STATISTICAL ANALYSIS OF DIABETIC PATIENTS WITH FOOT ULCER (A STUDY OF FEDERAL MEDICAL CENTRE, UMUAHIA, ABIA STATE)

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ABSTRACT

This research was carried out to investigate the Statistical Analysis of Diabetic Patients with Foot Ulcer (A Study of Federal Medical Centre, Umuahia, Abia State). The Federal Medical Center in Umuahia provided the secondary data for this study, which included censored and deceased diabetic patients with foot ulcers. The information on foot ulcer kinds, types of ulcers, and sites spans three years, from 2021 to 2023. The non-parametric survival model was the analytical tool employed in this study. 37.5% of the results were female, and 62.5% were male. Of these patients, 57.33% were censored and 42.67% of the female patients passed away. Of the male patients, 54.4% were censored and 45.6% were dead. About 21% of the diabetic patients in the study had type 1 diabetes, whereas 79% had type 2 diabetes. Of the patients with diabetes, 40.5% had type 1 diabetes and 45.6% had type 2 diabetes at the end of the study. Neuroishemic, ishemic, and neuropathic ulcers affect 77.5%, 15.5%, and 7.0% of the patients, respectively. 75.5% of the patients have the ulcer on their forefoot, 12.5% and 12 % have the ulcer on their mid foot and hind foot respectively. Additionally, statistical studies utilizing the Breslow and log-rank tests reveal no significant differences across the groups of diabetic complications. The survival plot suggests that patients with neuropathy have a higher chances of survival to those with other ulcer types, patients with ulcer on their fore foot have a higher chances of survival to those affected in other area, female patients have a lower chances of survival to a male patient & diabetic type 2 patients have a lower chances of survival to diabetic type I patient. The study also found that two significant explanatory factors are ulcer size and age. Based on the findings of this study, it was recommended that effective health care system should be provided by government at all levels to meet the needs of diabetic patients and prevent diabetic foot ulcer.

Keywords: *foot ulcer, diabetes, survival probability, diabetes patients*

INTRODUCTION

Diabetes is a long-term metabolic illness marked by high blood glucose (blood sugar) levels. Serious damage to the heart, blood vessels, eyes, kidneys, and nerves can result from diabetes over time. One of the major worldwide health concerns nowadays is diabetes, and the number of people with the disease is steadily rising. WHO (2020) projects that by 2010, there would be over 221 million diabetics worldwide, up from an estimated 151 million in 2000. In just ten years, a growth of 70 million people equated to a 46% increase. According to a WHO prediction made by Hillary King, by 2025, this number is expected to increase to 300 million (Wong, 2017).

Between 1992 and 2000, the percentage of hospitalizations with diabetic complications per 1,000 patients diagnosed with the disease rose to 24%. About 192 hospitalizations with a diabetes diagnosis occurred in 2000 for every 1,000 hospitalizations with a diabetes diagnosis (Nurudeen et al., 2019). An open wound or sore that typically appears on the bottom of the foot, diabetic foot ulcers affect about 15% of patients with the disease. Hospitalization is a possibility for 6% of patients with foot ulcers because of infection or other ulcer-related problems.

Peripheral neuropathy, atherosclerotic peripheral arterial disease, and mechanical alterations in the foot's bone architecture are some of the causes of diabetic foot ulcers; these conditions are all more common and severe in the diabetic population (WHO, 2020). Many developing nations are paying more and more attention to the issue of chronic diseases. Among other things, the WHO has spearheaded the development of suitable procedures and methods for monitoring the risk factors for chronic diseases and has helped nations by offering training as well as financial and technical support (2020).

The survival probability is the likelihood of surviving at the conclusion of an interval is contingent upon the subject's survival at the start of the interval. According to Yunir et al. (2022) survival is determined at each time point by multiplying the conditional probability of survival for each interval of time. The survival rate of people with diabetic foot ulcers has been the subject of comparatively few investigations. In addition, a large number of these studies are based on common instances, which overstate mortality because ulcers had probably been there for months or even years prior to the patients being enrolled. Ultimately, scant information exists regarding the prognosis of individuals suffering with neuropathic, neuroischemic, or ischemic foot ulcers (Yunir et al., 2022).

According to Sarwar et al. (2018), diabetic patients may have a 25% lifetime risk of getting diabetic foot ulcers, making them a prevalent and greatly dreaded consequence of diabetes. Most patients and caregivers find it challenging to administer the lengthy and intense treatment needed for foot ulcers. The majority of diabetic foot ulcer sufferers have passed away while still residing with their loved ones. This study aims to conduct research on the statistical analysis of diabetic patients with foot ulcers in light of the Federal Medical Center, Umuahia's rising death rate. The specific objectives of this study are: Estimate the parameters of the factors affecting the survival rate of diabetes patients with foot ulcers, to fit an appropriate survival model, and compare the survival probability of diabetic patients with foot ulcers and identify significant risk factors for mortality and morbidity.

LITERATURE REVIEW

By modeling the survival probability of diabetes patients undergoing follow-up, Derbachew, Fikre, and Cheru (2015) were able to identify important risk variables for both death and morbidity. At Yekatit-II Hospital in Ethiopia, recorded hospital data were acquired for a cohort of 462 patients. The patients were observed between September 2003 and August 2011. The survival time is estimated using the parametric, non-parametric, and semi-parametric survival models. Additionally, the relationship between the survival time and various risk behavior, health, and demographic characteristics is investigated. According to the data, the majority of causes considerably shorten the survival period for people with diabetes mellitus. These factors include being overweight, using tobacco or alcohol, having type I diabetes, its complications, patients with these conditions, uncontrollably high blood pressure, high blood cholesterol, high fasting blood sugar, and a positive family history of the disease. Therefore, it is advised that people should be aware of the impact of these risk factors and knowledgeable about the illness.

Banik, Barua, and Moniruzzaman (2020) investigated the risk of diabetic foot ulcers and the factors that are related to them in patients from Bangladesh. The study evaluated the incidence of diabetic foot ulcers (DFU) and identified risk variables for these conditions in Bangladeshi participants with type 2 diabetes (T2D). A modified version of the International Working Group on the Diabetic Foot (IWGDF) Risk Classification System was used to evaluate the risk of DFU. Peripheral neuropathy (PN), peripheral arterial disorders (PAD), deformity, ulcer history, and amputation were the five characteristics that comprised the modified method. Group 0 (no PN, no PAD), Group 1 (PN, no PAD and no deformity), Group 2A (PN and deformity, no PAD), Group 2B (PAD), Group 3A (ulcer history), and Group 3B (amputation) were the classifications used to identify the hazards. Multinomial logistic regression was used to identify the related determinants of DFU risk for each risk group independently. Overall, 44.5% of the individuals were determined to be at risk of DFU, according to the results. In comparison to the urban population, this risk was higher among men (45.6%) than among women, and among those who lived in rural areas (45.5%). Group 0, Group 1, Group 2A, Group 2B, Group 3A, and Group 3B had risk distributions of 55.5%, 4.2%, 11.6%, 0.3%, 20.6%, and 7.9%, respectively, based on IWGDF categories. A history of trauma, age $\geq$50, living in a rural location, low socioeconomic status, insulin use, diabetic retinopathy, and diabetic nephropathy were the related factors of DFU (OR >1). The study found that a sizable portion of the T2D participants were at risk for DFU, necessitating the implementation of a successful screening program to lower the morbidity and mortality associated with DFU.

In three referral hospitals in Mogadishu, Somalia, Salad, Duale, Sheikh, Hassan, and Farah (2023) investigated the prevalence of diabetic foot ulcers and related variables among adult diabetic patients. Between August and November of 2022, a cross-sectional study centered at an institution was carried out with 193 people who had diabetes. The study comprised all eligible diabetic patients receiving care at De Martini Hospital, Madina General Hospital, and Deynile General Hospital during the study period. A logistic regression model, both bivariate and multivariable, was built to determine the factors linked to diabetic foot ulcers. A 95% confidence interval-based odds ratio was calculated to assess the degree of significance. The participants in the study were 50.9 ± 13.6 years old on average. 15% of people with diabetes had foot ulcers. Patients were more likely to develop diabetic foot ulcers (DFU) if they were overweight or obese (OR 4.63, CI: 2.08–10.30), did not inspect their feet on a regular basis (OR 3.33, CI: 1.74–6.36), or both (OR 1.99, CI: 1.08–3.66). DFUs were linked to an increased body mass index, a lack of family support, and infrequent foot checks. Health care is challenged by the high frequency of DFUs and the multitude of demands of individuals with DFUs. It need a unified healthcare system to address the requirements of people with diabetes and prevent DFUs.

A review was done on diabetic foot ulcers by David et al. (2023). They discovered that diabetic foot ulcers are caused by neurological, vascular, and biomechanical causes. Between 50 and 60 percent of ulcers develop an infection, and 20 percent of moderate to severe infections result in the amputation of a lower limb. About 30% of people with diabetic foot ulcers die within 5 years, and the rate rises to almost 70% in cases of serious amputation. Those with diabetic foot ulcers had a mortality rate of 231 deaths per 1000 person-years, while those without the condition have a mortality rate of 182 deaths per 1000 person-years. Compared to White people, Black, Hispanic, or Native American individuals as well as those with poor socioeconomic position had greater rates of diabetic foot ulcers and consequent amputations. It is possible to determine the risk of limb-threatening disease by categorizing ulcers according to the extent of tissue loss, ischemia, and infection. When compared to standard care, a number of interventions lower the risk of ulcers: wearing pressure-relieving footwear (13.3% vs. 25.4%; relative risk, 0.49; 95%CI, 0.28-0.84); measuring the skin of the feet and off-loading them when hot spots (i.e., a difference of more than 2 °C between the affected and unaffected foot) are detected (18.7% vs. 30.8%; relative risk, 0.51; 95%CI, 0.31-0.84); and treating preulcer signs. Surgical debridement, minimizing pressure from weight bearing on the ulcer, and treating lower extremity ischemia and foot infection are first-line therapy for diabetic foot ulcers. Randomized clinical trials support therapies to speed wound healing and culture-directed oral antibiotics for localized osteomyelitis. Diabetic foot ulcers affect approximately 18.6 million people worldwide each year and are associated with increased rates of amputation and death. Multidisciplinary care, typically consisting of podiatrists, infectious disease specialists, and vascular surgeons in close collaboration with primary care clinicians, is associated with lower major amputation rates relative to usual care (3.2%vs 4.4%; odds ratio, 0.40; 95%CI, 0.32-0.51). Approximately 30% to 40% of diabetic foot ulcers heal at 12 weeks, and recurrence after healing is estimated to be 42% at 1 year and 65% at 5 years.

Ulandari, Kurniawan, and Muhadi (2023) looked at the NLR analysis in those with Type 2 diabetes mellitus who had diabetic foot ulcers and those who did not. A retrospective analysis of the medical records of 120 patients, 60 in each group with T2DM with and without diabetic foot ulcers, was conducted at Dr. Wahidin Sudirohusodo Hospital in Makassar between September 2019 and October 2021. Using the flow cytometry approach, leukocytes, neutrophils, lymphocytes, and NLR were determined based on standard blood findings. The Kruskal-Wallis test was employed to examine the link between NLR and Wagner's classification, and the Mann-Whitney test was utilized to compare the two groups on NLR. T2DM patients with diabetic foot ulcers had significantly different leukocyte, neutrophil, lymphocyte, and NLR from those without ($p<0.001$); 16.2±8.6 and 9.8±4.2 103/μL; 13.3±8.4 and 5.0±3.8 103/μL ($p<0.001$); 1.6±1.7 and 2.5±2.5 103/μL ($p<0.001$); 10.0±10.1 and 3.5±4.5, respectively. With significant statistical test results ($p<0.037$), the association between the NLR and Wagner's classification was lowest at Wagner grade 2 (6.18±7.83) and highest at Wagner grade 5 (12.87±5.0). Because of systemic inflammation, there was an increase in NLR in T2DM patients with diabetic foot ulcers. The NLR combines various immunological pathways, including lymphocytes that regulate inflammation and neutrophils that cause an inflammatory response. Compared to individuals without diabetic foot ulcers, T2DM patients with diabetic foot ulcers had greater lymphocyte counts and NLR levels.

Through a comprehensive review and meta-analysis, Akhtar et al. (2022) investigated the frequency of foot ulcers among diabetic patients in Pakistan. Our goal was to ascertain Pakistan's pooled prevalence of diabetic foot ulcers. We conducted a thorough search of MEDLINE (PubMed), Web of Science, Google Scholar, and local databases to find research on the prevalence of foot ulcers among diabetes patients in Pakistan that were published up until August 10, 2022. Summaries were produced using a random-effects meta-analysis. Meta-regression models and subgroup analysis were employed to tackle the problem of significant heterogeneity. Independently, two writers found relevant papers, gathered information, and carried out a risk of bias analysis. The meta-analysis comprised twelve studies (14201, range 230–2199, diabetic individuals), seven of which were rated as "high" quality. Diabetic foot ulcers had a pooled prevalence of 12.16% (95% CI: 5.91–20.23%).While there was no statistically significant indication of publication bias ($p = 0.8544$), we did find significant between-study heterogeneity ($I2= 99.3\%$; $p < 0.001$). Significant variations in the occurrence of foot ulcers were discovered by subgroup meta-analysis based on the length of diabetes and the year of publication. Over the past two decades, there has been a noticeable increase in the frequency of diabetic foot ulcers. The highest prevalence was recorded in the most recent period, from 2011 to 2022 (19.54%), compared to the early 2000s (4.55%). According to this study, there is a considerable regional difference in the prevalence of diabetic foot ulcers in Pakistan, which is rather high. To find strategies for the population's early detection, prevention, and treatment, further research is needed.

In an unmatched case-control study, Woldemariam et al. (2022) investigated the risk factors for diabetic foot ulcers in adult patients with diabetes who visited the diabetic clinic at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia. One of the most prevalent side effects of diabetes mellitus, diabetic foot ulcers are linked to a high rate of morbidity and death in individuals with the disease. Due to the rising prevalence of diabetes, the incidence of diabetic foot ulcers is rising in the modern day. Ethiopia has done less research on the problem's risk factors, though. In order to better understand the factors that contribute to diabetic foot ulcers in adult patients with diabetes who visit a diabetic clinic at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia in 2019, this study was carried out.

A study involving 161 patients with diabetes (53 with foot ulcers and 108 without) was carried out using an institution-based unmatched case–control design. Patients with diabetes who had foot ulcers were the cases, while patients without diabetic foot ulcers were the controls, chosen by a rigorous random sample procedure. Utilizing a binary logistic regression model, the relationship between the independent and dependent variables was evaluated. The multivariable analysis included all factors with a P-value<0.25. A 95% confidence interval and a P-value less than 0.05 were used to determine statistical significance. Males made up 55 (50.9%) of the study's controls and 28 (52.8%) cases.

Diabetes-related foot ulcers were positively correlated with taking insulin alone (AOR=2.75, 95% CI=1.04–7.23), having peripheral neuropathy (AOR=7.56, 95% CI=2.82–20.24), not checking feet every day (AOR=5.61, 95% CI=2.24–14.05), and using moisturizing cream in between toes (AOR=3.35, 95% CI=1.35–8.32). Conversely, diabetic foot ulcers were negatively correlated with employed (AOR=0.35, 95% CI=0.14–0.87) and combined treatment (insulin and oral hypoglycemic agents) (AOR=0.11, 95% CI=0.02–0.57). The following factors were significantly linked to diabetic foot ulcers: occupation, type of diabetes mellitus therapy, peripheral neuropathy, daily foot inspections, and use of moisturizing cream between toes. Patients with diabetes will benefit if they check their feet every day and avoid putting moisturizing cream in between their toes.

METHODOLOGY

METHOD OF DATA COLLECTION

The data used for this work is secondary data from censored and dead patients who suffered from diabetes with foot ulcers in the Federal Medical Centre, Umuahia. The data covers a period of 3 years from 2021 to 2023 on types of diabetes, ulcer types and site ulcers on the foot.

METHOD OF DATA ANALYSIS

The method used for this analysis is non-parametric survival model.

KAPLAN-MEIER ESTIMATOR

The Kaplan-Meier estimator of the survivorship function (or survival probability)

$\hat{S} = P(T \geq t)$ is defined as:

$$\hat{S} = P[T \geq t] = \prod_{t_j < t} \left(\frac{n_j - d_j}{n_j} \right) \quad (1)$$

Where d_j is the number of individuals who experience the event at time t_j, and n_j is the number of individuals who have not yet experienced the event at that time (Hosmer and Lemeshow, 1998).

COMPARISON OF SURVIVORSHIP FUNCTIONS

It is usually a good idea to start with a graphical representation of the data in each group when comparing groups of participants. The overall pattern of one survivorship is depicted in the figure. If one function is above the other, it indicates that the group represented by the higher curve outlived the group represented by the lower curve or had a better chance of surviving (Yang and Goldstein, 2003). Whether the observed difference shown in the figure is significant is the statistical question. The general form of this test statistic is given by:

$$Q = \frac{\left[\sum_{i=1}^{m} w_i (d_{li} - \hat{e}_{li}) \right]^2}{\sum_{i=1}^{m} w_i^2 \hat{v}_{li}} \quad (2)$$

Where $\hat{e}_{li} = \frac{n_{li} d_i}{n_i}$, $\hat{v}_{li} = \frac{n_{1i} n_{0i} (n_i - d_i)}{n_i^2 (n_i - 1)}$, n_{0i} is the number at risk at observed survival time $t_{(i)}$ in group 0, n_{1i} is the number at risk at observed survival time $t_{(i)}$ in group 1, d_{0i} is the number of observed deaths in group 0, d_{1i} is the number of observed deaths in group 1, n_i is the total number of individuals or risk before time $t_{(i)}$ and d_i is the total number of deaths at $t_{(i)}$ If weights (w_i) equal to 1, i.e. $w_i = 1$,the Cochran-Mantel-Haenszel Log Rank test Q_{LR} is used ; otherwise if $w_i = n_i$, the Generalized Wilcoxon test Q_{GWt} I s used

$$Q_{LR} = \frac{\left[\sum_{i=1}^{m} (d_{li} - \hat{e}_{li}) \right]^2}{\sum_{i=1}^{m} \hat{v}_{li}} \quad (3)$$

$$Q_{GWt} = \frac{\left[\sum_{i=1}^{m} n_i (d_{li} - \hat{e}_{li})\right]^2}{\sum_{i=1}^{m} n_i^2 \hat{v}_{li}} \tag{4}$$

SEMI-PARAMETRIC SURVIVAL MODEL

- **THE COX PROPORTIONAL HAZARD MODEL**

Typically, it is expressed using the hazard model formula. This model provides a statement for the risk for a person with a specified collection of explanatory variables, indicated by X and it is generally given by;

$$h(t, \mathbf{X}_i, \beta) = h_0(t) \exp(\beta' \mathbf{X}_i) \tag{5}$$

Where $h_0(t)$ is the baseline hazard function that characterizes how the hazard function changes as a function of survival time, $\mathbf{X}_i$ is the vector of values of the explanatory Where $S_0(t)$ is the baseline survival function.

- **FITTING PROPORTIONAL HAZARD MODEL**

The Maximum Likelihood estimates of the Cox model parameters are derived by variables for the i^{th} Individual at time t and β is the vector of unknown regression parameters that are assumed to be the same for all individuals in the study, which measure the influence of the covariate on the survival experience. The formula for the cumulative hazard function is given by:

$$H(t) = H_0(t) \exp(\beta' \mathbf{X}_i) \tag{6}$$

The survivor function is:

$$S(t, \mathbf{X}, \beta) = S_0(t) \exp(\beta' X_i) \tag{7}$$

maximizing a likelihood function usually denoted as L. The likelihood function is a mathematical equation that shows, as a function of the unknown parameters (the $\boldsymbol{\beta}$'s) in the model under consideration, the combined probability of getting the data actually observed on the study participants. L is sometimes denoted as $L(\beta)$ where β denotes the collection of unknown parameters

The partial likelihood can be written as the product of several likelihoods, one for each of, say k failure times. Thus, at the j^{th} failure time, l_j denotes the likelihood of failing at this time, given survival up to this time. Note that the set of individuals at risk at the j^{th} the failure time is the risk set, $R(t_{(j)})$,and this set may changes and actually gets smaller in size as the failure time increases.

$$(\beta) = \prod_{j=1}^{k} l_j \tag{8}$$

In a general sense, the partial likelihood is given by the expression

$$l_p(\beta) = \prod_{i=1}^{m} \left[\frac{e^{X_i \beta}}{\sum_{j \in R(t_i)} e^{X_j \beta}} \right]^{c_i} \tag{9}$$

where the summation in the denominator is over all subjects in the risk set at time t_i denoted by $R(t_i)$ when there are no tied times, and it is often modified to exclude terms when $c_i = 0$,yielding

$$l_p(\beta) = \prod_{i=1}^{m} \left[\frac{e^{X_i \beta}}{\sum_{j \in R(t_i)} e^{X_j \beta}} \right], \log(l_p(\beta)) \tag{10}$$

$$= \sum_{i=1}^{m} \left\{ X_{(i)}\beta - \ln\left[\sum_{j \in R(t_{(j)})} e^{X_j \beta} \right] \right\} \tag{11}$$

where the product is over the m distinct ordered survival time and $X_{(i)}$ denotes the value of the covariance for the subject with ordered survival time $t_{(i)}$.

MODEL SELECTION

There are two ways we might choose the model that best predicts how long diabetic patients will live. The graphical method is the first (Schoenfeld, 1984). The typical residual plot for this method is the Cox-Snell plot. It is employed to assess the degree to which a certain distribution matches the observed data. If the theoretical distribution given is the right model, this plot will be roughly linear. Together with the goodness of fit tests, easy fit shows the reference diagonal line that the graph points should fall along; distribution plots can be useful in identifying the model that fits the data the best. This approach's primary distinction is that conclusions are very subjective, but goodness of fit tests are "exact" in that the results are independent of the researcher—as long as the tests are conducted correctly, that is. The plot method is said to be a more empirical way to choose a model. An information criteria (AIC) statistic was introduced by Akaikie (1974) for the purpose of comparing several models and/or models with varying numbers.

DATA ANALYSIS AND INTERPRETATION OF RESULTS

The study examined 200 diabetic individuals with foot ulcers; of these, 62.5% were men and 37.5% were women. Of these patients, 57.33% were censored and 42.67% of the female patients passed away. Of the male patients, 54.4% were censored and 45.6% were dead. About 21% of the diabetic patients in the study had type 1 diabetes, whereas 79% had type 2 diabetes. Of the patients with diabetes, 40.5% had type 1 diabetes and 45.6% had type 2 diabetes at the end of the study. Neuroishemic, ishemic, and neuropathic ulcers affect 77.5%, 15.5%, and 7.0% of the patients, respectively. Forefoot ulcers affect 75.5% of patients, while midfoot and hindfoot ulcers affect 12.5% and 12% of patients, respectively.

Table 1: Summary of the descriptive statistic

Covariates	Status		Total (%)
	Number of censored (%)	Number of deaths (%)	
Sex			
Female (2)	43(57.33%)	32(42.67%)	75(37.5%)
Male (1)	68(54.4%)	57(45.6%)	125(62.5%)
Type of Diabetes			
Type 1	25(59.5%)	17(40.5%)	42(21%)
Type 2	86(54.4%)	72(45.6%)	158(79%)
Ulcer type			
Neuropathic (1)	84(75.7%)	71(45.8%)	155(77.5%)
Neuroischemic (2)	18(16.2%)	13(41.9%)	31(15.5%)
Ischemic (3)	9(8.1%)	5(5.6%)	14(7.0%)
Site of Ulcer			
Forefoot (1)	94(62.2%)	57(37.8%)	151(75.5%)
Midfoot (2)	12(48%)	13(52%)	25(12.5%)
Hindfoot (3)	5(20.8%)	19(79.2%)	24(12%)

KAPLAN-MEIER ESTIMATES

The Kaplan-Meier estimates of the various groups of subjects (sex, ulcer types, foot site and diabetes type), are shown in the figures below using equation 1 to 4.

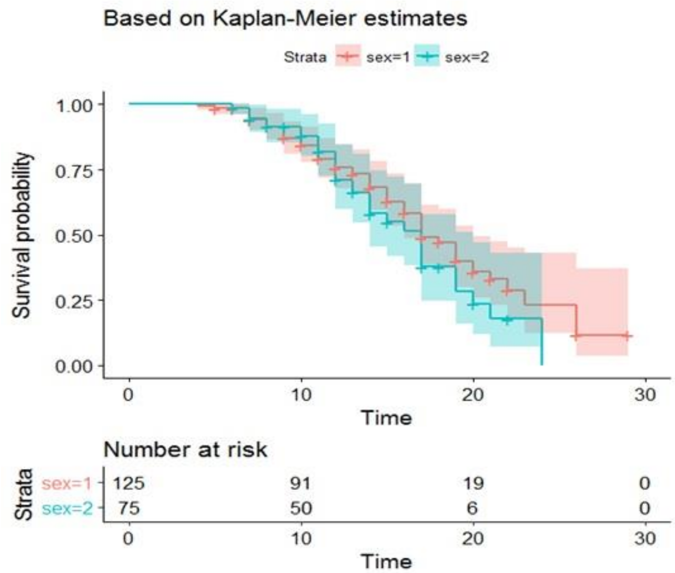

Figure 4.1: *Survival curves for sex based on Kaplan-Meier estimates*

The plot in figure 4.1 shows the survival curves of a female and male patients. Applying equation 1 to 4, the result suggests that sex 2 which representing the female patients have a lower chances of survival to a male patient (sex 1) based on Kaplan-Meier estimates.

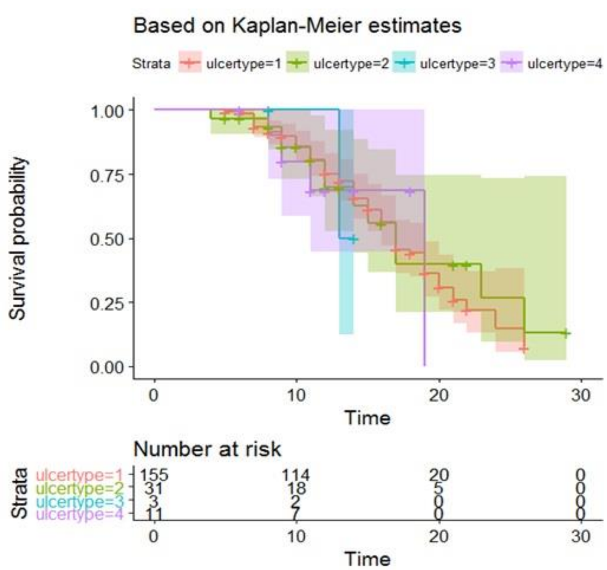

Figure 4.2: *Survival curves for the ulcer types based on Kaplan-Meier estimates*

The plot in figure 4.2 shows the survival curves of different ulcer types. Applying equation 1 to 4, the result suggests that patients with neuropathy have a higher chances of survival to those with other ulcer types.

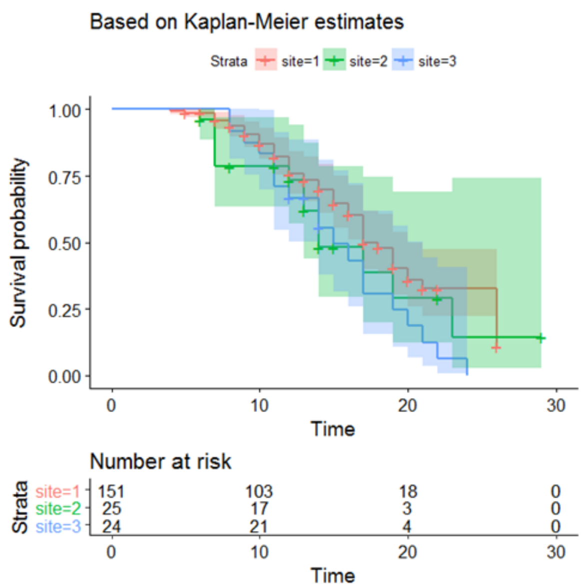

Figure 4.3: *Survival curves for the site of the affected foot based on Kaplan-Meier estimates.*

The plot in figure 4.3 shows the survival curves of different affected foot site. Applying equation 1 to 4, the result suggests that patients with ulcer on their fore foot have a higher chances of survival to those affected in other area.

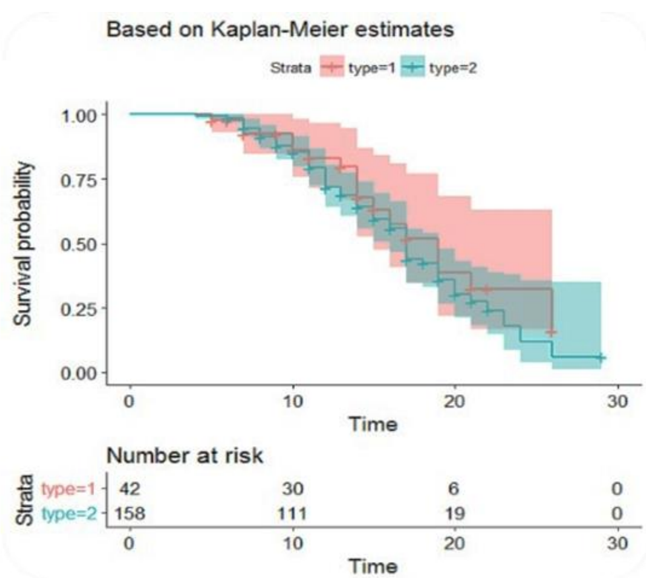

Figure 4.4: *Survival curves for diabetes type based on Kaplan-Meier estimates*

Figure 4.4 shows the survival curves of diabetes type I & II patient. Applying equation 1 to 4, the result suggests that diabetic type 2 patients have a lower chances of survival to diabetic type I patient base on Kaplan-Meier estimates.

Comparing Survival Probability of diabetic patients with foot ulcer

Table 2: Test of Equality over Groups

	Log-Rank(Mantel-Cox)		Breslow (Generalized Wilcoxon)	
	Chisq	p-value	Chisq	p-value
Sex	1.3	0.256	0.6	0.428
Type of Diabetes	0.8	0.375	0.6	0.453
Ulcer type	0.3	0.962	0.1	0.993
Site of Ulcer	5	0.0835	3.9	0.144

Additionally, from equation 2 to 4, the statistical studies utilizing the Breslow and log-rank tests as shown in Table 2, reveal no significant differences across the groups of diabetic complications. Additionally, there are no significant differences ($p>0.05$) between the patients' ulcer type and ulcer site on the feet, according to the results.

COX PROPORTIONAL HAZARD MODEL

The Cox proportional Hazard model from equation 5, was used to generate the result in table 3 as shown below.

Table 3: Results for the final Cox Proportional Hazard Model

	coef	exp(coef)	se(coef)	z	p
Age	-0.0096	0.99045	0.00864	-1.11	0.27
Sex	0.10348	1.10903	0.24026	0.43	0.67
Type	0.13224	1.14139	0.27884	0.47	0.64
Size	-0.0062	0.9938	0.11952	-0.05	0.96
ulcertype	0.02429	1.02459	0.16094	0.15	0.88
Site	0.23304	1.26244	0.14258	1.63	0.1

From the result above, the fitted survival model using equation 6 to 11, is given as;

$S(t) = \exp(-\exp[-1.02459/.88])t^{1/.88})$

Cox's regression shown in Table 3 included age and size of the ulcer (cm2) as explanatory variables, with the corresponding P value was 0.27 & 0.96 respectively. In this case, age and ulcer size are important explanatory variables and should be included in the analysis. Given that both patients are of the same sex, have diabetes, have the same type of ulcer, and have an ulcer on their foot, the patient who is one year older than the other has an exponentially higher probability of dying (0.9905). Given that both patients are of the same sex, have diabetes, have the same ulcer type, and have an ulcer on their foot, patient 1 who has a larger ulcer than patient 2 has an exponentially higher risk of dying (0.9938).

The logarithm of the hazard ratio for a female patient compared to a man patient of the same age and ulcer size is the coefficient for sex, or 0.1035. The value's exponential (antilog) is 1.1093, meaning that a female diabetic patient has a 1.1093-fold higher chance of dying at any given time than a male patient—that is, the risk of death for male patients seems to be significantly lower. The logarithm of the hazard ratio between a patient with type 2 diabetes and a patient with type 1 diabetes of the same age and ulcer size is the coefficient for diabetes type, or 0.1322. This value's exponential (antilog) is 1.1439, meaning that a type 2 diabetic patient has a 1.1439-fold increased risk of passing away at any point in their lifetime.

CONCLUSION AND RECOMMENDATIONS

According to the study's findings, 75.5% of the patients had forefoot ulcers, while 12.5% and 12% of the patients had midfoot and hindfoot ulcers, respectively. The categories with diabetes complications did not differ significantly from one another. Patients with neuropathy have a better prognosis than patients with other types of ulcers; patients with forefoot ulcers have a better prognosis than patients with ulcers in other areas; female patients have a lower prognosis than male patients; and diabetic type 2 patients have a lower prognosis than diabetic type I patients. The study also found that two significant explanatory factors are ulcer size and age. Based on the findings of this study, it was recommended that adequate healthcare system should be made available by the government at all levels, according to the study's conclusions. People should also be aware of the consequences of these risk factors and knowledgeable about the illness.

REFERENCES

1. Akhtar S, Ali A, Ahmad S, Khan MI, Shah S and Hassan F (2022) The prevalence of foot ulcers in diabetic patients in Pakistan: A systematic review and meta-analysis. *Front. Public Health* 10:1017201.
2. David, G. A., Tze-Woei T., Andrew J. M., and Sicco A. (2023). Diabetic Foot Ulcers: A Review. *Journal of American Medical Association*. 330(1):62-75.
3. Derbachew, A.T., Fikre, E. and Cheru, A. (2015). Survival Analysis of Diabetes Mellitus Patients Using Parametric, Non-Parametric and Semi-Parametric Approaches: Addis Ababa, Ethiopia. European e-journal for Research and Innovation Foresight, 7(1); 20 -39.
4. Guarnotta, V., Radellini. S, Vigneri, E, Cernigliaro, A., Pantò, F., Scondotto, S. (2021) Diabetic foot ulcers: Retrospective comparative analysis from Sicily between two eras. PLoS ONE 16(12): e0259405.
5. Hosmer, D.W. and Lemeshow, S. (1998). A Simplified Method of Calculating an Overall Goodness-of-Fit Test for the Cox Proportional Hazards Model. *Lifetime Data Anal* 4; 109–120.

6. Moulik, P. K., Mtonga, R., Gill, G. V. (2017). Amputation and Mortality in New-Onset Diabetic Foot Ulcers Stratified by Etiology. *Diabetes Care*, 26(2):491–494
7. Nurudeen, A. A., Kolawole I. A. and Nasiru R. (2019). Analysis of survival times of diabetic patients using cox proportional hazard model: case study. *Journal of the Nigerian Association of Mathematical Physics*, 2; 1-13.
8. Prompers, L., Schaper, N, Apelqvist, J., Edmonds, M., Jude, E. and Mauricio, D. (2018). Prediction of outcome in individuals with diabetic foot ulcers: focus on the differences between individuals with and without peripheral arterial disease. *Diabetologia*. 51(5):747-55.
9. Sarwar, N., Gao, P, Seshasai, SR., Gobin, R, Kaptoge, S. (2018). Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. Emerging Risk Factors Collaboration. Lancet. 26; 2215-2222H
10. Ulandari, R., Kurniawan, L.B. and Muhadi, D. (*2023).* Analysis of NLR in Type 2 Diabetes Mellitus with and without Diabetic Foot Ulcer. *Indonesian Journal of Clinical Pathology and Medical Laboratory, 29 (2): 185 -188*.
11. Woldemariam, G.T. Atnafu, N.T., Radie, Y.T., Wolde, G.T., and Gebremariam, A. (2022). Determinants of Diabetic Foot Ulcer Among Adult Patients with Diabetes Attending the Diabetic Clinic in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia: Unmatched Case–Control Study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 13: 3739–3747.
12. Wong, T. (2017). CD5-A Early retinal complications and vascular disease. Diabetes Research and Clinical Practice. 79(9):23-29.
13. World Health Organization WHO (2020). Diabetes. Accessed from https://www.who.int/news-room/fact-sheets/detail/diabetes
14. Yunir E, Hidayah CD, Harimurti K, Kshanti IAM. (2022). Three Years Survival and Factor Predicting Amputation or Mortality in Patients with High Risk for Diabetic Foot Ulcer in Fatmawati General Hospital, Jakarta. *Journal of Primary Care & Community Health*.13.