# Determinants of Recovery Time of Diabetic Patients in Uganda

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***Abstract***
*The study employed a frailty model to study the determinants of recovery time of diabetic patients from three hospitals in Uganda. It was found that Biguanides work better than Insulin, diet and exercise and Sulphonylureas. Disease duration did not have a significant effect on time to remission. It was concluded that duration of the disease does not have any effect on the effectiveness of the interventions. Time to remission was found to decrease with increase in body mass index and age. Females tend to recover faster than the male and the less or non-educated controlled the disease better than the educated ones.*

*It is concluded that Biguanides are better interventions than Insulin, diet and exercise and Sulphonylureas.*

## 1.0 Background

Diabetes is one of the most common non-communicable diseases globally. It is said to be the fourth or fifth leading cause of death in most developed countries and is epidemic in many developing and newly industrialized nations. Complications from diabetes, such as coronary artery and peripheral vascular disease, stroke, diabetic neuropathy, amputations, renal failure and blindness are resulting in increasing disability, reduced life expectancy and enormous health costs for virtually every society. Diabetes is regarded as one of the most challenging health problems in the 21st century (International Diabetes Federation, 2003).

According to information from the International Diabetes Federation (2003), of the conditions that are associated with diabetes, cardiovascular complications especially heart attack and stroke are among the most serious problems facing people with diabetes. People with diabetes are two or four times more likely to develop heart and blood related diseases than those without.

Diabetes Mellitus is described as a chronic metabolic disorder that is characterized by elevation of blood glucose concentration and caused by relative or absolute deficiency of insulin. Insulin is a body substance (a hormone) produced by the pancreas that is necessary for cells to be able to use blood sugar (glucose). In addition, there is disordered use of both fats and proteins in the body.

Diabetes mellitus is basically of two types: Type I diabetes or Insulin Dependent Diabetes Mellitus (IDDM) or juvenile diabetes and Type II diabetes or Non Insulin-Dependent Diabetes Mellitus (NIDDM) or adult onset diabetes. Type I diabetes, is primarily a disease of the pancreas. It results when the pancreas produces insufficient amounts of insulin to meet the body's needs. A Type I diabetic patient needs daily injections of insulin to live, hence the name IDDM. It develops most often in children and young adults, but the disorder can appear at any age. Type II diabetes, is a disease of insulin function and it is the most common form. Subjects with this type present with measurable quantities of insulin in the blood, and sometimes, as in obesity, the insulin levels are relatively high. This insulin is however ineffective because of the insensitivity of target tissues to its action.

About 90 to 95 percent of people with diabetes have Type II diabetes. This form of diabetes usually develops in adults over the age of 40 and is most common among adults over age 55. About 80 percent of people with Type II diabetes are overweight. Type II diabetes is often part of a metabolic syndrome that includes obesity, elevated blood pressure, and high levels of blood lipids. Unfortunately, as more children and adolescents become overweight, Type II diabetes is becoming more common in young people (International Diabetes Federation [IDF], 2001).

Diabetes mellitus is widespread throughout the world. In 1985, the World Health Organization noted that diabetes mellitus affects more than 30 million people worldwide (WHO, 1985). A decade later, the global burden of diabetes was estimated to be 135 million people. According to Mwagale (2001), over 150 million people are affected by diabetes worldwide and two thirds of them live in developing countries and about 300,000 in Uganda. In many countries, it is now the leading cause of death, disability and high health care costs. It is noted that approximately 177 million people are now diagnosed with diabetes worldwide and around 4 million deaths every year are attributable to its complications (WHO, 2000).

## 2.0 Problem Statement

Diabetes mellitus is one of the chronic diseases, which is a growing public health problem in both developed and developing countries causing severe and costly complications, including blindness, kidney and heart diseases, strokes, nerve damage and amputations. Uncontrolled diabetes can complicate pregnancy, and birth defects are more common in babies born to women with diabetes. In Uganda, the number of diabetic people has been increasing over the years since it attained independence (Uganda Diabetic Association, 1993).

Several interventions are available to control and prevent the development of diabetes complications. Some of the interventions which include among others, insulin therapy or injection, dietary restrictions and physical exercises are intended to slow down the progress of diabetes. They reduce the rate of further injury to a biological system without improving the current level of functioning. No systematic study to evaluate the different interventions in Uganda has ever been carried out. This study addresses this problem. This calls for the modelling of intervention effects at different levels of covariates or prognostic factors to assess their effectiveness.

## 3.0 Objectives of the Study

The main objective was to compare the effectiveness of the different interventions on diabetes mellitus patients. And the specific objectives were to model the time to remission of cases under different interventions and to evaluate the effect of intervention on surrogate measures of quality of life such as blood sugar level.

## 4.0 Significance of the Study

Diabetes mellitus is a multi system disorder. Its complications can involve any organ in the body. Some of these complications include visual impairment, cardiovascular disease, limb and brain damage, impotence, kidney failure, urinary tract and stroke. Because of its chronic nature, the severity of its complications and the means required to control them, diabetes is a costly disease, not only for the affected individual and his/her family, but also for the health authorities.

In addition, Type II diabetes, which is the most common form, affects mainly adults at the age of 40 and above (most productive age). Thus, death from diabetes or its complications leads to loss of production, which is likely to be more costly to the government than the direct health care costs. However, if proper interventions/ treatment is given, the disease can be controlled and substantially reduce the risk of developing these complications and slow their progression. It is therefore, hoped that the findings of this study will provide an optimal method to handle diabetic cases, which will help the society and the government at large to reduce on the strain and costs.

## 5.0 Literature Review

### 5.1 Glucose and Diabetes

Glucose is a simple sugar, which is the body's prime source of energy. The digestive process turns the carbohydrates of a meal eaten into this glucose which is then distributed throughout the body via the bloodstream, thus, "blood sugar". The brain and other cells in the body that need immediate energy use some of the blood sugar. The rest is stored in the liver and muscles as starch called "glycogen", or in adipose tissue as "fat" to be used later. The glycogen turns back its glucose when the body needs it. The normal body maintains an even balance of sugar in the blood so as to satisfy the body's energy needs. Any disruption in this delicate balance creates a chemical imbalance either hypoglycemia – too low blood sugar level; or hyperglycemia-too high blood sugar level. Insulin, the hormone secreted by the pancreas, is what maintains the proper levels of blood sugar. However, when the pancreas fails to produce enough insulin to create a proper release of glycogen from the liver to the bloodstream the result is high blood sugar, or diabetes mellitus. Subjects with diabetes mellitus have blood glucose level of greater than or equal to 180mg/100ml (10mmol/l) of blood. There are basically two types of diabetes mellitus; Type I or Insulin-Dependent Diabetes Mellitus (IDDM) and Type II or Non Insulin-Dependent Diabetes Mellitus (NIDDM).

### 5.2 Causes of Diabetes Mellitus

Connor and Boulton (1989) notes that the main factors which lead to the cause of diabetes mellitus, are hereditary (genetics) and environmental. Type I diabetes which develops most frequently in children and adolescents can be caused by viruses that have injured the pancreas and destruction of insulin making cells by the body's immune system. Also a family history of diabetes is a risk factor of Type I diabetes.

According to International Diabetes Federation (2003), Type II is a common and serious global health problem which, is associated with rapid cultural and social changes, ageing populations, increasing urbanization, dietary changes, reduced physical activity and other unhealthy, lifestyle and behavioural patterns. For example food, which can lead to obesity, is a risk factor for Type II diabetes. A family history of diabetes is also a risk factor. The World Health Organization (2000) also notes that eating an unbalanced diet, unhealthy food, lack of physical exercise and stress causes diabetes. Another prognostic factor that is associated with increased risk of Type II diabetes is smoking.

### 5.3 Treatment/Interventions of Diabetes Mellitus

According to Diabetes UK (2004) and Otim, et al (1998), the treatments or interventions for diabetes mellitus are grouped into three major categories namely, diet and exercise, oral medication and insulin. Oral medication is also grouped into two major categories, that is, Sulphonylureas and Biguanides.

### 5.3.1 Diet and Exercise

Diet and exercise is the 'first- line' treatment for diabetes mellitus. A diabetic person has to eat a diet low in fat, high in fibre, and with plenty of starchy foods, fruits and vegetables and should exercise regularly. This reduces the weight, which will help reduce the blood glucose/sugar and risk of having heart attack or stroke.

### 5.3.2 Metformin (Glucophage)

Metformin is a 'biguanide ' medicine. It lowers blood glucose mainly by decreasing the amount of glucose that the liver releases into the bloodstream. It also increases the sensitivity of the body's cells to insulin (so more glucose is taken into cells for a given level of insulin in the bloodstream.). Metformin is the first tablet advised if the blood glucose level is not controlled by diet and exercise alone. It is particularly useful if the person is overweight because it is less likely to cause weight gain. It does not also cause hypoglycaemia (low blood glucose level).

### 5.3.3 Sulphonylurea medicines

There are several types of sulphonylurea medicines and include: Glibenclamide, Gliclazide, Glimepiride, and Glipizide. They work by increasing the amount of insulin the pancreas produces. A sulphonylurea is used if someone cannot take metformin (because of side effects or other reasons), or if the person is not overweight.

### 5.3.4 Insulin

There are different types of insulin, which include among others, lente, soluble and mixtard, which is a mixture of the first two. Insulin injections lower blood sugar. Only some people with Type II diabetes need insulin, this is when the blood glucose is not well controlled by tablets oral medications (Sulphonylureas and Biguanides). Insulin is sometimes used alone or with oral medications.

### 5.3.5 Other types of diabetes treatment

According to Diabetes UK (2004), other types of treatments include, Thiazolidinediones, Nateglinide and repaglinide and Acarbose. Thiazolidinediones (commonly called Glitazones) are of two types namely; pioglitazone and rosiglitazone. They lower blood glucose by increasing the sensitivity of the body's cells to insulin (so more glucose is taken into cells for a given level of insulin in the bloodstream). They are not used alone, but are an option to take in addition to metformin or a sulphonylurea.

Nateglinide and repaglinide are newer medicines and are not commonly used. They have similar action to sulphonylureas. After taking a dose they are said to quickly boost the insulin level, but the effect of each dose does not last long. However, a sulphonylurea is generally preffered to these medicines. Nateglinide is licensed to be used in combination with metformin if metformin alone does not reduce blood glucose enough while repaglinide can be used alone, or in addition to metformin.

Acarbose works by delaying the absorption of carbohydrates (sugar based foods) from the gut. So, it can reduce the peaks of blood glucose which may occur after meals. It is an option if someone is unable to use other medication to keep the blood glucose level down.

It can also be used in addition to other glucose- lowering tablets. However, many people are said to develop gut-related side effects when taking acarbose (such as bloating, wind, and diarrhoea). Therefore, it is not widely used.

In Uganda 10-15% of Type II diabetic patients are said not to respond to sulphonylureas (Otim et al, 1998). Thus, sulphonylureas are first tried, and if they fail, biguanides are substituted. Sometimes initial treatment is with a combination of the two.

**6.0 Methodology**

The study made use of monthly records of diabetic patients held in medical registers in three hospitals. Patients who were considered in this study were recruited in the clinics between January 1994 and December 2003 and had been on treatment for at least 2 years and at most 5 years. Time for blood sugar level to reach normal range (4.0 -7.5mmol/l) or (70-130mm/dl) of blood since time of treatment/intervention was taken as the response variable for survival analysis. The covariates of interest included age, sex, intervention, BMI, family diabetes history, duration of the disease, age at onset of the disease, smoking and alcoholic status, upper and lower blood pressure and level of education.

The dependent variable was the time from start of treatment to return to normal blood sugar levels. The status variable in the model was whether the blood sugar was in normal range or not. Thus, the status variable was categorized as $Y = \begin{cases} 1 & in\ normal\ \ range \\ 0 & otherwise \end{cases}$

A Weibull accelerated time model with unshared frailty was employed to describe the survivorship (time to remission) of diabetic patients and to investigate the prognostic factors which affect time to remission.

In the traditional survival analysis models, observations are assumed to be heterogeneous and the population they come from is assumed to be homogeneous with respect to failure. In a situation where this is questionable, were some members are failure-prone (frail) than others due to unobserved heterogeneity, these models can lead to under or over estimated standard errors of estimates.

Frailties are unobserved effects or unmeasurable genetic factors of an individual (individual-specific or unshared) or shared by all members of the cluster or group (group-specific or shared). Hougaard (1995) points out that the impact of unmeasured covariates can lead to transformation of the hazard function and the coefficients of the measured covariates. Therefore, accounting for frailty using frailty models is important. Frailty models are an extension to the traditional survival models based on modelling dependence caused by frailties through random effects.

Indeed, there is anecdotal evidence that in practice hazard functions often converge in contradiction to the proportional hazards assumption (Barker and Henderson, 2004). Thus, an introduction of a frailty parameter in the traditional model to handle dependence between survival times is much realistic (Keiding et al ,1997 and Vaupel et al, 1979).

The concept of frailty was introduced by Vaupel et al. (1979) who studied the model with Gamma distributed frailties.

Let $\omega_i = (\boldsymbol{\omega}_{i1},\ldots,\boldsymbol{\omega}_{in_i})'$ be an $n_i$ x q matrix of random covariates (e.g. individual effects, unobserved genetic effects). Conditional on the random effects $\mathbf{b}_i$, the time-to-event $T_i$ are independent, with the hazard function for j[th] subject (j = 1, 2,…, $n_i$) in i[th] cluster given by

$$\lambda_{ij}(t_{ij} \mid z_{ij,}\omega_{ij};b_i,\beta) = \lambda_0(t_{ij})\exp(\mathbf{Z}_{ij}'\beta + \omega_{ij}'\mathbf{b}_i) \quad \ldots\ldots(11)$$

where $\mathbf{b}_i \sim N(0,D)$ and D is a q x q covariance matrix. The inclusion of the term $\omega_{ij}'\mathbf{b}_i$ in the model above or the use of the frailty model above was justified on the ground that patients given the same intervention may not necessarily be coming from the same hospital or were not exposed to the same events and their time-to-event are most likely not to correlate. These individuals may as well be very different for unobserved covariates. A commonly used frailty model is the gamma where $\omega_{ij} = 1$, *i.e.* $\exp(b_i) \sim gamma(\varsigma,\varsigma)$.
This was adopted in this study because of its simplicity and flexibility.

## 7.0 Findings

### 7.1 Socio- demographic characteristics

The distribution of diabetes mellitus by socio-demographic characteristics is illustrated in Table 1. About 70 percent of the sampled patients were female and 30 percent were male. It can also be seen that 27.9 percent were self-employed or working in private sector, 24.7 percent were peasants and only 5.2 percent had retired. The table further indicates that 32 percent attained primary school education. At least 62.3 percent attained secondary school education and only 6 percent had no formal education.

It can also be seen that over 90 percent were non-smokers and non-alcoholic drinkers. The majority of the patients were aged 50-64 years old and were followed by age group 35-49 (31.0%)

Table 1: Distribution of diabetes mellitus patients by socio-demographic characteristics

| **Variable** | **Number** | **Percentage** |
|---|---|---|
| **Sex of the patient** | | |
| Female | 712 | 70.2 |
| Male | 303 | 29.8 |
| Total | 1,015 | 100.0 |
| **Occupation** | | |
| Civil Servant | 24 | 15.6 |
| Private/Business | 43 | 27.9 |
| Peasant | 38 | 24.7 |
| Housewife | 25 | 16.2 |
| Student | 16 | 10.4 |
| Retired | 8 | 5.2 |
| Total | 154* | 100.0 |
| **Level of education** | | |
| None | 25 | 5.9 |

| | | |
|---|---|---|
| Primary | 136 | 31.9 |
| Secondary | 183 | 43.0 |
| Tertiary | 82 | 19.3 |
| Total | 426* | 100.0 |
| **Smoking** | | |
| No | 1,007 | 99.2 |
| Yes | 8 | 0.8 |
| Total | 1,015 | 100.0 |
| **Alcohol** | | |
| No | 982 | 96.8 |
| Yes | 33 | 3.3 |
| Total | 1,015 | 100.0 |
| **Age of the patient in years** | | |
| < 20 | 48 | 4.7 |
| 20-34 | 139 | 13.7 |
| 35-49 | 315 | 31.0 |
| 50-64 | 387 | 38.1 |
| 65-79 | 113 | 11.1 |
| > 79 | 13 | 1.3 |
| Total | 1,015 | 100.0 |

* Information not available on all patients

## 7.2 Clinical conditions

Clinical conditions of the patients were also investigated. Table 2 shows that 31.1 percent of the cases had a normal body mass index while 14.0 percent were obese and 8.3 percent were underweight. The majority of the cases (71.4%) were Type II diabetic and about 94 percent had no family history of the disease. The results further shows that the majority of the patients were first detected at the age of 50-64 years (40.2 %) and a few cases at age below 20 years (5.2 %). Also 39.3 percent of the cases had stayed with a disease for a period of between 1 month and 10 years while about 19 percent had stayed with it for over 10 years by the time of start of treatment. Those whom diabetes was just diagnosed were 41.7 percent. Also from Table 2, it can be seen that most of the cases had normal upper (systolic) (48.4 %) and lower (diastolic) (54 %) blood pressure.

Table 2: Distribution of diabetes mellitus patients by baseline clinical conditions

| Variable | Number | Percentage |
|---|---|---|
| **Hospital** | | |
| Mulago | 659 | 64.9 |
| Nsambya | 259 | 25.5 |
| Rubaga | 97 | 9.6 |
| Total | 1,015 | 100.0 |
| **Body mass index** | | |
| < 20 | 84 | 8.3 |
| 20-25 | 316 | 31.1 |
| 26-34 | 473 | 46.6 |
| ≥ 35 | 142 | 14.0 |
| Total | 1,015 | 100.0 |
| **Type of diabetes** | | |

| | | |
|---|---|---|
| Type I | 290 | 28.6 |
| Type II | 725 | 71.4 |
| Total | 1,015 | 100.0 |
| **Family history of diabetes** | | |
| No | 958 | 94.4 |
| Yes | 57 | 5.6 |
| Total | 1,015 | 100.0 |
| **Age at onset of diabetes (yrs)** | | |
| < 20 | 45 | 5.2 |
| 20-34 | 194 | 22.4 |
| 35-49 | 236 | 27.2 |
| 50-64 | 349 | 40.2 |
| ≥ 65 | 44 | 5.1 |
| Total | 868 | 100.0 |
| **Duration of diabetes from onset to start of treatment (months)** | | |
| 0 | 362 | 41.7 |
| 1-120 | 341 | 39.3 |
| 121-240 | 94 | 10.8 |
| 241-360 | 45 | 5.2 |
| >360 | 26 | 3.0 |
| Total | 868 | 100.0 |
| **Systolic blood pressure (mm/Hg)** | | |
| <110 | 93 | 9.2 |
| 110-130 | 491 | 48.4 |
| >130 | 431 | 42.5 |
| Total | 1,015 | 100.0 |
| **Diastolic blood pressure (mm/Hg)** | | |
| < 60 | 13 | 1.3 |
| 60-80 | 548 | 54.0 |
| > 80 | 454 | 44.7 |
| Total | 1,015 | 100.0 |

The results in Table 3 show that most of the cases (98.4 %) had very high blood sugar (hyperglycemia) while 1.6 percent had low blood sugar (hypoglycemia) at baseline. Urine sugar is also one of the measures of diabetes though not very effective. The table further indicates that 39.1 percent had no sugar (Nil), while 60.9 percent were found to have urine sugar.

The information from Table 3, on treatment given indicates that most cases were given lente or soluble insulin (39.4%) followed by Sulphonylureas, that is, Glibenclimide or Tolbutamide (30%) and about 1 percent were on diet and exercise.

Table 3: Distribution of diabetes mellitus patients by other baseline clinical conditions

| Variable | Number | Percentage |
|---|---|---|
| **Treatment /Interventions** | | |
| Diet and exercise | 8 | 0.8 |
| Sulphonylureas | 301 | 29.4 |
| Biguanides | 299 | 29.6 |
| Lente/Soluble insulin | 398 | 39.4 |

| | | |
|---|---|---|
| Mixtard insulin | 4 | 0.4 |
| Total | 1,010 | 100.0 |
| **Blood sugar/glucose in mg/dl** | | |
| Less than 70 | 16 | 1.6 |
| Above 130 | 999 | 98.4 |
| Total | 1,015 | 100.0 |
| **Urine sugar** | | |
| No sugar in the urine | 272 | 39.1 |
| Urine sugar present | 423 | 60.9 |
| Total | 695 | 100.0 |

### 7.3 The determinants of recovery time

To model "survivorship" or time to remission of diabetic patients under different interventions and other prognostic factors, a Weibull accelerated failure time model with gamma frailty was employed.

There were 5 categories of interventions namely; Diet and exercise, Sulphonylureas (e.g.Glibenclamide and Tolbutamide), Biguanides (e.g. Metformin), Lente/soluble insulin and Mixtard insulin. In model estimation, mixtard was combined with lente/soluble insulin to form category insulin due to few cases in that category. Insulin was the base for interventions.

The dependent variable used was time from start of treatment to return to normal blood sugar levels and the status variable was whether the blood sugar was in normal range or not. The independent variables included sex, age in years, smoking status, alcoholic status, family history of the disease, body mass index, upper (systolic) and lower (diastolic) blood pressure, type of diabetes, duration of the disease in months, level of education, and treatment/intervention. The hospital was also included in the model to capture its effect but could not be explained because some patients could be visiting more than one hospital.

The results in Table 4 show the estimated unshared frailty model. From the likelihood-ratio test, we find the frailty effect to be significant at 5% level. Thus, there is much evidence pointing towards a population that is heterogeneous. Also, the estimated $\rho = 0.9492$, shows that the estimated individual hazard for this model is monotone decreasing.

From the table, sex, body mass index, Biguanides intervention, primary and tertiary level of education, Type of diabetes and age in years are significantly associated with time to remission after controlling for other factors and heterogeneity.

**Table 4: Estimated Unshared Frailty Weibull (AFT) model with Gamma Frailty**

N = 1010 LR $\chi^2(18) = 316.88$

Log likelihood = -944.98214 $p > \chi^2 = 0.0000$

| Variable | Time Ratio | Coefficient | se | z | p>\|z\| |
|---|---|---|---|---|---|
| **Sex** | | | | | |
| Male | 1.3250 | 0.2814 | 0.1971 | 1.89 | 0.058 |
| Female | 1.0000 | 0.0000 | | | |
| **Family history of diabetes** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Yes | 1.2418 | 0.2166 | 0.4024 | 0.67 | 0.504 |
| No | 1.0000 | 0.0000 | | | |
| **Type of diabetes** | | | | | |
| Type I | 0.7232 | -0.3240 | 0.1402 | -1.67 | 0.095 |
| Type II | 1.0000 | 0.0000 | | | |
| **Smoking Status** | | | | | |
| Yes | 1.7468 | 0.5578 | 1.9023 | 0.51 | 0.608 |
| No | 1.0000 | 0.0000 | | | |
| **Alcoholic status** | | | | | |
| Yes | 2.1434 | 0.7624 | 1.0701 | 1.53 | 0.127 |
| No | 1.0000 | 0.0000 | | | |
| Body mass index (kg/m$^2$) | 0.9795 | -0.0207 | 0.0105 | -1.94 | 0.052 |
| Diastolic blood pressure (mm/Hg) | 1.0016 | 0.0016 | 0.0057 | 0.28 | 0.779 |
| Systolic blood pressure(mm/Hg) | 0.9987 | -0.0013 | 0.0035 | -0.36 | 0.720 |
| Age in years | 0.9882 | -0.0119 | 0.0068 | -1.74 | 0.082 |
| Disease duration from onset (months) | 1.0007 | 0.0007 | 0.0009 | 0.80 | 0.422 |
| **Treatment/Interventions** | | | | | |
| Diet & Exercise | 0.4757 | -0.7430 | 0.2683 | -1.32 | 0.188 |
| Sulphonylureas | 0.9502 | -0.0511 | 0.1551 | -0.31 | 0.754 |
| Biguanides | 0.6431 | -0.4414 | 0.1100 | -2.58 | 0.010 |
| Insulin | 1.0000 | 0.0000 | | | |
| **Level of education** | | | | | |
| No education | 1.0000 | 0.0000 | | | |
| Primary | 1.6557 | 0.5042 | 0.4018 | 2.08 | 0.038 |
| Secondary | 1.1719 | 0.1586 | 0.2371 | 0.78 | 0.433 |
| Tertiary | 1.9848 | 0.6855 | 0.6372 | 2.14 | 0.033 |
| **Hospital** | | | | | |
| Rubaga | 0.0381 | -3.2677 | 0.0077 | -16.10 | 0.000 |
| Nsambya | 0.3781 | -0.9726 | 0.0771 | -4.77 | 0.000 |
| Mulago | 1.0000 | 0.0000 | | | |
| Constant | | 6.1579 | 0.5713 | 10.78 | 0.000 |

Likelihood-ratio test of $\theta = 0$: $\chi^2_{(1)} = 2.67$, $p = 0.051$
Shape parameter, $\rho = 0.9492$

### 7.3.1 Sex of the patient

Sex is seen to be marginally significantly associated with the quality of life of the diabetic patient. After accounting for heterogeneity and other factors, it is found that the recovery time in months is increased by a factor of 0.33 if an individual is a male as compared to the female. That is, males tend to take a longer time to recover than their female counterparts do.

### 7.3.2 Type of diabetes

Type of diabetes has a marginally significant effect on the quality of life of diabetic patients. The recovery time in months is slowed down by a factor of 0.28 if a patient is a Type I diabetic rather than Type II.  Thus an individual suffering from Type I diabetes recovers faster than a Type II diabetic after controlling for other factors.

### 7.3.3 Body mass index

The results in the table show that body mass index is significantly associated with blood sugar level. After controlling for other prognostic factors and accounting for frailty, a unit increase in the body mass index reduces the recovery time in months by a factor of 0.02. This implies that the heavier the person is the faster the rate of recovering from diabetes or blood sugar level reaching the normal range.

### 7.3.4 Age in years

After adjusting for other factors, a one-year increase in age accelerates the recovery time in months by a factor of 0.012. That is the older an individual is the faster to recover from diabetes or to reach normal blood sugar level.

### 7.3.5 Treatment/Interventions

The adjusted recovery time in months is faster by a factor of 0.52, 0.05, and 0.36 when a patent is on Diet and Exercise, Sulphonylureas, and Biguanides, respectively as compared to those on Insulin. Although diet and exercise and sulphonylureas work faster to recovery, as compared to insulin, this is not statistically significant. Thus, Biguanides can be considered as the best treatment although we do not have enough statistical evidence to show that it is superior to diet and exercise and sulphonylureas.

### 7.3.6 Level of education

Level of education is significantly associated with the level of blood sugar ($p<0.05$). The recovery time in months is increased by a factor of 0.66 or 0.98 if an individual has attained either primary or tertiary education, respectively as compared to those with no formal education after controlling for other factors. Patients with secondary education have their recovery time in months accelerated by a factor of 0.17 as compared to those with no education though not statistically significant. Thus the lower the level of education the faster the rate of the blood sugar level returning to normal range.

### 8.1 Summary

The results reveal that after accounting for heterogeneity and other confounders in the data, surprisingly time to remission decreases with increase in body mass index and age. The results further reveal that the duration of the disease has no significant effect on the quality of life. Hence, we deduce that the duration of the disease has no significant effect on the effectiveness of the intervention given.

From the frailty model we found that Biguanides is more effective than other interventions. The duration of the disease was found not to be statistically significant. Thus from this we conclude that the duration of the disease has no effect on the effectiveness of the intervention.

### 8.2 Conclusion

Time to remission of diabetic patients, depended on the type of intervention given and the interventions had a significant effect on the quality of life. Biguanides work better than Insulin, diet and exercise as well as Sulphonylureas. The interventions were found not to be affected by their timing. Time to remission was found to decrease with increase in body mass index and age. Time to recovery was also found to be associated with the sex of the patient. Females tended to recover faster than males. Patients who were not educated controlled the disease better than the educated ones.

### 8.3 Recommendations

Since findings point to the fact that time to remission is lower for patients that are older and overweight, which could be a result of exercising and experience in managing the disease, the Health Personnel should intensify sensitisation campaigns on advantages of dieting and physical exercises for both the young and the old. Biguanides are recommended to be better interventions for diabetic patients.

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