

# Management of insulin-dependent diabetes in low-resource countries: results from the chronic non-communicable disease project in Iringa rural district of Tanzania

**Gestione del diabete insulino-dipendente nei paesi a risorse limitate: risultati del progetto sulle malattie croniche non trasmissibili nel distretto rurale di Iringa in Tanzania**

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## Abstract

**PURPOSE OF THE STUDY** Chronic non-communicable diseases are experiencing a major growth in disease burden, especially in low-resource countries. Among them, diabetes represents a major challenge: its prevalence is growing exponentially in Africa, where scarcity of accessibility to care and resources make the issue even more burdensome. Insulin therapy in particular is very expensive and unwieldy. The aim of the study is to find answers to the emerging needs of people with diabetes in these settings

**DESIGN AND METHODS** A retrospective, prospective observational study of the diabetic population undergoing Premixed regular insulin/NPH 30/70 insulin treatment was carried out as part of CUAMM's chronic non-communicable diseases project in Tosamaganga Hospital in a rural area of Tanzania, a low- to middle-income country in sub-Saharan Africa. Data were extrapolated from the project database and from interviews with patients on active insulin treatment from March to August 2023.

**RESULTS** Improvement in blood glucose, glycated haemoglobin, and weight values over time; a reduction in the number of hospitalizations; a marked improvement in performance status; and a low rate of major hypoglycaemias were found. 83.1% of patients do not have health insurance, most have financial difficulties to support the cost of transportation to visit; counselling received on therapy and lifestyle is found to be very helpful and effective.

**CONCLUSION** Premixed regular insulin/NPH 30/70 insulin is effective and safe. Its low cost and increased manageability make its use desirable in low-resource countries due to issues of compliance and affordability. Increasing access to care and fostering qualified personnel is important to improve diabetes care in low-resource countries.

**KEYWORDS** low-resource countries; non-communicable disease; diabetes mellitus; insulin Premixed regular insulin/NPH 30/70.

## Riassunto

**INTRODUZIONE** Le malattie croniche non trasmissibili stanno vivendo una importante crescita del carico di malattia, soprattutto nei paesi a basso e medio-basso reddito. Tra di esse il diabete rappresenta un'importante sfida: la prevalenza è in crescita esponenziale in Africa, dove scarsità di accessibilità alle cure e di risorse rendono la problematica ancor più gravosa. La terapia insulinica in particolare è molto costosa e poco maneggevole. L'obiettivo dello studio è quello di trovare risposte ai bisogni emergenti della popolazione diabetica in questi contesti.

**MATERIALI E METODI** È stato effettuato uno studio osservazionale retrospettivo e prospettico della popolazione diabetica in trattamento con insulina umana mista regolare/intermedia 30/70, nell'ambito del progetto *chronic non-communicable diseases* del CUAMM nell'ospedale di Tosamaganga in un'area rurale della Tanzania, paese a medio-basso reddito dell'Africa subsahariana. I dati sono stati estrapolati dal database del progetto e da interviste ai pazienti in trattamento insulinico attivo da marzo a agosto 2023.

**RISULTATI** Sono stati riscontrati un miglioramento dei valori di glicemia, emoglobina glicata e peso nel tempo; una riduzione del numero di ricoveri, un netto miglioramento del performance status e un basso tasso di ipoglicemie maggiori. L'83.1% dei pazienti non possiede una assicurazione sanitaria, la maggior parte ha difficoltà economiche a supportare i costi del trasporto per recarsi a visita; il counseling ricevuto su terapia e stile di vita è ritenuto molto utile ed efficace.

**CONCLUSIONE** L'insulina umana mista regolare/intermedia 30/70 è efficace e sicura. Il basso costo e la maggiore maneggevolezza ne rende auspicabile l'utilizzo nei paesi a basse risorse per questioni di

compliance e disponibilità economiche. Incrementare l'accesso alle cure e favorire personale qualificato è importante per migliorare la cura del diabete in paesi a basse risorse.

**PAROLE CHIAVE** paesi a risorse limitate; malattie croniche non trasmissibili; diabete mellito; insulina umana mista regolare/intermedia 30/70.

## Introduction and purpose of the study

Chronic non-communicable diseases (NCDs) are a serious public health issue worldwide: each year about 41 million deaths worldwide, accounting for 74% of global deaths, are caused by NCDs<sup>(1)</sup>. The number of deaths and the overall disease burden from these diseases has been steadily increasing since 1990<sup>(2-4)</sup>. Low-resource countries (low- and low-middle-income countries) have experienced a reduction in deaths from infectious and maternal-infant causes in recent decades, while experiencing a consistent growth in the burden of disease and deaths resulting from NCDs, thus representing a particular public health concern<sup>(3,5)</sup>. Among the NCDs, diabetes is the disease with the largest growth in disease burden, exceeding 80%<sup>(3,4,6)</sup>. It is widely prevalent in the global population with a prevalence of 10.5% among adults and about 1.2 million young people up to 19 years of age affected<sup>(7)</sup>. Prevalence is estimated to continue to rise globally, with the African continent experiencing the greatest increase. Africa also has the largest proportion of unaware, undiagnosed diabetics, and the issue of data collection and retrieval, especially regarding type 1 diabetes, is a huge problem<sup>(8)</sup>. In sub-Saharan Africa, as in all low-resource countries, poor health care infrastructure and accessibility to it, poor availability of means for diabetes diagnosis and monitoring, difficult availability of medications, shortage of trained health care workers, and poor education and disease awareness, all make diabetes management and treatment a major challenge in these countries; the challenge is even greater in rural areas where the poorest people live. Overall, barely 11% of diabetic patients in sub-Saharan Africa, receive the medicines they need for treatment<sup>(9)</sup>. In this landscape, insulin therapy deserves special mention, as the costs of the drug are very high and difficult to abate, due to the worldwide monopoly by three pharmaceutical companies<sup>(10)</sup>; the price of insulin analogues is significantly higher than human insulin in all sec-

tors both public and private<sup>(11)</sup>; sticks, lancets, and glucometers are needed for frequent blood glucose monitoring in addition to needles and syringes for drug injection; resources are needed to cope with complications and therapy of type 1 diabetes (hypoglycemia, diabetic ketoacidosis), so costs multiply. Finally, it turns out that self-administration of insulin is not easy, especially for uneducated people<sup>(9)</sup>.

In Tosamaganga Hospital, in the rural area of Iringa district in Tanzania, the Non-Governmental-Organization Doctors with Africa CUAMM, has launched a project dedicated to NCDs, in collaboration with local authorities. Tanzania is a low-middle-income sub-Saharan African country with a pyramidal and predominantly private health care system and very few health care providers<sup>(12,13)</sup>. It represents the first African country by prevalence of diabetes in adults<sup>(7)</sup>. Overall, it is estimated that just 6% of Tanzanians diagnosed with diabetes are properly treated and have controlled blood glucose values; moreover, accessibility to care is lower in rural areas than in urban areas, which represent a minority in Tanzania<sup>(14)</sup>. The CUAMM NCDs clinic is the only clinic located in a rural area throughout Tanzania, seeking to address this health issue where care is most lacking. Special attention is given to diabetic patients on insulin therapy, to whom a special day called “Insulin Day” is dedicated. It is held every 50 days: patients are educated about diabetes, insulin management, and receive the necessary therapy and tools for glycemic monitoring free of charge. The insulin administered is Premixed regular insulin/NPH 30/70 insulin, consisting entirely of human insulin in a ratio of 30/70 regular insulin/insulin intermediate neutral protamine hagedorn (NPH)<sup>(15)</sup>.

Our study stems from the need to overcome critical issues related to the care of diabetic patients who need insulin in a rural setting of low- and low-middle-income countries. The endpoints are to describe the diabetic population in the rural district of Iringa in Tanzania and to evaluate the impact of the proposed management model on the health of patients undergoing treatment.

## Materials and methods

An observational study was carried out. Two groups of patients were identified: group 1 consisting of patients who had taken insulin at least once and systematically entered into the management database of the CUAMM NCDs project from February

2019 to August 2023; group 2 consisting of patients on active follow-up and in insulin therapy during the period from March to August 2023. For the first group, data were retrospectively extrapolated from the database, obtaining information on anagraphic data, type of diabetes, nutritional status (expressed by body mass index - BMI), socioeconomic status and accessibility to the care (identified through possession of health insurance and type of work and peripheral health centre of origin), and glycemic control (through fasting blood glucose, glycosylated haemoglobin - HbA1c - values). Patients in Group 2 were interviewed on targeted topics, through which data were obtained on: anagraphic data, diabetes and related social issues, socioeconomic status and education, accessibility to care, ability to manage insulin therapy, adherence to treatment, relevance of NCDs clinic, number of hospitalizations for any cause (except childbirth and trauma), episodes of major and minor hypoglycemia and reported ability to work. Statistical analysis was performed using Epiinfo 7 and Excel 2007 programs.

## Results

### General features of the study population

#### Group 1

Since the project began, out of a total of 2020 patients attending the outpatient clinic, 59 patients have been recorded to have taken insulin at least once (2.9%). Of these, 50.9% were females and 49.1% were males (**Table 1**). Considering only the diabetic population (521 patients), the number of patients on insulin therapy represents a minority (11.3%) and they are predominantly young: all but 22 are younger than 40 years old; among them, 17 are under 25 years of age. The proportion of patients with type 1 and type 2 diabetes is similar (47.5% and 45.8%, respectively), of the 6.7% no classification was made. Predominantly patients are normal weight (49.1%), however a large proportion are underweight (20.3%) and as many patients are overweight or obese (10.2% respectively) (**Table 1**).

Considering the type of diabetes stratified by age and BMI, no patients younger than 25 years of age were classified as having type 2 diabetes, while patients over 40 years old were mainly classified as type 2 diabetes except one patient, considered type 1, and three patients unassigned. Two patients who were underweight at the first visit were

classified as having type 2 diabetes, and virtually all overweight or obese patients were classified as type 2 (Table 1). Among patients aged 25-40 years, 45% (9 of 20) were classified as having type 2 diabetes; only two were obese at the first visit and one underweight, the others were normal weight. Of these, 66.7% had a BMI at the lower limits of normal weight (BMI<21).

Regarding socio-health indexes and accessibility of care 45.8% of patients are farmers, 8 patients (13.6%) are students; 83.1% of patients do not have health insurance. Moreover, 64.4% of patients are from the Tosamaganga area, which is the area strictly surrounding the hospital (Table 1). On average, the distance travelled by patients to reach Tosamaganga is 42.9 km and the most frequently travelled distance is 27 km (median).

At the first visit, fasting blood glucose values averaged 15.7 mmol/L (282.6 mg/dL) and glycated haemoglobin values averaged 11.9%. Blood pressure values are within normal range. The main chronic complication of diabetes objectifiable at the time of the first visit is chronic renal failure. Very common is the issue of decreased visual acuity, reported by 27 patients (45.9% of the tested population) (Table 1). However, the nature and extent of this disorder could not be determined due to lack of diagnostic means and specialised personnel.

*Group 2*

The second group consists of 33 patients in active follow-up from March to August 2023, interviewed during insulin days. The patients are 54.5% male and the majority are between the ages of 15 and 40 years. 39.4% of patients report disease onset at less than 25 years of age and only 24.2% above 40 years of age. Mainly patients are normal weight (54.4%), a high percentage are underweight (21.2%) the rest are overweight (12.1%) and to a lesser extent obese (9.1%). Patients were mostly classified as type 2 diabetes (48%) and to a lesser extent as type 1 (45%) however 6% were not assigned. All patients with age at diagnosis less than 25 years were classified as having type 1 diabetes, all patients with age at diagnosis greater than 40 years were framed as having type 2 diabetes (Table 2). Among patients aged 25-40 years, 66.7% (n=8) were classified as having type 2; only one had an obese condition at the time of the first visit, one was underweighted and the others were normal weight; however, among normal weight, half had a BMI at the lower limits (BMI 19-20).

Almost all patients had at least one hospitalization due to diabetes (87.9%). Although 90.9% of patients are able to read, most attended only first-grade schools, defined as “Standard 1-7” (51.5%); only two people attended college or university. Most patients work as farmers (54.5%) while 15.2% have no occupation at all;

**Table 1 |** General features of Group 1 patients.

GROUP 1	Total patients (n=59)	Diabetes type 1 (n=28)	Diabetes type 2 (n=27)
Age			
- <15	- 3 (5.1%)	- 3 (10.7%)	- 0 (0)
- 15-24	- 14 (23.7%)	- 14 (50%)	- 0 (0)
- 25-40	- 20 (33.9%)	- 10 (35.7%)	- 9 (33.3%)
- >40	- 22 (37.3%)	- 1 (3.6%)	- 18 (66.7%)
Sex			
- Female	- 30 (50.9%)	-	-
- Male	- 29 (49.1%)	-	-
BMI			
- <18	- 12 (20.3%)	- 9 (32.1%)	- 2 (7.4%)
- 18-24	- 29 (49.1%)	- 14 (50%)	- 14 (51.8%)
- 25-29	- 6 (10.2%)	- 1 (3.6%)	- 4 (14.8%)
- ≥30	- 6 (10.2%)	- 0 (0%)	- 5 (18.5%)
- Not known	- 6 (10.2%)	- 4 (14.3%)	- 2 (7.4%)
Diabetes			
- Type1	- 28 (47.5%)	-	-
- Type2	- 27 (45.8%)	-	-
- Unspecified	- 4 (6.7%)	-	-
Farmer			
- Yes	- 27 (45.8%)	-	-
- No	- 30 (50.8%)	-	-
- Unspecified	- 2 (3.4%)	-	-
Health insurance			
- Yes	- 10 (16.9%)	- 3 (10.7%)	- 6 (22.2%)
- No	- 49 (83.1%)	- 25 (89.3%)	- 21 (77.8%)
Health center of origin			
- Idodi	- 1 (1.7%)	-	-
- Ifunda	- 3 (5.1%)	-	-
- Isimani	- 2 (3.4%)	-	-
- Kimande	- 1 (1.7%)	-	-
- Kiponzelo	- 3 (5.1%)	-	-
- Mgama	- 3 (5.1%)	-	-
- Mlowa	- 2 (3.4%)	-	-
- Nzihhi	- 4 (6.8%)	-	-
- Tosamaganga	- 38 (64.4%)	-	-
- Wenda	- 2 (3.4%)	-	-
Complications			
- Previous stroke	- 1 (1.7%)	-	-
- Previous AMI	- 0 (0%)	-	-
- Chronic heart failure	- 2 (3.4%)	-	-
- Diabetic foot	- 2 (3.4%)	-	-
- Lower limb amputation	- 1 (1.7%)	-	-
- CKD stage > IIIa	- 7 (11.9%)	-	-
- Visual impairment	- 27 (45.9%)	-	-

BMI = Body Mass Index; AMI = Acute Myocardial Infarction; CKD = Chronic Kidney Disease.

**Table 2** | General features of Group 2 patients.

Group 2			
Total patients (n=33)		Total patients (n=33)	
Age		Socio-economic conditions	
- <15	- 1 (3%)	- Farmer	- 18 (54.5%)
- 15-24	- 12 (36.4%)	- No occupation	- 5 (15.2%)
- 25-40	- 12 (36.4%)	- No source of income in the household	- 3 (9.1%)
- >40	- 8 (24.2%)	- 1 source of income in the household	- 17 (51.5%)
Sex		- > 1 source of income in the household	- 13 (39.4%)
- Female	- 15 (45.5%)	- Health insurance	- 5 (15.2%)
- Male	- 18 (54.5%)	- Difficulty in supporting transportation costs to travel to checkup	- 22 (66.7%)
BMI		Accessibility to care	
- <18	- 7 (21.1%)	- Time to visit < 1 hour	- 3 (9.1%)
- 18-24	- 18 (54.5%)	- Reaching the outpatient clinic on foot	- 1 (3%)
- 25-29	- 4 (12.1%)	- Reaching the outpatient clinic by public transportation	- 26 (78.8%)
- ≥30	- 3 (9.1%)	- No logistical difficulties in transportation	- 4 (12.1%)
- Not known	- 1 (3%)	- Presence of other points of care near one's home	- 13 (39.4%)
Diabetes		Therapy issues	
- Type1	- 15 (45%)	- Consultation of a traditional healer	- 9 (27.3%)
- Type2	- 16 (48%)	- No help with therapy	- 16 (48.5%)
- Unspecified type	- 2 (6%)	- Help in handling insulin and/or managing nutrition	- 17 (51.5%)
- Mean age at diagnosis	- 32	- Perception of stress or fear in injecting insulin	- 2 (6.1%)
- Perception of good health at diagnosis	- 1 (3%)	- Sense of shame in injecting insulin in front of other people	- 4 (12.1%)
- Familiarity for diabetes	- 11 (33.3%)	- Storage of insulin in the refrigerator	- 9 (27.3%)
- ≥ 1 hospitalization for diabetes	- 29 (87.9%)	- Injecting insulin changes lifestyle habits	- 13 (39.4%)
- ≥ 1 hospitalization for diabetes after diagnosis	- 26 (72.7%)	Treatment adherence	
- No oral hypoglycemic drugs before starting insulin	- 11 (33.3%)	- Failure to inject insulin >5 times in the past month	- 13 (39.4%)
- Perception of stigma because of diabetes	- 12 (36.4%)	- Failure to inject insulin due to hypoglycemia	- 19 (57.6%)
Awareness of illness		- Consumption of rice ≥ 2 times per week	- 1 (3%)
- Knowledge of diabetes before diagnosis	- 10 (30.3%)	- Consumption of whole-grain ugali	- 29 (87.9%)
- Full knowledge of the need for treatment and complications	- 11 (33.3%)	- Quantity of vegetables eaten per meal greater than the amount of ugali	- 22 (66.7%)
Comorbidities		- Consumption of whole grain bread or oatmeal for breakfast	- 27 (81.8%)
- No	- 22 (66.7%)	- Consumption of corn > 1 time per week	- 3 (9.1%)
- Hypertension	- 3 (9.1%)	- No alcohol consumption	- 29 (87.9%)
- HIV	- 2 (6.1%)	- No consumption of soda	- 30 (90.1%)
- Other	- 5 (15.2%)	- No physical activity	- 0 (0%)
- Hepatic steatosis	- 6 (18.2%)	- Physical activity 1-2 times per week	- 9 (27.3%)
- Vaccinated for HBV	- 1 (3%)	- Physical activity ≥ 3 times per week	- 23 (69.7%)
Education		- Time devoted to physical activity each session ≥ 1 hour	- 14 (42.4%)
- Ability to read	- 30 (90.9%)	- Time devoted to physical activity each session 30 minutes	- 18 (54.5%)
- Did not go to school	- 1 (3%)	Relevance of the NCDs outpatient clinic	
- Standard 1-7	- 17 (51.6%)	- No possibility of treatment in the absence of the NCDs clinic.	- 27 (81.8%)
- Basic vocational	- 1 (3%)	- People previously in care elsewhere	- 12 (36.4%)
- Forms 1-4	- 12 (36.4%)	- Counselling about diet carried out in the NCDs clinic is very helpful	- 33 (100%)
- College/University	- 2 (6.1%)		
Living conditions			
- Inhabitants with > 5 people	- 10 (30.3%)		
- Inhabitants with 2-5 people	- 22 (66.7%)		
- Electrical connection	- 16 (48.5%)		
- Mud and/or sheet metal houses	- 12 (36.4%)		

BMI = Body Mass Index; HIV = Human immunodeficiency virus; HBV = Hepatitis B virus; NCDs = chronic non-communicable diseases.

most families have only one source of income (51.5%) and 3 patients live in families with no income. Only 5 people (15.2%) possess health insurance (Table 2).

Fewer than half of the patients (39.4%) have an alternative facility available to the NCDs at Tosamaganga Hospital that is capable of delivering

care and is in close proximity to their homes. Only 9.1% of patients take less than an hour to reach the NCDs clinic, most (60.6%) take between one and two hours. Moreover, 78.8% reach the hospital by using public transportation, and 66.7% find it difficult to support the cost of transportation to go for follow-up visits. Only 4 people (12.1%) reported no logistical difficulties in transportation (**Table 2**), where the main problems are instead, in order of frequency, poor roads, rain, and low availability of public transportation.

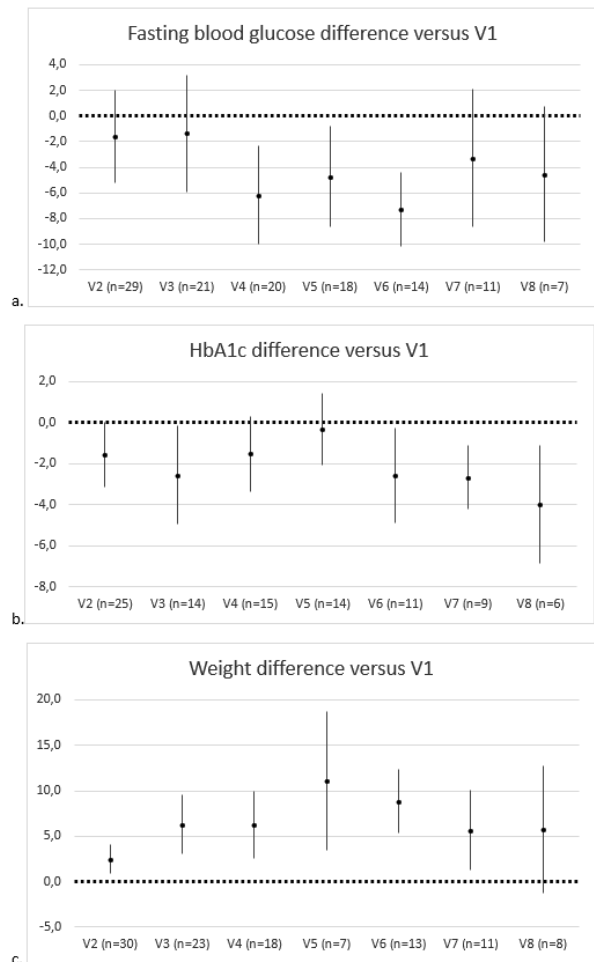
For 39.4% of patients, the beginning of insulin therapy resulted in a change in lifestyle habits: 12.1% experience shame in injecting insulin in front of other people; 51.5% are helped in the management of therapy; the support basically consists of handling insulin and/or following a proper diet. Among patients who receive support, 29.4% receive it relative to insulin, 29.4% receive it with feeding, and 41.2% receive it with both. Only a minority of patients, 27.3%, have the ability to properly store insulin in the refrigerator (**Table 2**).

In addition, 39.4% of patients in the month prior to the interview skipped insulin injection more than 5 times, 46.4% skipped it a maximum of 5 times; 24.2% always administered insulin; 76% of those who did not administer insulin report glycemic values below 5 mmol/L or presence of symptoms of hypoglycaemia as reasons (**Table 2**). It was observed that 69.2% (9/13) of those who missed injection more than 5 times in the month had a maximum education level up to “Standard 1-7” grades, namely a low level of schooling.

Nearly all patients (89.7%) consume whole-wheat ugali (local flour polenta) almost every day, preferring this lower glycemic index carbohydrate to non-whole-wheat ugali; for 66.7% of patients, the amount of vegetables consumed each day is greater than that of ugali. Furthermore, 87.9% of patients deny consuming alcohol and 90.1% deny consuming sodas. All patients engage in regular physical activity at least once a week for at least 30 minutes a day, while 69.7% practice it at least three times a week and 42.4% at least one hour per session (**Table 2**).

Nearly all patients (81.8%) stated that they would have no way of treatment at the present time in the absence of the NCDs clinic. The counselling carried out by the experienced nursing and nutritionist staff of the outpatient clinic regarding nutrition and diet to be followed is considered very helpful by all patients.

**Figure 1 |** Trends of fasting blood glucose (a), glycated haemoglobin (b) and weight over time (c).



V = visit; HbA1c = glycated haemoglobin.

## Clinical outcomes

### Group 1

Looking at the trend in fasting blood glucose and HbA1c over time (**Figure 1a and 1b**), there is an improving trend between the first visit (V1) and the subsequent six-monthly checkups. There is a significant average decrease of up to 7.3 mmol/L (131.5 mg/dL) in blood glucose and up to 2.6 percentage points in HbA1c after two and a half years (V6) of treatment in the NCDs clinic. Significant weight gain is observed for all patients as early as the six-month follow-up, which is maintained at subsequent visits with significant average weight gain up to 8.8 kg after two and a half years (V6) from the first visit (**Figure 1c**).



### Group 2

**Hospitalizations:** following enrolment in the project, the number of hospitalizations per patient for any cause dropped dramatically. Out of 33 people surveyed, 28 reported that they had gone through at least one hospitalization before starting treatment in Tosamaganga; of these, 82.1% did not undergo further hospitalizations thereafter (Figure 2).

**Major hypoglycemia:** 78.8% of patients presented no episodes in the month prior to the interview, 15.2% experienced one or two episodes (Figure 2).

**Minor hypoglycemia:** 72.2% of patients experienced at least one minor hypoglycemia in the month prior to the interview. Most frequently, there were three hypoglycemic episodes per patient. Mainly hypoglycemia occurred in the morning (58.3%) and only 12.5% occurred in the evening (Figure 2). Among those with a lower level of education (not going to school, “standard 1-7” schools or “basic vocational” schools), the number of observed hypoglycemic episodes tended to be 3 times higher than among those with a higher level of education (from “forms 1-4” schools to college).

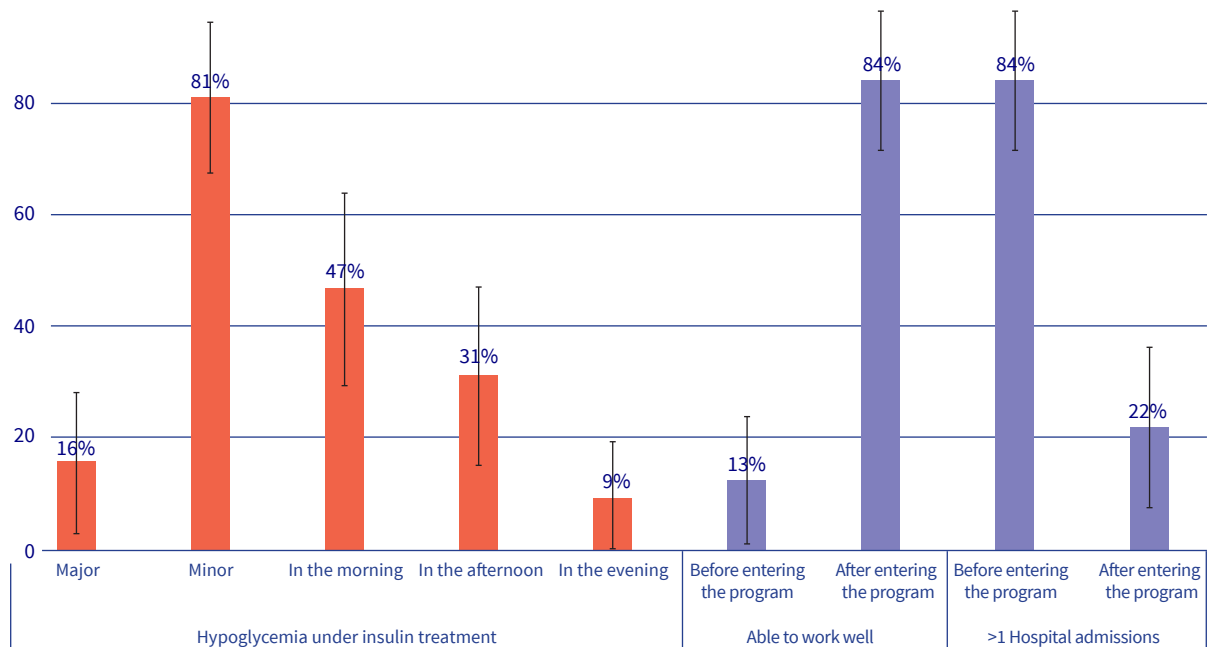
**Working capacity:** out of 33 patients surveyed, 32 are working or studying; among the latter, 87.5% reported difficulty in performing their daily work or study activities before the start of insulin therapy. Specifically, 34.4% continued to work with reduced

performance, while 53.1% had to stop their activities completely due to the disease. All but one of the patients resumed or perform better in their activities subsequent to taking assignment from the NCDs clinic (Figure 2).

## Discussion

In low-resource countries with low or low-middle income, diabetes management presents a daunting challenge. A large proportion of the population is poor and lives in rural areas far from health facilities, which are poorly represented on the ground and often lack the tools and drugs needed to manage the disease; they also lack health personnel with adequate diabetes training. The difficulties are even greater for the management of insulin therapy, which is considerably expensive, unavailable and difficult to handle, especially for people who are poorly educated, have difficulty reading and have an irregular diet. This study represents a picture of the critical issues encountered in the management of diabetic patients on insulin therapy, in a rural area of a low-middle-income country such as Tanzania. Insulin therapy is mainly needed by patients with type 1 diabetes, largely young due to onset in childhood/youth, and used by patients with type 2 diabetes who no longer respond to oral therapy at a more advan-

**Figure 2.** Description of events index of clinical outcomes: hospitalization, hypoglycemia and performance status.



ced stage of disease<sup>(16,17)</sup>. In agreement with what has been reported, the patients examined in our study are predominantly young people, 62.7% being under 40 years of age. However, against expectations, 45.8% of patients are classified in the dataset as type 2. This could be due to the diagnostic difficulties found in low-resource countries, especially in rural areas, where diagnosis is based solely on clinical history, age of disease onset and BMI at onset. Especially in the age range of 25 to 40 years, straddling adulthood and youth, these patterns can generate misclassifications. In group 1 in this age group, 45% of the patients are labelled as type 2 diabetes, however, only 2 are obese and frankly belong to this category; the others were normal weight and among these, most had a BMI at the lower limits of normal weight. Similarly in group 2, more than half are classified as type 2 but only one is obese, and among the normal-weight half have a BMI at the lower limits of normal. The proportion of patients whose type of diabetes is not specified at the first visit is a further indication of the diagnostic difficulty encountered. It would be interesting to be able to investigate this question further to see whether, in these doubtful cases, we are actually dealing with type 1 diabetes, particular forms of diabetes prevalent in Africa such as that related to malnutrition, or even whether the low weight is due to glycemic decompensation in type 2 as well.

In our cohort, patients on insulin therapy are 49.1% male and among patients in active follow-up males are 54.5%. This male sex proportion is unusual: NCDs clinics in Tanzania are mainly attended by women, with a small number of men on treatment, due to a social and cultural factor<sup>(18-20)</sup>. Probably the extent of symptomatology due to diabetes also prompts men to seek health care help to deal with the problem. In fact, almost all the patients interviewed, prior to starting treatment, had either gone through hospitalisation or perceived a state of poor health with marked weakness and asthenia, so much so that they were unable to work in a performant manner or dropped out of work or study completely. In addition, most patients do not have a family history of diabetes or particular comorbidities, so there are few opportunities for contact with health care facilities, except for women who, in the maternal and child health setting, are more accustomed to frequenting health care environments; therefore, it is not surprising that for many patients the diagnosis is generally made in conjunction with an episode of diabetic ketoacidosis<sup>(21)</sup>.

From the socio-economic status indices, it appears that patients predominantly present a poor substratum. This can be deduced from the significant number of mud or sheet metal dwellings, poor availability of electric light (present in less than half of the houses), living in large families (often at least 5 people), and low economic income per family, amounting to only one source of income in 51.5% of cases. In addition, the main occupation is farming, and 15.2% of the patients surveyed have no occupation; more than 80% of patients have not passed the elementary school level ("Standard 1-7"), and do not have health insurance; nearly 70% face economic difficulties in supporting transportation costs to travel to check-up in Tosamaganga. The economic component is undoubtedly a major factor in influencing the origin of patients from different peripheral health centres, so much so that the Tosamaganga area is the most represented (64.4%). However, the economic-geographical factor is not the only one influencing accessibility to care: poorly travelled roads, long distances, rainfall, and scarcity of public transportation are major obstacles to continuity of care. Therefore, it is highlighted that decentralisation of care and accessibility to diabetes services at the grassroots level is vital. Lack of services on the ground generates health inequity, making continuum of care accessible only to the wealthier population.

Insulin therapy is certainly the most expensive of all diabetes therapies, both because of the cost of insulin itself, but also because of the need for close monitoring several times a day of blood glucose values through test strips and glucometer. Together with needles and the syringes required to inject the drug, they represent an added cost to the overall budget per person. To limit health inequities as much as possible, Doctors with Africa CUAMM's NCDs project offers free treatment to patients on insulin. Considering that the cost of the cheapest insulin regimen is equal to about four salaries of an early-career nurse, in the absence of health insurance, it becomes extremely difficult to meet this expense. Hence, predictably, 81.8% of the patients surveyed said they would have no way to treat themselves in the absence of the Tosamaganga insulin clinic.

All guidelines, from high-income countries as well as lower-income countries, indicate diet and physical activity as an integral part of care. For this reason, the NCDs clinic has a nutritionist who conducts counselling. Such counselling was found to be very



helpful by all patients interviewed. High dietary adherence is found: consumption of carbohydrates is low and whole-grain carbohydrates are preferred; consumption of alcoholic and sugary beverages such as sodas is exceptional, in contrast to what is usually seen in the general population. In addition, most patients reported that they engage in regular physical activity. Our study demonstrates how qualified health personnel can make a difference and how it is critically important that all services enjoy the presence of these specialised figures.

About half of the patients surveyed (51.5%) said they need help handling insulin and/or following proper nutrition. Overall, 70.6% of them need support in handling insulin; for example, many patients have visual impairment and cannot read the small numbers written on the syringe by themselves so that they can independently inject themselves with the correct number of insulin units. Some perceive shame in injecting themselves with insulin in front of other people or experience stress and fear about injecting and more than 1 in 3 people perceive social stigma due to their disease. The insulin regimen used is the Premixed regular insulin/NPH 30/70 30/70 insulin regimen with two daily administrations (breakfast and dinner). Existing literature data report a higher rate of hypoglycemias with the premixed regimen and human insulin, compared with the basal bolus regimen with insulin analogs<sup>(22)</sup>. In the study population, reported hypoglycemias are numerous; however, major hypoglycemias, which are more dangerous, occurred in a minority of patients (15.2%), in no more than two per patient in a month. In contrast, symptomatic minor hypoglycemias are very prevalent in almost 8 in 10 people, frequently occurring in numbers of at least three per month. They occur mainly in the morning, after prolonged fasting at night. A survey regarding the regularity of diet and the amount of food taken at each meal could help to understand whether there is any margin to reduce these hypoglycemias through modification of eating habits. In addition, the number of hypoglycemic episodes observed tended to be higher in those with a lower level of education, which also accounts for the majority share of the study population. A higher degree of education would probably allow for more careful handling of insulin, without confusion in counting the units to be injected, and is associated with higher economic status, which allows for a more regular diet without skipping meals or reducing quantities. In this con-

text, counselling by health care professionals to recognize symptoms of hypoglycemia early and resolve them without complications is crucial.

It is indicative of the effectiveness of the medical intervention that patients followed by the NCDs clinic reported a significant benefit on the other clinical outcomes considered. In fact, an improvement in blood glucose, glycated haemoglobin, and weight values over time was observed, although without reaching the target. The number of hospitalizations for any cause excluding childbirth and trauma decreased dramatically after patients were enrolled in the NCDs clinic: more than 80% no more experienced hospitalization. Performance status improved dramatically: almost all patients resumed and improved their work ability following the initiation of insulin therapy.

Limitations of the study include: the limited sample size, which is largely related to the very epidemiology of type 1 diabetes and the tendency to procrastinate, as much as possible, the initiation of insulin therapy in patients with type 2 diabetes. The difficult data collection in the described setting for several reasons: it is not easy to obtain clear information about the medical history and medications taken, sometimes even the age of the patients themselves is difficult to define; in addition, sometimes the reagents made available for haematochemical tests become out of stock and the results are not always reliable; patients often get lost at follow-up or miss scheduled checkups.

In conclusion, there are many challenges to be faced in a low-middle-income country like Tanzania, especially in a rural setting. Increased access to treatment at the grassroots level and training of qualified personnel would be appropriate to improve disease control and reduce the dangerous adverse effects represented by hypoglycemia. Spreading awareness of the problem, currently rather small, so that interest in it develops at the community level is a winning strategy to spark new initiatives and achieve tangible and lasting goals over time. All outcomes considered improve with the proposed management model, the medical intervention described, and the counseling performed. Based on the results obtained from this study, Doctors with Africa CUAMM promotes the use of the insulin regimen with pre-mixed 30/70 insulin. Compared with basal-bolus, because of only two daily administrations, it is less expensive and more manageable for patients. In this way adherence to treatment as well as cost sustainability to support as many patients as possible

are promoted. It results in important clinical improvements related to performance status and reduced hospitalizations, in the presence of an otherwise limited number of major hypoglycemia and improved glycaemic control over time. In a setting such as the one described, the use of Premixed regular insulin/NPH 30/70 insulin is therefore desirable.

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