Research Ethics Committee.

## IV. RESULTS

In the period from 2017 to 2021, 857,490 hospitalizations for endocrine nutritional and metabolic diseases Brazil were reported. The number of ranged from 155,383, with an average of 171,498 cases annually. An increase in hospitalizations was observed between 2017 and 2019 (3.6%) and a decrease in 2020 (16.2%) and 2021 (15.7%). However, the mortality rate was higher in 2020 and 2021 (6.09%), during Covid-19 pandemic period (Figure 1).

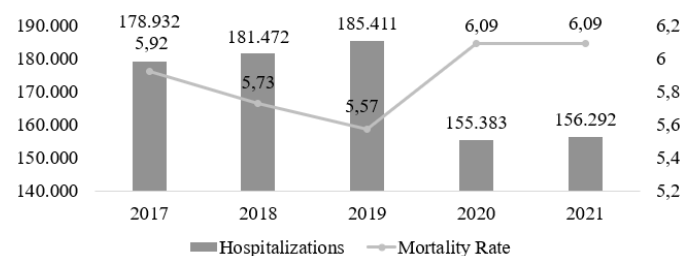


Fig. 1. Number of hospitalizations and mortality rate for endocrine nutritional and metabolic diseases in Brazil, 2017 to 2021.

Regarding the number of hospitalizations and mortality rate by region, we see a higher number and higher rate in the Southeast (37.2% and 7% respectively) and Northeast (30% and 6% respectively) (Figure 2).

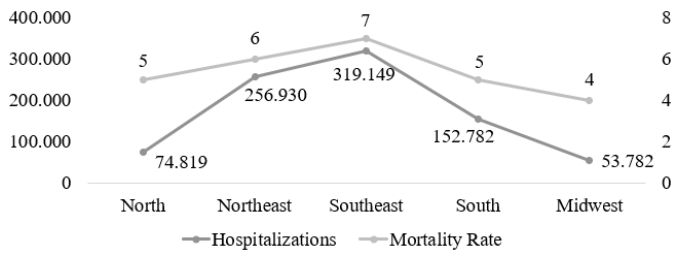


Fig. 2. Number of hospitalizations and mortality rate for endocrine nutritional and metabolic diseases according to regions of Brazil, 2017 to 2021.

Hospitalization; AVH: Average Value Hospitalization; TV: Total Value; DM: Diabetes Mellitus; MS: Malnutrition and its Sequelae; OB: Obesity

According to the sociodemographic and clinical data of the patients analyzed hospitalized for Diabetes Mellitus, there is a predominance of the disease in males (50.35%), in the age group  $\geq 70$  years (28.61%), and in browns (39.44%). As for malnutrition and sequelae, similarly to the patients hospitalized for DM, there was a predominance in males (55.50%), in ages  $\geq 70$  years (39.65%), and in brown skin color/race (37.27%). Finally, regarding patients hospitalized for obesity, there is a predominance of the disease in females (86.55%), in the age range of 30 to 39 years (33.15%) and in the color/race white (62.74%). As for the type of care, most cases of patients hospitalized for Diabetes Mellitus and malnutrition and sequelae were emergencies (94.59% and 95.36%, respectively), while elective hospitalizations stood out in patients hospitalized for obesity (90.59%) (Table 2).

TABLE II. Sociodemographic and clinical data of patients hospitalized for nutritional and metabolic endocrine diseases in Brazil, 2017 to 2021.

Variables	Diabetes Mellitus	Malnutrition and Sequelae	Obesity
<b>Sex</b>			
Male	329.249	82.887	7.305
Female	324.587	66.450	47.012
<b>Age Group</b>			
Less than 10 years old	14.548	21.429	14
10 to 19 years old	31.530	3.825	511
20 to 29 years old	26.991	4.450	8.336
30 to 39 years old	38.436	7.828	18.006
40 to 49 years old	69.121	12.256	15.912
50 to 59 years old	128.608	18.019	8.992
60 to 69 years old	160.513	22.323	2.418
More than 70 years old	184.089	59.207	128
<b>Color/race</b>			
White	180.651	46.649	34.081
Black	30.093	7.133	2.101
Brown	257.869	55.661	12.312
Yellow	21.437	3.336	415
Indigenous	1.482	1.178	2
No information	162.304	35.380	5.406
<b>Character</b>			
Elective	35.332	6.931	49.208
Urgency	618.504	142.406	5.109

Regarding hospitalizations, Diabetes Mellitus had the highest number in all regions, an average of 130,767, the lowest number being in the Midwest (44,861) and the highest in the Southeast (236,113). Followed by Malnutrition, with an average of 29,867, with the highest number in the Southeast (63,395) and the lowest number in the Center-West (7,617), except in the South region, in which Obesity ranked second in hospitalizations, with a number of 19,641, its average being 10,863, and the region with the lowest number in this category was the North (345). In relation to mortality, Malnutrition and its sequelae obtained the highest number in all regions, with a total rate of 14.1. The average hospitalization rate for malnutrition was the highest in all regions of Brazil, a total of 7.4. It was highest in the Northeast region (8.3) and lowest in the South (6.8). Whereas the lowest average hospitalization rate was for Obesity, with a total of 2.8.

The total value of hospitalizations by SUS of the three diseases in the country from 2017 to 2021 was 932,166,082.2 Reais. It is observed that the highest total value spent on hospitalizations was for Diabetes Mellitus, with a cost of 524,065,376.39 Reais, owning an average hospitalization value of 622.012, followed by Obesity, which obtained a total value of 285,763,906.96, being the condition with the highest average value per hospitalization (average of 3,640.66 Reais) and finally Malnutrition, with the lowest value spent of 122,336,798.85 and an average value per hospitalization of 950.65 (Table 1).

TABLE I. Hospitalizations, mortality rate, average length of stay, mean value and total value of hospitalizations for nutritional and metabolic endocrine diseases, according to regions of Brazil, 2017 to 2021.

R	D	H	%	MR	AH	AVH	TV
N	DM	65.966	88,2	4,3	6,7	668,4	44.021.072,46
	MS	8.508	11,4	9,6	7,1	795,27	6.764.256,74
	OB	345	0,5	0,3	4,1	3.401,27	1.173.437,68
Ne	DM	209.753	81,6	4,8	6,7	668,56	144.007.225,92
	MS	43.003	16,7	15,8	8,3	1.003,15	43.131.418,97
	OB	4.174	1,6	0,3	3,4	4.245,82	17.722.046,72
Se	DM	236.113	74,0	4,8	6,5	938,03	221.480.046,22
	MS	63.395	8,4	16,0	7,2	1.034,05	45.880.138,94
	OB	19.641	6,2	0,3	3,1	7.615,72	90.657.326,11
S	DM	97.143	36,6	3,6	5,4	835,23	81.136.924,76
	MS	26.814	17,6	14,6	6,8	1.040,87	19.862.046,65
	OB	28.825	0,9	0,1	2,5	5.940,47	171.234.103,01
M	DM	44.861	83,4	3,5	6,0	743,64	33.360.107,03
	MS	7.617	14,2	10,9	7,3	879,92	6.698.840,69
	OB	1.332	2,5	0,3	3,6	3.736,48	4.976.993,44
T	DM	653.836	76,2	4,5	6,4	801,52	524.065.376,39
	MS	149.337	17,4	14,1	7,4	839,46	122.336.798,85
	OB	54.317	6,3	0,2	2,8	5.261,03	285.763.906,96

R: Region; N: North; Ne: Northeast; Se: Southeast; S: South; M: Midwest; T: Total; D: Disease; H: Hospitalization; MR: Mortality Rate; AH: Average

## V. DISCUSSION

By analyzing the results, it was possible to notice a high number of hospitalizations for endocrine nutritional and metabolic diseases in greater Brazil, mainly in the southeast and northeast regions in the last 5 years, evidencing a worrisome situation. Between 2017 and 2019 the percentage of hospitalizations increased 3.6% and in 2020 and 2021 decreased 16.2% and 15.7% respectively, period of the COVID-19 pandemic.

The appearance of these complications, are a result of the current sedentary lifestyle of the population associated with dietary imbalances and the aging of the citizens, causing obesity, dyslipidemia pictures, systemic arterial hypertension, type 2 diabetes, leading to a Metabolic Syndrome picture [24].

The increase in hospitalization rates for these diseases can also be linked to the lack of demand for health services by users, who most often only seek care when hospitalization is already

necessary, when there is ignorance of the disease itself and of preventive measures or by refusal of self-care [25]. This condition tends to impair the quality of life of the patient, increasing the burden on the health service [26].

The reduction in the number of hospitalizations during the pandemic period of COVID-19 may be related to the fact that during this period many services were suspended or reduced, such as elective surgeries, transplants and procedures with diagnostic purposes. In addition, many patients stopped seeking services for fear of contracting the infection and the social distancing together with the *lockdown* significantly promoted the reduction of trauma and, consequently, the hospitalizations for external causes, promoting a reduction in the number of hospitalizations in general [27].

The mortality rate for endocrine nutritional and metabolic diseases in Brazil was lower between 2017 and 2019 and higher in the period of the COVID-19 pandemic, predominating in the southeast (7%) and northeast (6%) regions. The epidemiological survey conducted by Formiga (2014), also highlights a higher mortality rate for endocrine, nutritional and metabolic diseases in the northeast and southeast regions, which translates as an association the educational and socioeconomic factors [28].

These nutritional and metabolic disorders have an impact on the health-disease process of the population. In this sense, it is observed that the mortality of these diseases is related to the lifestyle of the population, since with the changes in living standards from the second half of the twentieth century, with the change in eating habits, decreased physical exercise and stress recurrence accentuate the development of these diseases [29]. Thus, identifying the factors involved in the progression of the severity of these diseases helps in risk stratification to generate more effective interventions [30].

Regarding the number of hospitalizations according to the list of nutritional and metabolic endocrine diseases, Diabetes Mellitus (DM) had the highest number in all regions, with a higher prevalence in the Southeast and Northeast regions of the country. This result is ratified by the study conducted by Negreiros (2021), which showed a predominance in these regions regarding the number of hospitalizations for DM in the period from 2016 to 2020 [31].

The higher number of hospitalizations for DM demonstrates the reality of a disease susceptible to serious complications, and according to Negreiros (2021), several biopsychosocial factors lead the patient to develop them [31]. Moreover, there is a prevalence of this condition in people with low levels of education and family income, explaining the difficult control of this pathology in the cited population, being also associated with increased sedentary lifestyle and poor eating habits.

Regarding mortality, the highest rate found was due to malnutrition and its sequelae in all regions of Brazil, besides being more prevalent in the elderly, which corroborates the fact that the total number of deaths by age group is increasing. This is intrinsically related to the increase in population aging, a reflection of the increased life expectancy in the country in recent decades [32].

In addition, malnutrition was the category that obtained the highest number of days hospitalized in all regions, with a total

average of 7.4. This is because other chronic conditions in the elderly can lead to complications during hospitalization, prolonging their length of stay [33]. On the other hand, Obesity showed shorter hospitalization time, with a total mean of 2.8 days. Fact related to the possible negative outcomes of hospitalizations, since obese patients tend to have more postoperative complications than non-obese patients, increasing the mortality rate in the hospital environment [34].

Regarding the amounts spent, Obesity led with the highest amount per hospitalization, mainly due to the high cost of surgical interventions for bariatric procedures. Despite this, it is a financially advantageous measure in patients with DM who are also obese, since Diabetes leads in number of hospitalizations in Brazil, indirectly fighting complications and hospitalizations for this disease [35]. In addition, obesity is more prevalent in the South and Southeast regions, and according to Ramos (2020), it is a disease more incident in developed and urbanized regions, explaining the data found, since they are the places considered more developed in the country [36].

Observing the sociodemographic profile of inpatients with DM, there is a slight predominance of males (50.35%), in the age group greater than or equal to 70 years (28.61%) and of brown skin color/race (39.44%). These data showed to be controversial in relation to the study conducted by Malta (2019) that identified a higher prevalence in females and in black color/race, however, the same study highlights the higher prevalence of females in treatment, thus reducing the worsening of morbidity and the need for hospitalizations [37, 38].

Furthermore, research by Pallason (2021) found a higher prevalence of hospitalization for Diabetes Mellitus involving males (23.0 per 10,000 population) compared to females (18.4 per 10,000 population), as observed in the data [39].

In the age group of 10 to 19 years, a significant increase in hospitalizations for DM is observed in relation to the age group younger than 10 years, with an increase of (116, 73%). With the development of protocols and medications related to the complications of DM, there has been a reduction in the mortality rate of children with DM, in view of this, the number of hospitalizations of this age group, which has a higher risk of complications, due to low adherence to the means of treatment and late diagnosis of DM, presents itself in growth [40].

In the sociodemographic profile of patients hospitalized for malnutrition and sequelae, we evidenced a predominance in the age group over 70 years (39.65%) and in the range of 60 to 69 years (14.98%), bearing in mind that the process of population aging makes the population more vulnerable to the development of pathologies resulting from nutritional deficiency [41]. Among the factors contributing to this increase, it stands out the growth in the number of obese elderlies, which due to the appearance of an individual with large energy reserve, masks the presence of malnutrition associated with essential substances [19].

In addition, the third most affected age group is those younger than 10 years old (14.34%). In the period of the COVID-19 pandemic, from 2020 to 2021, there was an increase in the National Consumer Price Index which generated an increase in general family expenses, among them food,

affecting child nutrition in low-income families in Brazil [42]. Thus, it is noticeable the need for permanence and improvement of measures already implemented to combat child malnutrition, especially in the post-pandemic period [43].

The most affected color/race was brown (34.93%), showing a correlation with socioeconomic status, especially education and income, acting as factors that expose this portion of the population in a position of vulnerability to malnutrition and sequelae [44]. It was observed greater hospitalization of an emergency nature (95.36%), it is worth noting that many patients hospitalized for other reasons the length of hospitalization proves to be significant for the increase of patients in a state of nutritional deficiency, and consequently increased emergency hospitalization [45].

The current study showed 54,317 obesity-related hospitalizations, of which 47,012, approximately 86.5%, are female and 7,305, approximately 13.4%, are male. Other studies, such as about bariatric surgeries performed by the single health system between 2010 and 2016, had similar numbers to this article, being 46,035 hospitalizations. Still, of this total, 39 thousand hospitalizations were female patients, approximately 85%, and more than 6 thousand male patients, approximately 14% [46].

The total number of hospitalizations for obesity in Brazil between 2017 and 2021 was more than 6 times higher among females than males. This numerical discrepancy can also be explained by women's concern about physical appearance than men, thus being an aesthetic motivation that is imposed by society and media [47].

The age group with more hospitalizations in relation to obesity was between 30 and 39 years and 40 and 49 years. In comparison, also, with the bariatric surgeries performed by the health system between 2010 and 2016, it was found similarity in the average age of hospitalizations evidenced 39 years, with a variation of 10 years more or less [46].

The white race had the highest number of hospitalizations (34,081), followed by the brown race with 2,101, between 2017 and 2021. In another study, it was found that south and southeast had 89% of surgeries performed in the country between 2010 and 2016 [46]. An important association is, according to Agência Brasil, that 76.8% and 52.2% declared themselves as white in the southern and southeastern regions, respectively, these two regions being, according to IBGE, the wealthiest in the country [48, 49].

Thus, this data puts into question the result obtained in the current study, since most hospitalizations were of women between 30 and 49 years of age, white, and elective, data validated with other studies, but we also know that obesity has serious deleterious consequences in children, adolescents, young adults and adults of all age groups and both sexes that burden the Unified Health System (SUS) due to the high costs with treatment and complications [50].

Regarding the limitations of this study, we point out that the use of the database of the computer department in the Brazilian National Health System (DATASUS), prepared for administrative functions, does not allow the researcher to have control over the registration and typing errors. Moreover,

manipulations are possible, given the administrative/accounting purpose of the system.

## VI. CONCLUSION

In view of the study presented, it can be seen that nutritional and metabolic diseases represent a large part of the hospitalization rates in the Unified Health System (SUS), generating high costs for public health. This reflects the impact of the lifestyle of the Brazilian population on the health-disease process with regard to eating habits, physical exercise, and mitigating factors such as stress and population aging itself.

It was observed that Malnutrition was responsible for the highest mortality rate throughout the country and Diabetes Mellitus for the highest number of hospitalizations. With the significant prevalence of these diseases and the reduction of investments in public health, it is necessary to reflect on effective interventions to reduce the development of complications from these conditions.

Although the pandemic of COVID-19 showed a decrease in the number of hospitalizations, there was a significant effect on the increase in mortality rates for these pathologies during this period due to the greater chance of worsening of the infection.

Thus, it is evident that chronic noncommunicable metabolic and nutritional diseases are a major challenge to public health in the country. Therefore, it is reinforced that health programs focused on primary prevention should be strengthened and increasingly stimulated to control the incidence as well as the secondary prevention of complications and severity.

## REFERENCES

- [1] J.V.S. Guerra, M.M.G. Dias, A.J.V.C. Brilhante, M.F. Terra, M. García-Arévalo, A.C.M. Figueira, "Multifactorial Basis and Therapeutic Strategies in Metabolism-Related Diseases," *Nutrients*, vol. 13, issue 8, pp. 1-50, 2021.
- [2] D.R. Duerksen, M. Laporte, K. Jeejeebhoy, "Evaluation of Nutrition Status Using the Subjective Global Assessment: Malnutrition, Cachexia, and Sarcopenia," *Nutrition in Clinical Practice*, vol. 36, issue 5, pp. 942-956, 2020.
- [3] M. Hancková, T. Betáková, "Pandemics of the 21st Century: The Risk Factor for Obese People," *Viruses*, vol. 14, issue 1, pp. 1-16, 2021.
- [4] M.K. Zinöcker, I.A. Lindseth, "The Western Diet-Microbiome-Host Interaction and Its Role in Metabolic Disease," *Nutrients*, vol. 10, issue 3, pp. 1-15, 2018.
- [5] K. Wagner, L. Schwingshackl, A. Draxler, B. Franzke, "Impact of dietary and lifestyle interventions in elderly or people diagnosed with diabetes, metabolic disorders, cardiovascular disease, cancer and micronutrient deficiency on micronuclei frequency – a systematic review and meta-analysis," *Mutation Research. Reviews in mutation research*, vol. 787, pp. 108367, 2021.
- [6] V. Rani, G. Deep, R.K. Singh, K. Palle, U.C.S. Yadav, "Oxidative stress and metabolic disorders: Pathogenesis and therapeutic strategies," *Life Sciences*, vol. 148, issue 1, pp. 183-193, 2016.
- [7] V. Kotsis, F. Martinez, C. Trakatelli, J. Redon, "Impact of Obesity in Kidney Diseases," *Nutrients*, vol. 13, issue 12, pp. 4482, 2021.
- [8] H. Gill, B. Gill, O. Lipsitz, N.B. Rodrigues, D.S. Cha, S. El-Halab, R.B. Mansur, J.D. Rosenblat, D.H. Cooper, Y. Lee, F. Nasri, R.S. McIntyre, "The impact of overweight/obesity on monetary reward processing: A systematic review," *Journal of Psychiatric Research*, vol. 137, pp. 456-464, 2021.
- [9] D.A. Antonetti, P.S. Silva, A.W. Stitt, "Current understanding of the molecular and cellular pathology of diabetic retinopathy," *Nat Rev Endocrinol*, vol. 17, issue 4, pp. 195-206, 2021.
- [10] M.C. Mentella, F. Scaldaferrri, A. Gasbarrini, G.A.D. Miggiano, "The Role of Nutrition in the COVID-19 Pandemic," *Nutrients*, vol. 13, issue 4, pp. 1-13, 2021.

- [11] L.V.A. Oliveira, B. Santos, "Prevalência da Síndrome Metabólica e seus componentes na população adulta brasileira," *Ciência e saúde coletiva*, vol. 25, issue 11, pp. 4269-4280, 2020.
- [12] M.C.C. Kuschmir, K.V. Bloch, M. Szklo, C.H. Klein, L.A. Barufaldi, G.A. Abreu, b. Schaan, G.V. Veiga, T.L.N. Silva, M.T.L. Vasconcelos, "ERICA: prevalência de síndrome metabólica em adolescentes brasileiros," *Revista de Saúde Pública*, vol. 50, issue. suppl 1, pp. 1s-11s, 2016.
- [13] A.P.S. Ferreira, A.L. Szwarcwald, G.N. Damacena, P.R.B. Souza Júnior, "Aumento nas prevalências de obesidade entre 2013 e 2019 e fatores associados no Brasil," *Revista Brasileira de Epidemiologia*, vol. 24, issue suppl 2, 2021.
- [14] A. Hernández-Ruiz, C. Madrigal, M.J. Soto-Méndez, A. Gil, "Challenges and perspectives of the double burden of malnutrition in Latin America," *Clínica e Investigación en Arteriosclerosis*, vol. 34, issue suppl 1, pp. S3-S16, 2022.
- [15] J. Harreiter, M. Roden, "Diabetes mellitus – Definition, Klassifikation, Diagnose, Screening und Prävention," *Wiener klinische Wochenschrift*, vol. 131, issue suppl 1, pp. 6-15, 1965.
- [16] American Diabetes Association, "2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2021," *Diabetes care*, vol. 44, issue suppl 1, pp. S15-S33, 2021.
- [17] M. Guasch-Ferré, A. Hruby, E. Toledo, C. B. Clish, M. A. Martínez-González, J. Salas-Salvadó, F. B. hu, "Metabolomics in Prediabetes and Diabetes: A Systematic Review and Meta-analysis," *Diabetes Care*, vol. 39, pp. 833-846, 2016.
- [18] K. Ogurtsova, J.D.R. Fernandes, Y. Huang, J.E. Shaw, A.W. Ohlrogge, S. Karuranga, B. Malanda, "IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040," *Diabetes research and clinical practice*, vol. 128, pp. 40-50, 2017.
- [19] I. Özkaya, M. Gürbüz, "Desnutrición en el anciano con sobrepeso y obesidad," *Nutrición Hospitalaria*, vol. 36, issue 1, pp. 39-42, 2019
- [20] C.C. Damo, M. Doring, A.L.S. Alves, M.R. Portella, "Risco de desnutrição e os fatores associados em idosos institucionalizados," *Revista Brasileira de Cirurgia e Gerontologia*, vol. 21, issue 6, pp. 735-74, 2018.
- [21] S. Mosca, G. Araújo, V. Costa, J. Correia, A. Bandeira, E. Martins, H. Mansilha, M. Tavares, M.P. Coelho, "Dyslipidemia Diagnosis and Treatment: Risk Stratification in Children and Adolescents," *Journal of nutrition and metabolism*, vol. 2022, pp. 4782344, 2022.
- [22] N.A.D. Souza, S.A. Vieira, P.C.D.A. Fonsêca, C.S. Andreoli, S.E. Priore, S.D.C.D.C. Franceschini, "Dislipidemia familiar e fatores associados a alterações no perfil lipídico em crianças," *Ciência & Saúde Coletiva*, vol. 24, pp. 323-332, 2019.
- [23] L.P. Mayoral, G.M. Andrade, E.P. Mayoral, T.H. Huerta, S.P. Canseco, F.J.R. Canales, H.A. Cabrera-Fuentes, M.M. Cruz, A.D. Pérez Santiago, J.J. Alpuche, E. Zenteno, H.M. Ruiz, R.M. Cruz, J.H. Jeronimo, E. Perez-Campos, "Obesity subtypes, related biomarkers & heterogeneity," *The Indian journal of medical research*, vol. 151, issue 1, pp. 11–21, 2020.
- [24] Lira Neto, J. C. G., Oliveira, J. F. D. S. F., Souza, M. A. D., Araújo, M. F. M. D., Damasceno, M. M. C., & Freitas, R. W. J. F. D. Prevalência da síndrome metabólica e de seus componentes em pessoas com diabetes mellitus tipo 2. *Texto & Contexto-Enfermagem*, vol. 27, issue 3, pp. 1-8, 2018.
- [25] L. M. O. Gonzaga, M. A. R. Borges, V. M. Ferreira, "Tendência das Internações Hospitalares por Diabetes Mellitus Sensíveis à Atenção Primária," *Unimontes científica*, vol. 19, no. 2, pp 138-145, 2017
- [26] M. A. Silva, M. A. F. Gomes, M. Faria, M. C. R. Adami, J. A. Araújo, L. K. Martins, H. P. Pena, "Doenças metabólicas e nutricionais: Uma análise do número de internações ocorridas na região Centro Oeste de Minas Gerais, período de 2008 a 2018," *Brazilian Journal of Health Review*, vol. 4, no. 3, pp. 10774-10784, 2021.
- [27] Campos, F. C. C. D., & Canabrava, C. M. O Brasil na UTI: atenção hospitalar em tempos de pandemia. *Saúde em Debate*, vol. 44, issue 4, pp.146-160, 2020.
- [28] M.C.C. Formiga, P.C.F. Ramos, N.D.L. Costa, K.F. Silveira, A.L.B. Lima, "Um recorte da transição nutricional no Brasil: trajetória da mortalidade por Doenças Endócrinas Nutricionais e Metabólicas (DENM), no contexto das desigualdades sociais," in *VI Congreso de la Asociación Latinoamericana de Población*, 2014.
- [29] S.A. Cruz, I.M. Araújo, J.B.M. Silva, Y.F. Jucá, L.P. Lopes, A.C.M. Almeida, C.M. Cruz, "Análise do índice de mortalidade associada a doenças endócrino, nutricionais e metabólicas no Brasil entre 2010 e 2019," *Brazilian Journal of Health Review*, vol. 4, issue 4, pp. 16786-16800, 2021.
- [30] T.I. Hariyanto, A. Kurniawan, "Dyslipidemia is associated with severe coronavirus disease 2019 (COVID-19) infection. Diabetes & Metabolic Syndrome," *Clinical Research & Reviews*, vol. 14, issue 5, pp. 1463-1465, 2020.
- [31] R.V. Negreiros, E.N.R. Fonseca, R.A. Abreu, E.E. Freire, E.O. Gaudêncio, G. Safra, J.M.S. Mendes, A.O.B. Sousa, "Internação por diabetes mellitus no Brasil entre 2016 e 2020," *Brazilian Journal of Development*, vol. 7, issue 8, pp. 77218-77232, 2021.
- [32] A.A. Paixão, L.S.V. Ximenes, E.T. Santos, "Tendências temporais da mortalidade por desnutrição em idosos no estado de Mato Grosso do Sul, no período de 2002-2012," *Revista Eletrônica da Associação dos Geógrafos Brasileiros*, vol. 1, issue 31, pp. 48-65, 2020.
- [33] N.B.M. Arruda, L.M.L. Silva, A.C.R. Araújo, A.E.A.O. Silva, M.K.S.C. Angelim, A.J.S. Araújo, E.A.B. Souza, L.G. Orange, "Associação entre o tempo de internação e indicadores de massa muscular em idosos hospitalizados," *Brazilian Journal of Development*, vol. 6, issue 4, pp. 21832-21847, 2020.
- [34] M.R. Costa, J.W.F. Gomes, C.C.R. Bezerra, N.S. Silva, D.M.S.D. Silva, M.C.R. Araújo, F.A.X. Mota, H.K.S.S. Lima, "Obesidade e cirurgia de reconstrução de trânsito – Análise do tempo de internação, tempo cirúrgico e complicações," *Brazilian Journal of health review*, vol. 3, issue 6, pages 17108-17118, 2020.
- [35] A.C.L.S. Delboni, I.P. Oliveira, L.S.A. Garcia, P.R. Dias, V.S. Delboni, N.F.G. Amâncio, E. Antonacci Jr, "Avaliação do custo-benefício da gastroplastia com derivação intestinal em Y-de-Roux no Sistema Único de Saúde comparada aos gastos com tratamento das comorbidades geradas pela Diabetes Mellitus II," *Brazilian Journal of Development*, vol. 6, issue 1, pp. 1354-1361, 2020.
- [36] A.P.S. Ramos, M.F.G.A. Melo, J.A. Paiva, G.N. Paula, A.K.V. Rios, L.A.G. Ramalho, J.B.R. Castro, "Epidemiological profile of hospitalizations for obesity in Brazil, in the period from 2017 to 2021," *Research, Society and Development*, vol. 11, issue 4. pp. e39111427460, 2022.
- [37] D.C. Malta, B.B. Duncan, M.I. Schmidt, I.E. Machado, A.G. Silva, R.T.I. Bernal, C.A. Pereira, G.N. Damacena, S.R. Stopa, L.G. Rosenfeld, C.L. Szwarcwald, "Prevalência de diabetes mellitus determinada pela hemoglobina glicada na população adulta brasileira. Pesquisa Nacional de Saúde," *Revista Brasileira de Epidemiologia*, vol. 22, issue suppl 02, pp. 1-13, 2019.
- [38] J. Muzy, M.R. Campos, I. Emmerick, R. Sabino, "Oferta e demanda de procedimentos atribuíveis ao diabetes mellitus e suas complicações no Brasil," *Ciência & Saúde Coletiva*, vol. 27, issue 04, pp. 1653-1667, 2022.
- [39] R.R. Palasson, E.P.A. Pas, G.L. Marinho, L.F. Pinto, "Internações hospitalares por Diabetes Mellitus e características dos locais de moradia," *Acta Paulista de Enfermagem*, vol. 34, 2021.
- [40] M.F.G.L. Merino, R.R. Oliveira, P.L.A.R. Silva, M.D.B. Carvalho, S.M. Pelloso, I.H. Higarashi, "Hospitalization and mortality by diabetes mellitus in children: analysis of temporal series," *Revista Brasileira de Enfermagem*, vol. 72, issue suppl 3, pp. 147-153, 2019.
- [41] K. Norman, U. Haß, M. Pirlich, "Malnutrition in older adults—recent advances and remaining challenges," *Nutrients*, vol. 13, issue 8, pp. 2764, 2021.
- [42] L.G.L. Vasconcelos, N.B. Almeida, M.O.A. Santos, J.A.C. Silveira, "Time-trend analysis (2008-2018) of overweight prevalence among low-income infant and preschool children," *Ciência & Saúde Coletiva*, vol. 27, issue 1, pp. 363-375, 2022.
- [43] L.R.S. Garcia, A.G. Roncalli, "Determinantes socioeconômicos e de saúde da desnutrição infantil: uma análise da distribuição espacial," *Saúde e pesquisa*, vol. 13, issue 3, pp. 595-606, 2020.
- [44] M. Besora-Moreno, E. Llauradó, L. Tarro, R. Solà, "Social and economic factors and malnutrition or the risk of malnutrition in the elderly: a systematic review and meta-analysis of observational studies," *Nutrients*, vol. 12, issue 3, pp. 737, 2020.
- [45] M.I.T.D. Correia, M.I. Perman, D.L. Waitzberg, "Hospital malnutrition in Latin America: A systematic review," *Clinical Nutrition*, vol. 36, issue 4, pp. 958-967, 2017.
- [46] A.S. Carvalho, R.S. Rosa, "Cirurgias bariátricas realizadas pelo Sistema Único de Saúde no período 2010-2016: estudo descritivo das

- hospitalizações no Brasil,” *Epidemiologia e serviços de saúde*, vol.28, issue 1, 2019.
- [47] E.C.L. Bastos, E.M.W.G. Barbosa, G.M.S. Soriano, E.A. Santos, S.M.L. Vasconcelos, “Fatores determinantes do ganho ponderal no pós-operatório de cirurgia bariátrica,” *Arquivos Brasileiros de Cirurgia Digestiva*, vol. 26, pp. 26-32, 2013.
- [48] Campos, A. C. (2017, November 24). População brasileira é formada basicamente de pardos e brancos, mostra IBGE [Web page]. Retrieved from <https://agenciabrasil.ebc.com.br/economia/noticia/2017-11/populacao-brasileira-e-formada-basicamente-de-pardos-e-brancos-mostra-ibge#:~:text=Entre%20as%20grandes%20regi%C3%B5es%20do,pardos%20e%209%25%2C%20pretos.>
- [49] Produto Interno Bruto. (2022). Retrieved november 5, 2022, from IBGE: <https://www.ibge.gov.br/explica/pib.php>.
- [50] Sobrepeso e obesidade como problemas de saúde pública (2022, october 18). Retrieved November 5, 2022 from Gov: <https://www.gov.br/saude/pt-br/assuntos/saude-brasil/eu-quero-ter-peso-saudavel/noticias/2022/sobrepeso-e-obesidade-como-problemas-de-saude-publica>.