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Prevalence and factors associated with infection in patients with *diabetes mellitus* who underwent amputation

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ABSTRACT

Objective: To analyze the prevalence and factors associated with infection in patients with *diabetes mellitus* who underwent lower extremity amputation. **Method:** Cross-sectional, retrospective, and analytical study carried out in a high complexity hospital in Teresina, Piauí, with 70 medical records of patients admitted from January 2015 to December 2016. Inferential analysis was performed using χ^2 association tests. Pearson and Fisher's exact, considering p<0.05 to be significant. **Results:** Of the 70 participants, 81.4% were over 60 years old, 57.1% were married, 41.4% had low education, 82.8% had an income of 1 to 2 minimum wages, and 52.9% were coming from the interior of Piauí. The average length of stay was 25 days. The leg was the most prevalent site of amputation (38.6%). The prevalence of infection was 74.4% and only 7.1% of patients underwent culture. Family income (p=0.032) and length of stay (p=0.014) were significantly associated with infection. **Conclusion:** The prevalence of infection in patients with *diabetes mellitus* who underwent lower extremity amputation was high, being associated with family income and length of stay, highlighting the importance of understanding these factors for implementing preventive measures.

DESCRIPTORS: Infections. Diabetes mellitus. Diabetes complications. Amputation, surgical. Enterostomal therapy.

Prevalência e fatores associados à infecção em pacientes com diabetes *mellitus* que sofreram amputação

RESUMO

Objetivo: Analisar a prevalência e os fatores associados a infecção em paciente com diabetes *mellitus* que sofreram amputação de extremidade inferior. **Método:** Estudo transversal, retrospectivo e analítico realizado em um hospital de alta complexidade em Teresina, Piauí, com 70 prontuários de pacientes internados no período de janeiro de 2015 a dezembro de 2016. A análise inferencial foi realizada por meio dos testes de associação χ^2 de Pearson e Exato de Fisher, considerando significativo o valor de p<0,05. **Resultados:** Dos 70 participantes, 81,4% tinham idade superior a 60 anos; 57,1% eram casados; 41,4% tinham baixa escolaridade; 82,8% renda de 1 a 2 salários-mínimos e 52,9% eram procedentes do interior do Piauí. O tempo médio de internação foi de 25 dias. A perna foi o local de amputação mais prevalente (38,6%). A prevalência de infecção foi de 74,4% e somente 7,1% dos pacientes realizaram cultura. A renda familiar (p=0,032) e o tempo de internação (p=0,014) apresentaram associação significativa com a infecção. **Conclusão:** A prevalência de

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infecção em pacientes com diabetes *mellitus* que sofreram amputação em extremidade inferior foi elevada, tendo associação com a renda familiar e o tempo de internação, destacando a importância da compreensão desses fatores para implementação de medidas preventivas.

DESCRITORES: Infecções. Diabetes mellitus. Complicações do diabetes. Amputação cirúrgica. Estomaterapia.

Prevalencia y factores asociados a la infección en pacientes con diabetes mellitus que han sufrido amputación

RESUMEN

Objetivo: Analizar la prevalencia y los factores asociados a la infección en pacientes con *diabetes mellitus* sometidos a amputación de extremidades inferiores. **Método:** Estudio transversal, retrospectivo y analítico realizado en un hospital de alta complejidad de Teresina, Piauí, con 70 prontuarios de pacientes ingresados entre enero de 2015 y diciembre de 2016. Se realizó análisis inferencial mediante pruebas de asociación de Chi-cuadrado y exacto de Fisher, considerando p<0,05 como significativo. **Resultados:** De los 70 participantes, el 81,4% tenía más de 60 años, el 57,1% estaba casado, el 41,4% tenía baja escolaridad, el 82,8% tenía ingresos de 1 a 2 salarios mínimos y el 52,9% provenía del interior de Piauí. La estancia media fue de 25 días. La pierna fue el sitio de amputación más frecuente (38,6%). La prevalencia de infección fue del 74,4% y sólo el 7,1% de los pacientes realizaron cultivo. El ingreso familiar (p=0,032) y la duración de la estancia (p=0,014) se asociaron significativamente con la infección. **Conclusión:** La prevalencia de infección en pacientes con diabetes mellitus sometidos a amputación de extremidades inferiores fue alta, asociada con el ingreso familiar y la duración de la estadía, destacando la importancia de comprender estos factores para implementar medidas preventivas.

DESCRIPTORES: Infecciones. Diabetes mellitus. Complicaciones de la diabetes. Amputación quirúrgica. Estomaterapia.

INTRODUCTION

Diabetes mellitus (DM) is a chronic condition characterized by elevated blood glucose levels and is classified into two main types: type 1 and type 2. Type 1 DM results from the pancreas' inability to produce insulin or the production of insufficient amounts. Type 2 DM is primarily marked by insulin resistance[1].

Globally, it is estimated that 537 million adults have DM, with projections indicating an increase to 643 million by 2030 and 783 million by 2045. In 2021, DM accounted for 6.7 million deaths and incurred approximately 966 billion dollars in healthcare costs, reflecting a 316% increase over the past 15 years. In Brazil, the prevalence of DM in adults is 10.5%, with the associated costs of the disease and its complications reaching 2,728.5 dollars, considering only the 20 to 79 age group[2].

Persistent and uncontrolled hyperglycemia in DM can lead to various acute and chronic complications. Acute complications include diabetic ketoacidosis, hyperglycemic hyperosmolar state, and hyperglycemic diabetic coma. Chronic microvascular complications involve neuropathy, nephropathy, and retinopathy, while chronic macrovascular complications include coronary artery disease, peripheral arterial disease, and cerebrovascular disease. As a result, prolonged hyperglycemia elevates the risks of cardiovascular disease, blindness, renal failure, and lower limb amputations[3].

Hyperglycemia impairs the immune system by inducing mitochondrial dysfunction and promoting the production of reactive oxygen species, leading to oxidative stress. At the cellular level, prolonged oxidative stress disrupts insulin signaling pathways and increases inflammation. Additionally, it affects immune cells by activating pro-inflammatory cytokines. Over time, the sustained exposure of cells to elevated glucose levels, oxidative stress, free radicals, and an inflammatory state causes damage to target organs[4].

Hyperglycemia is likely the most significant factor in increasing the risk of infection, as it weakens immunity, impairs the chemotaxis of immune cells, reduces the production of neuropeptides such as substance P and nerve growth factor, delays wound healing, and consequently heightens the risk of further infections. Other factors contributing to an elevated infection risk include neuropathy, which impairs leukocyte migration in denervated tissues, and vascular damage, which reduces blood flow, thereby promoting bacterial replication and diminishing the effectiveness of antibiotics at the infection site[5].

Among diabetic complications, peripheral neuropathy is one of the most prevalent and can lead to chronic pain, foot ulcers, infections, and amputations. The global estimated prevalence of diabetic ulcers is 6%, with risk factors including advanced age, low body mass index, prolonged disease duration, hypertension, diabetic retinopathy, and smoking. Approximately 25% of individuals with DM will develop a foot ulcer during their lifetime, which may progress to infection and, in severe cases, result in lower limb amputation. Furthermore, about 90% of hospital admissions for diabetic ulcers are associated with peripheral neuropathy and infection[6].

Despite a well-established etiology and pathophysiology, DM continues to present high rates of complications, such as lower limb amputations resulting from infections, which elevate mortality risk, diminish patients' quality of life, and increase healthcare costs. Consequently, research of this nature can inform effective public policies aimed at enhancing care for individuals with DM.

OBJECTIVES

Therefore, this study aimed to analyze the prevalence and factors associated with infections in patients with DM who have undergone lower extremity amputation.

METHODS

This is a cross-sectional, retrospective, and analytical study, and the report adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.

The study was conducted in a highly complex public hospital located in Teresina, Piauí, a state known for its specialized treatment of patients with lower limb complications due to DM.

The study population comprised 70 patients with DM who underwent lower limb amputations. The inclusion criteria were as follows: patients must be 18 years old or older, have undergone lower limb amputation between January 2015 and December 2016, and have a diagnosis of either type 1 or type 2 DM, with documented infections in their medical records. The exclusion criteria included medical records that lacked information on the presence of infection, such as antibiotic use and culture results, as well as detailed descriptions of the infectious process, including the presence of purulent or foul-smelling exudate.

The data source utilized for this study was secondary, comprising information extracted from medical records. A total of 4,423 medical records archived from November 2016 to January 2017 at the Medical Archive and Statistics Service (*Serviço de Arquivo Médico e Estatística* – SAME) were reviewed. To facilitate the search, the audit service provided a list of patients who underwent amputations; however, due to the manual archiving process organized by monthly competence, it was necessary to review medical records from 2015 to 2016 that were not specifically related to amputation. It is important to note that only medical records with authorization for hospital admission billing are archived. Records with disallowances, pending issues, or appeals are analyzed and archived at a later date. Consequently, it is possible that losses occurred, leading to a reduction in the studied population. Additionally, the medical records from November and December 2016 were not yet archived and, therefore, were not included in the analysis.

Data were collected using a form developed by the study authors, informed by the literature and the researchers' practical experience. The form included variables related to the sociodemographic aspects (age, gender, education, origin, marital status, and family income) and clinical aspects of patients with DM who underwent lower extremity amputation (length of hospital stay, amputation site, presence of infection, and culture results). Data collection was conducted by two

trained students, one in nursing and the other in medicine. It is noteworthy that a pilot test was performed prior to data collection, involving three eligible medical records to assess the relevance and clarity of the form.

Data were entered into databases using double entry in a Microsoft Excel spreadsheet to identify potential typing errors and were subsequently processed using the Statistical Package for the Social Sciences (SPSS) software, version 21.0. For descriptive statistics, quantitative variables were analyzed to calculate the mean, standard deviation, median, interquartile range, and minimum and maximum values, while qualitative variables were assessed for absolute and percentage frequencies. The association between the sociodemographic and clinical characteristics of patients with DM and the presence of infection was evaluated using Pearson's chi-square test and Fisher's exact test. A p-value <0.05 was considered significant.

This study adhered to the ethical principles outlined in resolutions No. 466 of 2012 and No. 510 of 2016 from the National Health Council, which govern research involving human subjects[7]. It received approval from the Research Ethics Committee of Universidade Estadual do Piauí, under the Certificate of Presentation of Ethical Appreciation (CAAE) 58030716.8.3001.561 and opinion No. 1.795.121.

RESULTS

Of the 70 port workers with DM who underwent lower extremity amputation, 57 (81.4%) were aged 60 years old or older, with a median age of 69 years, ranging from 19 to 96 years. Among these patients, 36 (51.4%) were male. Regarding educational attainment, 29 (41.4%) were illiterate. The majority of patients (37) (52.9%) were from the interior of Piauí. In terms of marital status, 40 (57.1%) were married/in a stable union. The family income of 58 (82.9%) patients fell within the range of 1 to 2 minimum wages. The average length of hospital stay for these patients was 25 days (±12.378), ranging from 1 to 51 days. Concerning the amputation sites, 27 (38.6%) had their leg amputated, 16 (22.9%) had their foot amputated, 15 (21.4%) had their toes amputated, and 12 (17.1%) had their thigh amputated. The prevalence of infection found in this study was 74.4%, indicating that 52 of the patients who underwent amputation had a diagnosis of infection; however, a culture exam was performed in only 7.1% of these patients (Table 1).

Regarding sociodemographic and clinical characteristics, a statistically significant association was observed between family income and the presence of infection (p = 0.032), as well as between length of hospital stay and the presence of infection (p = 0.014), as presented in Table 2.

Table 1. Sociodemographic and clinical characteristics of patients with *diabetes mellitus* who underwent lower limb amputation. Teresina (PI), 2017 (n=70).

Characteristic/Category	N (%)	$\bar{x}$	Min/Max	SD*
Age (years)				
19 to 59	13 (18.6)	69†	19/96	16‡
≥60	57 (81.4)			
Gender				
Male	36 (51.4)			
Female	34 (48.6)			
Education				
Illiterate	29 (41.4)			
Incomplete elementary education	03 (4.3)			
Complete elementary education	24 (34.3)			
Complete high school	07 (10.0)			
Complete higher education	01 (1.4)			
Data absent	06 (8.6)			

Continue...

Table 1. Continuation.

Characteristic/Category	N (%)	$\bar{x}$	Min/Max	SD*
Origin				
Teresina	29 (41.4)			
Interior of Piauí	37 (52.9)			
Other states	04 (5.7)			
Marital status				
Single	05 (7.1)			
Married/stable union	40 (57.1)			
Separated/divorced	06 (8.6)			
Widowed	10 (14.3)			
Data absent	09 (12.9)			
Family income (salaries)[§]				
Less than one	05 (7.1)			
1 to 2	58 (82.9)			
3 to 5	05 (7.1)			
More than 5	02 (2.9)			
Length of hospitalization (days)				
1 to 10	10 (14.3)	25	1/51	12.378
11 to 20	15 (21.4)			
21 to 30	22 (31.4)			
More than 31	23 (32.9)			
Amputation site				
Thigh	12 (17.1)			
Leg	27 (38.6)			
Foot	16 (22.9)			
Toes	15 (21.4)			
Presence of infection				
Yes	52 (74.3)			
No	18 (25.7)			
Culture performed				
Yes	05 (7.1)			
No	65 (92.9)			

*Standard deviation; [†]Median; [‡]Interquartile range; [§]Minimum wage during the data collection period: R$ 937.00. Min: minimum; Max: maximum; SD; standard deviation.

Table 2. Association between sociodemographic and clinical characteristics with the presence of infection in patients with *diabetes mellitus* who underwent lower limb amputation. Teresina (PI), 2017 (n=70).

Characteristic/Category	Presence of infection				Total	χ^2	p
	Yes		No				
	n	%	n	%	n		
Age (years)							
19 to 59	10	14.3	03	4.3	13	1.000*	0.809
≥60	42	60.0	15	21.4	57		
Gender							
Male	25	35.7	11	15.7	36	0.909[†]	0.340
Female	27	38.6	07	10.0	34		

Continue...

Table 2. Continuation.

Characteristic/Category	Presence of infection				Total	χ^2	p
	Yes		No				
	n	%	n	%	n		
Education							
Illiterate	20	28.6	09	12.9	29	7.187†	0.207
Incomplete elementary education	03	4.3	00	0.0	03		
Complete elementary education	17	24.3	07	10.0	24		
Complete high school	07	10.0	00	0.0	07		
Complete higher education	00	0.0	01	1.4	01		
Data absent	05	7.1	01	1.4	06		
Origin							
Teresina	18	25.7	11	15.7	29	4.545†	0.103
Interior of Piauí	30	42.9	07	10.0	37		
Other states	04	5.7	00	0.0	04		
Marital status							
Single	02	2.9	03	4.3	05	3.573†	0.467
Married/stable union	30	42.9	10	14.3	40		
Separated/divorced	05	7.1	01	1.4	06		
Widowed	08	11.4	02	2.9	10		
Data absent	07	10.0	02	2.8	09		
Family income (salaries)							
Less than one	01	1.4	04	5.7	05	8.822†	0.032
1 to 2	45	64.3	13	18.6	58		
3 to 5	04	5.7	01	1.4	05		
More than 5	02	2.9	00	0.0	02		
Length of hospitalization (days)							
1 to 10	05	7.1	05	7.1	10	10.676†	0.014
11 to 20	08	11.4	07	10.0	15		
21 to 30	18	25.8	04	5.7	22		
More than 31	21	30.0	02	2.9	23		
Amputation site							
Thigh	10	14.3	02	2.9	12	7.642†	0.054
Leg	22	31.4	05	7.1	27		
Foot	13	18.6	03	4.3	16		
Toes	07	10.0	08	11.4	15		

*Fisher's exact test; †χ^2 test.

DISCUSSION

The prevalence of infection was higher among aged, female, and low-education patients. Although the relationship between these variables and the presence of infection did not demonstrate statistically significant associations, it is acknowledged that the occurrence of DM increases with age. Additionally, diabetic ulcers result from disease decompensation, which are risk factors for infection and loss of lower limbs[8]. This is supported by a study indicating a significant association between DM and age, with a higher incidence of skin and soft tissue infections observed in 66% of patients with DM[9,10].

Although most patients who underwent lower limb amputation were male, which aligns with studies indicating that the incidence of amputation in men is twice as high as in women[11,12]; the prevalence of infection was more pronounced in females. This may be related to the tendency for women to seek diagnosis and follow-up for DM earlier, whereas men often seek care only after the condition has become severe[13].

Low levels of education were prevalent in this study, which can complicate the treatment and monitoring of these individuals, as they may exhibit greater resistance to information. Additionally, individuals with low educational attainment may struggle to understand the guidelines provided by the healthcare team. This situation necessitates more effective management strategies, tailored to the needs of each patient, focusing on individualized and intensive self-care education[14]. Such measures aim to prevent foot ulceration in individuals with DM, thereby reducing the incidence of lower extremity amputations.

It is noteworthy that the reference health services in Piauí are concentrated in the capital, Teresina, which attracts a significant number of individuals from rural areas seeking treatment and surgical procedures. This influx justifies the high number of amputations among patients from inland regions, as well as the increased prevalence of infection, corroborating findings from a study conducted in Australia[15].

Regarding marital status, a higher prevalence of infection was observed in patients who were in stable unions or married, likely due to the majority of participants having a partner. Additionally, family income demonstrated a statistically significant association with the presence of infection, as most participants reported low income, specifically one to two minimum wages. It is important to note that low income, coupled with having more than three individuals living in the same household, directly impacts disease management. This situation affects the adoption of essential self-care practices and creates challenges in accessing goods and services that could enhance the quality of treatment[11].

The most common complications among DM patients with ulcerations in the lower limbs include lesion infections, followed by amputations, which may be associated with peripheral arterial obstructive disease. In this study, the prevalence of infection in DM patients who underwent amputation was notably high when compared to another study[8], which may be attributed to local socioeconomic and demographic characteristics.

The length of hospital stay demonstrated a statistically significant association with the prevalence of infection among the patients in this study. The presence of DM directly influences susceptibility to infections, as hyperglycemia reduces the effectiveness of white blood cells, thereby increasing the risk of infection in individuals with DM. Consequently, infection is a contributing factor to prolonged hospital stays for these patients. Conversely, individuals who remain hospitalized for extended periods due to other comorbidities, complications, or delays in scheduling procedures are also more likely to acquire infections as a result of the unsanitary conditions often found in hospital environments[16].

In general, the degree of amputation is determined by the location and extent of the diabetic foot lesion, with surgeons striving to preserve as much of the lower extremity as possible. However, this is often unattainable due to the clinical condition of the limb and the presence of infection[17], which can lead to more extensive amputations. This study found that the site with the highest frequency of amputation and prevalence of infection was the leg, corroborating findings from another study conducted in the interior of the state[17]. This data can be attributed to the state reference hospital for high-complexity care serving all 224 municipalities in Piauí through a regulated system, which complicates timely access to specialized services. If early treatment of diabetic ulcers, imaging diagnostics, and lower limb revascularization were administered promptly, the need for more extensive amputations at the thigh level in individuals with DM could be significantly reduced.

In most cases, amputations are preceded by neuroischemic ulcers, which can result from factors such as the absence of appropriate footwear tailored to the foot type. Initial symptoms may be absent due to neuropathy, even in cases of severe ischemia, making early treatment challenging. To mitigate the incidence of amputations related to DM, it is essential to implement strategies that enhance primary health care. These strategies should include preventive measures, such as the provision of adapted footwear, education for patients, family members, and health professionals, risk assessment and classification using standardized instruments provided by health services, and multidisciplinary care with effective support for high-complexity cases. Such approaches could significantly reduce the rate of amputations resulting from DM[18].

It is important to recognize that amputations, in addition to their clinical and physical impacts, have significant repercussions on social, labor, social security, hospital, and overall public health aspects. Scientific evidence highlights the seriousness and negligence surrounding amputations, as most patients did not receive proper foot assessments in primary care settings[19]. Consequently, upon hospital admission, due to the severity of their conditions or the absence of institutional

protocols, many patients with infected diabetic ulcers who undergo lower extremity amputation do not have samples collected to isolate the bacteria responsible for the infection. This situation underscores the need for improvement in the care provided to individuals with DM.

In this context, it is important to highlight that only 7.1% of patients with DM who underwent lower limb amputation had cultures performed, despite evidence suggesting that culture-guided antibiotic therapy should be considered. This approach is crucial, as bacterial resistance has been increasing over the years, leading to prolonged hospitalizations, heightened risks to patient health, increased strain on healthcare teams, and greater costs for healthcare institutions[20].

The limitations of this study include challenges in locating patient records due to the absence of a computerized filing system at the time. The research team was required to manually access all records according to the monthly billing period for the Hospital Admission Authorization, which may have introduced opportunities for errors during the selection process. Additionally, the lack of documentation regarding the reasons for amputation in the medical records may have affected the accuracy of the number of records included in the study.

CONCLUSION

This study demonstrated that the prevalence of infection in patients with DM is significantly high and is associated with family income and length of hospital stay. Therefore, understanding these factors can assist in identifying aspects of preventive care that require reinforcement in Primary Health Care. This approach aims to prevent complications of DM from progressing to high-complexity hospitals in an irreversible manner, ultimately reducing the incidence of lower limb amputations.

In this context, it is crucial to highlight the significance of early prevention and treatment of complications arising from DM, particularly those related to diabetic neuropathy and the development of lesions in the lower limbs. Such conditions can lead to infections that may ultimately result in amputations. Therefore, there is a pressing need for health education interventions aimed at this population to raise awareness about lesion prevention. Additionally, training healthcare teams in the evaluation, prevention, and treatment of diabetic ulcers is essential to reduce the incidence of infections and lower limb amputations.

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