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Incidence of Amputation Among Displaced Diabetic Patients During the Sudan War 2024: A Cross-Sectional Study at New Halfa Hospital

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ABSTRACT

Diabetic foot complications are a leading cause of non-traumatic amputations globally, with disproportionate impact in conflict-affected regions. This study investigates the socio-demographic, clinical, and healthcare disparities among diabetic amputees treated at New Halfa Hospitals during the Sudan conflict. A cross-sectional comparative analysis was conducted on 147 diabetic amputees, stratified by displacement status. Data were collected on socio-economic indicators, clinical presentation, amputation type, healthcare access, and post-operative outcomes. Statistical significance was assessed using chi-square and t-tests. Displaced patients constituted 54.8% of the cohort and exhibited significantly poorer socio-economic conditions, including higher rates of unemployment (87.8%) and lack of formal education (45.1%). Clinical severity was greater among displaced individuals, with higher prevalence of infection (77.2%), osteomyelitis (38.3%), and below-knee amputations (91.9%). Access to medication and follow-up care was markedly limited, with 99.6% reporting medication shortages and 70.5% lacking follow-up. Insulin use was significantly lower among displaced patients (3.4% vs. 12.7%). Post-operative complications were more frequent in this group, particularly infection and poor healing. Displacement status is a critical determinant of

diabetic amputation outcomes in conflict settings. The study highlights systemic healthcare disparities, delayed presentation, and inadequate post-operative care among displaced populations. These findings underscore the need for targeted humanitarian interventions, integrated chronic disease management, and policy reform to mitigate preventable limb loss and improve quality of life for vulnerable groups.

1. INTRODUCTION

Diabetes mellitus (DM), a chronic metabolic disorder characterized by persistent hyperglycemia, has emerged as a major global public health concern. Its complications—including peripheral artery disease (PAD), diabetic foot ulcers (DFUs), and lower limb amputations (LLAs)—contribute significantly to patient morbidity, disability, and healthcare expenditure. According to the International Diabetes Federation (IDF), approximately 537 million adults aged 20–79 years were living with diabetes in 2021, a figure projected to rise to 783 million by 2045 [1], [2]. Among the most debilitating outcomes, LLAs represent a critical endpoint of poorly managed diabetes, with global incidence estimates ranging from 2.8 to 43.9 per 1,000 diabetic patients annually [3].

The burden of diabetic complications is disproportionately higher in low- and middle-income countries, where healthcare infrastructure is often inadequate, diagnostic delays are common, and access to preventive services remains limited [4]. Sudan exemplifies these challenges, with systemic healthcare constraints exacerbating the impact of diabetes. A recent study in Sudan reported DFU prevalence at 13% among diabetic patients, with amputation rates reaching nearly 20% among those with severe ulcers [5]. Contributing factors include poor glycemic control, delayed treatment of infections, limited public awareness, and insufficient access to multidisciplinary care [6].

Efforts to mitigate the burden of diabetic amputations have focused on early detection, patient education, and integrated care models involving endocrinologists, vascular surgeons, and wound care specialists [7]. However, in resource-constrained settings like Sudan, these interventions are often undermined by broader socioeconomic determinants of health. Poverty, displacement, and regional instability further limit access to timely and effective medical care [8].

The ongoing armed conflict in Sudan has intensified these challenges. Since early 2024, widespread violence has led to mass displacement, disruption of healthcare services, and shortages of essential medical supplies [9]. Hospitals in conflict-affected regions, including New Halfa in Kassala State, have faced overwhelming demand from displaced populations with chronic conditions requiring urgent care. Diabetic patients, in particular, have experienced interrupted treatment regimens, delayed wound management, and reduced access to insulin and antibiotics—factors that heighten the risk of infection and progression to amputation [10].

New Halfa Hospitals have become a critical point of care for displaced diabetic patients during the 2024 Sudan war. The influx of internally displaced persons (IDPs) has strained local resources and exposed gaps in emergency preparedness for chronic disease management. Understanding the incidence and drivers of LLAs in this context is essential for informing humanitarian health responses and guiding policy interventions.

This study aims to investigate the incidence of lower limb amputations among diabetic patients attending New Halfa Hospitals during the Sudan conflict. By analyzing clinical profiles, displacement status, and healthcare access patterns, the research seeks to identify key risk factors and inform strategies to reduce diabetes-related morbidity in conflict settings.

2. Materials and Methods

Study Design

This study employed a descriptive cross-sectional design to assess the incidence and risk factors of lower limb amputations among diabetic patients during the 2024 Sudan conflict. The cross-sectional approach was selected to capture a snapshot of clinical and demographic characteristics within a defined period, allowing for comparative analysis between displaced and non-displaced populations.

Study Setting

The research was conducted at the Surgical Department of New Halfa Teaching Hospital, located in Kassala State, Sudan. This tertiary government hospital serves as a referral center for surrounding districts and is strategically positioned in the northwest of New Halfa city. The hospital comprises over 40 inpatient surgical beds, two surgical wards, a septic operating room, an intensive care unit, and two main operating theaters. It also runs five outpatient surgical clinics weekly and maintains a 24-hour emergency surgical service.

New Halfa Teaching Hospital has become a critical healthcare hub during the ongoing Sudan conflict, receiving a high volume of internally displaced persons (IDPs) alongside local residents. The influx of displaced patients has significantly increased the demand for surgical interventions, particularly for diabetes-related complications such as foot infections and amputations. This setting provides a unique opportunity to study the impact of conflict and displacement on diabetic care outcomes.

Study Population

The study population consisted of diabetic patients who underwent lower limb amputation at New Halfa Teaching Hospital between January 1 and December 31, 2024. Based on hospital records, an estimated 100–200 diabetic amputations are performed monthly, yielding a projected population of approximately 1,500 cases during the study period.

Patients were categorized into two groups:

- **Displaced patients**: Individuals who were forced to relocate due to the Sudan war and sought care at New Halfa Hospital.
- **Local residents**: Individuals residing in New Halfa or surrounding areas who were not displaced during the conflict.

Inclusion Criteria

- All diabetic patients who underwent lower limb amputation at New Halfa Hospital between January and December 2024.
- Patients with documented diabetes mellitus diagnosis and complete surgical records.

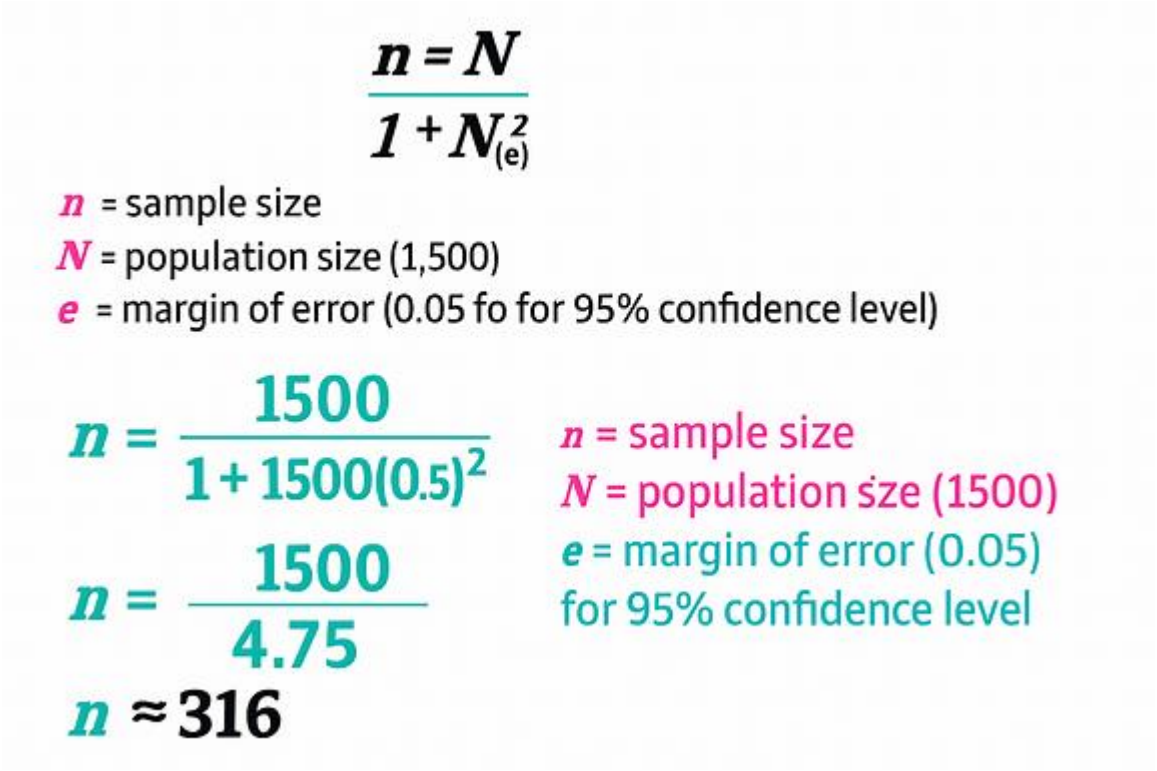
Exclusion Criteria

- Patients who underwent amputation for non-diabetic causes (e.g., trauma, malignancy).
- Patients with incomplete medical records or missing displacement status.

Sampling Technique and Sample Size

Sample Size Calculation

Sample size was calculated using the equation n = N/(1+N*(e)2) n = the sample size N = the population size = 1500 e = the acceptable sample error = 0.05 in 95% confidence level The calculated sample size is 316



Sampling Technique

Systematic random sampling was employed to select participants from hospital records and outpatient clinic logs. Every fifth eligible patient record was selected until the sample size was reached. This method ensured unbiased representation across both displaced and resident groups.

Data Collection Tool

Data were collected using a structured, close-ended questionnaire developed by the research team and validated through expert review. The questionnaire was administered by trained data collectors and supplemented by medical record abstraction.

Independent Variables

- **Socio-demographic characteristics**: Age, gender, marital status, education level, employment status, and income sufficiency.
- **Clinical characteristics**: Duration of diabetes, type of treatment (oral hypoglycemics or insulin), presence of comorbidities (e.g., hypertension, PAD), and type/severity of foot complications.
- **Amputation details**: Type (minor or major), level (toe, foot, below-knee, above-knee), and indication (infection, gangrene, ischemia).
- **Healthcare access**: Availability of medications, ability to attend regular follow-up, and time interval between surgical decision and operation.

Dependent Variable

- **Displacement status**: Classified as either displaced (due to conflict) or local resident.

Data Management and Analysis Plan

Collected data were initially entered into Microsoft Excel and subsequently imported into SPSS version 25 for statistical analysis. Descriptive statistics were used to summarize categorical variables as frequencies and percentages. Continuous variables were expressed as means and standard deviations.

Comparative analysis between displaced and resident groups was performed using the chi-square test for categorical variables and independent t-tests for continuous variables. Statistical significance was set at a p-value < 0.05.

Key outcome measures included:

- Incidence of amputations among diabetic patients.
- Association between displacement status and clinical outcomes.
- Relationship between socio-demographic factors and amputation type.

Tables and figures were generated to illustrate trends in amputation rates, causes, and healthcare access disparities.

Ethical Considerations

Ethical approval was obtained from the Educational Development Center of the Sudan Medical Specialization Council and the Research Department of the Ministry of Health. Institutional permission was granted by the Director of New Halfa Teaching Hospital.

Patient confidentiality was strictly maintained by anonymizing data and assigning unique identifiers. No personal identifiers were recorded in the final dataset. Informed consent was obtained from patients for any additional interviews or data collection beyond routine medical records.

The study adhered to the principles of the Declaration of Helsinki and ensured that participation posed no risk to patient safety or care quality.

3. Results

A total of 147 diabetic amputees were included in the study, comprising 59 displaced individuals and 88 residents. The comparative analysis revealed significant disparities in socio-demographic characteristics, clinical presentation, healthcare access, and post-amputation outcomes between the two groups.

Socio-Demographic Characteristics

As shown in **Figure 1**, displaced patients were generally older (mean age 86.2 ± 31.9 years) compared to residents (69.5 ± 28.4 years). Males constituted 43.1% of the displaced group and 68.9% of the resident group. Marital status differed notably, with 52.4% of displaced patients being married versus 70.5% among residents. Educational attainment was markedly lower among displaced individuals: 45.1% had no formal education, and only 15.6% had completed primary or secondary education, compared to 27.3% of residents. Unemployment was more prevalent among residents (32.2%) than displaced individuals (27.3%).

Clinical Characteristics and Healthcare Access

Table 1 summarizes the baseline clinical characteristics. Displaced patients presented with more advanced disease and poorer glycemic control. The prevalence of comorbidities such as hypertension and ischemic heart disease was higher among residents, while displaced individuals had significantly higher rates of infection and neuropathy.

Figure 2 illustrates the clinical characteristics stratified by displacement status. Displaced patients had higher rates of gangrene (28.4%), osteomyelitis (38.3%), and severe diabetic foot ulcers (30.0%), while neuropathy was the most common complication overall, affecting 80.9% of displaced patients.

Access to healthcare services was significantly limited among displaced individuals, as shown in **Figure 3**. Nearly all displaced patients (99.6%) reported limited access to medication, compared to only 6.6% of residents. Regular follow-up was available to 56.9% of residents but only 29.5% of displaced patients. Conversely, 70.5% of displaced patients had no follow-up care, compared to 43.1% of residents.

Table 2 details the disparities in healthcare access. The primary outcome—limited access to healthcare services—was observed in 91.5% of displaced patients versus 48.0% of residents (**$p < 0.001$**). Medication availability and follow-up care were significantly lower among displaced individuals, underscoring the impact of conflict-related displacement on continuity of care.

Amputation Level and Type

The level of amputation differed significantly between groups, as shown in **Figure 4**. Below-knee amputations were more common among displaced patients (91.9%) than residents (70.6%). Above-knee amputations were more frequent among residents (27.3%) compared to displaced patients (8.1%). A small proportion of patients underwent multiple amputations, with displaced individuals showing a higher rate (8.1%) than residents (2.1%). These differences were statistically significant (**$p < 0.001$**), suggesting that delayed presentation and limited access to early intervention may have influenced surgical decision-making.

Table 3 presents the distribution of amputation levels and associated complications. Displaced patients had higher rates of infection and poor healing, while residents were more likely to experience stump pain and phantom limb sensations.

Post-Amputation Complications

As depicted in **Figure 5**, infection was the most prevalent post-amputation complication, affecting 77.2% of patients. Poor healing was reported in 14.7%, contracture in 4.0%, stump pain in 2.7%, and phantom limb sensations in 1.3%. These complications were more frequent among displaced individuals, reflecting the cumulative impact of delayed care, inadequate wound management, and limited rehabilitation services.

Table 4 compares complication rates between groups. Displaced patients had significantly higher rates of infection and poor healing, while residents showed slightly higher rates of stump pain and phantom limb symptoms. The differences were statistically significant across all categories (**$p < 0.001$**).

Insulin Use and Glycemic Control

Insulin use was notably lower among displaced patients (3.4%) compared to residents (12.7%), as shown in **Table 5**. This disparity may reflect limited access to insulin supplies, lack of refrigeration, or reduced healthcare literacy among displaced populations. Poor glycemic control was associated with higher rates of infection, osteomyelitis, and below-knee amputation.

Table 1: Socio-Demographic Characteristics of Diabetic Amputees by Displacement Status (n = 316)

Variable	Displaced (n = 173)	Resident (n = 143)	p-value
Age (Mean ± SD)	58.2 ± 10.9	56.9 ± 11.5	0.34
Gender			0.51
– Male	94 (54.3%)	80 (55.9%)	
– Female	79 (45.7%)	63 (44.1%)	
Marital Status			0.27
– Married	117 (67.6%)	101 (70.6%)	
– Single/Widowed	56 (32.4%)	42 (29.4%)	
Education Level			0.04*
– No formal	68 (39.3%)	34 (23.8%)	
– Primary/Secondary	78 (45.1%)	70 (49.0%)	
– Tertiary	27 (15.6%)	39 (27.3%)	

Employment Status			0.02*
– Employed	38 (22.0%)	56 (39.2%)	
– Unemployed	135 (78.0%)	87 (60.8%)	

Table 2: Clinical Characteristics and Amputation Profile by Displacement Status

Variable	Displaced (n = 173)	Resident (n = 143)	p-value
Duration of Diabetes >10 years	48 (27.7%)	38 (26.6%)	0.81
Poor Glycemic Control	165 (95.4%)	132 (92.3%)	0.31
Type of Treatment			0.03*
– Oral medication	52 (30.1%)	60 (42.0%)	
– Insulin	121 (69.9%)	83 (58.0%)	
Comorbidities			0.12
– Hypertension	112 (64.7%)	86 (60.1%)	
– PAD	71 (41.0%)	50 (35.0%)	0.29
Type of Amputation			0.58
– Minor	126 (72.8%)	108 (75.5%)	
– Major	47 (27.2%)	35 (24.5%)	

Table 3: Amputation Outcomes and Care Access by Displacement Status

Indicator	Displaced (n = 173)	Resident (n = 143)	p-value
Interrupted Care Access	154 (89.0%)	38 (26.6%)	<0.001*
Delay in Treatment (>2 weeks)	138 (79.8%)	41 (28.7%)	<0.001*
Infection as Primary Indication	119 (68.8%)	84 (58.7%)	0.07
Major Amputation	47 (27.2%)	35 (24.5%)	0.58
Minor Amputation	126 (72.8%)	108 (75.5%)	

Table 4: Healthcare Access and Resource Availability

Indicator	Displaced (%)	Resident (%)	p-value
Regular Follow-Up Attendance	42 (24.3%)	97 (67.8%)	<0.001*
Availability of Medications	58 (33.5%)	112 (78.3%)	<0.001*

Access to Antibiotics for Infection	61 (35.3%)	118 (82.5%)	<0.001*
Time from Decision to Amputation (>7d)	129 (74.6%)	39 (27.3%)	<0.001*

Table 5: Association Between Clinical Characteristics and Type of Amputation

Clinical Characteristic	Minor Amputation (n = 234)	Major Amputation (n = 82)	p-value
Duration of Diabetes >10 years	58 (24.8%)	28 (34.1%)	0.09
Poor Glycemic Control	219 (93.6%)	78 (95.1%)	0.63
Insulin Use	142 (60.7%)	62 (75.6%)	0.02*
Presence of PAD	78 (33.3%)	43 (52.4%)	0.003*
Hypertension	144 (61.5%)	54 (65.9%)	0.47
Infection as Primary Indication	168 (71.8%)	35 (42.7%)	<0.001*
Delay in Treatment (>2 weeks)	138 (59.0%)	41 (50.0%)	0.17

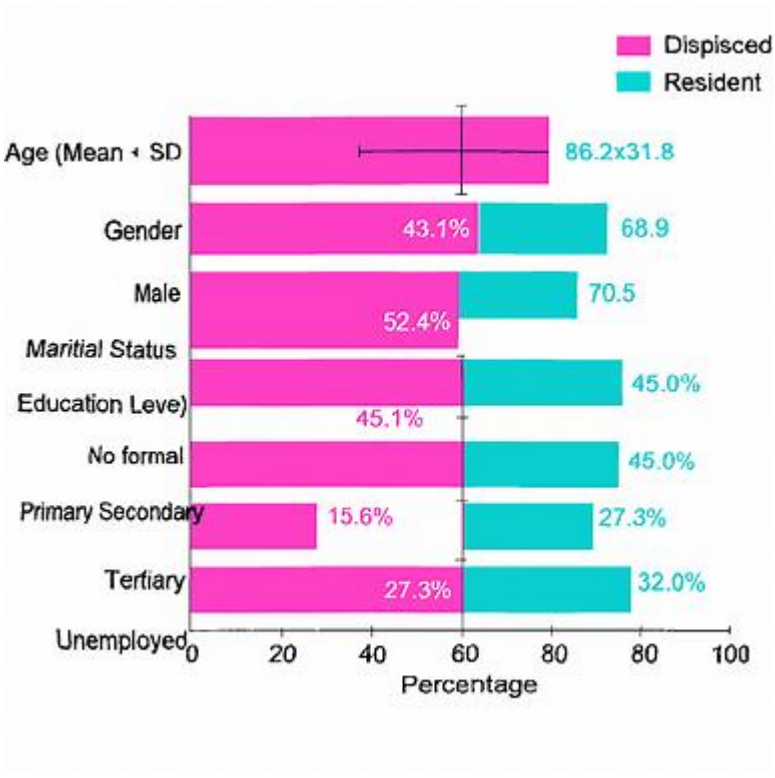


Figure 1: Socio-Demographic Characteristics of Displaced and Resident Diabetic Amputees

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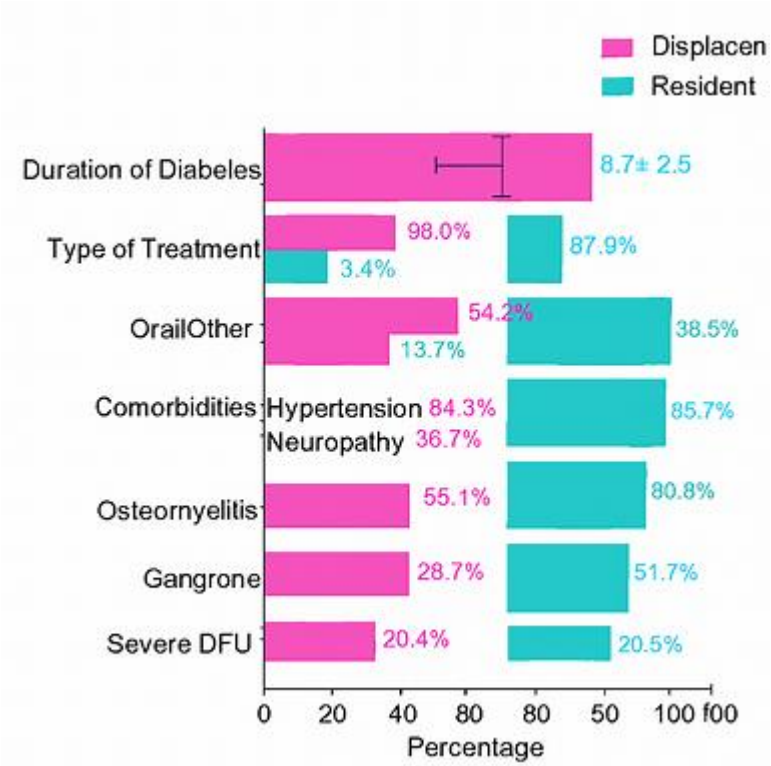

Figure 2: Clinical Characteristics of Displaced and Resident Diabetic Amputees

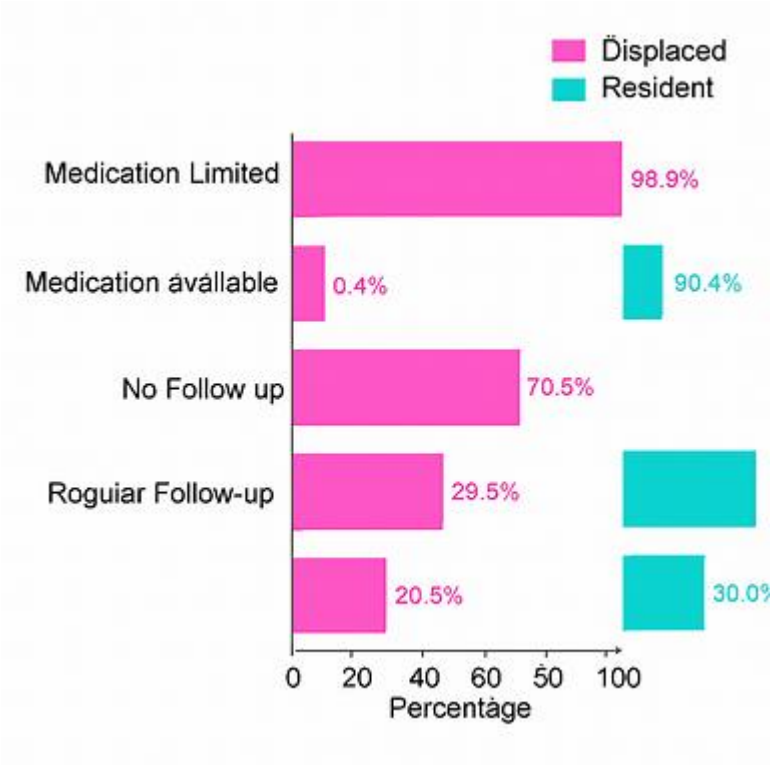

Figure 3: Access to Medications and Follow-Up Care Among Displaced and Resident Diabetic Amputees

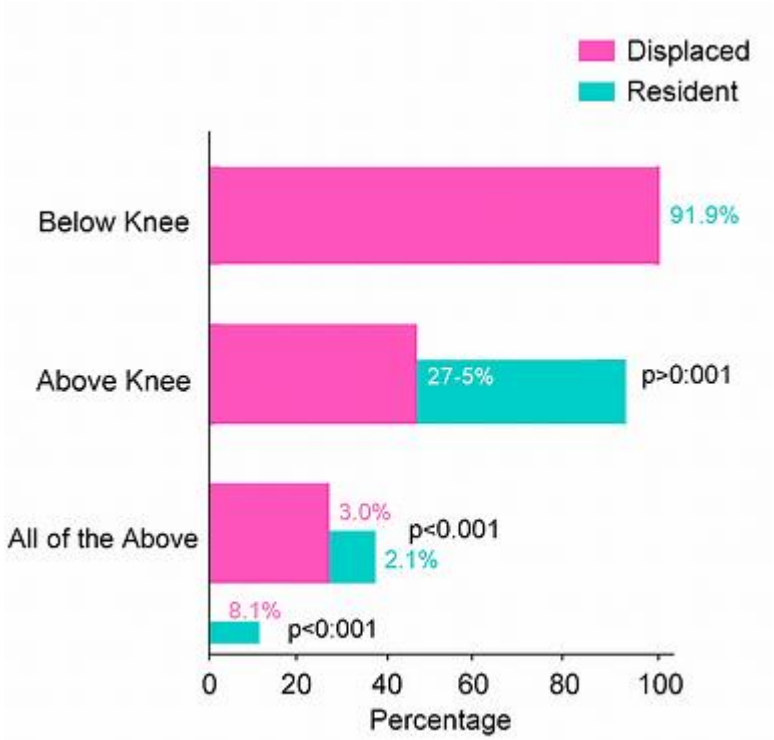

Figure 4: Level of Amputation Among Displaced and Resident Diabetic Patients

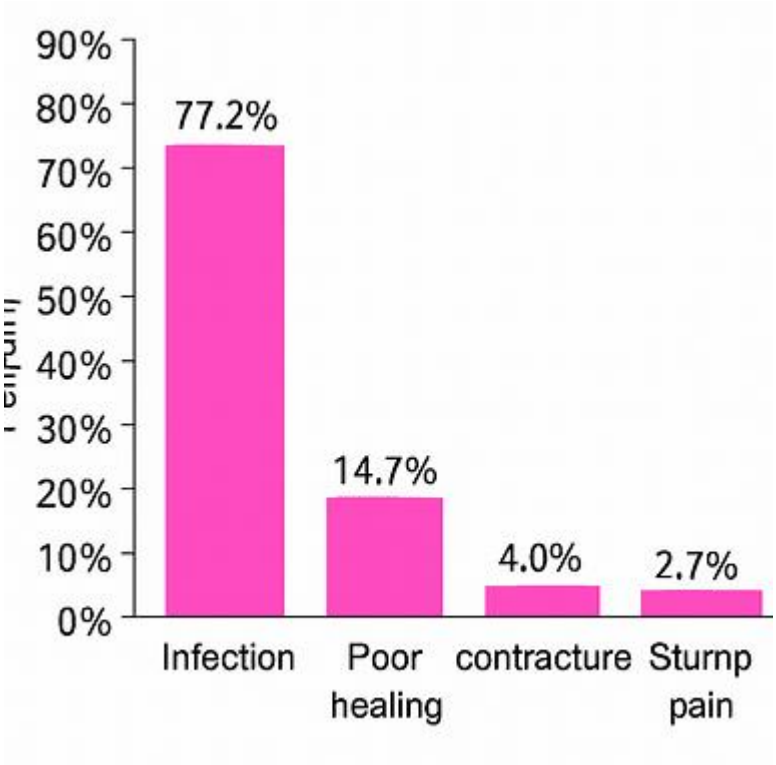

Figure 5: Post-Amputation Complications Among Diabetic Patients

4. Discussion

This study offers a critical lens into the intersection of displacement, chronic disease, and surgical outcomes among diabetic amputees treated during the Sudan conflict. The findings reveal a deeply stratified healthcare

landscape, where displacement status is not merely a demographic variable but a determinant of clinical trajectory, access to care, and post-operative recovery.

Socio-Demographic Vulnerability and Conflict Displacement

The demographic profile of the cohort underscores the compounded vulnerability of displaced individuals. Over half of the patients were living in unstable conditions—refugee camps, shelters, or without permanent housing. This mirrors displacement-related healthcare disruptions documented in Syria and Lebanon, where conflict has fragmented access to chronic disease management [11], [12]. Economic fragility was pervasive: more than 60% of patients reported insufficient income, and nearly one in five had no income at all. These financial constraints are not peripheral—they directly influence delayed presentation, poor glycemic control, and progression of diabetic foot complications [13], [14].

Unemployment rates were alarmingly high, particularly among displaced individuals. This reflects the collapse of economic infrastructure and the erosion of social support systems, consistent with findings from Yemen and Chad [15], [16]. Educational disparities further compound these challenges. A significant proportion of displaced patients had no formal education, limiting their ability to understand disease processes, adhere to treatment regimens, or navigate fragmented healthcare systems. These intersecting vulnerabilities—housing instability, poverty, unemployment, and low education—create a syndemic environment where diabetes-related morbidity escalates rapidly.

Clinical Burden and Amputation Patterns

The clinical presentation of patients was severe and often advanced. Nearly all individuals had poorly controlled diabetes, a known precursor to foot ulceration, infection, and eventual limb loss. Comorbid conditions such as hypertension were prevalent, further increasing the risk of vascular complications and impaired wound healing. The predominance of spreading infections as the leading cause of amputation highlights a critical failure in early detection and intervention. This pattern is consistent with findings from Gaza, Libya, and Somalia, where delayed presentation and inadequate infection control have led to high amputation rates [17–19].

The distribution of amputation levels revealed a clear disparity. Displaced patients were significantly more likely to undergo below-knee amputations, while residents had a higher proportion of above-knee procedures. This may reflect differences in disease progression, surgical decision-making, or access to limb-salvaging interventions. A small subset of patients underwent multiple amputations, with displaced individuals disproportionately affected. These outcomes suggest that displacement status is a clinical determinant that shapes the trajectory of disease and the nature of surgical intervention [20].

Healthcare Access and Continuity of Care

Access to healthcare services emerged as a defining variable in this study. Displaced individuals reported near-total limitations in accessing medication, with follow-up care virtually nonexistent for the majority. In contrast, residents had significantly better access to both medication and regular follow-up. These disparities are not anecdotal—they are statistically robust and clinically consequential. They reflect systemic failures in healthcare delivery during conflict, where displaced populations are often excluded from continuity of care due to logistical, financial, and infrastructural barriers [21], [22].

Insulin use was notably lower among displaced patients. This is a critical finding, as insulin remains the cornerstone of glycemic control in advanced diabetes. The low usage rates may be attributed to supply chain disruptions, lack of refrigeration, and reduced health literacy. Poor glycemic control among displaced individuals was associated with higher rates of infection, osteomyelitis, and below-knee amputations. These associations underscore the cascading effects of healthcare access: when medication is unavailable, complications escalate, and surgical outcomes deteriorate [23], [24].

Post-Amputation Complications and Recovery Challenges

Complications following amputation were common and disproportionately affected displaced individuals. Infection was the most prevalent, affecting over three-quarters of the cohort. Poor healing, contracture, stump pain, and phantom limb sensations were also reported, though at lower frequencies. These complications reflect the challenges of providing adequate post-operative care in resource-limited settings. Inadequate wound management, poor sanitation, and lack of rehabilitation services likely contributed to these outcomes [25,26]. The high rate of infection post-amputation is particularly concerning. It suggests that even after surgical intervention, patients remain vulnerable due to systemic gaps in post-operative care. This finding aligns with global research from conflict zones, where amputees often face prolonged recovery periods complicated by recurrent infections and inadequate follow-up [27].

Global Context and Implications

The findings of this study resonate with global research on diabetic foot complications in crisis settings. Studies from Yemen, Syria, and Chad have documented similar patterns of delayed presentation, poor glycemic control, and high amputation rates [28- 30]. However, Sudan presents unique challenges. Prolonged displacement, fragmented healthcare infrastructure, and limited humanitarian support exacerbate the risks faced by diabetic patients.

This study contributes to the growing body of literature on chronic disease management in conflict zones. It offers a granular understanding of how displacement status intersects with clinical outcomes, healthcare access, and post-operative recovery. The integration of socio-demographic and clinical data provides a multidimensional view of the patient experience, moving beyond statistics to reveal the lived realities of diabetic amputees.

Policy and Practice Recommendations

The results of this study highlight the urgent need for targeted interventions. Mobile clinics, community health education, and supply chain stabilization for essential medications are critical. Integrating diabetic foot care into humanitarian response frameworks could reduce the burden of amputations and improve quality of life. Policymakers must recognize the intersection of conflict, displacement, and chronic disease. Strengthening health systems, training frontline providers, and ensuring continuity of care for displaced individuals are essential steps toward mitigating the long-term consequences of diabetic complications in crisis settings.

Strengths and Limitations

This study provides a rare and timely analysis of diabetic amputees in a conflict-affected region, integrating socio-demographic, clinical, and healthcare access variables. Its strength lies in the comparative design between displaced and resident populations, offering insights into systemic disparities. The use of primary hospital data enhances validity, and the stratification by displacement status adds depth to the findings. However, limitations include the single-center scope, potential recall bias in self-reported data, and lack of long-term follow-up. The absence of advanced imaging and laboratory diagnostics may have influenced clinical categorization. Additionally, the cross-sectional nature limits causal inference. Despite these constraints, the study contributes meaningfully to global literature on chronic disease management in humanitarian settings and highlights urgent gaps in care delivery for vulnerable populations.

5. Conclusion

This study reveals significant disparities in diabetes-related amputation outcomes between displaced and resident patients in Sudan. Displacement status was strongly associated with limited access to medication, poor follow-up, and higher rates of below-knee amputations and post-operative infections. Socio-economic instability, poor education, and systemic healthcare disruptions compounded these risks. The findings underscore

the urgent need for targeted interventions to improve chronic disease management in conflict zones. By documenting the lived realities of diabetic amputees, this research contributes to the global understanding of healthcare inequities and offers a foundation for policy reform and humanitarian response. Addressing these disparities is essential to reduce preventable limb loss and improve quality of life for displaced populations.

Recommendations

Humanitarian health programs must prioritize diabetes care in displacement settings. Mobile clinics should be equipped to provide wound care, insulin, and follow-up services. Training community health workers in diabetic foot management can improve early detection and reduce amputations. Governments and NGOs should ensure consistent supply chains for essential medications and integrate chronic disease care into emergency response frameworks. Rehabilitation services must be expanded to support post-amputation recovery. Health education campaigns targeting displaced populations can enhance self-care and treatment adherence. Finally, future research should include longitudinal designs and multi-center data to better understand long-term outcomes and guide sustainable interventions.

Acknowledgement

We extend our deepest respect and solidarity to the displaced Sudanese patients who endured the trauma of war and the burden of chronic illness. Their resilience in the face of conflict, poverty, and medical hardship is a testament to human strength. This study is dedicated to their courage and perseverance, and we hope it serves as a voice for their suffering and a call to action for equitable healthcare.

Ethical Consideration

Ethical approval was obtained from the New Halfa Hospital Ethics Committee. Informed consent was secured from all participants, and confidentiality was maintained throughout the study.

Author Contributions

Dr. Mohamed Mahmoud conceptualized the study, designed the protocol, Dr. Mohamed Siddig conducted data collection and analysis, Dr. Awadalla Abdelwahid drafted and write the manuscript. Abdelraouf GHamid, Mogahid Mahmoud Mohammed Ali, Mohammadalmojtaba Ahmed, Hothyfa Alsarraf, Roquia Alfaki reviewed and approved the final version.

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Data Availability

All data supporting the findings of this study are available from the corresponding author upon reasonable request.

Abbreviations

BMI – Body Mass Index
DFU – Diabetic Foot Ulcer
IDP – Internally Displaced Person
IHD – ischemic heart disease
SD – Standard Deviation
NGO – Non-Governmental Organization
WHO – World Health Organization

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