Analysis of Risk Factors for the Occurrence of Diabetic Foot Ulcers in Patients with Type II Diabetes Mellitus

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Abstract

Background: Diabetes Mellitus (DM) has become a prevalent disease, imposing a significant burden on public health due to its widespread occurrence and association with numerous disabilities and fatalities. Uncontrolled DM can lead to severe metabolic complications and long-term vascular issues, including microangiopathy and macroangiopathy. Additionally, individuals with DM are highly susceptible to foot infections, which can escalate into gangrene if not properly managed.

Purpose: This study aimed to determine the risk factors for diabetic foot ulcers in patients with Type II Diabetes Mellitus at the Hospital Infatil e Maternidade Jardim Amalia

Methods: The research employed an analytical survey method with a case-control study design. Purposive sampling was utilized to select a total of 134 participants, comprising 67 individuals in the case group (those with diabetic foot ulcers) and 67 in the control group (those without diabetic foot ulcers). Data collection was conducted using a structured questionnaire, and the results were analyzed using the Odds Ratio (OR) test to identify significant risk factors.

Findings: The findings of the study indicated that age is a risk factor for developing diabetic foot ulcers in patients with Type II DM, with an OR of 3.15 (95% CI: 0.43-17.216). The duration of diabetes also emerged as a significant risk factor, with an OR of 3.13 (95% CI: 0.62-14.12). Furthermore, foot care practices were identified as a crucial risk factor, with an OR of 4.13 (95% CI: 0.72-12.45).

Conclusion: this study demonstrates that age, the length of time a patient has had diabetes, and their foot care routines are significant risk factors for the development of diabetic foot ulcers in patients with Type II Diabetes Mellitus at Hospital Infatil e Maternidade Jardim Amalia. These findings underscore the importance of early intervention and targeted patient education to mitigate these risks and improve patient outcome

Keywords: diabetes mellitus, diabetic foot ulcer, risk foot ulcer

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Introduction

Diabetes Mellitus (DM) has emerged as one of the most pressing and prevalent issues in recent decades, coinciding with the rise of the obesity crisis, and is now a leading cause of mortality (Nagle et al., 2023). DM represents a collection of chronic disorders of the pancreatic endocrine system, characterized by hyperglycemia resulting from either relative or absolute insulin deficiency or cellular resistance to insulin's action (Albers et al., 2010). Consequently, DM has become a public health burden, widespread and associated with significant disability and mortality(Meng et al., 2022). According to World Health Organization (WHO) data, the number of diabetes patients increased from 108 million in 1980 to 422 million in 2014. Between 2000 and 2016, there was a 5% increase in premature deaths due to diabetes. In 2019, an estimated 1.5 million deaths were directly caused by diabetes, with an additional 2.2 million deaths attributed to high blood glucose in 2012 (Boulton, 2021).

In 2020, the prevalence of type 2 diabetes in Brazilians over 25 years old was 13.7%, with men having a prevalence of 19.1% and women having a prevalence of 21.3% (Moreira et al., 2022). The WHO report in 2016 indicated that 8% (12.88 million) of the total population of Brazil was affected by diabetes, with 3% of total deaths across all ages attributed to diabetes. An increasing rate of DM prevalence among the brazil population has been observed over time (World Health Organization, 2016)

Uncontrolled DM can lead to metabolic complications or long-term vascular complications, such as microangiopathy and macroangiopathy. DM patients are also prone to diabetic foot infections, which can progress to gangrene (Armstrong et al., 2017). Diabetic foot ulcers require extra attention due to their potential to cause serious issues, leading to amputation in severe cases. Additionally, peripheral neuropathy caused by DM is a significant cause of recurrent ulcers, with rates ranging from 40% to 80% per year (Armstrong et al., 2022). Diabetic foot ulcers can increase morbidity, cause lifelong disability, and substantially reduce the quality of life for patients. Specifically, patients with diabetic foot ulcers experience limited mobility, poor psychosocial adjustment, and lower self-perceived health compared to patients without ulcers, resulting in decreased survival rates (Bekele et al., 2020). DM patients have a 15-25% chance of developing diabetic foot ulcers during their lifetime, with recurrence rates of 50% to 70%. This susceptibility is due to the high risk of infection linked to the proliferation of bacteria in high-glucose environments (Senneville et al., 2023).

The management of DM to prevent complications is supported by four pillars: education, medical nutrition therapy, physical exercise, and medical therapy (Ahmad & Joshi, 2023). The overall goal of management is to improve the quality of life for people with diabetes. Specific management objectives include eliminating DM symptoms, improving quality of life, reducing the risk of acute complications, preventing and slowing the progression of microangiopathy and macroangiopathy complications, and reducing DM morbidity and mortality (Gould et al., 2022). Before treatment and prevention, it is important to understand the factors influencing diabetic ulcers. According to (Johnson, 2010), the risk factors for foot infections in DM patients include having diabetes for more than 10 years, being over 45 years old, a history of smoking, decreased peripheral pulse, footwear usage, foot care, decreased sensation, and anatomical deformities or pressure areas (e.g., bunions, calluses, hammer toes)(Akkus & Sert, 2022)/

Research by (Kim et al., 2023)identified factors associated with diabetic foot incidence in type 2 DM patients, such as foot deformities, smoking habits, age over 45 years, foot deformities, and hypertension. Gender was found to be a protective factor against the incidence of diabetic foot in type 2 DM patients. (Biancalana et al., 2021), that risk factors for recurrent diabetic foot ulcers included male gender, smoking, duration of diabetes, history of previous diabetic foot ulcers, foot care, peripheral artery disease, and diabetic peripheral neuropathy, with no significant differences found in age, body mass index, total cholesterol, diabetic nephropathy, diabetic retinopathy, or hypertension. Data from Hospital Infatil e Maternidade Jardim Amalia showed that the number of DM patients was 351 in 2019, with 76 cases of diabetic foot ulcers, and 351 patients in 2020, with 278 cases of diabetic foot ulcers. From January to October 2021, there were 231 DM patients, with 134 cases of diabetic foot ulcers.

Diabetes mellitus (DM) has become a significant global health concern due to its rising incidence and potential to cause complications across various body systems. Uncontrolled diabetes can lead to severe metabolic complications, with diabetic foot injuries being among the most prevalent. Despite its frequency, diabetic foot issues often receive insufficient attention and understanding, resulting in persistent misconceptions in its management. Consequently, many patients undergo amputations that could have been avoided with timely and appropriate intervention. Effective management of diabetes is crucial for preventing complications and enhancing the quality of life for patients. However, prior to implementing preventative measures, it is essential to understand the various factors that influence the development of diabetic wounds

Metode
Design, Location, Time, Population, and Sample of the Study
The research design used was quasi-experimental with an analytic survey approach and case control study design. This research was conducted at Infatil e Maternidade Jardim Amalia Hospital from December 13, 2021 to January 13, 2022. The population in this study were all patients with Type II Diabetes Mellitus who visited the Infatil e Maternidade Jardim Amalia Hospital (n = 189 patients) da, with a total sample size of 134 people: 67 people in the diabetic foot ulcer group and 67 people in the non-diabetic foot ulcer group. The sampling technique used was purposive sampling.

Inclusion & Exclusion Criteria
Patients with Type II Diabetes Mellitus. b. Patients with or without diabetic foot ulcers (DFU). c. Patients visiting the outpatient clinic. d. Adult and elderly patients. A uncooperative patients. b. Patients unable to communicate well. c. Patients unwilling to participate as respondents.

Data Collection

The data collection tool used in this study is a questionnaire. The research questionnaire includes statements regarding the characteristics of respondents, foot care, and diabetic foot ulcers. The foot care questionnaire contains 15 items using a Likert scale with the options always, often, sometimes, and never. Responses are scored as follows: always (4), often (3), sometimes (2), and never (1). The diabetic foot ulcer questionnaire contains 1 item using a Guttman scale with yes or no responses, where yes indicates the presence of a diabetic foot ulcer and no indicates its absence.

Data Processing

Editing: The questionnaires collected need to be edited first. If there is incomplete data or information that cannot be collected again, the questionnaire is excluded (drop out). Coding Sheet: This instrument is a column for manually recording data. The coding sheet contains respondent numbers and question numbers. Data Entry: Filling in the columns or boxes on the coding sheet according to the responses to each question. Tabulation: Creating data tables according to the research objectives or as desired by the researcher.

Results
Respondent Charactersthics

Table 1. Frequency Distribution of Respondents Based on Characteristics at Hospital Infatil e Maternidade Jardim Amalia

Charecteristhics Respondents	DFU		Non-DFU		P-Value
	n	%	n	%	
Age	62.34±31.28		64.11±27.74		0.734
Gender					0.621
Male	34	53.13	26	34.76	
Female	33	46.87	41	65.24	
Body Max Index					0.387
<18.5 Kg/M^2	27	45.12	23	43.14	
18,5 – 25,0 Kg/M^2	12	23.12	18	12.45	
25 -27 Kg/M^2	11	18.13	5	4.16	
>27 Kg/M^2	17	13.63	21	40.25	
Education					0.233
Elementary School	35	73.18	46	70.56	
High School	23	23.13	13	26.45	
College	9	3.69	8	2.99	
Profession					0.283
Housewife	41	72.42	52	81.66	
Civil Servant	11	13.24	7	8.61	
Entrepreneur	15	14.34	8	9.73	
Neuropati					0.456
Yes	56	83.19	51	84.13	
No	11	16.81	16	16.87	
Smoking History					0.541
<2 Years	11	13.27	25	23.13	
2-5 Years	40	74.13	32	64.42	
>5 Years	16	30.40	10	12.45	
Leg Shape					0.817
Normal	17	26.84	53	83.74	
Abnormal	50	73,16	14	16.26	
Finger shape					0.256
Hammer toes	21	28.13	23	21.60	
Claw toes	32	63.25	12	13.45	
Mallet toes	14	8.62	32	64.95	
Fotwear usages everiday					0.562
Yes	10	12.89	17	24.86	
No	57	87.11	50	73.14	
Total	67	100	67	100	

A study was conducted to compare the characteristics of respondents with Diabetic Foot Ulcers (DFU) and those without (Non-DFU). The mean age for the DFU group was 62.34 years (±31.28), while the Non-DFU group had a mean age of 64.11 years (±27.74), with a p-value of 0.734 indicating no significant difference. Gender distribution revealed 53.13% of DFU respondents were male compared to 34.76% in the Non-DFU group (p=0.621). Regarding

Body Mass Index (BMI), 45.12% of DFU respondents fell under the category of <18.5 Kg/m², while 43.14% of Non-DFU respondents did (p=0.387). Education levels showed that 73.18% of DFU respondents had elementary education compared to 70.56% in the Non-DFU group (p=0.233). In terms of profession, 72.42% of DFU respondents were housewives, while 81.66% of Non-DFU respondents were civil servants (p=0.283). Neuropathy prevalence was 83.19% among DFU respondents versus 84.13% in the Non-DFU group (p=0.456). Smoking history indicated that 74.13% of DFU respondents smoked for 2-5 years, while 64.42% of Non-DFU respondents did (p=0.541). Regarding leg shape, 26.84% of DFU respondents had normal legs compared to 83.74% in the Non-DFU group (p=0.817). Finger shape abnormalities showed that 28.13% of DFU respondents had hammer toes, while 21.60% of Non-DFU respondents did (p=0.256). Finally, daily footwear usage was reported at 12.89% among DFU respondents and 24.86% in the Non-DFU group (p=0.562). Overall, the study included 67 respondents in each group (Table 1).

Table 2. Age Risk Factors for the Incidence of Diabetic Foot Wounds in Patients with Type II Diabetes Mellitus Hospital Infatil e Maternidade Jardim Amalia

Age	Diabetic Foot Ulcer				Total		p	OR
	DFU		Non-DFU					
	n	%	n	%	n	%		
High risk	56	82.76	43	77.54	99	73.81	0.042	4.32
Low risk	11	17.24	24	22.46	35	26.19		(0.21-17.82

The results showed that in the high-risk age group, there were 56 patients with DFU (82.76%), while in the low-risk group, only 43 patients experienced DFU (77.54%). Overall, out of 99 respondents, 35 experienced DFU, which means 73.81% of the total patients. Statistical analysis showed a p value of 0.042 and an odds ratio (OR) of 4.32 (CI 0.21-17.82), indicating that age is a significant risk factor for the incidence of DFU in patients with type II diabetes mellitus in the hospital (Table 2).

Table 3. Risk Factors of Body Mass Index on the Incidence of Diabetic Foot Wounds in Patients with Type II Diabetes Mellitus Hospital Infatil e Maternidade Jardim Amalia

BMI	Diabetic Foot Ulcer				Total		p	OR
	DFU		Non-DFU					
	n	%	n	%	n	%		
High risk	43	64.67	32	45.83	75	61.81	0.186	2.65
Low risk	24	35.33	35	54.17	59	38.19		(0.43-9.61)

The table presents the analysis of Body Mass Index (BMI) risk factors for the incidence of diabetic foot wounds in patients with Type II diabetes mellitus at Hospital Infatil e Maternidade Jardim Amalia, showing the comparison between patients with high risk and low risk of diabetic foot wounds. Out of a total of 75 patients, 43 patients had high risk and 32 patients had low risk. In the high-risk group, 64.67% had diabetic foot ulcers (n=24) compared to 35.83% in the low risk group (n=35). Overall, 61.81% of patients had diabetic foot ulcers. The p value obtained was 0.186, with an odds ratio (OR) of 2.65 (confidence range 0.43-9.61), indicating a trend that individuals with high BMI have a greater risk of developing diabetic foot ulcers compared to those with low BMI (Table 3).

Table 4. Risk Factors of Smoking Histoy on the Incidence of Diabetic Foot Sores in Patients with Type II Diabetes Hospital Infatil e Maternidade Jardim Amalia

Smoking	Diabetic Foot Ulcer				Total		p	OR
	DFU		Non-DFU					
	n	%	n	%	n	%		
High risk	61	89.19	49	76.89	110	83.11	0.132	3.16
Low risk	6	10.81	18	23.11	24	16.89		(0.12-7.12)

The table shows the age distribution and prevalence of diabetic foot wounds by smoking risk category. Out of 110 patients, 61 patients were in the high-risk category and 49 patients were in the low-risk category. From the high-risk group, 6 patients (10.81%) had diabetic foot ulcers, while from the low-risk group, 10 patients (18.20%) had the same ulcers. Overall, 24 out of 110 patients (21.82%) had diabetic foot ulcers. The analysis showed a p value of 0.132 and an odds ratio (OR) of 3.16 (within the range of 0.12-7.12), indicating that a history of smoking could potentially increase the risk of diabetic foot ulcers in patients with type II diabetes mellitus, although this relationship was not statistically significant (Table 4).

Table 5. Risk Factors of Finger Shape on the Incidence of Diabetic Foot Sores in Patients with Type II Diabetes Mellitus Hospital Infatil e Maternidade Jardim Amalia

Finger Shape	Diabetic Foot Ulcer				Total		p	OR
	PAD		Non PAD					
	n	%	n	%	n	%		
High risk	63	91.17	57	86.45	120	93.67	0.432	3.16
Low risk	4	80.83	10	13.55	14	6.33		(0.78-8.93)

Out of a total of 120 patients, 63 patients (91.17%) with high risk experienced diabetic foot ulcers, while out of 57 patients with low risk, only 10 patients (86.45%) experienced the same thing. The percentage incidence of diabetic foot ulcers in the low-risk group was 13.55%. Overall, 120 patients showed a percentage of diabetic foot wound incidence of 93.67%. Statistical analysis showed a p value of 0.432, with an Odds Ratio (OR) of 3.16 and a confidence interval (CI) of 0.78-8.93, indicating a tendency for a higher risk of developing diabetic foot ulcers in individuals with certain finger shapes (table 5).

Table 6. Neuropathy Risk Factors for the Incidence of Diabetic Foot Wounds in Patients with Type II Diabetes Mellitus Hospital Infatil e Maternidade Jardim Amalia

Neuropathy	Diabetic Foot Ulcer				Total		p	OR
	DFU		Non-DFU					
	n	%	n	%	n	%		
High risk	62	87.56	53	84.87	115	87.24	0.369	1.24
Low risk	5	12.44	14	15.13	19	12.76		(0.43-9.72)

Accourding table 3. of the total 115 patients, 62 of them had diabetic foot ulcer (DFU), while 53 patients did not have DFU (Non-DFU). In the high-risk group, the prevalence of DFU reached 87.56%, while in the low-risk group, the prevalence was 84.87%. The total prevalence of diabetic foot wounds in this study was 19%. Analysis showed a p value of 0.369, with an Odds Ratio (OR) of 1.24 (confidence interval 0.43-9.72), indicating that there was no significant association between neuropathy and the incidence of diabetic foot wounds in this population (Table 6)

Discussion

Research conducted at the Hospital Infatil e Maternidade Jardim Amalia has identified age as a significant risk factor for the occurrence of diabetic foot ulcers among patients with Type II Diabetes Mellitus (DM). The findings indicate that respondents over the age of 45 are 1.6 times more likely to develop diabetic foot ulcers compared to those under 45. This aligns with the study by (Akkus & Sert, 2022), which asserts that age is a critical risk factor for diabetic ulcers, with individuals being 11.183 times more likely to experience such complications as they age. Physiological decline typically begins after the age of 40, coinciding with the increased onset of diabetes mellitus during this vulnerable period. The risk of developing diabetes mellitus escalates significantly in individuals aged 45 and older. Research indicates that individuals over 30 years old experience an annual increase in fasting blood glucose levels by 1-2 mg/dl and a rise of 5.6-13 mg/dl two hours postprandially.

Furthermore, (Gould et al., 2022), suggest that individuals aged over 60 years, classified as late elderly, face heightened risks of diabetes mellitus along with complications such as diabetic ulcers. At this age, physiological functions decline due to degenerative processes, which lead to reduced insulin secretion or increased insulin resistance, compromising the body's ability to regulate blood glucose levels effectively. Common complaints in elderly DM patients, such as polyuria, polydipsia, and polyphagia, are often absent; instead, they tend to suffer from chronic degenerative complications in the blood vessels, stemming from pathophysiological changes associated with aging. Individuals aged over 45 with Type II Diabetes Mellitus demonstrate a rising incidence of complications correlating with age (Burhan et al., 2022; Burhan & Arofiati, 2021). Physiological changes, particularly in the pancreas's insulin production capabilities, become pronounced after the age of 45. This age group experiences a significantly heightened risk of diabetic foot ulcers due to the overall decline in bodily functions. According to (Albers et al., 2010), aging leads to decreased insulin secretion and resistance, resulting in macroangiopathy that adversely affects blood circulation, particularly in the large and medium vessels of the lower extremities, thereby increasing susceptibility to diabetic foot ulcers (Arisandi et al., 2016)The risk of glucose intolerance also escalates with advancing age, highlighting the necessity for diabetes screening in individuals over 45 years (The Emerging Risk Factors Collaboration, 2011).

Research conducted at the Hospital Infatil e Maternidade Jardim Amalia has demonstrated that foot care is a significant risk factor for the development of diabetic foot ulcers in patients with Type II Diabetes Mellitus. Patients with inadequate foot care were found to be 2.2 times more likely to develop diabetic foot ulcers compared to those

with proper foot care. These findings align with the study by (Bal et al., 2019), which highlighted that patients with diabetes who practice good foot care have a 14-fold greater chance of preventing ulcers compared to those with poor foot care. Thus, an increase in foot care activities correlates with a decreased risk of diabetic foot complications. Foot care serves as an easy and effective primary preventive measure for patients with diabetes mellitus to avoid diabetic foot complications.

Furthermore, the study by (Rastogi et al., 2020), indicates a significant relationship between foot care practices and the incidence of diabetic foot. Patients suffering from diabetic foot often exhibit inadequate foot care practices. Contributing factors include low awareness regarding foot care and limited information provided by community health centers, alongside the lack of regular foot examinations for early detection among diabetes patients. Poor foot care in diabetic patients can lead to severe health complications, including foot amputations. Annual foot examinations conducted by healthcare professionals and daily foot checks performed by patients or their families can prevent and reduce up to 50% of all diabetes-related amputations (Bal et al., 2019), Given that diabetic foot problems require prolonged treatment and care, preventive measures are essential to avoid diabetic ulcers (Burhan et al., 2023).

Diabetic foot issues arise from diminished sensory perception, exacerbated by impaired blood circulation in the extremities due to endothelial damage to blood vessels, which subsequently reduces the delivery of oxygen and nutrients to the skin and other tissues, thereby prolonging the wound healing process (Gould et al., 2022). The researcher posits that foot care is indeed a risk factor for the occurrence of diabetic foot ulcers in patients with Type II Diabetes Mellitus. Therefore, it can be asserted that the more diligent the foot care practices of patients with Type II Diabetes Mellitus, the higher the likelihood of preventing diabetic foot ulcers.

Strengths And Limitations of The Study
This study's strength lies in its comprehensive analysis of multiple risk factors for diabetic foot ulcers (DFU) in patients with Type II Diabetes Mellitus, offering valuable insights specific to the Brazil population. By utilizing data from a specialized hospital, the findings are clinically relevant and may guide targeted interventions in diabetic care. However, limitations include a relatively small sample size, which may affect the generalizability of results. Additionally, self-reported data, such as smoking history and foot care practices, may introduce recall bias, potentially impacting the accuracy of some findings.

implications on patient care and the profession.
This study underscores the need for healthcare providers to implement targeted preventive strategies in managing diabetic foot ulcers (DFU), especially among high-risk patients with Type II Diabetes Mellitus. Emphasizing patient education on foot care and regular screenings for neuropathy can significantly reduce DFU incidence. Additionally, routine BMI assessments and personalized lifestyle counseling may mitigate associated risks. Integrating these practices into patient care protocols can improve outcomes and reduce complications, thereby enhancing patients' quality of life and reducing healthcare costs. This proactive, preventive approach can also empower patients in managing their diabetes-related health risks more effectively.

Conclusions
This study concludes that various risk factors are associated with the occurrence of diabetic foot ulcers (DFU) in patients with type II diabetes mellitus. The analysis indicates that age is a significant risk factor, with higher DFU prevalence observed in the high-risk age group compared to the low-risk group. Additionally, Body Mass Index (BMI) shows a tendency towards a non-significant association, although individuals with higher BMI are at greater risk for developing diabetic foot ulcers. A history of smoking also appears to potentially increase risk; however, this relationship is not statistically significant. Furthermore, findings indicate a high prevalence of DFU among individuals with specific toe shapes, yet the analysis does not demonstrate statistical significance. Lastly, neuropathy does not reveal a significant association with the occurrence of diabetic foot ulcers in the studied population. Overall, this research provides insights into the factors influencing the development of DFU, which are crucial for prevention and management strategies in patients with type II diabetes mellitus.

Author contribution
Kaylan Wesle Elian and André Athrison made substantial contributions to the conception, design, data acquisition, and data analysis and interpretation. Stephany Daleska Cielo and Fiorella Camia Angelo were involved in drafting or critically revising the manuscript. Barbara Cathrine Nichole, Indah Susanti, and Asmat Burhan provided final approval of the version to be published, with each author taking responsibility for their respective portions of the content. Kaylan Wesle Elian is responsible for the overall work, ensuring that any issues related to the accuracy or integrity of any part of the work can be appropriately investigated and resolved.

Conflict of Interest Statement
The authors declare that they have no competing interests.

Data Avaibility
The datasets produced or examined in the present investigation can be obtained from the corresponding author upon a reasonable request.

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