THE EAST AFRICA DIABETES STUDY GROUP

EADSG
Together we can fight Diabetes

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EADSG CLINICAL
PRACTICE GUIDELINES

PRACTICAL APPROACHES TO THE MANAGEMENT OF TYPE 1 DIABETES

Edited by
Silver Bahendeka,
MBChB, MSc; Cert D&E; FRCPI, PhD

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Chair EADSG & the EADSG Guidelines Committee

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Abbreviations

ACE	Angiotensin Converting Enzyme Inhibitor
AHRQ	Agency for Health Research and Quality
ARB	Angiotensin Receptor Blocker
BP	Blood Pressure
COVID-19	Corona Virus Disease 2019
DESMOND	Diabetes Education and Self-Management for Ongoing and Newly Diagnosed
DKA	Diabetic Ketoacidosis
DMP	Diabetes Management Plan
DSME	Diabetes Self-Management Education
DS-MEST	Diabetes Self-Management Education and Support Tutelage
EADSG	East Africa Diabetes Study Group
GAD	Glutamic Acid Decarboxylase
HbA1c (A1c)	Glycosylated Haemoglobin
HCP	Health Care Professional
HDL	High Density Lipoprotein
HLA	Human Leucocyte Antigen
IDF	International Diabetes Federation
ISPAD	International Society for Paediatric and Adolescent Diabetes
IM	Intramuscular
IV	Intravenous
LDL	Low Density Lipoprotein
MDI	Multiple Daily Injections
NPH	Neutral Protamine Hagedorn
ORS	Oral Rehydration Solution
SARS-CoV-2	Severe Acute Respiratory Syndrome Corona Virus 2
SGLT	Sodium-dependent Glucose Co-Transporters (Sodium-Glucose linked transporter)
SHARE	Seek, Share, Help, Assess, Reach and Evaluate
SMBG	Self-Monitoring of Blood Glucose
SSA	Sub-Saharan Africa
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
TB	Tuberculosis
TDD	Total Daily Dose
WHO	World Health Organization

A Word About this EADSG Guidelines

The *EADSG Guidelines: Practical Approaches to the Management of Type 1 Diabetes in Primary Health Care in sub-Saharan Africa* was jointly developed by the East Africa Diabetes Study Group (EADSG) and the International Diabetes Federation (IDF), Africa Region. Members of EADSG and IDF Africa Region formed the expert group that contributed the required clinical and methodological expertise. The *Guidelines* have come in at the most crucial time when the global prevalence and impact of Type 1 Diabetes (T1DM) on healthcare, particularly in sub-Saharan Africa (SSA) has increased substantially. Moreover, countries in SSA are currently facing unique challenges in healthcare delivery due to the compounded phenomenon arising from inadequate financial resources; lack of adequately trained health care workers; unavailability of essential medicines and associated technologies; differences in urban and rural disease patterns; and inequity imposed by public and private sector health care. It is probably because of these unresolved challenges that T1DM in SSA has a greater impact on morbidity and mortality than any other region in the world. In order to address these unacceptably poor trends, experts from EADSG and IDF Africa Region met and formulated contextualized strategies for identification and management of T1DM within SSA. Special attention was paid to resource-and cost-related issues affecting care for children and adolescents with diabetes. Therefore, we are delighted to see that the *Guidelines* have addressed a broad range of topics in T1DM; from assessment and treatment of child and adolescent diabetes ("patient – oriented" parameters) to broadening of clinician knowledge in specialized areas of diabetes in children ("clinician-oriented" parameters). Most importantly the *Guidelines* point out *minimum* standards of care. While this is debatable, it remains one of the most important **tools for bargain** in health financing in most developing countries. Emphasis has been put on individual centres developing a contextualised self-management plan comprising of insulin use, blood glucose monitoring, physical activity and a healthy diet. Remarkable is that this plan is an integral component of the initial intensive patient-family/caregiver education (**Diabetes Tutelage**) that clearly points out the importance of **Patient Support** in the management of T1DM. The management paradigm shift is on **'treating to target' and not 'treating to failure'** pointing out the following main elements:

1. T1DM should have dependable access to insulin with appropriate syringes or pens;
2. blood glucose monitoring, noting that greater frequency of fingerstick glucose monitoring is associated with lower HbA1c in persons with T1DM (a consensus of a minimum of 3-days pre-meal and one 3:00 am glucose measurements per week was held) and where funds are available, opt for continuous glucose monitoring (CGM);
3. monitoring in T1DM, performed by the patients, families, and the diabetes care team, is an integral feature of diabetes care and should be prioritized for allocation of funds;
4. glycated haemoglobin (HbA1c) measured at least twice a year;
5. separate but integrated T1DM clinics within the health facility and planned along the chronic care model and
6. the provision of an enabling support for the children and adolescents with T1DM to achieve pre-defined goals.

The expert group were cognizant of the challenging socio-economic situation in SSA, but were convinced that with appropriate planning and priorities on T1DM management, these are achievable, with no further compromise on quality of care. It cannot be overemphasized that it will require extra effort of health care professionals together with entire international community to achieve these goals. This *Guidelines* should become a good resource for both clinical and public health practices and research in terms of management T1DM in SSA. The *Guidelines* dovetails well with other guidelines on management of T1DM and should be used alongside them to better

manage T1DM. A statement on the rights of children to health is included and is a wakeup call for all health policy makers in SSA. **It is our conviction that all governments in SSA should prioritize the management of T1DM, as management is cost effective and is affordable.** The guidelines underwent an extensive review process, including review by external experts, to whom we extend our sincere gratitude. We are confident that these efforts will be translated to improved quality of life for T1DM in SSA. Finally, we are extremely grateful to the sponsors and to those who have worked tirelessly to produce the Guidelines; both in English and French.

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The East Africa Diabetes Study Group (EADSG) gratefully acknowledges the contribution of the Dr Graham D Ogle, FRCP; General Manager, Life for a Child Program, Diabetes NSW & ACT and Adjunct Professor, University of Sydney, who devoted a lot of his time to reviewing the manuscript and provided very useful guidance of its detail.

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The Study Group would like to thank and gratefully acknowledge financial support of Novo Nordisk who supported the Consensus Development meeting in Kigali and the production of its final format.

Dedication

On the 19 December 2022 we lost a gallant son of Africa, Prof Naby Balde, MD. When we lose someone special to us, we never forget them. We, therefore want to express what that person meant to us, show our love and remember the life they lead. Finding the words or phrases that truly reflect a person's life is incredibly hard. The authors of this guideline dedicate the work and leadership of the exemplary Prof Naby Balde.

What's New

- The recommendations urge health workers to set up clinics for type 1 diabetes care organized along the chronic care model and in all cases establish a registry that will assist in identifying priority areas for improving health; and context-specific approaches which draw on policy and technical expertise from health planners. This recommendation extends to include data collection via standardized protocols for T1DM management at each clinic to inform on the national burden of disease and thus further contribute to accurate drug and associated technology forecasting.
- The recommendations seek to adopt the conceptual chronic care model adapted to address contextual factors unique to SSA: (i) quality improvement of existing care (follow guidelines; staff competence); (ii) health systems (follow the traditional essential medicines, essential diagnostics, systematic monitoring and evaluation and decentralized care); (iii) decision support (adherence to medications, adherence to follow and communication with the specialist); and (iv) human resources (train and retrain staff; and dedicated staff to manage T1DM clinics).
- The recommendations emphasize an all-inclusive, individualized care plan written for each patient with T1D, that is understood by the caretaker and family and given to the patient to take home.
- In most of sub-Saharan Africa, patient's participation in decision making is poorly developed; with most patients leaving decision making to the health worker. The recommendations point out that this does not mean that decision making for patients and their caregivers in sub-Saharan Africa is a *fait accompli* matter; rather health workers should spend a little more time to understand the patient's unmet needs and choices so that the decisions made are patient - centred.
- The recommendations recognize that in adapting disease guidelines in the face of extreme shortages of health care workers as commonly encountered in SSA, requires non-physician clinicians to be delivering care. Therefore, to ensure effective implementation of management programmes, it is recommended that standardized protocols for diagnosis, treatment and monitoring to be put in place, and mentorship programmes be established as better ways of training health workers in 'task shifting'.
- Education has been singled out as one of the most important pillars of care and should be systematic and structured, with extra emphasis on the first encounter. This should be given alongside the **philosophy of identifying areas of support** in the care of diabetes. This is particularly important in the newly diagnosed – Diabetes Education and Self-Management for Ongoing and Newly Diagnosed (acronym **DESMOND** by the National Health Service Organisations in the UK).
- Generalized lack of self-management support was singled out as a major underlying factor of poor outcomes in the management of T1DM. The health worker should work with the patient's family and together they identify support for the person with type 1 diabetes soon after diagnosis. **Self-management Education and Support structures should be reviewed at all patient reviews**. This may be a difficult task in an environment of scarce resources, but it should be addressed to its most meaningful terms.
- Recommendations on emergency planning are designed to provide a guide to the health worker and the patient a comprehensive assessment and risk stratification in setting up an emergency plan; and thus, be able to provide an individualized multi-dimensional integrated approach to the comprehensive management of T1DM for immediate and long-term benefits.
- Glycaemic targets have been tagged to the **available resources and the health care setting** rather than to age, as these are the limiting factors in achieving the target HbA1c in SSA.

Clinicians should follow guidelines for updates, understanding that **optimal glycaemic control is a moving target**.

- Recommendations recognize that having a referral pathway is indispensable in the health system; but point out that referral pathways are poorly developed in most of SSA and the immediate solution seems to be an **immediate communication with a doctor or specialist rather than arranging immediate transport to another facility** and that this could optimize patient management and should become an **essential component of the referral system** in low resource setting of SSA.
- An **Individualized Diabetes Management Plan (IDMP)** for children going to school and a look at the special situations of SSA where there may be no school nurse, communication is poor and food may be insufficient in schools is an essential component in the management of T1DM going to school.
- Traditional and spiritual healers in the management of T1DM. Whether or not we practice in a country dominated by traditional healers, health care systems across the World are becoming more diversified, and the clinician needs to be aware that many families and patients with T1DM will seek care from traditional and / or spiritual healers and will quite often detrimentally stop insulin therapy. The family and patient's beliefs should be incorporated into the consultations and these should be addressed through patient's self-management diabetes and community education structures.

Introduction

Type 1 Diabetes Globally and in sub-Saharan Africa

The incidence of childhood type 1 diabetes (T1DM) has been growing globally since the past few decades; though stagnation in prevalence figures has been observed in a small number of regions around the World. While there are clear indications of geographic differences in trends, globally, the estimate is an overall annual increase of about 3% [1]. Data on the epidemiology of T1DM in sub-Saharan Africa (SSA) is scanty; the available data, mainly health facility-based studies, suggest an increasing incidence of childhood T1DM associated with a disproportionate prevalence after accounting for increased mortality [2]. Countries in SSA are faced with the triple burden of communicable and non-communicable diseases plus acute injuries [2]; and therefore, likely to face challenges of priorities. Moreover, the economic cost of managing T1DM remains high even with the recent technological advancements (Sussman, M., et al., *Estimated Lifetime Economic Burden of Type 1 Diabetes.* Diabetes Technol Ther, 2020. **22**(2): p. 121-130.10.1089/dia.2019.0398). It is against this background that contextually appropriate guidelines for the management of type 1 diabetes in primary care in SSA deemed necessary.

The East Africa Diabetes Study Group (EADSG) in partnership with the International Diabetes Federation (IDF) Africa Region, conceptualized this guideline. The expert group recognized that an important limiting factor for producing specific evidence-based clinical practice guidelines for the management of T1DM in primary care in SSA was the lack of data coupled with lack of recent large randomized controlled trials in the management of T1DM in SSA; and subsequently the need to extrapolate from studies carried out in regions where clinical care pathways are well-resourced to the resource-restricted regions SSA. Moreover, in some areas of clinical applications, it was consensus rather than evidence that prevailed. This group of experts has considered this implication and has attempted to seek evidence from a wide range of studies that provide enough confidence for the basis of each recommendation. This limitation has influenced the decision of grading the recommendations at a particular level of evidence; and instead opted to provide references for the recommendations in each section. The recommendations are designed to support health care workers to provide an individualized multidimensional integrated approach to the comprehensive management of T1DM. The *Guidelines* therefore, presents appropriate recommendations to assist patients and practitioners in making decisions regarding clinical practice of high importance; and have, as far as possible, been based on the body of evidence evaluated and integrated by systematic reviews; with the balance between benefits and harms carefully evaluated by the panel of experts.

The *Guidelines* come in after the publication of LFAC/ISPAD Pocketbook Guideline 2nd Edition, which addresses similar issues of managing T1DM in low resource settings and we would like to stress that the *EADSG Guidelines* is complementary in homing in these issues to the healthcare professional working in this difficult environment. The *EADSG Guidelines* briefly looks at the unique socio-economic and political environment in which most of the health systems in SSA operate. It is hoped that this will stimulate research in this field so as to better understand the modalities required to improve healthcare in this environment.

In most SSA countries, there are significant unmet needs in the health care services and limited resources to identify and manage diabetes. There is lack of trained staff and access to treatment protocols and diagnostic equipment coupled with an inconstant supply of essential drugs, training, supervision and monitoring to manage diabetes [3,5,6]. Moreover, there are also a number of other unmet needs specific to the management of T1DM; implying the constant need for innovative strategies directed at improving care. Several recent approaches have been suggested for the management of T1DM in low resource setting [7, 8]; unfortunately all of them conceding to the reality of competing priorities - a situation that does not favour a push for more

resource allocation towards the management of T1DM. In drawing up the *EADSG Guidelines*, the body of experts, while cognizant of the socio-economic and political situations of low- and middle-income countries, found it difficult to ignore bringing the attention of governments and health authorities their obligations in providing care to all sick children embedded in United Nations (UN) Convention on the Rights of the Child. Governments in SSA ratified, and therefore remain party to the treaty, the UN Convention on Rights of the Child [9], which adopts an integrated and holistic approach to the rights of children. In other human rights instruments, economic, social and cultural rights have been dealt with separately from civil and political rights, but in the UN Convention on Rights of the Child, all (economic, social and cultural rights) have been brought together in an innovative way. The rights are seen as necessary for the full and harmonious development of the child's personality and inherent to the dignity of the child. These are summarized below.

(i) The four general principles in the UN Convention on Rights of the Child are:
(ii) all the rights guaranteed by the convention must be available to all children without discrimination of any kind (Article 2)
(iii) the best interests of the child must be a primary consideration in all actions concerning children (Article 3)
(iv) every child has the right to life, survival and development (Article 6); and
(v) the child's view must be considered and taken into account in all matters affecting him or her (Article 12)

Furthermore, the *EADSG Guidelines* stresses the need to uphold to the paradigm shift of ***Hit Early & Hit Hard*** in the managing of diabetes [10]; and all efforts must made to manage diabetes optimally as soon as detected based on the fact that majority of damage caused by initial poor treatment are irreversible (the "metabolic memory "and "legacy effect").

In drawing up the *EADSG Guidelines*, the focus was on **primary health care** as viewed by the World Health Organization (WHO). In this context, primary health care refers to a *whole-of-society approach to health and well-being*, centred on the needs and preferences of individuals, families and communities. It addresses the broader determinants of health and focuses on the comprehensive and interrelated aspects of physical, mental and social health and wellbeing. It should be stressed that most countries of SSA do not have well developed structures of primary healthcare as seen in the *Western World* and therefore primary care does not necessarily imply the availability of a functional secondary and tertiary care. The reader may therefore find some areas of management placed at primary care more than what is usually envisaged, but this has come as a result of some countries having no functional secondary and tertiary care. Secondary, with this view of primary health care, one cannot ignore the traditional and cultural beliefs about illness, the roles of traditional healers, and the community and societal approach to the management of a chronic illness.

Common Scenarios in Diabetes Management in sub-Saharan Africa

Disease status

- Failure to lower glycated haemoglobin (HbA1c). The level of HbA1c is high in most published and unpublished data from SSA, whereas it should be lower, particularly early in the course of the disease.
- Stunting and poor weight gain are still a problem in SSA
- Severe hypoglycaemia remains an important and immediate complication of insulin therapy, especially where there is an inadequate diabetes education, monitoring and self-management support.

- Diabetic keto-acidosis remains an issue even in those patients who are presumably well managed
- Cardiovascular risk in T1DM is high and essentially unaddressed by any clinical trial in SSA.
- Chronic kidney disease remains a common complication of T1DM in SSA

Socio-economic:

- One of the major barriers towards initiating early treatment for children with T1D, is the *stigma* related to it and the preference to seek "*a cure*" from traditional and spiritual healers. There may be strong cultural beliefs that lead family or patient to consult traditional / spiritual healers, especially in a disease the family / patient or the community do not easily comprehend.
- The individualistic families are unable to support care for children with T1DM due to the economic limitations and inadequate public health support system for the chronic lifelong disease.
- For rural hinterlands, access to healthcare may be very challenging, especially in emergency situations and follow up clinic visits, because of harsh geographical terrains.
- Low health literacy levels to enable optimal care.
- Patients presenting with eye lens opacities (cataracts) at diagnosis of T1DM is a disabling and devastating eye complication resulting from delayed diagnosis.

Services and resource:

- Due to the competing priorities, T1DM is not yet adequately resourced even when the amount of funding required to manage all the children with type 1 diabetes in the country is negligible compared to the overall health budget.
- Whether the family is based in rural, semi-urban or urban areas, the cost of managing T1DM is unaffordable to the family, and multidimensional in nature.
- Most of the public health systems in SSA are geared towards managing acute illnesses rather than chronic illnesses, whether in children, adolescents or adults [11].
- While the national health policies have now started recognizing the increasing burden of non-communicable diseases (including type 2 diabetes) and its social, economic and individual impact, T1DM has hardly been recognized.
- Functional chronic care models are almost non-existent in most of the countries in SSA. There is a lack of good clinical and epidemiological studies of T1DM in resource-poor settings. The neglect is particularly evident in SSA despite increasing recognition that T1DM is a significant and widespread health problem associated with unacceptably high rates of morbidity and mortality.

Key Principles Underpinning the Guidelines

Guiding Principles

All clinical guidelines require a set of guiding principles that influence the decisions to be taken and recommendations to be provided; and principles which describe the philosophy expressed by the writing group. In this *EADSG Guidelines*, we emphasise the importance of the individualized approach to care for patients with T1DM who are then placed at the centre of care. We have kept in mind the cost considerations and the prevailing weak health systems of SSA. We recognize the scarcity of data in this area which has limited our conclusions in this respect.

The guiding principles include:

- An all-inclusive T1DM care clinic that should be planned and started on a chronic care model - contextualizing all its six elements: the health system (organization support - culture of the practice and system leadership, including safety of patients); self-management support; delivery system design; clinical information systems; clinical decision support systems and community resources and community policies.
- An all-inclusive, individualized care plan written for each patient with T1DM.
- Increased availability of self-management education support for patients with T1DM and their families/carers; at diagnosis (*diabetes tutelage,* DS-MEST) and on follow up in the clinic.
- Implementation of local health strategies to access insulin and associated technologies and receive self-management support so as to minimize unnecessary hospital/emergency department attendances due to shortages of insulin and other supplies, development of ketoacidosis or hypoglycaemia.
- The principle of quality use of medicines including pharmacovigilance that can be further developed by the health professionals and their employers as a part of local health strategies
- Assisting clinicians where possible to undertake therapeutic decisions that are based on a comprehensive assessment of the local situations including functional assessment in those with restriction of activities of daily living, assessment of skills in insulin administration and self-blood glucose monitoring, and assessing the risk of hypoglycaemia.
- The recognition that comorbidity [tuberculosis (TB), human immunodeficiency virus infection (HIV) and acute infections like malaria] is a common finding in SSA and adversely affects management of T1DM, recognising that diabetes is a risk factor for TB infection.
- The recognition of cultural and religious beliefs.
- The quality of care provided should be audited on a regular basis and the outcomes of the audits used to revise care.

Scope of the Guidelines

The *EADSG Guidelines: Practical Approaches in the Management of Type 1 Diabetes in Primary Health Care in sub-Saharan Africa* will act as reference for the following three groups:

- Healthcare professionals
- Commissioners and providers of diabetes services
- Persons with T1DM, their families and care providers

Process of Development of Guidelines

A consensus development meeting comprising of expert healthcare providers managing children and adolescents with T1DM from 14 countries in SSA was held in Kigali, Rwanda, 30th August to 2ndSeptember 2018. All the participating countries had active programs to manage children and adolescents with T1DM, although at different levels of quality of care. From the

available literature and individual expert opinion, unmet needs specific to the management of T1DM in SSA were tabled at this workshop and every single need was discussed in detail to generate consensus. The team also reviewed the recommendations from a literature search prepared by two of the team (Wenceslaus Sseguya & Silver Bahendeka). The literature search was done using Medline, PubMed and Index African Health Journals Database. The search was focused on the period 1990 and 2018, and was restricted to full articles and the English Language. MeSH terms *type 1 diabetes, diabetes in children, diabetes in adolescents, Insulin Dependent Diabetes, diabetes care, diabetes in Africa and diabetes in poor resource countries, were used*. Three of the authors (Edna Mujaliwa, Kaushik Ramaiya & Silver Bahendeka) summarized the literature review and prepared the initial draft used in the workshop. In addition, the following worked as a resource for the guideline development: The International Society for Paediatric and Adolescent Diabetes (ISPAD) guidelines https://www.ispad.org/page/ISPADGuidelines2018; the International Diabetes Federation (IDF) and ISPAD guidelines: **Global IDF/ISPAD guideline for diabetes in childhood and adolescence 2014**; Changing Diabetes in Children Program (CDiC) and ISPAD: **Diabetes in children and adolescents - Basic training manual for healthcare professionals in developing countries**; and the recently published Pocketbook for Management of Diabetes in Childhood and Adolescence in Under-Resourced Countries: **ISPAD, IDF & LFaC Pocketbook Guidelines**.

The EADSG writing group (full list given in appendix) finalized the manuscript that was further reviewed by an external reviewer (Graham Ogle, Australia). Publication of the *Guidelines* got delayed because of the unforeseen COVID-19 pandemic. A statement on the effect of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the strain of coronavirus that causes coronavirus disease 2019 (COVID-19), the respiratory illness responsible for the ongoing COVID-19 pandemic, was added by the editor – Silver Bahendeka.

Definition Diagnosis and Classification

Definition

Type 1 diabetes (T1DM) is a chronic autoimmune disease in which destruction of the beta-cells in the islets of Langerhans results in insulin deficiency with consequent hyperglycaemia [20]. It is the most common chronic endocrine pathology among children [21]. Accurate data on SSA trends in T1DM prevalence and incidence are not available, but data from many high-income countries indicate an annual increase of between 3% and 4% in the incidence of T1DM in childhood. Data on T1DM in SSA is still scanty, but few reports, mostly health facility based suggest increase in the incidence, with a disproportionately low prevalence probably because of high mortality. Recent predictions using a modelling procedure suggest increasing incidence and prevalence of type 1 diabetes in SSA (Gregory, G.A., et al., *Global incidence, prevalence, and mortality of type 1 diabetes in 2021 with projection to 2040: a modelling study. The Lancet Diabetes & Endocrinology, 2022: p. DOI: 10.1016/S2213-8587(22)00218-2;* Ward, Z.J., et al., *Estimating the total incidence of type 1 diabetes in children and adolescents aged 0–19 years from 1990 to 2050: a global simulation-based analysis. The Lancet Diabetes & Endocrinology, 2022: p. DOI: 10.1016/s2213-8587(22)00276-5*)

Common Clinical Presentation of T1DM in sub-Saharan Africa

Early symptoms

- Polyuria
- Polydipsia
- Polyphagia
- Weight loss and / or poor weight gain
- Enuresis/Nocturia
- Fatigue
- Blurred vision
- Perineal candidiasis especially in prepubertal girls
- Inability and decreasing performance at school

Severe symptoms without loss of consciousness

- Polyuria with severe dehydration
- Polydipsia
- Fast deep breathing (hyperventilation)
- Presence of fruity (sweet) breath

Severe symptoms with coma

- Severe hyperglycaemia which may progress to neurological compromise, seizures and coma

Pathophysiology of Type 1 Diabetes

The initial presentation is usually characterized by severe hyperglycaemia with or without ketosis that can be well managed with appropriate insulin therapy; however, patients with poor access to health care often fail to survive the initial severe hyperglycaemia episode because of either ketosis, infection or just lack of adequate care. Indeed, in SSA, the diagnosis of T1DM is often late and later associated with more severe complications including diabetic ketoacidosis (DKA), hyperosmolar non-ketotic coma, and hypoglycaemia [17].

Autoantibodies and Type 1 Diabetes

Even though the information related to the presence of antibodies is limited, autoimmunity measured in T1DM patients in Uganda, Cameroon, Tanzania and South Africa reveal a varying, but low prevalence of antibodies, ranging from 8–11% for Islet Cell Autoantibodies (IAA); 4.9–24% for Glutamic Acid Decarboxylase Enzyme Autoantibody (GADA) and 18.3–29% for Zinc Transporter Family Member 8 Autoantibody (ZnT8-Ab) [15].

The low prevalence of auto-antibodies in type 1 diabetes in the SSA population suggests that autoimmunity-based markers, very useful in phenotyping Caucasian populations, may not be considered a prime tool for diagnosis of T1DM in SSA. Similarly, genetic markers, such as HLA DR3/4, which are known to confer susceptibility to T1DM in Caucasians, have lower prevalence among T1DM patients in SSA than in European populations [15, 17, 18]. These findings highlight the need for more studies in the genetics of diabetes in SSA, while demonstrating marked differences in the genetic and immune-mediated underpinnings of the disease [19]. Recent reviews on the subject keep the same view (Katte, J.C., et al., *The phenotype of type 1 diabetes in sub-Saharan Africa. Front Public Health, 2023. 11: p. 1014626. Doi: 10.3389/fpubh.2023.1014626*).

Diagnosis

Diagnosis of Type 1 Diabetes

Improve the detection of T1DM by the following measures

- Scale up case detection: improve the community awareness through sensitization of community health workers (CHW), sensitize the health care professionals (HCPs), adapt the health system to make an early diagnosis utilizing digital systems (m-health)
- Algorithm on casual blood glucose and diagnosis of type 1 diabetes at primary health facility level. Consult with higher level facility by phone is advisable.
- Risk assessment chart development for primary health facility level
- Develop a care pathways from clinical practice guidelines for the health care givers. Every sick child who comes into contact with the health system should have a blood glucose test done.

At community level

The community needs to be sensitized about T1DM so as to increase the awareness about the disease, dispel myths that surround it and be able to involve the community in the care of those diagnosed with the disease. Parents, teachers, church-community, mosque-community, caregivers, etc., need to be educated on the classical symptoms of T1DM (polyuria, polydipsia, polyphagia, weight loss, enuresis/nocturia), and the importance of taking the affected children / adolescents to the health facility for appropriate diagnosis and management. This should take the form of community engagement by the health care workers.

At healthcare facility level

- Diagnosis in a patient who does not have all the classical symptoms requires two abnormal test results, which can be done from the same test parameter (e.g., a blood glucose) on different days, or from different test parameters (blood glucose and HbA1c) performed on either the same day or different days. If only one test comes back abnormal, repeat the abnormal test on a different day. Two abnormal readings constitute a diagnosis of diabetes. This is not the common presentation of T1DM in children and adolescents in SSA.
- Diagnosis for **a patient with classic symptoms of hyperglycaemia** (i.e., polyuria, polydipsia, weight loss) can be made with a single random plasma glucose result of 11.1 mmol/L (200 mg/dL) or higher. A repeat measurement is not required.
- Any acutely ill child (e.g., severe problem with airway breathing, circulation or acute deterioration of conscious state) should be tested for blood glucose using a glucose meter and

strips. Every health facility should have at least one blood glucose meter with appropriate strips to check blood glucose.

- A persistent blood glucose ≥ 11.1 mmol/L (200mg/dL) is diagnostic of diabetes. Note that in critical illness, high blood glucose levels may occur in otherwise previously normoglycaemic children. This is usually transient, and is referred to as stress hyperglycaemia.
- Diabetes is more likely if the child has the classic symptoms of diabetes or symptoms of poor growth or frequent fungal infections or has ketones in the urine.
- A normal HbA1c favours stress hyperglycaemia, but does not completely exclude diabetes.
- A blood glucose of 7–11mmol/L should be viewed with suspicion and requires follow up for confirmation of diagnosis and to rule out other causes of hyperglycaemia.

Autoantibodies for diagnosis of Type 1 Diabetes

Beta cell destruction in T1DM may be assessed by measuring serum autoantibodies against incompletely identified islet cell cytoplasmic or molecularly defined antigens while insulin deficiency may be assessed by measuring C-peptide levels [15]. Figure 1 illustrates the systematic Approach for the diagnosis of Type 1 Diabetes in accordance with the WHO classification [22, 21].

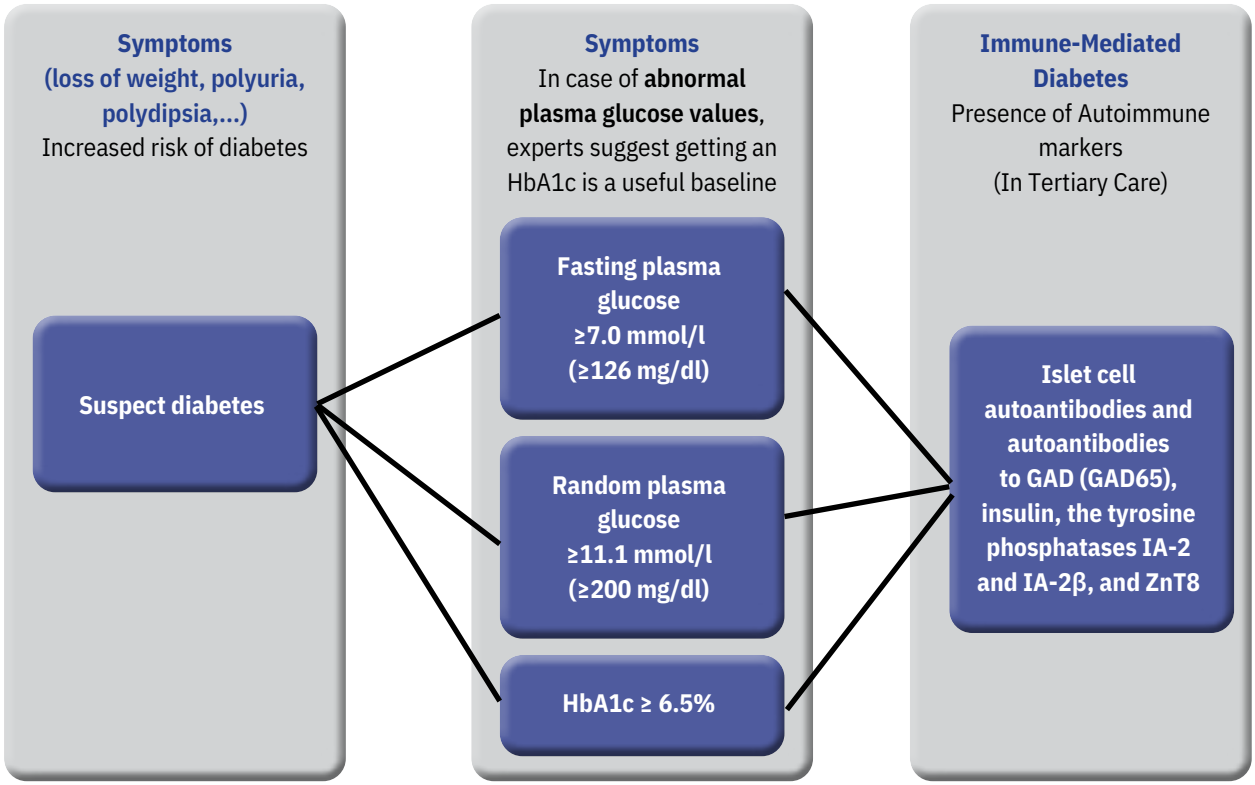

Fig 1: Systematic Approach for Diagnosis of Type 1 Diabetes

In a patient with classic symptoms, measurement of blood glucose is sufficient to diagnose diabetes (symptoms of hyperglycaemia or hyperglycaemic crisis plus a random plasma glucose ≥ 11.1 mmol/l [≥ 200 mg/dL]). Some providers may also want to know the HbA1c at the baseline. The HbA1c ≥ 6.5% (48 mmol/mol) is considered a diagnosis of diabetes mellitus [22]. This is not required for T1DM; and may in fact cause undue delay of treatment.

T1DM is marked by the presence of one or more of autoimmune markers [islet cell autoantibodies and autoantibodies to GAD (GAD65), insulin (IAA), the tyrosine phosphatases IA-2 and IA-2β, and Zinc Transporter Family Member 8 Auto-antibodies (ZnT8-Ab)]. Furthermore, T1DM has strong HLA associations, with linkage to the DQA and DQB genes. The HLA-DR/DQ alleles can be either predisposing or protective [22].

Note: In most cases, the presence of autoantibodies for T1DM precludes further testing for monogenic diabetes, although the presence of autoantibodies in patients with monogenic diabetes has been reported [23]. Testing for monogenic diabetes should be done in all infants diagnosed < 9 months of age, and in older subjects if a family history fits a single gene defect and the clinical features are consistent.

C-peptide has been shown to denote endogenous insulin production and correlates with type of disease, duration of diabetes, as well as age of diagnosis. In insulin-treated individuals, fasting C-peptide of less than 0.2 nmol/l and glucagon stimulated test of less than 0.32 nmol/l have been found to correlate significantly with T1DM, with greater sensitivity and specificity than urinary testing of C-peptide. This test may be used to define T1DM in tertiary institutions.

Overall recommendation

- Establish the diagnosis of diabetes based on recognized criteria with or without association with symptoms
- Plasma blood glucose rather than HbA1c should be used to diagnose the acute onset of T1DM in individuals with symptoms of hyperglycaemia.
- Screening for T1DM with a panel of autoantibodies is currently recommended only in research settings or in first-degree family members of a proband with T1DM.
- Persistence of two or more autoantibodies predicts clinical diabetes and may serve as an indication for intervention in the setting of a clinical trial.

Classification of Diabetes Mellitus in Children

The confirmation for the type of diabetes in an individual often depends upon the condition at the time of diagnosis; noting that most of the patients with diabetes cannot easily be designated into single class. Table 2 summarizes the characteristics of patients presenting with hyperglycaemia in SSA.

Table 1: Children and adolescents presenting with hyperglycaemia in SSA

	Type 1 diabetes	Type 2 diabetes	MODY*	Hybrid Forms of diabetes**
Prevalence	~85%	~12%	~1–4%	≥10% in population of African descent
Age of onset	Throughout childhood and adolescence	Puberty, rare <10 years	<25 years	Pubertal
Onset	Acute severe	Insidious to severe	Gradual	Moderate or Acute and severe
DKA at onset	~30%	~6%	Not typical	Variable
Affected sibling	5–10%	60–90%	50–90%	>75%
Female to Male	1:1	1.1:1.8	1:1	Variable
Inheritance	Polygenic	Polygenic	Autosomal dominant	Polygenic
HLA-DR3/4	Association	No association	No association	No association but variable
Ethnicity	All but Caucasian at highest risk	All	All	More in patients of African descent
Insulin (C-peptide) secretion	Decreased/ absent	Variable	Variably decreased	Variably decreased

	Type 1 diabetes	Type 2 diabetes	MODY*	Hybrid Forms of diabetes**
Insulin sensitivity	Normal when controlled	Decreased	Normal	Normal
Insulin dependence	Permanent	Variable	Variable	Intermediate to complete with time
Obesity	No†	>90%	Uncommon	Varies with population
Acanthosis nigricans	No	Common	No†	No†
Islet autoantibodies	Yes§	No	No	No

* MODY: maturity-onset diabetes in the young (MODY is a group of monogenic disorders characterized by autosomal dominantly inherited non-insulin dependent form of diabetes classically presenting in adolescence or young adults before the age of 25 years. MODY is a rare cause of diabetes [1% of all cases] and is frequently misdiagnosed as type 1 or type 2 diabetes. A precise molecular diagnosis is essential because it leads optimal treatment of the patients and allows early diagnosis for their asymptomatic family members)

** Hybrid form of diabetes is the new term for the two forms of diabetes: ketosis-prone type 2 diabetes (atypical diabetes which has also been referred to as Flatbush diabetes, type 1.5 diabetes, and idiopathic type 1 diabetes), and slowly evolving immune - mediated diabetes of adults

† Mirrors rate in general population.

§ Diabetes-associated (islet) autoantibodies to insulin, islet cell cytoplasmic, glutamic acid decarboxylase, or tyrosine phosphate (insulinoma-associated) antibody (IA-2, ICAS12, ZnT8 antibodies in 85–95%) at diagnosis.

Epidemiology

Epidemiology of Type 1 Diabetes in Africa

There are a few articles in the literature reporting the incidence and prevalence of type 1 diabetes (T1DM) in sub-Saharan Africa [12]. The International Diabetes Federation (IDF) in 2013 reported the prevalence of type 1 diabetes in sub-Saharan Africa to be the lowest globally (~0.009%); an estimated absolute figure of 39,100 children (age range: 0 to 14 years) living with type 1 diabetes [13]. In 2017 the estimated number of children and adolescents below the age of 20 years living with T1DM had almost doubled; with an estimate of 50,600 children living with T1DM [13]. There has, however, been a wide variation in the reported incidence and prevalence figures of type 1 diabetes in the region. Incidences reported range between 1.5/ 100,000 in Tanzania to 10.1 / 100,000 in the Sudan; while the prevalence varied from 0.25 / 1,000 in Nigerian Igbo to 3.1 / 1,000 in North-West Nigeria. Studies on the epidemiology of T1DM in sub-Saharan Africa (SSA) seem to indicate that the pattern of presenting disease in SSA differs substantially from that of the West [14, 15]. Typically, the peak age of onset of the disease is more than a decade later with a male excess in some studies; and a low prevalence of indicators of islet-cell autoimmunity. An association with markers of undernutrition has been reported in some of the studies [14].

Due to poor health care facilities and services in some parts of sub-Saharan Africa, patients who are diagnosed with T1DM may not survive more than a year after initial diagnosis [16]. This unfortunate reality along with poor data collection and low rates of detection may in part explain the low prevalence estimates for T1DM in SSA. Table 2 shows recent figures reported by IDF in 2019. The table displays the estimated incident (newly-diagnosed) cases of type 1diabetes per annum and prevalent (existing) cases in the 0–14 and 0–19-year age -group by IDF Africa Region after adjustment for mortality [2].

Table 2: Estimated incidence and prevalence of T1DM per annum in SSA

Number of countries with incidence rates available	Incident Cases per annum (1,000s)		Prevalent Cases (1,000s)	
3/47 (6%)	0–14 year	0–19 year	0–14 year	1–19 year
	4.3	10.3	9.4	25.8

Assigning Diabetes Type in Clinical Settings

A recent recommendation by the World Health Organization (WHO) [21] provides a practical clinical guide for clinicians faced with the challenge of assigning a type of diabetes to individuals at presentation with hyperglycaemia to help choose an appropriate treatment, particularly whether or not long-term insulin treatment should be started. Countries and centres able to test for genes, for islet autoimmunity and for endogenous insulin production can use these to increase the accuracy of clinical subtyping of diabetes.

Steps in clinical subtyping an individual first diagnosed with diabetes

Steps in clinical subtyping of an individual in the clinical setting have been proposed by a WHO expert group [21]:

1. Confirm diagnosis of diabetes in an asymptomatic individual
2. Exclude secondary causes of diabetes
3. Consider the following which may assist in differentiating subtypes
    - Age at diagnosis as a guide to subtyping diabetes
        - Age less than 6 months - monogenic neonatal diabetes - transient or permanent; Type 1 diabetes - extremely rare

- Age at 6 months to less than 10 years
  - Type 1 diabetes more likely
  - Monogenic diabetes – less common; consider in mild metabolic presentation
  - Type 2 diabetes - rare before puberty
- Age 10 to less than 25 years
  - Type 1 diabetes; type 2 diabetes; monogenic diabetes. The relative proportions of different types of diabetes in this age group differ by ethnic group. Type 2 diabetes with onset in youth occurs most often during the second decade of life and there is usually a strong family history of type 2 diabetes in first - and second -degree relatives. Features favouring a diagnosis of type 2 rather than T1DM at diagnosis include: - overweight or obesity; age above 10 years; strong family history of type 2 diabetes; presence of acanthosis nigricans; undetectable islet autoantibodies (if measured); elevated or normal C - peptide (if assessed).
- Age 25 to 50 years
  - Type 2 diabetes; slowly evolving immune-mediated diabetes; Type 1 diabetes. Slowly evolving immune-mediated diabetes in adults usually presents after the age of 25 years and mostly after the age of 35 years. Pancreatic autoantibodies (especially GAD autoantibodies) are a feature. Subtypes of diabetes other than type 2 diabetes should be considered in adults who have a normal weight and are without other metabolic syndrome features. These features are present in about 33% of adults with slowly evolving immune -mediated diabetes, compared to 83% in people with type 2 diabetes. T1DM accounts for an estimated 5% of diabetes diagnosed between the ages of 31 and 60 years. T1DM should be especially considered on clinical grounds in adults presenting with one or more of the following: ketosis, rapid weight loss, age of onset below 50 years, BMI below 25 kg/m^2, or personal and /or family history of autoimmune disease.
- Age over 50 years
  - Type 2 diabetes; slowly evolving immune-mediated diabetes in adults; type 1 diabetes. The same considerations apply in this age group as those that apply to individuals aged 20–50 years, although T1DM presenting in this age group is less common.

4. Differential diagnosis of individuals presenting with ketosis or ketoacidosis
   - Type 1 diabetes; Ketosis-prone type 2 diabetes; Type 2 diabetes with onset in youth; and type 2 diabetes with onset in adults. In people with diabetes diagnosis before the age of 20 years, diabetic ketoacidosis at the time of diagnosis occurs in approximately 25% but varies within and across populations. The prevalence decreases with age from 37% in children aged 0–4 years to 15% among those aged 15–19 years. Diabetic ketoacidosis prevalence is significantly higher in people with T1DM (about 30%) compared type 2 diabetes (10%). The possibility of ketosis-prone type 2 diabetes should always be considered in adults of all ethnicities who present with ketosis, but otherwise have most features of type 2 diabetes. Note the emerging category of adult-onset type 2 diabetes in low body mass index (BMI) people that may mimic type 1 diabetes

Screening

Due to low population prevalence, screening for type 1 diabetes is not recommended. However, in order to reduce delay in the diagnosis of affected individuals, community awareness strategies on type 1 diabetes should be adopted. These include talking about symptoms that may accompany type 1 diabetes onset.

Establishing a Management Plan and Glucose Regulation

First Encounter at Diagnosis

The first patient visit is critical and often sets the pace and quality of relations between the care centre and the patient. The disease process should be defined in the simplest way the patient and family can comprehend and one which relieves their anxiety and give them hope.

Remember "you never get a second chance to make a first impression", therefore:

- Address the fears of the patient, parents and relatives
- Admit child if in DKA or if they are from a distant area
- Provide counselling/guidance on diabetes, their fears and psychosocial issues and concerns
- Provide education on insulin administration (technique, transportation, storage)
- Provide education to identify hypoglycaemia and what to do
- Provide basic dietary advice e.g., just to avoid sugar and use an artificial substitute in diet till diet counselling session
- Educate on importance of regular and lifelong follow-up, since diabetes is a chronic disease and can lead to serious complications
- Schedule future education sessions – weekly or fortnightly at first, and subsequent as appropriate
- Agree on one or two goals to work on
- Provide patients and caregivers with a provisional management plan and review this from time to time; updating it to suit the patient.
- Discuss the self-management support as a main pillar in achieving goals of care
- Discuss the cultural beliefs and practices in relation to traditional medicines and the importance of not being deceived that they provide a cure for diabetes.

An Outline of Diabetes Self-Management Education (DSME)

The diagnosis of diabetes is often overwhelming, and most children and families will require regular consistent support within and beyond the hospital. The health provider should identify the support the patient will get and have this clearly noted in the patient's case notes. The goal is to empower the patient for self-care.

Hospital Based Support

- Identify the children with emotional/psychosocial issues: refer to a counsellor or attach to a social worker
- Enable access to supplies: provide resource list and contacts
- Start support group for parents or link them to an existing support group
- Where a family has financial issues/food insecurity (explore their options within their limitations) worse case refer to charitable organisations, use social worker
- Identify abandoned children: engage social worker/children's department in health facility
- Organise camps for children with diabetes for psychosocial support

Diabetes in School (See Later for a More Detailed Description)

- Inform administration, staff after consent from parents / child and completing an **individual management plan**.
- Train school nurse and staff on signs and symptoms of diabetes and how to manage diabetes
- Provide education on hypoglycaemia and need to have remedy at all times in the school (school or parent can provide)
- Provide education on physical activity, risk of hypoglycaemia, healthy eating behaviour

- Educate on how to handle child with diabetes during celebrations in the school setting, e.g. birthday and to ensure the child is not restricted from such events but is safely guided on what and how much to consume
- Provide a child with space to have injections (privacy)
- Provide nutritional recommendations: often the child will not need a special diet but rather a healthy eating plan, however the centre (nutritionist) can assess the school menu and advise appropriately
- Provide education to other school children to know about diabetes and their potential in helping one of them in managing his/her diabetes

Diabetes at the community level

The community plays an important role in the identification of possible T1DM and appropriate referral to care centre. If they are well informed, it reduces stigma on diabetes.

- Create awareness on diabetes and address related local myths and socio-cultural barriers to appropriate access of health care
- Health education (signs and symptoms of diabetes) in public meetings (*barazas*) to increase the index of suspicion
- Address myths, social perceptions, cultural practices that may hinder self-care
- Education on healthy living and eating plan
- Linkage of parents / child to support groups, and diabetes associations

Life course approach to DSME

0–5 years

- Insulin administration; but this should always be supervised by adults despite the children getting more independent and able to perform the tasks
- Identify mood changes and relating to glycaemic extremes especially hypoglycaemia
- Monitoring and interpretation of blood sugar levels
- Growth and developmental monitoring
- Pump therapy if they can afford. The patient and caregiver should be referred to the centre that has experience in pump therapy.

6–10 years

- Insulin administration; but this should always be supervised by adults despite the children getting more independent and able to perform the tasks
- Identify mood changes and relating to glycaemic extremes especially hypoglycaemia
- Monitoring and interpretation of blood sugar
- Growth and developmental monitoring
- Pump therapy if they can afford
- Start involving children in the self-management:
  - Children should learn how to check their blood sugar and how to react to deferent readings.
  - Teach insulin doses in relation to food intake and exercise plans should be decided together with parents or adult supervisors.
  - The importance of good glycaemic control to avoid short-term and long-term complications
  - The importance of normal physical growth and pubertal development.
- Assess for emotional or psychological disturbances and address them
- Link parents to care resources and support groups

11–19 years – the adolescence and accompanying issues.
Most of education for ages 6–10 especially on monitoring, medication and self- care still apply, and in addition:

- Coping with diabetes management conflict

- Growing autonomy, -taking charge and being accountable
- Emotional and psychosocial issues
- Peer pressure
- Self – image / self esteem
- Drug and substance abuse, alcohol use and cigarette smoking
- Sex and the use of contraceptives and related issues
- Work options

Quality of care

- The aim should be to maintain high standards of care based on management protocols and guidelines, implying a need to utilize non-physician practitioners (nurses and clinical officers)
- Due to persistent shortage of human resources for health in sub-Saharan Africa, the few experts in the management of type 1 diabetes should train and retrain non-physician practitioners and concurrently establish professional development programs. Establish *interception* and *perception* visits so as to maintain high standards of quality of care.
- M-health to reach both health care providers (for continuing medical education) and patients for continued education and monitoring and self-management support.
- Continuous Glucose Monitoring (CGM) is getting freely available, although cost still prohibitive for most families. Where the family/institution can afford this should be utilized.

Organization of diabetes care

Equipment, insulin, medical records, supply and logistics, storage

Table 3 illustrates the approach for setting up a diabetes clinic at the primary health care level, adopting the chronic care model [24, 26, 27, 28]. Emphasis is placed on contextual factors unique to SSA. Health worker shortages is prevalent across the continent, and therefore the need to utilize non-physician practioners.

The conceptual model of patient-centred care consists of multiple domains: patient demographics and clinical characteristics, hospital, nurse and physician attributes which influence treatment choice, process of care and outcomes. Patient-centred care encompasses informed decision-making. In particular the process of decision-making by the patient and physician is where the patient: 1) understands the risk of seriousness of the disease or condition to be prevented; 2) understands the preventive service, including ther risks , benefits, alternatives and uncertainties; 3) has weighed his or her values regarding the potential benefits and harms associated with treatment; and 4) has engaged in decision making at a level that he or she desires and feels comfortable. Patients and care givers differ, across age and ethnicity, in the extent to which they wish to be involved in decision making for their medical care. Although some patients prefer to actively participate in decision making , majority of patients and caregivers in SSA opt for a more passive role and defer decisions to the health worker. Thus the health worker is encouraged to tailor the medical care per the preferences of patients. Since patients' decision about healthcare utilization may be influenced by their tastes and preferences, it is important to have a better understanding of these preferences. Respecting the patients' needs and preferences and improving the trust between a patient and their caregiver is one of the key attributes of patient-centred care. Thus, patient-centred care model integrates (1) understanding the patient and the illness; (2) arriving at mutual understanding regarding illness management and therapeutic alliance; (3) providing valued information; (4) enhancing hospital, doctor and patient relationship; and (5) sensitivity about resource allocation and cost. Measures to report on patient-centred care should therefore reflect the main components of patient-centred decision quality. This ensures that the patients and caregivers have adequate knowledge and understanding of the decision to be made and the choices presented, establish

trust in shared information and decision, and the treatement decision reflect the patient's desire for involvement in decision making and his/her values and preference. Measuring decision quality and process of care outcome allows patients, physicians, and other interested stakeholders to evaluate the patient centeredness of the overall care.

Table 3: Key elements of the chronic care model for setting up a T1DM clinic

Element of Care	Implementation of Care Element
The health system: organization support – culture of the practice & system leadership. This includes patient's safety	Integrate and streamline the healthcare delivery process for T1DM, thereby increase efficiency with the minimum resources available. Patient safety is a priority in setting up a facility as T1DM clinic.
Self-Management Support	Education programs include tele-support from diabetes nurses and other health care using mobile phone technology where applicable. Diabetes Self-Management Education (DSME) starts on the very day of diagnosis. In this training, the DSME takes advantage of the known self-management skills to improve outcomes: problem-solving; decision making; resource utilization (for example how to use internet and social media), patient – provider relationship, and taking action. Health workers should specifically be instructed to clearly identify support structures for self-care for the patient during sessions on DSME. Family support is considered the most important single factor in the T1DM management.
Delivery System Design: Patient / Health care Professional Interface and cultural competency / case management	Multidisciplinary input (diabetologist, diabetes nurse specialist, and dieticians). As these are not easily available, opt for mentorship from the referral units using interception and perception visits. A standard curriculum of training of health care professionals should be developed and followed. Peer mentors and patient support groups help in counselling those with newly detected diseases and those with difficulty in achieving goals. Evidence Based Practice Guidelines are used for care of patients.
Clinical Information Systems including care coordination	Electronic Medical Records (EMR) are useful where available, otherwise comprehensive clinical records should be kept at health facility, and for every visit the patient should be given a clear summary of the proceedings of the visit and a resulting management plan. The current practice is that patients are given care objectives by the clinical team and this is documented in a summary form in the management plan that is retained by patient and reflected in his/her clinical case records. More in depth management details where appropriate - like pumps / complications are addressed as special sessions.
Clinical Decision Support Systems	Glucose meters are used for self-monitoring of blood glucose (SMBG) and patients keep a log book. The recommended minimum number of blood glucose tests in a stable patient is 4 for 3 consecutive days and more tests per day in unstable patients. HbA1c is done at least every 4 months and records are entered in patient's log book and in the clinic files. Multidisciplinary review: doctor and nurse and family. SMS are utilized for reminder messages and answering simple queries. Continuous Glucose Monitoring (CGM) is a useful tool in monitoring glucose levels, but poses economic challenges.
Community Resources and Community Policies	Patients with T1DM, their families, experts in curriculum development, teachers and social scientists involved in the development of the type of care that would be best for the patient with T1DM in the specific country. Linkages with the community for peer-support, care coordination, and community-based interventions, like exercise centres (gym), swimming including subsidized medications. Recognition of hypoglycaemia by the community and its appropriate management was a priority. Positive community policies, for example encouraging sick children and adolescents to attend health facilities rather than seek traditional medicines are encouraged.

In adapting the chronic care model, the priorities for disease management in primary care were identified as: availability of essential diagnostic tools and medications at local primary health clinics and the use of standardized protocols for diagnosis, treatment, monitoring, and referral to specialist care. Adapting disease guidelines in the face of extreme shortages of health care workers requires non-physician clinicians to be delivering care. As a result with the majority of care delivered via non-physician clinicians, there is need to ensure appropriate quality assurence. Therefore the recommendations seek to adopt the conceptual chronic care model adapted to address contextual factors unique to SSA: (i) quality improvement of existing care (follow guidelines; staff competence); (ii) health systems (follow the traditional essential medicines, essential diagnostics, systematic monitoring and evaluation and decentralized care); (iii) decision support (adherence to medications, adherence to follow-up and communication with the specialist); and (iv) human resources (train and retrain staff; and dedicated staff to manage T1DM clinics). Having a referral pathway was indispensable but more immediate communication with a doctor or specialist was regarded as very essential in optimizing patient management, especially where majority of care has been transferred to non-physician clinicians. The CCM identifies the essential elements of a health care system that encourage high-quality chronic disease care. These elements are the health system, self-management support, delivery system design, clinical information systems, decision support and the community.

Table 4a: Physical items required for setting up a T1DM clinic

Item to set up	Reason for the action and type of action
Separate children from adults	The physical space may be same day but different times.
Well-lit environment	The environment should be conducive for examination and provide sufficient privacy
Weighing scales, height measuring scales, growth charts (0–20 years), blood pressure machine	These should be calibrated and inspected regularly to ensure they work
Point of Care (POC) devices for blood glucose, Ketones and if possible HbA1c, Urine Albumin Creatinine Ratio (ACR)	This may be the only chance to have a glucose measured in some patients because of lack of resources to do SMBG
Couch, desk chairs for health worker	To accommodate all health workers
Information, education and communication materials and samples	Information materials for health providers (DKA, hypoglycaemia, sick days chart etc) Education materials for patients Communication materials for patients Samples for nutrition education and insulin & syringes Register books Diagnosis posters
Computer-desk top and accessories	For medical records if it is applicable and is policy
Application programs for tracking attendees and defaulters	Electronic medical records (EMR) where possible, otherwise manually created diaries
Refrigerators, and improvised tools for safely keeping insulin for transporting insulin from health facility and for keeping insulin at home.	For the safe storage of insulin which is not in use
Emergency Kit for Managing Hypoglycaemia	IV-fluids including giving set and cannulas, 50% Dextrose; Glucagon (if possible).

Services, equipment and supplies for primary care levels of care

Levels 1 = front line care; first level of care, usually a dispensary;
Level 2 = usually a health centre [25].

Option 1/Level 1 (frontline care)

- Diagnosis of diabetes
- Recognise the role of insulin
- Understand principles and priorities of treating children with diabetes
- Understand storage and use of insulin
- Assist with continuing care even when one **not** acutely ill.
- Local support of the child with diabetes
- Recognize and initiate treatment for DKA
- Keep or secure medicines in clinics for use, in cupboards
- Use of glucometers including battery change
- Syringes & insulin syringes, insulin pens
- Lancets
- Glucose strips; urine dipsticks for glucose, ketones and protein; otoscope; 10-g monofilaments for testing sensation; HbA1c point of care machine; BP machines (adult and children cuffs); stethoscope.

Option 2 for Level 2

- Have basic exposure to diagnosis and treatment of diabetes
- Have insulin and diabetes supplies on site
- Know how to start treatment with insulin
- Recognize and start basic measures for DKA
- Distribute insulin and diabetes supplies to patients
- Supervise care prescribed by an echelon 3 facility

In additions to option 1 secure

- Drip setting equipment and intravenous (IV) fluids
- Infusion/syringe pumps

Table 4b: Laboratory and pharmacy requirements at a frontline care facility

Laboratory	Point of Care (POC) devices for managing DKA are vital: Sodium, Potassium and Bicarbonate at a minimum; blood gases (VBG) optional but nice to have. Do blood glucose, ketones in blood or urine and HbA1c
Referral Tertiary Level Laboratory (for special cases)	Antibodies, hormone tests like Insulin levels, c-peptide
Pharmacy	Insulin: short acting, intermediate and long acting Antihypertensives Glucose powder or tablets Blood glucose meter Blood glucose strips

Medical records

Initial and follow up forms are attached. The option of electronic medical records should be considered where possible.

Storage of insulin at the health facility

Insulin should be stored at 2–8 ˚C in refrigerator or cool boxes of respective temperatures at all levels of clinics. Follow the *EADSG Guidelines on Insulin storage and optimisation of injection technique in diabetes management.*

Written instructions should be availed for users, including use of local devices for insulin storage in hot climates without refrigeration.

Transporting and storage of Insulin by the patient / caregiver/family

While carrying insulin from a pharmacy to home, it should not be exposed to extreme heat conditions (like above 32˚C). In addition, precautions should be taken to prevent exposure of the insulin to direct sunlight. An insulated bag or a cooling pouch is ideal for transportation of insulin to avoid sudden temperature variations. A transport box can be improvised by using a plastic box with a layer of cotton at the bottom and top, ice then cotton to "sandwich" the insulin during transportation. The common practice of placing insulin in ice cubes; or strapping insulin directly on an ice pack is strongly discouraged as it may result in temperatures lower than 2˚C recommended and may result in reduced potency of insulin. Transporting insulin immersed in water is strongly discouraged, as it destroys the labels on the insulin vial.

Insulin in use should be kept in a clean plastic container, at room temperature (25˚C), protected from sunlight, for up to six weeks; and for four weeks for temperatures 25–30˚C. Storage at a higher temperature during use may degrade insulin or convert it to higher molecular weight components thereby reducing its potency. Refrigeration is required if room temperatures are higher than 30 ^{0}C. Clay pots with sand or water have been used and are recommended temperatures are hot (> 30 ^{0}C) [7], but extra precautions should be taken to keep the insulin bottle clean and from getting in contact with the water.

Initiation of Treatment

Type 1 diabetes (T1DM) is characterised by a progressive decline of insulin secretion until its virtual disappearance 1–5 years after diagnosis. Thus, people with T1DM are dependent on insulin to survive. Insulin therapy should always be coupled with self-monitoring of blood glucose (SMBG), monitoring of carbohydrate intake and proper precautions for illness and physical activity. In this way insulin can be adjusted safely and effectively and individualized to age, lifestyle, eating habits, state of health, and physical activity. Well managed intensive insulin therapy helps the patient avoid extreme metabolic crises such as hypoglycaemia and ketoacidosis, achieve and maintain good glycaemic control, and reduce the risk of diabetes complications. **Goals of treatment should be clearly defined by the health care provider, and support to the patient identified for the patient to achieve these goals. Time and effort should be spent with T1DM patient and the caretaker so as to give appropriate care that will translate into long-term good quality of life. This cannot be over emphasized**. **Patient looks good is not enough.**

- Patients with T1DM are dependent on insulin to survive, and therefore access to insulin supplies should be clearly defined from the start of treatment.
- Insulins commonly used in sub-Saharan Africa are: recombinant human insulin, with the same amino acid sequence as native human insulin (with or without protamine to delay its absorption, onset, and duration) and recombinant human insulin analogs, in which the amino acid sequence is altered to affect its absorption, onset, and duration of action.
- Insulin actions are classified by duration of action (rapid, short, intermediate, and long acting)
- Insulin regimen should be tailored to the needs of the individual patient. Adjustments in the insulin or specific insulin doses should be based on actual glycaemic values obtained from patient self-monitoring of blood glucose (SMBG) (or continuous glucose monitoring) rather than on "textbook" predictions of insulin.
- It is nearly impossible to adequately treat T1DM with once-daily insulin. Similarly twice daily injections of the 'split and mixed" combination of short- (or rapid-) and intermediate-acting insulin before breakfast, and before supper gives suboptimal control. Most patients with T1DM will find it difficult to achieve good glycaemic levels with two injections per day.
- Most physiologic multiple component 'flexible' regimens emphasize the difference between basal and prandial (bolus) insulin. These insulin regimens consist of:

  - Three or more daily injections (prandial/bolus and basal insulins)
  - Insulin pump therapy
- Insulin needs may fluctuate during the first weeks or months of treatment. If a honeymoon or remission has occurred, insulin dose must be appropriately reduced, occasionally to as little as 0.1–0.3 units/kg/day, but it should not be discontinued or replaced with an oral hypoglycaemic agent. Patients and their families should be educated on this.
- Regimens using insulin algorithms place more demands on both patient and health worker than does a fixed course of treatment, but they provide greater flexibility in lifestyle. All forms of intensive therapy require high degree of long-term commitment and flexibility on the part of the patient, the family, and the diabetes management team.

Goals of Therapy

The aim for glycaemic control is a blood glucose profile that closely resembles a natural physiologic state and avoids wide fluctuations in glucose levels, using multiple daily injections (MDI) or insulin pumps, based on glucose levels and food intake, activity, stress, and absorption of insulin so as to normalize glucose levels while avoiding hypoglycaemia.

- Normal blood glucose varies between 3.5–7.0 mmol/l throughout the day
- Normally peak postprandial blood glucose does not exceed 7.8 mmol/l despite wide fluctuations in nutritional intake, physical exercise, and other physiological, psychological and iatrogenic determinants of plasma glucose
- After food intake, plasma glucose rises to a peak in 30–60 minutes and returns to basal or below basal concentrations within 2–3 hours.
- Time in Range (TIR) with CGM: at least 70% of the day in 3.9–10.0 mmol/l; less than 4% of the day below 3.9% and minimize time each day above 10.0 mmol/l. Time in range can also be calculated without CGM) by getting the blood glucose levels obtained with a finger stick and manually dividing the number of in-range finger sticks by the total number of fingers sticks and multiply by 100. Aim at consistent, in-range blood glucose levels referred to as ‘flat, narrow, in -range” (FNIR).

The health worker and patient, with the diabetes management team and family, must set the treatment goals together. Although this concept seems obvious, overlooking this often leads to failure. The health worker convinced of the importance of the stringent glycaemic control in every case will be frustrated by a patient and family who do not understand the need for, or are unable to accept the goal or methods used to achieve glycaemic control. Conversely, the patient and family who want blood glucose levels to be normal all the time and are truly willing to work for it will be frustrated by the health worker who lacks the time, facilities, conviction, or training to help achieve this goal; or who is unable to guide the patient and the family to achieve safe and realistic set of goals. Therefore, treatment must always be individualized with regard to specific goals. Goals should be realistic and achievable, and they will likely change over time in concert with the life cycle of the patient. **ISPAD 2018 Guidelines recommend an HbA1c of < 7.0% for all children and adolescents with T1DM. As noted above, the time in range for those with CGM and proportion of glucose values in target range in SMBG may now be more applicable in motivating patients and achieving appropriate goals rather than setting HbA1c target value. It is important to encourage the best goals achievable without demanding the impossible, unsafe, or impractical. Furthermore, it is important to note than a reduction in HbA1c, although not achieving target, still offers a large benefit from a reduction in the risk of complications.**

The reality is that in most of SSA, the resources available and the current health systems cannot support an HbA1c of less than 7.0% safely. The consensus in the working group (and also see Graham Ogle, 2015) is that the glycaemic targets should be tagged to available resources and health care setting. This has been depicted diagrammatically below.

Key concepts in setting up glycaemic goals and ensuring that the set goals are supported by the available resources and health care setting:

- Appropriate daily monitoring of blood glucose is a prerequisite for achieving the primary targeted HbA1c. Complacency on monitoring is like "allowing to drive a car at a high speed in the dark without lights" or "try to land a flying aeroplane without being able to judge how far it is from the ground" – all terribly dangerous; you run a very high danger of crushing.
- The time in range (TIR) with continuous blood glucose monitoring (CGM). The percentage of the time an individual's blood glucose is within the target values. This metric correlates well with the control of diabetes and the implied development of complications. Similarly, in SMBG with a glucose meter, the readings in range may be a more visible (easily obtained from home blood glucose meters) and useful target for blood glucose control and motivation. If these are taken care of, the HbA1c takes care of itself!
- HbA1c is remains the overall target of glycaemic control in the setting of SSA
- Postprandial glucose may be targeted if HbA1c goals are not met despite reaching pre-prandial glucose levels.
- For those who want to look at HbA1c more closely, it should be noted that the evidence for HbA1c levels and diabetes complications is interpreted differently by organisations such as the American Diabetes Association and International Society for Paediatric and Adolescent Diabetes, resulting in guidelines that differ between organisations and countries – current guidelines range between 6.5 and 7.5%. HbA1c targets also differ within countries for children and adults. **Reaching lower HbA1c levels requires greater effort from people with diabetes and their families and can be associated with more stress and possibly an increased risk of hypoglycaemia, which in itself can be burdensome and lead to unconsciousness and severe sequalae brain damage**. Below is a summary of the different goals in the various guidelines (61). It is therefore stressed that whereas the consensus presented above still lacks the back-up clinical trials (which we hope will be organised soon); it still looks the safest approach in SSA in comparison to what is presented below.

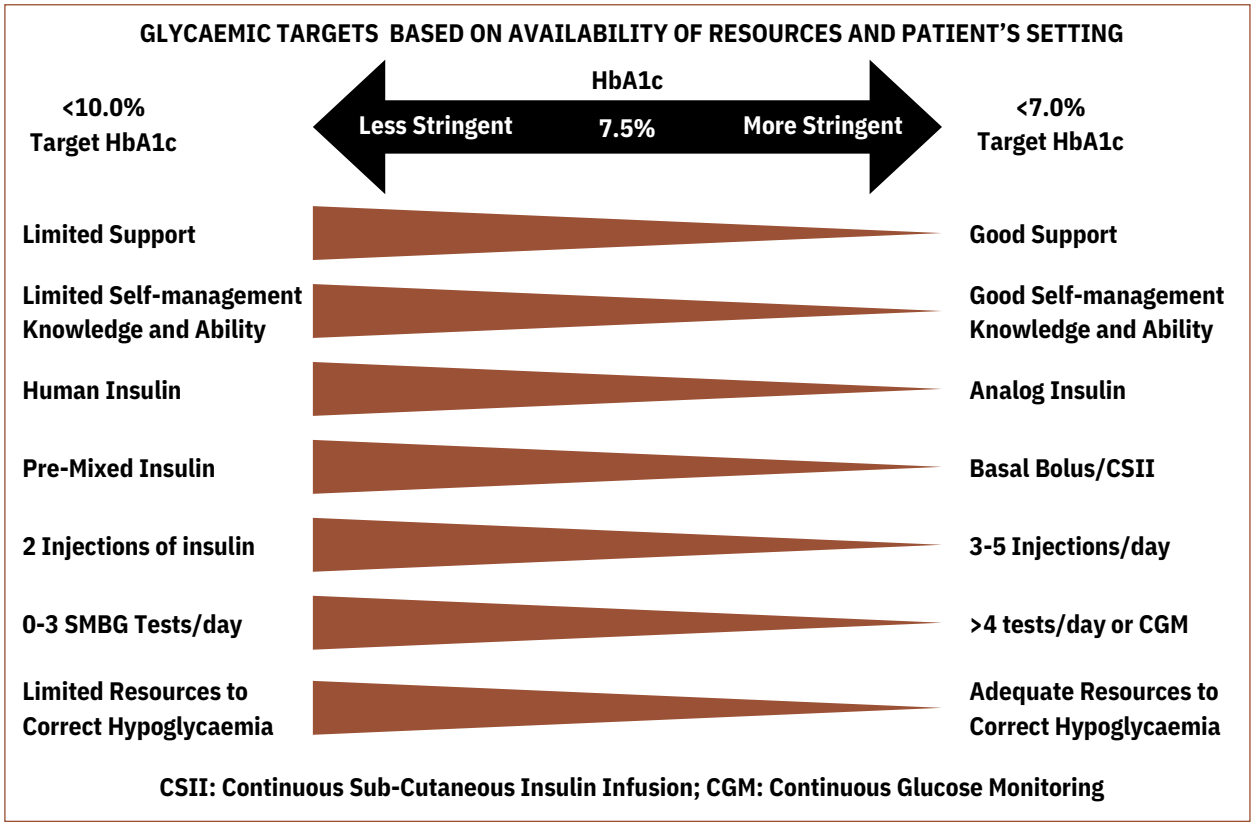

Fig 2: Glycaemic control targets at different levels of resources

Pre-prandial (Fasting) capillary plasma glucose (FPG):	3.9–7.2 mmol/l
Peak (1.5–2-hr) post-prandial capillary glucose (2-hr PPD):	< 10.0 mmol/l

Table 6: Variation in targets of HbA1c in different associations

Association	HbA1c in Children with T1D	HbA1c in Adults with T1D
American Diabetes Association (ADA)	<7.5% (<58 mmol/mol)	<7.0% (<53 mmol/mol)
National Institute for Health and Care Excellence (NICE)	<6.5% (<48 mmol/mol)	<6.5% (<48 mmol/mol)
Swedish	<6.5% (<48 mmol/mol)	<7.0% (<53 mmol/mol)
International Society for Pediatric and Adolescent Diabetes (ISPAD)	<7.0% (<53 mmol/mol)	<7.0% (<53 mmol/mol)

Initial goals

For the new-onset acutely decompensated patient or the previously diagnosed patient with poor control, goals should include:

- Eliminating ketosis
- Returning to desirable body weight range by reversing water and extracellular electrolyte losses and replenishing lean body weight mass (protein and intracellular electrolytes)
- Eliminating obvious consequences of hyperglycaemia, e.g., gross polyuria and polydipsia, vaginitis or balanitis, recurrent infections, and visual blurring due to reversible refractive changes
- Avoiding cerebral oedema in cases of DKA

Additional goals

Once the initial goals have been achieved, additional goals should include

- Near-normalization of blood glucose values and HbA1c with avoidance of severe hypoglycaemia
- Preventing symptoms of hyperglycaemia, such as excessive thirst and urinary frequency, and disturbing sleep, school, work, social, or recreational activities
- Preventing spontaneous and illness-induced ketosis
- Maintaining weight within a desirable range
- Simulating catch-up growth and sexual maturation in children with poor glycaemic control
- Maintaining normal growth rate in children and adolescents
- Maintaining maximum exercise tolerance and stamina
- Maintaining a sense of psychosocial well-being and normal initiative in self-care
- Minimizing self-treatable hypoglycaemia and avoiding severe hypoglycaemic events resulting in seizures, accidents (e.g., while driving), and coma
- Avoiding hospitalization
- For women, achieving normal fertility and pregnancy outcome
- Sustaining normal family and marital relationships and sex life
- Preventing diabetes-dictated or diabetes-oriented lifestyle (i.e., diabetes controlling the patient rather than vice versa)
- For the youth, planning for and achieving transition to adult diabetes care

Insulin Regimens, Initiation and Considerations

"***In theory*** there is no difference between theory and practice - in practice there is» (Yogi Berra)

- All types of insulin work if taken at the right dose and at the right time.
- Low blood sugars reactions limit the ability to achieve perfect blood sugar control.
- Context and circumstance often dictate treatment realities.

Overview of insulinization approaches

The goal in diabetes management is to safely and effectively maintain blood sugars as close to the normal range as possible without excessive hypoglycaemia. To achieve this goal requires a thorough understanding of the available insulin preparations and to tailor a regimen that will best fit the patient and their circumstances.

Active versus passive insulinization

An “active” insulinization regimen is one that intensively tries to mimic the body’s physiologic insulin secretion and uses basal, intermediate or long-acting insulin, together with meal/snack rapid acting insulin or insulin pump therapy. The meal dose of insulin is calculated based upon carbohydrate to insulin ratios, either carbohydrate exchanges or carbohydrate gram counting or a combination to calculate the “food dose” and a “corrective dose” to correct pre-prandial blood sugars to a designated target blood sugar. This approach requires testing at every meal and possible in between as dosing decision are continuously updated based on the meal content and prevailing blood glucose.

“Passive” insulinization regimens include fixed dosage basal bolus regimens and premixed regimens, where the insulin dose is predetermined and is not dependent on the prevailing blood glucose level or meal intake. The regimen is optimised intermittently through structured testing and adjustment of the insulin dose and meal intake to achieve a specified target glucose “on average”. This approach works well when strips are limited, where the meal intake and daily routine are relatively stable.

Shared decision making

Regimen choice should be derived in conjunction with the patient and the family in a shared decision-making process. In that way a joint treatment plan is agreed upon that is respectful and cognisant of culture, personal preference, availability of insulin options, affordability of insulin and strips, meal and snack preferences, availability and content, frequency of injections and flexibility in lifestyle versus fixed dose regimens.

The health care provider should introduce options with the family and patient and then discuss the benefits, limitations, risks and expected barriers with each option. Create a clear understanding of how the regimen choices will play out in the family context. One can use the SHARE model devised by the Agency for Health Research and Quality (AHRQ) for shared decision making.

- **S**eek your patient’s participation
- **S**hare the diagnosis and possible treatment options
- **H**elp your patient explore and compare treatment options
- **A**ssess your patient’s values and preferences
- **R**each a decision with your patient
- **E**valuate your patient’s decision

Sometimes the newer insulins are not always the best choice. Never expect too much from your insulin- “***Ask not what your insulin can do for you- ask what you can do for it***”.

Understanding insulin

Insulin is required in a quick release form to cover the meal-time period by suppressing glucagon dependent glucose production from the liver and store incoming ingested carbohydrates to return blood glucose to pre-meal levels. A low continuous background insulin secretion together with glucagon maintains normal blood glucose levels between meals and during fasting. All insulin regimens try to mimic this physiologic pattern.

Different formulations of insulin have different pharmacological properties with regards to onset, peak and duration of action. They are classed as rapid acting insulin analogues, short or regular acting insulin, intermediate acting insulin, long and ultra-long-acting insulin analogues. The basic structure of insulin has been modified to produce a range of insulins with different rates of onset and time to peak levels and duration of action to suite various needs. Insulins can also be combined in fixed combinations or mixed prior to administration to provide a designer action profile.

The ideal quick acting insulin should have a very rapid onset of action, a peak within 1 hour and duration of action of less than 3 hours. Such an insulin has not yet been created.

The ideal basal insulin should be “peak less” and last for 24 hours or longer.

The onset, peak and duration, called the insulin profile- needs to be considered when developing the insulin regimen factoring in exercise, meal plan and lifestyle to maintain blood glucose levels in the desired target range with minimal low- and high blood sugars.

The newer long acting and ultra-long acting analogues have a proven ability to reduce night-time low blood sugars when compared to intermediate acting insulins that peak during the night.

The rapid acting insulin analogues can reduce the peak after meal blood glucose level and reduce the risk of delayed hypoglycaemia.

Benefits in terms of HbA1c are however modest at best and come at a significantly higher monetary cost.

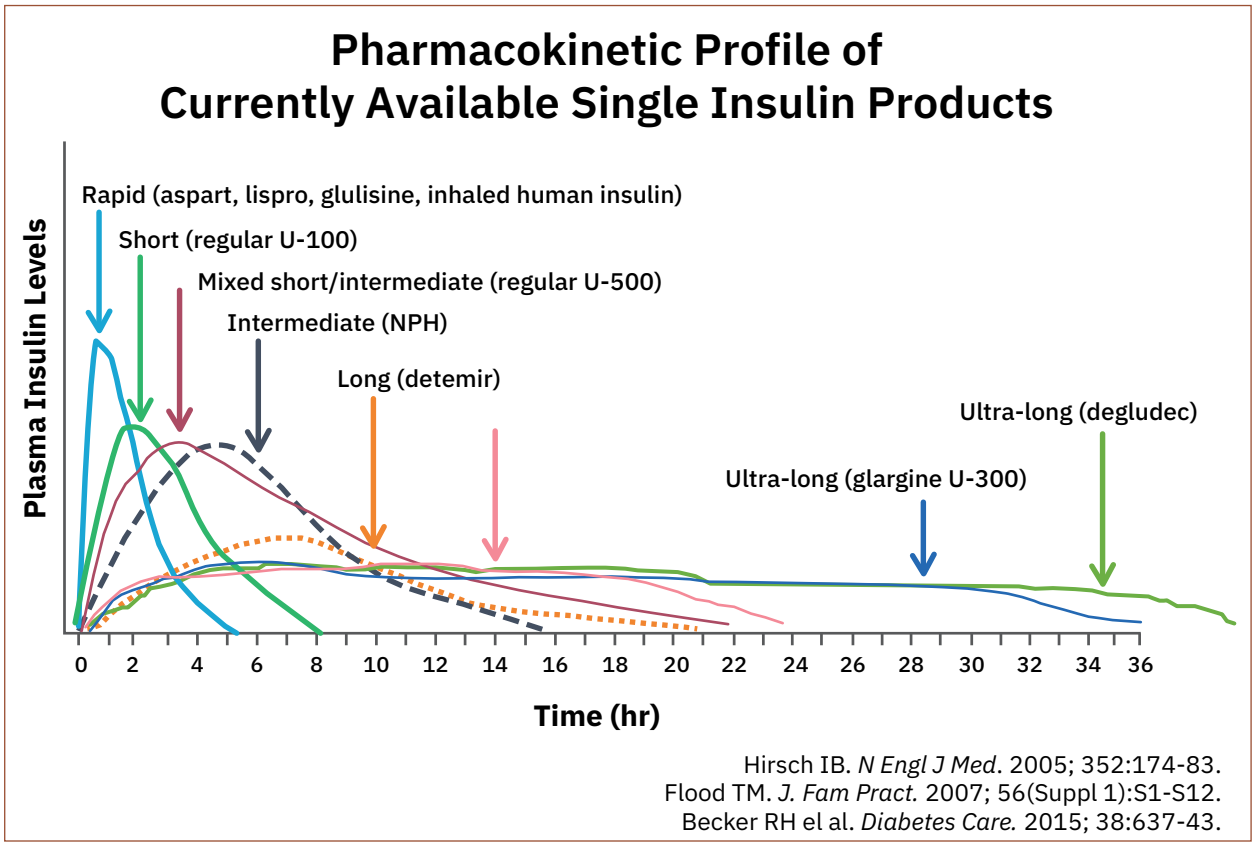

Fig 3: Pharmacokinetic profile of available single insulin products

Rapid acting analogues (Humalog®, NovoRapid® and Apidra®)

Have an onset within 30min, peak at 1–2 hours and last 4–5 hours. This is our current meal time insulin of choice and should be injected before meals (preferably 15min and up to 30 minutes) and is also used for correcting high blood glucose levels. Their major advantages are that insulin can be injected immediately prior to the meal coupling flexibility with convenience compared to the difficulties of administering regular human insulin 30-min prior to the meal. The short duration of action may also reduce the need for snacks. More concentrated recently introduced insulin include the Human regular U-500 insulin and Insulin lispro U-200.

Regular or short human insulins (Humulin R®, Actrapid®, and Insuman®)

Have an onset after 30–60 minutes necessitating an injection at least 30min prior to meals. The delayed peak at 2–3 hours requires a snack to prevent a delayed drop in blood sugar after the meal, unless a large carbohydrate load is eaten. However, the delayed peak can be used to

cover snacks when snacks are a desired part of the meal plan. The prolonged duration of action increases the risk for delayed low blood sugars but also allows for 3 x daily dosing.

Intermediate insulin (NPH, Protaphane®)

Have an onset of 1–2 hours, a delayed peak at 4–6 hours and duration of action that allows for twice daily dosing or at a stretch a single daily injection at bedtime. The delayed peak is often used to cover mid-morning snacks in school age children when used as a daytime basal. The same peak effect however increases the risk for night-time lows necessitating a bedtime snack and higher bedtime glucose target.

Long-acting analogues (Glargine, Detemir)

Have a slow onset and are relatively peak less. The dose of the medication influences its duration of actions, such that most dosages in children will not last 24 hours and split dosing is required. Because of their relatively peak less nature they minimize the risk of night-time lows, but also limit the amount of between meal snacking that can take place.

Ultra-long-acting analogues (Glargine U300, Degludec, Degludec U-200)

Have a slow onset and almost peak less 24 hours plus profile. In practice they require all carbohydrate containing snacks to be covered and adjusting dosages takes a few days for the changes to become visible.

Premixed insulins: (Actraphane®, Humulin 30/70®, Biosulin 30/70®, Novomix 30® and Humalog Mix 25®)

Ready mixed preparations contain a short acting (analogue premixes) or rapid acting insulin (human premixes) combined with an intermediate acting insulin (the intermediate acting insulin in analogue premixes has a lower peak than human intermediate acting insulin). Their major advantage is simplicity. The advantage of biphasic pre-mixed insulin is that it may minimize the number of daily injections and may be suitable if the patient has a semi-rigid meal and snack plan and tend to follow the same routine from day to day. They also do well in patients suffering from diabetes burnout who just want the safety and simplicity of a simpler regimen. Their major limitation is the fixed ratio of the two insulins which does not easily allow for alterations in meal size and timing. This can be overcome by adding in a short acting insulin dose for bigger meals, unexpected snacks or when blood sugars are high, and a correction dose is required to bring them down.

Insulin regimens

The following regimens are presented in a holistic manner, taking into consideration, cost, number of daily injections, insulin availability, testing frequency and meal planning.

Starting doses

The starting dose of insulin is dependent on age, pubertal status, degree of beta cell depletion at the time of diagnosis and the planned daily carbohydrate intake. Adolescents and patients presenting in DKA tend to require higher starting doses.

In reality, the starting does is not that critical, it is more important to adjust the dose daily or every few days to safely achieve the desired blood glucose levels.

The honeymoon period

The honeymoon period covers the period from insulin initiation through the period of low insulin requirements and stable blood glucose levels and emerges with greater glycaemic variability and higher fasting blood glucose levels.

In the first few days and weeks insulin administration relieves glucotoxicity, allowing the remaining beta cells to naturally increase their insulin production. This period is characterised

by low insulin requirements (TDD <0.3u kg/day, a tight clustering of fasting blood glucose and minimal daytime variability). This period is also accompanied by an increase in appetite, usually until the previous body weight has been regained. Insulin and food choices/portion control will need frequent fine tuning during this period. Insulin doses are usually up titrated for the first few weeks followed by down titration as the "hungry" phase resolves and the beta cells become more operational.

The honeymoon period can last weeks to months. Lower carbohydrate intake, and tight glycaemic control can prolong the honeymoon period.

Increasing fasting and dinner blood glucose with greater glycaemic variability are evidence of emergence from the honeymoon phase. This period requires more intensive monitoring and dose adjustment and meal planning to prevent deterioration into poor control. Intercurrent infections, and steroids can accelerate the emergence from the honeymoon period.

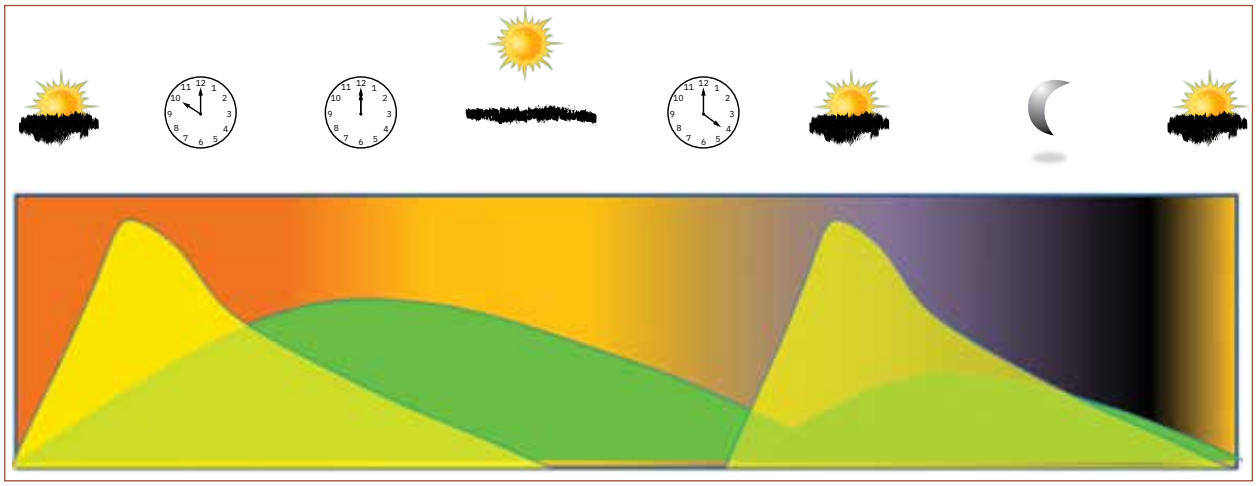

Fig 4: Twice daily dose calculation for Pre-mixed insulin

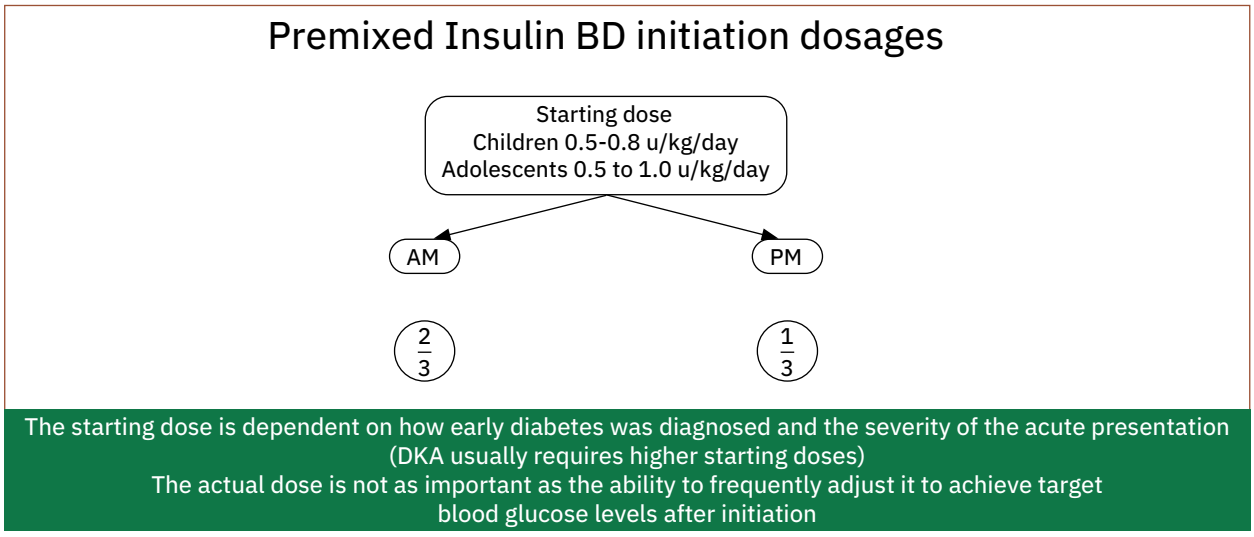

Fig 5: Profile of Pre-mixed insulin

Premixed human insulin regimens

Premixed human and analogue insulins are widely available in SSA. While they are not ideal, they can be used effectively if accommodations are made and the limitations of the regimen are understood. Analog insulins are more costly than human insulin. Premixed and human intermediate insulins require mixing prior to administration.

Timing: Due to the short acting component it should be injected 30 min prior to meals.

Pharmacodynamic considerations: There are 2 peaks to be considered. The short acting insulin peaks at 2–3 hours which can be useful to cover the mid-morning snack, but the evening peak may necessitate a bedtime snack (also needed to cover the intermediate peak to prevent nocturnal hypoglycaemia). The NPH peak in the day is useful to cover lunch (if the lunch carbohydrate content can be limited to match the NPH peak).
Eating plan: This regimen requires meal sizes (Carbohydrate content) to be adjusted along with the dose to reach a "best match" such that target blood glucose levels are achieved most of the time. Snack content and timing are important.
Limitations: include the rigidity of the meal plan, the risk of delayed hypoglycaemia, hypoglycaemia with exercise and missed snacks, the requirement for snacks and the inability to adjust the dose for variable carbohydrate intake or to correct out of range blood glucose levels. This can be addressed with the use of a top-up dose using either short or rapid acting insulin. Afternoon carbohydrate intake needs to be limited.
Advantages: Fewer injections, readily available and affordable in some countries.
Testing requirements: Due to the fixed dose a structured testing protocol is required. The morning dose is adjusted to achieve lunch and dinner readings in range. The evening dose is adjusted to keep bedtime or 2 am and fasting readings in range, without hypoglycaemia.
Intensification: If lunch readings are on target but dinner targets cannot be reached then either the lunch carbohydrates need to be reduced, the afternoon snack must be carbohydrate free or a lunch time short or rapid acting insulin must be introduced.

Basal bolus with Intermediate acting insulin once daily and short acting insulin at meals

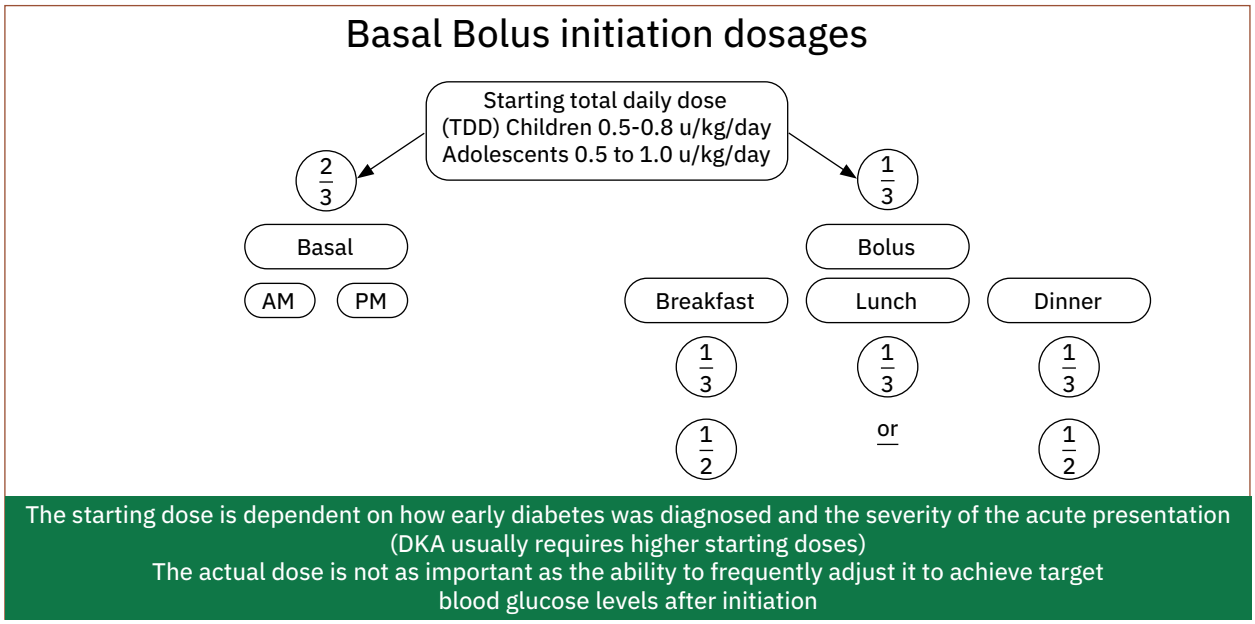

Fig 6: Titrating a basal bolus

Timing: Due to the short acting component it should be injected 30 min prior to meals.
Pharmacodynamic considerations: The short acting insulin peaks at 2–3 hours which may require snacks between doses if the carb content of the meal is not adequate to prevent hypoglycaemia. The Intermediate peak combined with the dinner short acting may necessitate a bedtime snack to prevent nocturnal hypoglycaemia.
Eating plan: This regimen requires meal sizes (Carbohydrate content) to be adjusted along with the dose to reach a "best match" such that target blood glucose levels are achieved most of the time. Snack content and timing are important.

Limitations: the risk of delayed hypoglycaemia, hypoglycaemia with exercise and missed snacks, and the requirement for snacks. On fixed dose regimens the meal carbohydrate intake will need to stay consistent. Carb counting will allow for flexible dosing.
Advantages: more flexible than premix regimens, readily available and affordable.
Testing requirements: If fixed doses are used a structured testing protocol is required. The morning dose is adjusted to achieve lunch readings in target, the lunch dose is adjusted to reach dinner targets, the dinner dose is adjusted to achieve bed/2am targets. The intermediate evening dose is adjusted to reach fasting blood glucose targets without intervening hypoglycaemia.
Intensification: If fixed doses and meals become too limiting then a switch to carb counting with correction doses is an option. This will require more frequent testing. Analog rapid acting insulin can be used for meals and analogue basal insulin for evenings.

Basal bolus with analogue basal once daily and rapid acting insulin at meals

Timing: Analog bolus insulin can be injected from right before to 30 minutes prior to the meal.
Pharmacodynamic considerations: The short acting insulin peaks at 60–90 minutes with a duration of 3–5 hours, therefore snacking to prevent delayed hypoglycaemia is not required. In fact, carbohydrate snacks may require additional coverage. The flatter acting basal insulin removes the requirement for a bedtime snack. The shorter duration of action of basal analogues in paediatric doses may require split dosing of the basal insulin.
Eating plan: This regimen requires meal sizes (Carbohydrate content) to be adjusted along with the dose to reach a "best match" such that target blood glucose levels are achieved most of the time. Carbohydrate containing snacks will need to be covered with insulin.
Limitations: Cost. Additional coverage for snacks. Multiple daily injections.
Advantages: There is a lower risk of nocturnal hypoglycaemia and more convenience around mealtime insulin delivery. Very flexible regimen.
Testing requirements: If fixed doses are used a structured testing protocol is required. The morning dose is adjusted to achieve lunch readings in target, the lunch dose is adjusted to reach dinner targets, the dinner dose is adjusted to achieve bedtime targets. The basal evening dose is adjusted to keep blood glucose levels stable from bed to breakfast time.
Intensification: If fixed doses and meals become too limiting then a switch to carb counting with correction doses is an option. This will require more frequent testing.

Human intermediate daytime basal, analogue evening basal with mealtime analogue

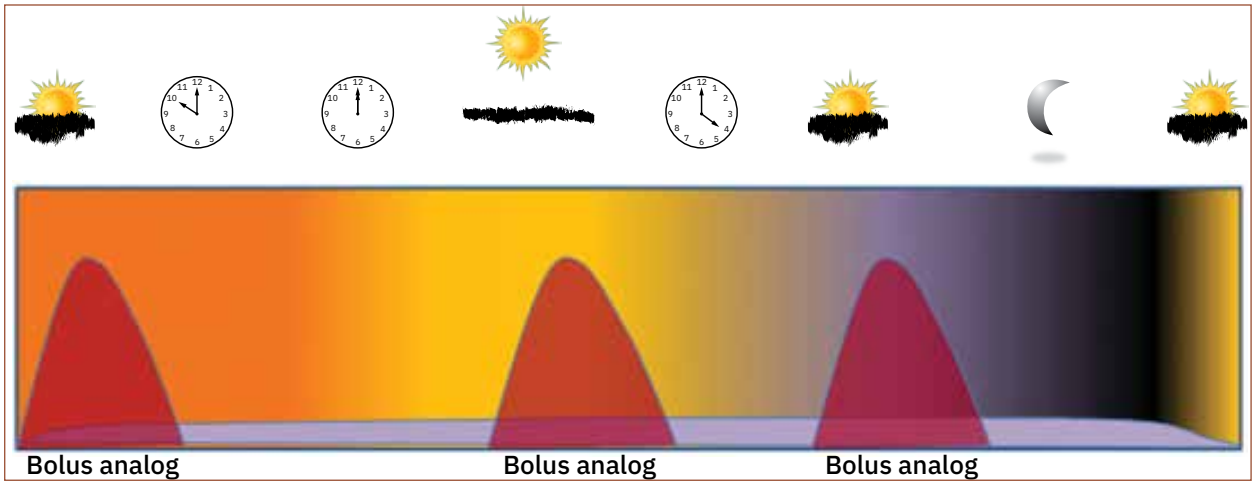

Fig 7: Basal analog (magenta) timings with meals.

Timing: Analog bolus insulin can be injected from right before to 30 minutes prior to the meal.
Pharmacodynamic considerations: The short acting insulin peaks at 60–90 minutes with a duration of 3–5 hours, therefore snacking to prevent delayed hypoglycaemia is not required.

In fact, carbohydrate snacks may require additional coverage. The intermediate acting daytime basal covers the snacks at school. The analogue night-time basal insulin removes the requirement for a bedtime snack.

Eating plan: This regimen requires meal sizes (Carbohydrate content) to be adjusted along with the dose to reach a "best match" such that target blood glucose levels are achieved most of the time. This regimen allows a limited amount of carbs during the morning snacks, typically at school when it is difficult to inject at school. Afternoon snacks will need to be low carb or covered with insulin.

Limitations: Cost. Multiple daily injections.

Advantages: There is a lower risk of nocturnal hypoglycaemia and more convenience around mealtime insulin delivery. Very flexible regimen. Allows carbohydrates to be eaten at school while also allowing the lunch time insulin dose to be administered at home after school.

Testing requirements: If fixed doses are used a structured testing protocol is required. The morning rapid acting dose is adjusted to achieve pre-snack targets, the intermediate acting insulin is adjusted along with the snack carbohydrate intake to achieve lunch time targets. The lunch dose is adjusted to reach dinner targets, the dinner dose is adjusted to achieve bedtime targets. The basal evening dose is adjusted to keep blood glucose levels stable from bed to breakfast time.

Intensification: If fixed doses and meals become too limiting then a switch to carb counting with correction doses is an option. This will require more frequent testing.

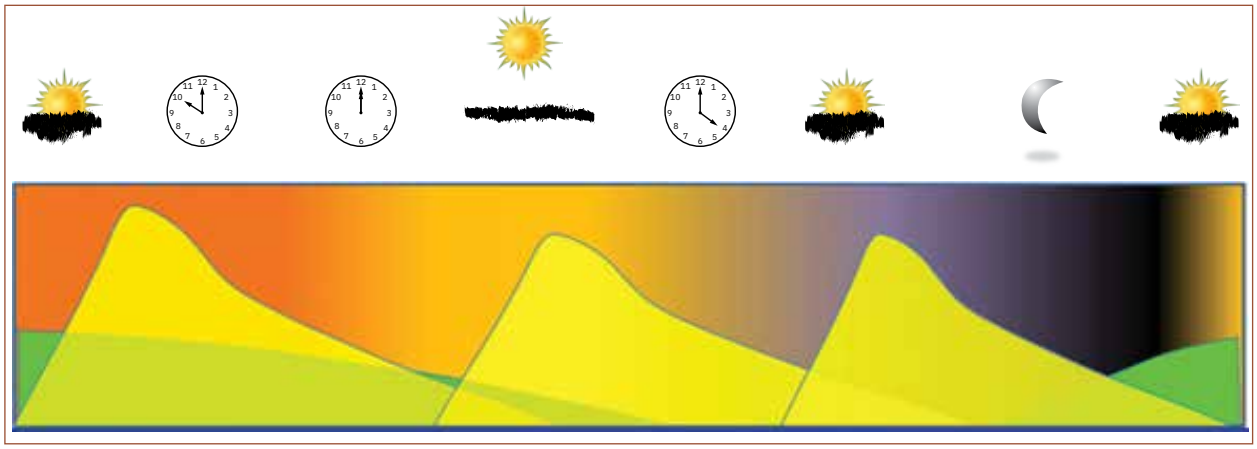

Fig 8: Action profile of once basal insulin

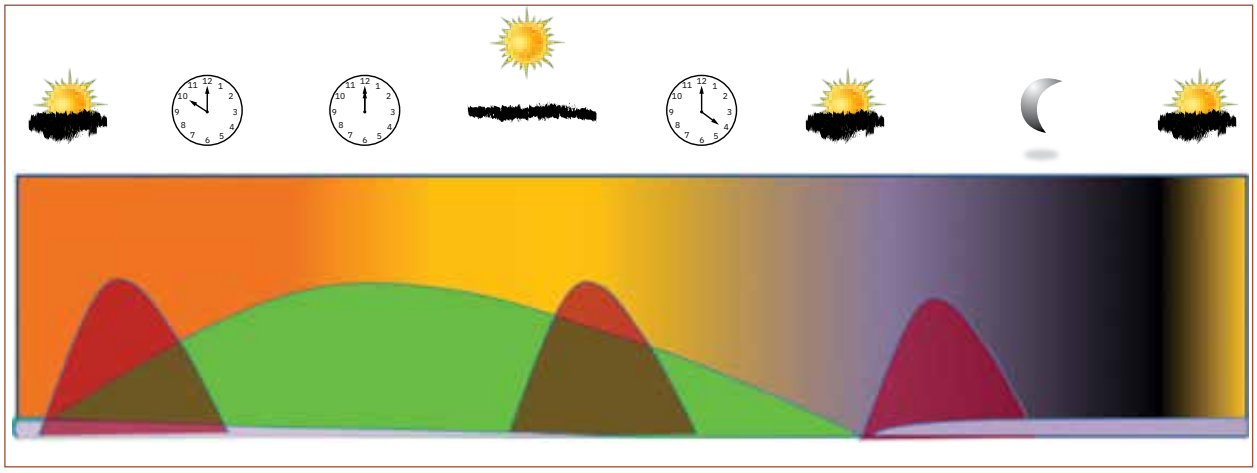

Fig 9: Action profile twice basal insulin in relation to thrice bolus insulin

Continuous insulin infusion pumps

With continuous subcutaneous insulin infusions, a predetermined basal rate is infused continuously, and bolus doses of insulin are given with each meal and when the blood glucose level is high. The amount of insulin given at meals is determined by the amount of carbohydrate eaten and the personal carbohydrate to insulin ratio. The amount given to correct high blood glucose levels is calculated using your insulin sensitivity factor. Only a single analogue insulin is used to provide both basal and bolus insulin requirements typically lispro or aspart.

Timing: Analog bolus insulin can be bloused from right before to 30 minutes prior to the meal/ snack

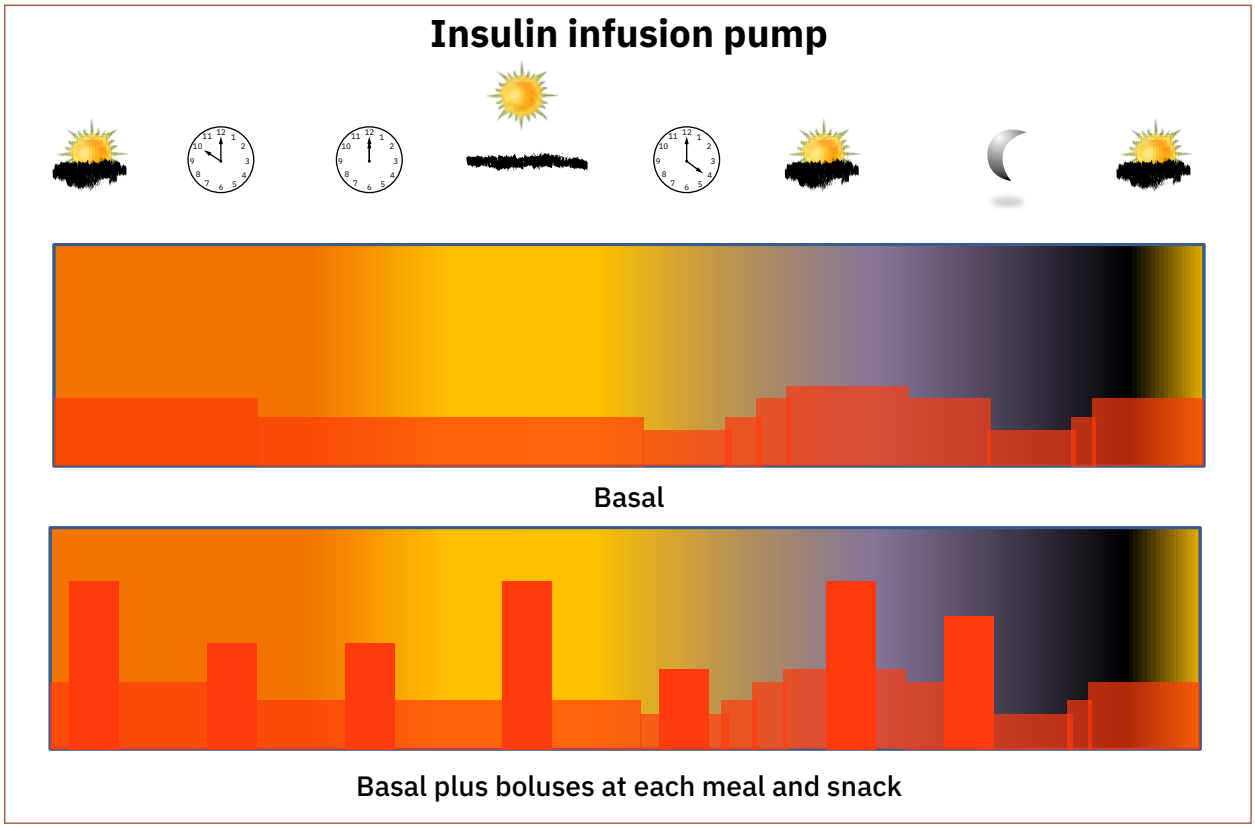

Fig 10: Insulin excursions with continuous insulin infusion in a pump

Pharmacodynamic considerations: The short acting insulin peaks at 60–90 minutes with a duration of 3–5 hours, therefore snacking to prevent delayed hypoglycaemia is not required. The basal insulin delivery can be adjusted per hour if needed to maintain stable fasting and between meal glucose levels. There is no insulin on board with a pump, so any discontinuation of continuous insulin delivery will result in glucose elevation progressing to ketone body production.

Eating plan: CSII allows for the most flexible eating plan. However, adherence to good eating behaviours such as limiting CHO portions to less than 45g and covering every snack will still be required for a good outcome.

Limitations: Cost, wearing a pump continuously, trouble shooting, frequent testing, ketones.

Advantages: Insulin is always “on-hand” so it is easier to take insulin for meals and snacks, micro-dosing is possible, variable dosing formats are on offer, no injections.

Testing requirements: More frequent testing is required, at a minimum at mealtimes to calculate the dose (carb counting plus correction dose), but also to verify that blood glucose levels are normal indicating that the pump is still delivering insulin. The motivated patient should test in a structure purposeful manner to optimise their settings on a regular basis.

Intensification: Sensor augmented pump therapy.

Remember a pump is an operator driven device, if the operator fails the pump fails.
Diabetes must become part of life and the patient's diabetes treatment regimen should be custom built to their needs while still being able to achieve and maintain blood glucose targets. Cultural, financial, social, occupational and recreational factors must be taken into consideration. Diabetes inevitably forces dietary change, usually for the better and dietary input is essential to match the patient's carbohydrate intake to their insulin therapy to attain optimal control. An eating plan that is affordable, acceptable and appropriate is essential for long term control.

Diabetes management is not like any other chronic condition where a specific medicine is prescribed at a predetermined once size fits all dose with a predictable effect. Insulin type, timing, dose, injection site, mood, carbohydrate load, glycaemic index, sleep, exercise and work all affect blood glucose levels.

The best regimen is the one that works for your patient. As situations change so too should the treatment plan. Patient input is essential. Having a good working relationship within the healthcare team will allow for a vigorous debate on the merits of the different options and a treatment plan can be built that makes all parties happy.

Carbohydrate Counting

Note the following important elements:

- Messages on meals should be specific and actionable – "eat healthy " is very vague. It is more specific to say "fill half my plate with vegetables";
- Realistic and Sustainable Messages-"not eating" is not sustainable – eat slowly and stop before 100% full and bad weather and not able to exercise – is inevitable – but overeating after can be avoided.

Carbohydrate counting is a tool that can assist the patient to match ingested carbohydrates with an appropriate dose of insulin *analogous* to a beta cell producing a proportionate amount of insulin for a given sampled glucose level.

The perfect dose is the dose that stores the incoming carbohydrates away such that the pre-prandial blood glucose level is reached after the meal-time insulin has completed its actions, remaining neither too high nor too low relative to the starting glucose level.

To be able to develop competency in diabetes nutrition management the patient must develop the knowledge skill and ability to make dietary choices and adjust insulin to achieve glycaemic goals.

Level 1: Macronutrient awareness- what is a carb, a fat and a protein.
Level 2: Identify common sources of carbs.
Level 3: Be able to quantify a portion of carbohydrate either in terms of a CARB quantum (sometimes called an exchange, typically 10 or 15g) or in grams of carbohydrate content.
Level 4: Identify the different glycaemic effects of equivalent carb quantities of different carbohydrates.

Carb Ratio

The carb ratio is the amount of carbohydrate covered by 1 unit of meal time insulin.
This is often estimated from the TDD
i.e., carb ratio = 500/TDD
If the TDD is 50u, then the carb ratio is 500/50 = 10
That is 1u covers 10g of carbohydrate
In reality this number needs to be tested and fine-tuned.

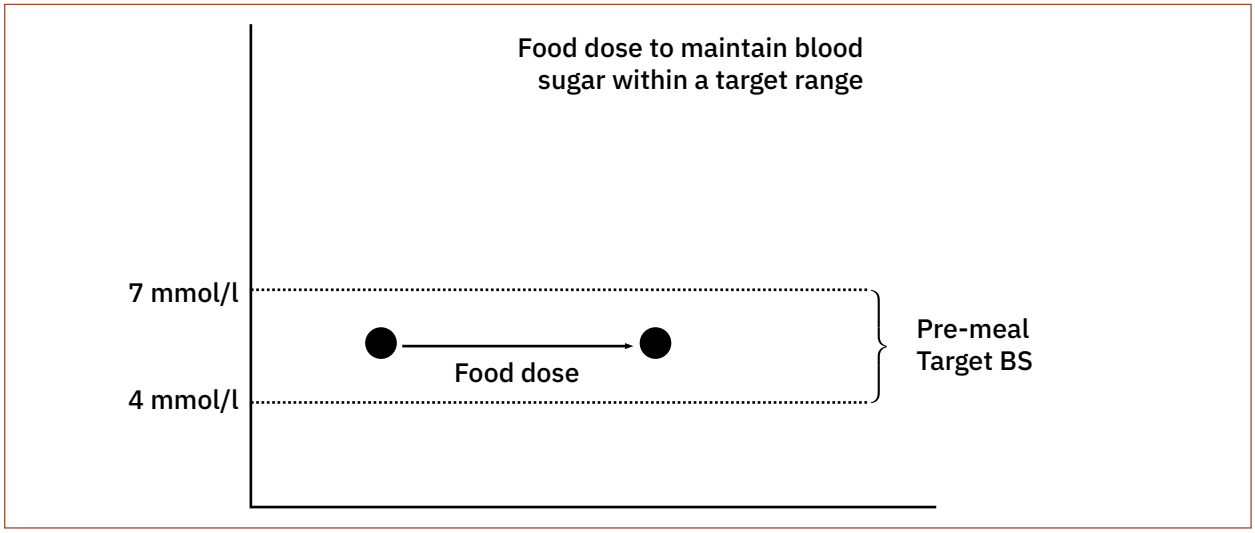

Fig 11: Target range of blood glucose

E.g., If the starting blood glucose is 6 mmol/l, no correction is required only insulin to cover the meal carbohydrate content. If 4 slices of bread is consumed (15g per slice) and the carb ratio is 1u per exchange or 1u per 10g then the meal time dose is 6u.

Correction Doses and insulin Sensitivity

In addition to covering carbohydrates eaten at a meal, additional insulin (corrective dose) needs to be administered if the blood sugar is above the target range. The corrective dose is then added to the "food dose" to return blood sugars towards the target range. Corrective doses are calculated based upon an individual's sensitivity to insulin, which is the amount one would expect the blood sugar to fall following administration of 1unit of rapid acting insulin.
The sensitivity is estimated from the TDD.
Sensitivity = TDD/100
E.g., if the TDD is 50u then the sensitivity = 100/50 = 2
That is 1u lowers the blood glucose by 2 mmol/l

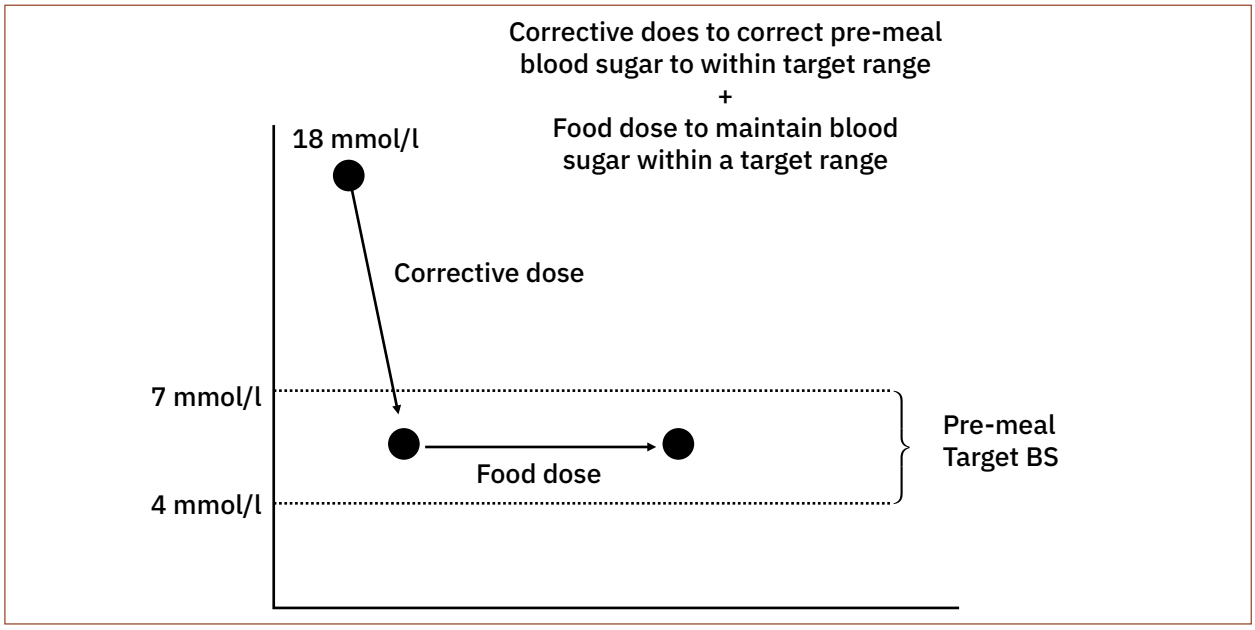

Fig 12: Corrective doses of insulin

For example, if the blood sugar is 18 and the target blood sugar is 6mmol/l and one unit of insulin lowers the blood sugar by 2 mmol/l (insulin sensitivity) then 6 additional units of insulin should be given to bring the blood sugar from 18 to 6mmol/l. Each individual has their own specific sensitivity which is influenced by age, sex, pubertal status and type of long-acting insulin used.

A Fixed Carbohydrate Meal Plan

The meal plan can be designed in conjunction with the patient and tested by iteratively adjusting the fixed dose of insulin to cover a specified recurring meal with a fixed carbohydrate content. Once this dose is identified is it administered routinely and tested occasionally to verify that it is still correct.

Limitations: Reduced flexibility, higher or lower carbohydrate intake results in glycaemic variability.

Advantages: Easy to apply in a poor resource setting, or a setting where meal intake is predictable and with low variability, does not require many tests.

A Flexible Carbohydrate Meal Plan

Requires the carb ratio to be calculated. i.e. how many grams of carbohydrate are covered per unit of insulin. e.g., 1u covers 10 g of CHO

This ratio can differ by time of day.

Limitations: requires greater patient understanding, basic mathematics skills, more frequent testing.

Advantages: Offers the greatest degree of flexibility and accuracy.

Nutritional Management in Type 1 Diabetes

Food is material consisting essentially of protein, carbohydrate, and fat used in the body of an organism to sustain growth, repair, and vital processes and to furnish energy. Supplementary substances include minerals, micronutrients, condiments and water. There is no 'one-size-fits-all' in nutrition management for individuals with diabetes and therefore their plans have to be tailored to the individual circumstances.

Terms used in Dietary Management

Simple carbohydrates

Simple carbohydrates are various forms of sugar, completely metabolized and are the quickest source of energy. They include monosaccharides (glucose, fructose, and galactose) and disaccharides (sucrose, maltose, and lactose).

Complex carbohydrates

Complex carbohydrates include starch and dietary fibre. Starch is completely metabolized to glucose. For example, rice, potato, and refined wheat and maize flour. Dietary fibre is non-starchy polysaccharides and lignin that are not digested by enzymes in the small intestine and typically refers to the nondigestible carbohydrates from plant foods. Because dietary fibre is not digested in the human small intestine, it is not considered a part of the immediate glucose supply. An intake of more than 50 g/day of fibre has been shown to lower pre-prandial glucose.

Glycaemic Index of Foods

Glycaemic Index (GI) is the ability of carbohydrate to raise the blood glucose. The GI assesses the blood glucose response of a fixed amount of **available carbohydrate** (generally 50 g) from the test food to the same amount of **available carbohydrate** from a standard food (glucose or white bread). The test food's blood glucose response area is then expressed as a percentage of the standards. Foods high in protein and / or high fibre have a low GI.

Low-Glycaemic Index foods (< 55)

- Cereals and pulses: parboiled rice, green peas, fresh kidney beans,
- Milk and milk products: Milk, Curd, Yogurt
- Vegetables: All vegetables grown above the ground and underground vegetables like carrots and turnip
- Fruits: Apple, orange, papaya, and guava

Medium-Glycaemic Index foods (55–69)

- Cereals: Whole wheat, basmati rice, brown rice, maize flower, millet flower, oatmeal.
- Fruits: Mango, green-ripened banana, pineapple, black grapes, beet root.

High-Glycaemic Index foods (>70)

- Rice, Potato, Cornflakes, sugar, rice products, white bread, and boiled bananas (*matooke*)

Methods to lower Glycaemic Index of the meal

- Choose and include in the meal at least one Low-GI food
- Combine a high-GI food with a low-GI food. For example, combine rice with beans and vegetables.
- Whole grain bread when available should be preferred to white bread
- Include fresh fruit and vegetables in the days meal plan as they have a low GI and provide the micronutrients as well.

Glycaemic Load

The glycaemic load (GL) is a way of ranking the carbohydrate content of foods so that portions of foods as they are consumed may be compared, based on their GI and a standardized portion of size of 100 g. Note the difference between a portion and a serving.

Portion

A portion is the amount of a food that you choose to eat for a meal or snack. It can be big or small— you decide. Portions are the important measure of quantity of carbohydrate consumed.

Serving

A serving is a measured amount of food or drink, such as one slice of bread or 1 cup of milk. Some foods that most people consume as a single serving actually contain multiple serving sizes (e.g., a 20-ounce soda, or a 3-ounce bag of chips). Nutrition recommendations use serving sizes to help people know how much of different types of foods they should eat to get the nutrients they need. The Nutrition Facts Label on packaged foods also lists a serving size. The serving sizes on packaged foods are not always the same as those included in nutrition recommendations. However, serving sizes are standardized to make it easier to compare similar foods. Portions consumed may have more than one serving.

As the standard for the calculation of the GI is 50 g of carbohydrate, the quantity of food tested is variable. For example, while testing for GI, 65 g of rice and 300 g of mango, which give 50 g of carbohydrate, will be tested. But the usual portion size of the small mango may be around 100 g and GI does not take into consideration the portion size. GL of a particular food is the product of the GI of the food and the amount of carbohydrate in a serving.

GL = (GI x Amount of Carbohydrate in the portion consumed in the meal) / 100
For example, apple has a GI of 40 and a serving of a medium-size apple (100g) contains 15 g of carbohydrate.
GL = (40 x 15) ÷ 100 = 6
A potato has a GI of 80 and a serving of potato (100g) contains 23g of carbohydrate.
The ***GL = (80 x 23) ÷ 100 = 18***
Watermelon has a GI of 73 and a wedge portion of watermelon (100g) contains 8g of carbohydrate.
The ***GL = (73 x 8) ÷ 100 = 6***

Therefore, although equal sizes of apple, potato and watermelon are available for consumption (100g), the potato will cause three times the rise in blood sugar compared to the apple and watermelon; and the apple and watermelon would be good as snacks.

- GL higher than 20 is considered high
- GL 11–19 is considered medium
- GL of 10 or less is considered low

Objectives of the Nutrition Care Plan

- To achieve and maintain blood glucose levels in the normal range or as close to normal as is safely possible
- To address individual nutrition needs, taking into account personal and cultural preferences
- To address needs of evolving dietary modifications in management of diabetes complications
- To promote family participation in incorporating and adopting dietary changes to regular family dietary pattern

Medical Nutrition Therapy (MNT)

- The ideal diet for someone with diabetes is a healthy diet that the entire family enjoys and benefits from.

Diet Plan

- The diet approach should be informed by individual food choices and preferences, affordability and accessibility of food within the home; and capability of the family to sustain the plan. It is worth noting that planning within the locally available foods can also make a successful meal plan that can contribute to good glycaemic control
- Allow for flexibility in food choices and variety
- Developing a diet plan for people with diabetes is always guided by what an individual can eat (food quality), how much an individual can eat (food quantity), and when an individual can eat (timing of meals). The food quality is in reference to nutrient (carbohydrate, fat, protein) content; food quantity in reference to meal (carbohydrate) portions/servings; and timing in reference to meal frequency and schedule. All these aspects should be matched to insulin therapy.
- The objective of a diet plan is to establish these aspects and match them with insulin therapy. This however should be individualised
- It is important to note that carbohydrate content varies for different groups of food. Certain foods such as starchy roots and tubers, cereals and cereal products have a relatively higher content of carbohydrate, whereas foods such as meat, poultry, fish and eggs have only trace/insignificant amounts. Refer to table on a simple categorization of foods based on carbohydrate content.

High carb foods (>20g/100gEP)	Cereals, grains, starchy tubers, starchy roots, plantain,
Moderate carb foods(>10–15g/100gEP)	Milk, yoghurt, fruits, dry legumes
Low carb foods (≤5g/100gEP)	Most nuts, non-starchy vegetables,
Zero carb foods (<1g/100gEP)	Meat, poultry, fish, cheese, oils, fat,

EP, edible portion. Foods chosen from these categories when eaten within the same amounts will impact on blood glucose differently, with highest impact potentially realised with high carb-containing foods

Meals

- We recommend three main meals i.e. breakfast (usually taken early in the day), Lunch (usually taken in the afternoon) and supper (usually taken late evening or towards bedtime). Two to three healthy snacks are recommended in between the three main meals, i.e. midmorning snack (between breakfast and lunch time), mid-afternoon snack (between lunch and supper time), and an optional bedtime snack depending on need (for example if supper was eaten more than 2 hours before bed).
- The timing and size of meals is adapted to individual age, physical activity and insulin regimen.
- Observe meal times. Unless during night sleep, do not allow more than 4 hours without eating. Allowing long/extended hours without eating increases the likelihood of the individual eating much food at the next meal, which impacts significantly on post-prandial blood glucose.
- About half of the insulin requirement each day is used to control glucose levels from eating. The other half is needed for the body to function normally, even when the person does not eat at all. If the child is ill and insulin-resistant, the total amount of insulin needed may still be the same as on a normal day, even when the person is not eating.
- You may need different insulin regimens for different meal plans. Always try to adapt the insulin regimen to suit the meal plan.
- Different regimens may increase flexibility on meal plans or may have to be adjusted to the local meal frequency.

Energy Intake

- Energy and nutrient intake of people with type 1 diabetes is the same as recommended for the general population of the same age, sex and activity level. 1000 calories (4184kj) + 100 calories/year of age **or calculating the specific total energy expenditure**
- Energy distribution of 50–60% for carbohydrate, 15–20% for protein and no more than 30% for fat of the total daily Calorie intake. These can however be adjusted in certain individual circumstances where modification in intake is required such as in case of managing complications.

Food and Insulin

- Balance food and insulin
- Adapt insulin to suit meals (meal carb content and timing) rather than adapting meals to suit insulin
- A twice daily regimen, especially one that uses a fixed ratio, premixed insulin will require a meal plan that has regular snacks and meals. There are risks of hypoglycaemia when meals or snacks are missed and therefore one should emphasize consistency in portion sizes and meal times

General recommendations on foods

- Note the difference between “portions” and “servings” of food to be consumed; a portion is the amount of food that an individual wish to eat at a meal or snack. Portions of the same food can vary from person to person depending on individual choices. A serving on the other hand is a standard measured amount of food or drink, such as 30 g of bread or 1 tea-cup of milk and usually has an attached amount of carbohydrate estimate. Note: In diabetes meal planning, food servings are quantified in terms of carbohydrate (e.g. 1-Carb choice of milk = 15 g carbohydrate) rather than food weight (e.g. 300 ml of milk ~15 g carbohydrate). 1 carbohydrate serving of starchy or sugary foods gives an equivalent of 15 g carbohydrate, and 1 carbohydrate serving for non-starchy vegetables is an equivalent of 5 g carbohydrate.
- Eat a broad variety of foods, that should include sufficient fibre
- Opt to eat unrefined or less refined cereals more, or other locally available starches like tubers but control total carbohydrate intake.
- Eat at least 2 servings of fruits each day, preferably as snacks, between breakfast and lunch; lunch and dinner/supper. **Remember fruits have carbohydrate.** Fruits are categorized into one cup servings. A small apple; a large sweet banana; 32 grapes; a medium pear; 1 small wedge of watermelon; 8 large strawberries; ½ cup of dried fruit; or 3 plums all count as one cup serving of fruit. If taken with meals, they are included in the carbohydrate counting. See Fig 4 and 5.
- Eat plenty of vegetables each day wherever possible especially at main meals. Aim for 2 or more servings of vegetables each day. A vegetable serving is a cup of green salad, a size of a baseball or the size of an adult’s fist.
- Avoid refined sugar and juices as part of daily eating plans; sugar-sweetened foods and beverages such as sweets, candies and cakes, regular sodas and fruit juices
- In young children fat intake should not be restricted but older children and adolescents should avoid foods with excess fats, particularly animal fat
- Opt for liquid vegetable oils (such sunflower, olive, corn, safflower oils) instead of solid fat (such as butter, hard margarine, lard) or tropical oils (such as palm and coconut oil). Liquid vegetable oils are high in mono-unsaturated and poly unsaturated fats
- Two or more servings of fish per week are encouraged whenever possible.
  - Eat a 1 or 2 cup serving of diary
  - Eyeball 1 cup of vegetables

- Go for about ½ cup of fruit
- Aim for 1 oz of grains
- Eat 1–2 tablespoons of added fat.

Fig 13 gives a summary of the plate as may be in most of sub-Saharan Africa.
Fig 14 gives a summary of the general fruit plate available. *Note that a serving of bananas is one banana (one finger of a banana); while portions consumed is usually two.*

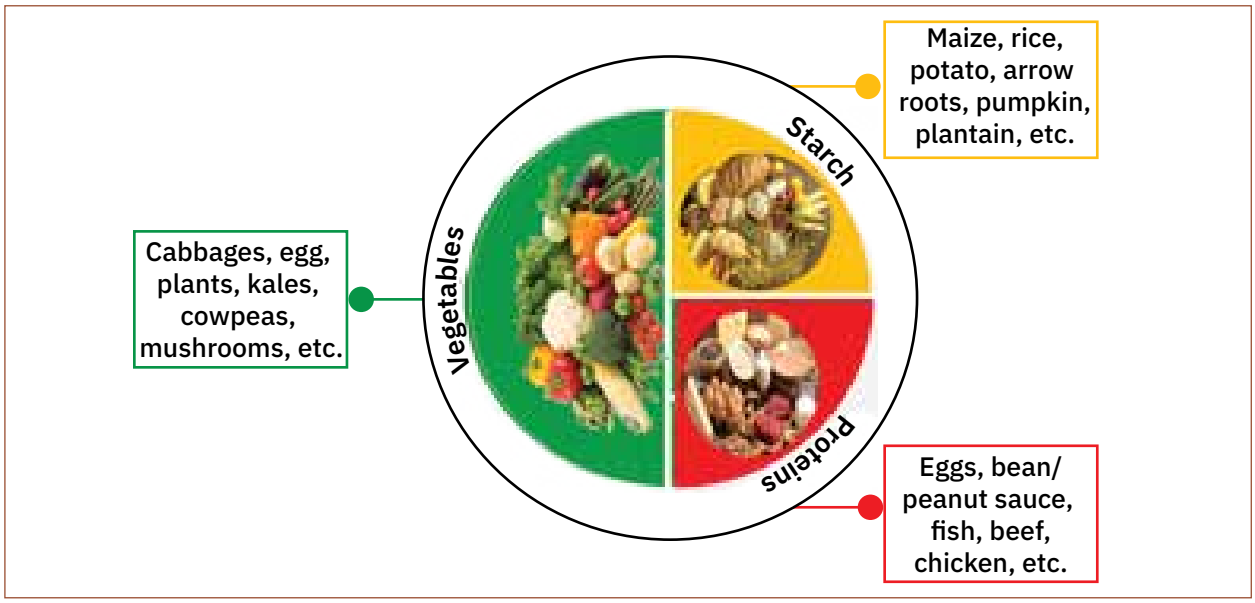

Fig 13: Food portions in a typical plate

Fruits provide additional carbohydrate to the main meal and should therefore be considered in carbohydrate counting.

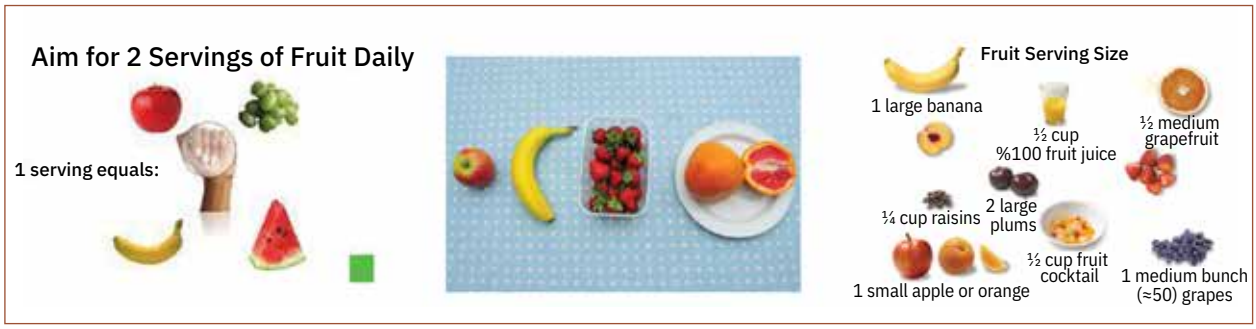

Fig 14: Examples of fruit commonly available shown in servings; the first panel is a "hand jive" (a serving may be less than a portion; a portion being what is usually consumed at ago, like it's usually two bananas)

The amount of fruit shown in the plate is more than a portion allowed at time. A portion allowed would be two bananas or a bunch of the grapes; not all the fruits on the plate to be consumed at the same time. They are all included on the plate to emphasize what is commonly seen in normal day-to-day life. Take a portion and leave the rest!!
Note that a serving of bananas is one banana (one finger of a banana); while portions consumed is usually two. Not all these fruits would be consumed at ago!

Macronutrients

The components of a balanced are summarized in Fig 15.

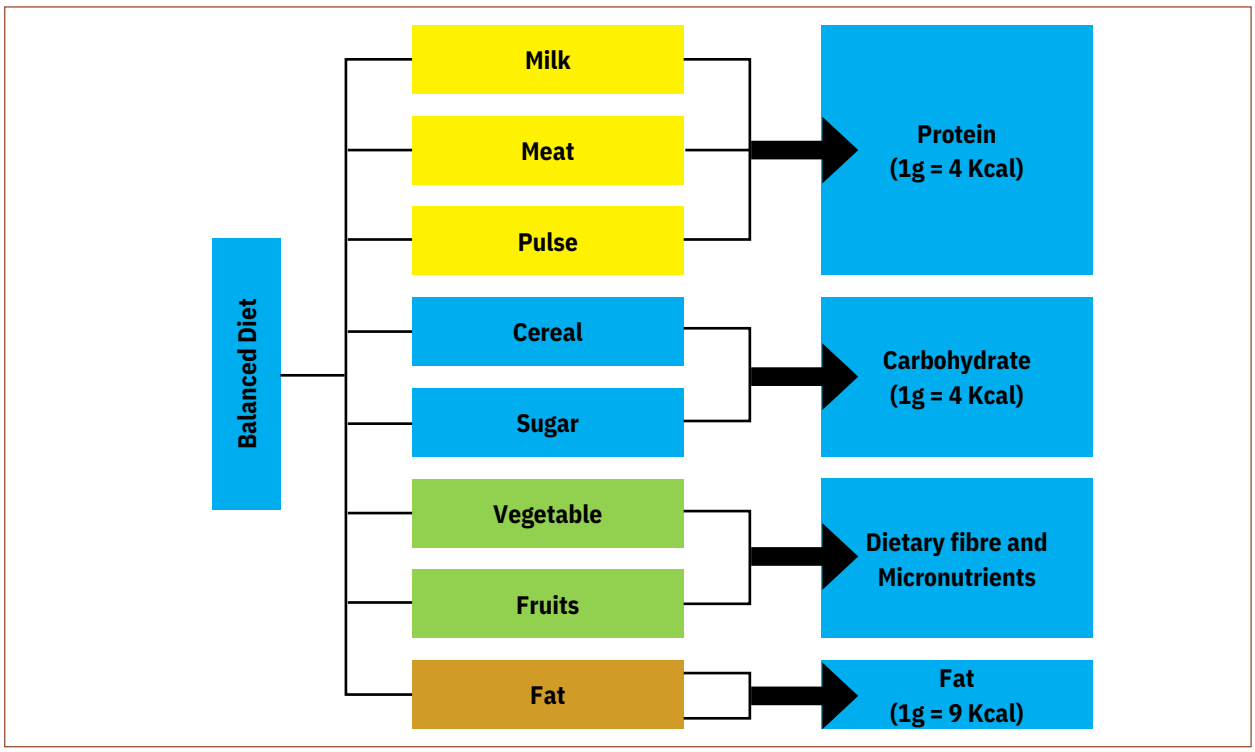

Fig 15: The components of a balanced diet

Summary of Dietary Recommendations

- Dietary recommendations for children with diabetes are based on healthy eating principles suitable for all children and their families.
- Nutritional advice should be adapted to cultural, ethnic and family traditions as well as the cognitive and psychosocial needs of the individual child.
- On-going annual nutrition counselling and reassessment should be provided regularly, or more often as required and requested.
- Advice should focus on amount, type and distribution of carbohydrate to include in regular balanced meals and snacks over the day.
- Advice should be individualized based on glucose control, medication and physical activity. The dynamic relationship between carbohydrate intake, physical activity and insulin should be explained.
- Fluids with a high concentration of sucrose or foods with high levels of saturated fat should be avoided.
- Advice should be given on the use of fluids and foods in the prevention and management of hypoglycaemia.
- Prevention of overweight/obesity is a key strategy of care.
- Consider advice on the effect of alcohol before the adolescent is exposed to it. If alcohol is included in the lifestyle of the adolescent, education on the prevention of hypoglycaemia and ways to reduce alcohol intake should be provided.

Diabetic Ketoacidosis

Definition Diabetic ketoacidosis (DKA) is one the most common complications of T1DM. It is defined as hyperglycaemia (blood glucose > 11.1 mmol/L) with a serum pH < 7.3 and / or serum bicarbonate level < 15 mmol/L [28]. The blood glucose level is nearly universally elevated at presentation in children with new onset diabetes, while those with pre-existing diabetes may be euglycaemic or even hypoglycaemic if insulin was administered by the child or family prior to health facility arrival. DKA is a medical emergency requiring treatment with close monitoring. Morbidity and mortality is still high in sub-Saharan Africa.

DKA is always due to absolute or relative insulin deficiency. The counter regulatory or stress hormones which include glucagon, catecholamines, cortisol, and growth hormone are markedly elevated in DKA. Acting in concert with the deficiency of insulin, they augment the metabolic derangements characteristic of DKA:

- Hyperglycaemia secondary to increased glucose production and decreased utilization
- Osmotic diuresis and dehydration secondary to hyperglycaemia
- Hyperlipidaemia secondary to increased lipolysis
- Acidosis secondary to increased production and decreased utilization of the acetoacetic acid and 3-ß-hydroxybutyric acid derived from fatty acids
- An increased anion gap secondary to elevated ketoacids and lactate

Morbidity and mortality from DKA can be reduced by early treatment. In particular, early adequate hydration and active management of shock are crucial and may be life-saving. Written treatment protocols should be available at all levels of the healthcare system, including clinics. DKA should be suspected in all children with unexplained reduced level of consciousness, vomiting, abdominal pain and difficulty in breathing. A blood glucose test should be performed in all cases.

DKA occurs when there is insufficient insulin action, is commonly seen at diagnosis but may occur at any stage of diabetes, and signifies a life-threatening clinical situation for the child. The child must be transferred to the nearest available site of care. Arrange for transfer as soon as the diagnosis is suspected or confirmed but initiate treatment at the health facility prior to transfer. This should include rehydration, even where administration of insulin is not possible.

Common Presenting Symptoms and Signs in DKA

Symptoms

- Weakness and nonspecific malaise that may precede other symptoms
- Nausea and vomiting
- Thirst and polyuria
- Abdominal pain - severe enough to mimic a surgical emergency
- Somnolence – sleepiness or drowsiness – i.e., a state of strong desire for sleep, or sleeping for unusually long periods

Signs

- Dehydration
- Hyperpnea or Kussmaul breathing
- Impaired consciousness and / or coma with no history of head injury
- Fruity odour

The elevated blood glucose causes polyuria and polydipsia and may be confirmed by an elevated blood glucose value or glucose in the urine. Dehydration has similar clinical signs to dehydration from other causes. These signs include sunken eyes, dry mouth, decreased skin turgor, absence

of tears and decreased perfusion. The decrease perfusion is also a sign of circulatory shock. Alterations in electrolyte levels may cause irritability and changes in the level of consciousness. With breakdown of fat, ketones are produced. The presence of ketones may cause nausea, vomiting, abdominal pain, acidotic breathing and an altered level of consciousness. With worsening dehydration and acidosis, the child will develop circulatory shock. Left untreated this will cause death. Death may be the result of severe dehydration, acidosis or changes in electrolytes.

Summary of clinical presentation of DKA

Clinical features - What you see	Pathophysiology - What is wrong
High blood glucose or urine glucose, polyuria, polydipsia	Lack of insulin
Sunken eyes, dry mouth, decreased skin turgor, decreased perfusion (shock rare)	Dehydration
Irritability, change in level of consciousness	Altered electrolytes
Rapid and deep breathing, nausea, vomiting, abdominal pain, altered level of consciousness	Metabolic acidosis

Assessment

- History and examination including:
  - Severity of dehydration. If uncertain about this, assume 10% dehydration in significant DKA
  - Level of consciousness
- Measure weight
- Determine blood glucose and blood ketones in the laboratory or use glucose meters or test strips. Urine glucose and urine ketones are useful parameters to assess if urine is available.
- Laboratory tests: blood glucose, urinalysis, urea and electrolytes, creatinine, haemoglobin, white cell count, arterial blood gases (where available).
- Take appropriate microbiological samples if infection is suspected.
- If no laboratory is available, take the appropriate samples and send with the patient to the next level of care

Table 7: Diagnostic criteria and body deficits of water and electrolytes in ketoacidosis

Diagnostic criteria*	
Blood glucose:	>13.9 mmol/l (250 mg/dl)
pH:	<7.3
Serum bicarbonate:	<15 mmol/l
Urinary ketone:	≥3+ †
Serum ketone:	positive at 1:2 dilutions†
Serum osmolality:	Variable
Typical deficits	
Water:	Deficit: up to 100 mL per kg body weight
Sodium:	Deficit: up to 7 to 10 mmol per kg body weight
Potassium:	Deficit: up to 3 to 5 mmol per kg body weight
Phosphate:	Deficit: up to 1.0 mmol per kg body weight

*—Not all patients will meet all diagnostic criteria, depending on hydration status, previous administration of diabetes treatment and other factors.
†—Nitroprusside reaction method.
Adapted with permission from Ennis ED, Stahl EJ, Kreisberg RA. Diabetic ketoacidosis. In: Porte D Jr, Sherwin RS, eds. Ellenberg and Rifkin's Diabetes mellitus. 5th ed. Stamford, Conn.: Appleton & Lange, 1997;827–44.

Differential diagnosis

- Gastroenteritis: in DKA vomiting is without diarrhoea
- Surgical emergencies presenting with acute abdominal pain e.g., acute appendicitis
- Metabolic acidosis from any other cause
  - Severe pneumonia
  - Severe malaria
- "Respiratory distress" – in DKA with Kussmaul's breathing, lungs are clear

Management

Diabetic Keto Acidosis is a medical emergency and correction of the clinical and chemical changes must occur gradually to prevent the associated complications, particularly hypokalaemia and cerebral oedema. Fluid replacement is initially more important than insulin therapy, as early mortality is due to dehydration and shock rather than hyperglycaemia. Insulin therapy is needed to correct the acidosis and hyperglycaemia. Treatment should be initiated at the healthcare site of first contact, and the patient should be transferred as soon as possible to the **nearest best available site** of care with diabetes experience. If insulin is not available at the healthcare site, transfer is urgent, however fluid treatment must be initiated immediately.

It is of the extreme importance that inhouse protocols for management of DKA are developed for each healthcare facility looking after T1DM, and that such protocol has a sound referral system.

Strategic incompetence

We refer to the situation of referring patients with diabetes emergencies, in order to get rid of a difficult medical situation from a healthcare facility, as "***Strategic Incompetence***". Strategic incompetence is the art of avoiding undesirable tasks by pretending to be unable to do them. This tactic, however effective it can be in the short term, can prove disastrous in the long run, as they weaken the entire health system; a "***no care***" attitude being attached to the sick patient. This should be avoided. It is unfortunately common in SSA

The principles of DKA management include correction of shock, dehydration, hyperglycaemia, deficit of electrolytes, acidosis, infection and complications. This is summarized in Figure 7 below.

Points to Consider in Treating DKA

- A precipitating cause can be identified in most patients.
- An ECG is indicated in all adult patients – when can be accessed.
- Isotonic saline is initially preferred to rehydrate patients.
- Intravenous (IV) insulin is the preferred route of delivery, but intramuscular route (IM), when IV is not possible, should not be delayed.
- DKA patients are deplete of total-body potassium.
- Administration of glucose is necessary to clear ketosis.
- Bicarbonate is rarely needed.
- Cautious replacement of phosphate is sometimes used.
- Preventing DKA is a long-term goal of diabetes management.

At home

- Children known to have diabetes and presenting with symptoms of loss of consciousness, vomiting, abdominal pain or difficulty in breathing should be assumed to have DKA until otherwise proven.
- Blood glucose measurement should be taken and is usually elevated.
- Urine ketones can be tested where possible and where positive confirm diagnosis.

- Arrangements should be made for immediate transfer to a health facility capable of providing care for DKA.
- Meanwhile offer the child one teaspoon of water (*light coke or zero coke*) every minute if alert. Oral rehydration salts (ORS) is a solution containing 90 mEq/l of sodium with glucose and giving a total osmolarity of 311 mOsm/l. This can be given at rate of 1 ml/kg/min as the patient is being transported to another health facility.

In the community – school, places of religious & cultural gatherings, sports grounds, etc.

- Move child to a safe environment. Contact caregiver or other responsible adult and if child is alert, can be assisted to perform a blood glucose measurement.
- Arrangements should be made for immediate transfer to a nearest health facility.
- At primary Care Health Facility
- Perform blood glucose and urine ketone test where available
- Begin intravenous fluid using isotonic (normal) saline or ringer's lactate at 1.5 times of maintenance dose. The maintenance fluid is calculated as follows:

Weight	Maintenance Fluid / 24 hours
0–10 kg	: 100 ml/kg/24 hours
10–20 kg	: 100 ml/kg for the first 10 kg + 50 ml/kg for the next 10 kg
>20 kg	: 100ml/kg for the first 10 kg + 50 mls.kg for the next 10 kg + 20mls /kg for the remaining kg

- If intravenous rehydration is not possible, use an alternative method as per the chart provided
- Administer subcutaneous soluble insulin at 0.3 units per kilogram body weight and transfer to a health facility capable of providing care for DKA.

Note: Minimum expected requirement for health facility to manage DKA is:

a) Experience with DKA management.
b) There should be laboratory support (Blood glucose, electrolytes, and ketone testing)
c) Medical supplies (Insulin, Intravenous fluids and Potassium)

At the Secondary / Tertiary Care Facility

- Confirm diagnosis using blood glucose and urine ketone or blood ketone testing.
- Administer treatment as per DKA protocol

Resuscitation

- The first step in the management of the child is resuscitation of the shocked or critically ill child. This must start as soon as the assessment has revealed a shocked or critically ill child.
- Ensure appropriate life support (Airway, Breathing, Circulation, etc.) Make sure that there is an adequate airway and that the child is breathing. Support breathing by bagging and artificial ventilation. Give oxygen to children with impaired circulation and/or shock.
- Set up a large IV cannula. If IV therapy is not available at the site, set up intra-osseous access.
- Treat shock (decreased perfusion) with fluid intravenous or through an intraosseous line. Use normal saline or Ringers lactate at 10–20 ml/kg over 30 minutes. Repeat boluses of 10 ml/kg until perfusion improves. If you are uncertain about the degree of dehydration, assume dehydration to be 10%. Replace this fluid volume over 48 hours. It is safer to rehydrate slowly rather than too rapidly.
- If IV/intra-osseous access is not available rehydrate orally with oral rehydration solution (ORS)
  - Use nasogastric tube at a constant rate over 48 hours

- If a nasogastric tube is not available, give ORS by oral sips at a rate of 1 ml/kg every 5 min if decreased peripheral circulation, otherwise every 10 min. If the child is vomiting repeatedly, decrease rate to half of the previous rate.
- Arrange transfer of the child to a facility with resources to establish intravenous access as soon as possible
- On completion of the resuscitation, you need to move onto the next step which is correcting the dehydration.
- Do not start insulin until the child has been adequately resuscitated, i.e.. good perfusion and good circulation

Rehydration

Give normal saline as indicated in the table below. In calculating fluid replacement, do not add the urine output to the replacement volume. Reassess clinical hydration regularly.
Once the glucose is less than 15 mmol/l, add dextrose to the IV fluids. This could be done by adding 100 ml of 50% dextrose to each litre of saline or you could use 5% dextrose saline.

Table 8: Fluid amount and infusion rate in DKA rehydration

Weight (kg)	Volume in 24 hours	Rate (mls/hr)	Drip rate adult IV set (20 drops = 1 ml)	Drip rate paediatric burette (60 drops = 1 ml)	3 hourly bolus feed volume
3	300	13	4	13	40
4	400	17	6	17	50
5	500	21	7	21	60
6	600	25	8	25	75
7	700	29	10	29	90
8	800	33	11	33	100
9	900	38	13	38	110
10	1000	42	14	42	125
11	1050	44	15	44	130
12	1100	46	15	46	140
13	1150	48	16	48	140
14	1200	50	17	50	150
15	1250	52	17	52	150
16	1300	54	18	54	160
17	1350	56	19	56	160
18	1400	58	19	58	175
19	1450	60	20	60	175
20	1500	63	21	63	185
21	1525	64	21	64	185
22	1550	65	22	65	185
23	1575	66	22	66	185
24	1600	67	22	67	200
25	1625	68	23	68	200

Summary of DKA Flow Sheet [28]

	Clinical parameter	Monitoring interval
	Mental status	1 hour
	Vital signs (T, P, R, BP)	1 hour
	ECG	Initially and as indicated
	Weight	Initially and daily
Therapy		
	Fluid intake and output (ml/h)	4 hours
	Insulin (units/h)	1 hour
	Potassium (mmol/L)	4 hours
	Glucose (mmol/L)	4 hours
	Bicarbonate and phosphate	4 hours (if indicated)
Laboratory		
	Glucose (bedside)	1 hour
	Potassium, pH	2 hours
	Sodium, Chloride, Bicarbonate	4 hours
	Phosphate, magnesium	4 hours
	BUN and creatinine	4 hours

Routine Care

Insulin therapy

Start insulin therapy only after circulation has been restored and the patient is haemodynamically stable.

The best way to correct the high blood glucoses is to start an insulin infusion of short acting insulin. Deliver insulin at 0.1 U/kg/hour. This rate should be controlled with the best available technology (infusion pump). For example, a 14 kg child should receive 1.4 u/hour of short acting insulin. If a dose equivalent to body weight is added into 100 ml of saline, then an infusion rate of 10 ml per hour will deliver 0.1 U/kg/hour. Many centres in SSA lack infusion pumps. The next best device is to use a barrette to deliver these small doses of insulin. Healthcare workers are advised to have a separate line to deliver insulin and separate line for other intravenous fluids.

In children under 3 years of age, consider using a lower rate of insulin delivery e.g., 0.05 U/kg/hour.

Insulin infusion must be continued until both hyperglycaemia and acidosis are corrected. Treating acidosis requires higher doses on insulin than reversing hyperglycaemia. Therefore, when blood glucose levels approach < 14 mmol/l, 5% glucose should be added to the rehydration fluid to allow continuation of adequate doses of insulin therapy until the acidosis resolves. **Not giving glucose will delay clearing the acidosis.**

Do not correct glucose too rapidly; aim for a glucose reduction of about 5 mmol/l per hour. A more rapid decline may contribute to the development of cerebral oedema. If glucose declines very rapidly, decrease the rate of insulin delivery.

If no suitable control of the rate of the insulin infusion is available, or if you cannot gain intravenous access, use sub-cutaneous or intra-muscular insulin. Give 0.1 u/kg of short acting insulin subcutaneously or IM into the upper arm [10, 29].

Due to its pharmacokinetic properties, it has been suggested that long-acting insulin analogues may have a role in facilitating the transition from continuous intravenous infusion to subcutaneous maintenance therapy in patients with DKA for prevention of rebound hyperglycaemia, particularly if there is high insulin requirements [30]. Concomitant

administration of basal insulin analogues with regular insulin infusion accelerates ketoacidosis resolution.

Transition to subcutaneous insulin therapy

Oral fluids should be introduced only when substantial clinical improvement has occurred, metabolic acidosis has been corrected (though ketosis may persist) and the patient indicates a desire to eat. As oral feeds are advanced, intravenous fluids are reduced and a change to subcutaneous insulin is planned.

- Insulin infusion is no longer necessary if all the following are reached:
  - Glucose <11 mmol/l
  - Serum bicarbonate ≥ 18 mmol/l
  - Venous pH > 7.3 and
  - Calculated anion gap ≤ 12 mmol/l
- Once the DKA has been adequately treated and the child is able to feed, start subcutaneous insulin
- To prevent rebound hyperglycaemia, the first subcutaneous injection should be given 1–2 hours before stopping insulin infusion.

Timing of switch to subcutaneous route*:* The ideal time to begin administration of subcutaneous insulin is just before a meal. In order to avoid rebound hyperglycaemia, rapid acting insulins (lispro or aspart) are administered 15–30 min prior and regular insulin 1–2 hours prior, to stopping insulin infusion. With intermediate - or long-acting insulin, the overlap should be longer and the IV insulin gradually lowered.
Important: *The presence of ketones suggests inadequate insulin delivery. Continue giving insulin IV or hourly plus 5% dextrose infusion, until ketones have been cleared.*

Monitoring in DKA

The patient's clinical condition should be monitored frequently using a data flow sheet as indicated above. Also note the following:

- Blood glucose levels should be hourly at the beginning of therapy until it reaches 13.9 mmol/l and when the patient's condition is stable, then every 2 hours
- Electrolytes and venous pH (repeat arterial blood gases are not necessary) should be checked every 2 to 4 hours; currently this is not possible in many centres in SSA. Efforts should be made to improve monitoring towards this standard level.
- As noted above, resolution of DKA is indicated by all the following: a glucose level less than 11 mmol/l, serum bicarbonate level of 18 mmol/l or greater, and venous pH of greater than 7.3 [28].
- Clearance of ketone bodies takes a longer time than the resolution of hyperglycaemia and acidosis. Ketones in the blood or urine are generally measured by the nitroprusside method, which only measures acetoacetic acid and acetone and not ß-hydroxybutyrate (which is the strongest and most prevalent acid in DKA). During therapy, ß-hydroxybutyrate is converted to acetoacetic acid, which may lead the clinician to believe that acidosis has worsened. Therefore, assessment of serum or urinary ketones by the nitroprusside method should not be used as an indicator of response to therapy; direct measurement of ß-hydroxybutyrate in the blood is the preferred method for monitoring ketones during the management of DKA.
- Careful monitoring for the occurrence of complications is an important aspect in the management of DKA.
- Hypoglycaemia may result from high doses of insulin (some patients may need dextrose 10% to keep glucose in the acceptable range) while interruption or discontinuation of insulin therapy after resolution of DKA without administering subcutaneous insulin may lead to hyperglycaemia.

Table 9: Monitoring record template for glycaemic control

Name:				Age:		Weight:				Centre:		Date:	
Time	**LOC**	**HR**	**BP**	**Glucose**	**Ketones**	**U&E**	**Fluid type**	**Route**	**Rate**	**Total**	**Insulin**	**Urine**	**Management**
07h00													
08h00													
09h00													
10h00													
11h00													
12h00													
13h00													
14h00													
15h00													
16h00													
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24h00													
01h00													
02h00													
03h00													
04h00													
05h00													
06h00													

LOC : 1=alert; 2=lethargic (easily aroused), 3=stupor (aroused with difficulty), 4= (unarousable)
Use GCS if available and used regularly
HR : Record heart rate BP: Blood pressure

Complications

Electrolyte abnormalities

The electrolyte abnormalities are the most common complication associated with DKA [3331]. Obtain a blood sample for determination of electrolytes at diagnosis of DKA

Low Potassium (K^+) Levels

Patients with DKA are depleted in total body potassium despite a normal or even elevated serum potassium level. The reasons for this are complex and include catabolic state, potassium wasting in urine secondary to polyuria, inability of kidney to rapidly conserve potassium, and often, the effects of vomiting and /or diarrhoea. Correct potassium replacement requires both caution and timely action. The following should be noted:

- Establish urine output to be certain patient does not have renal failure.
- Send blood samples to the laboratory to measure serum potassium. Potassium levels should always be checked prior to initiating insulin therapy.

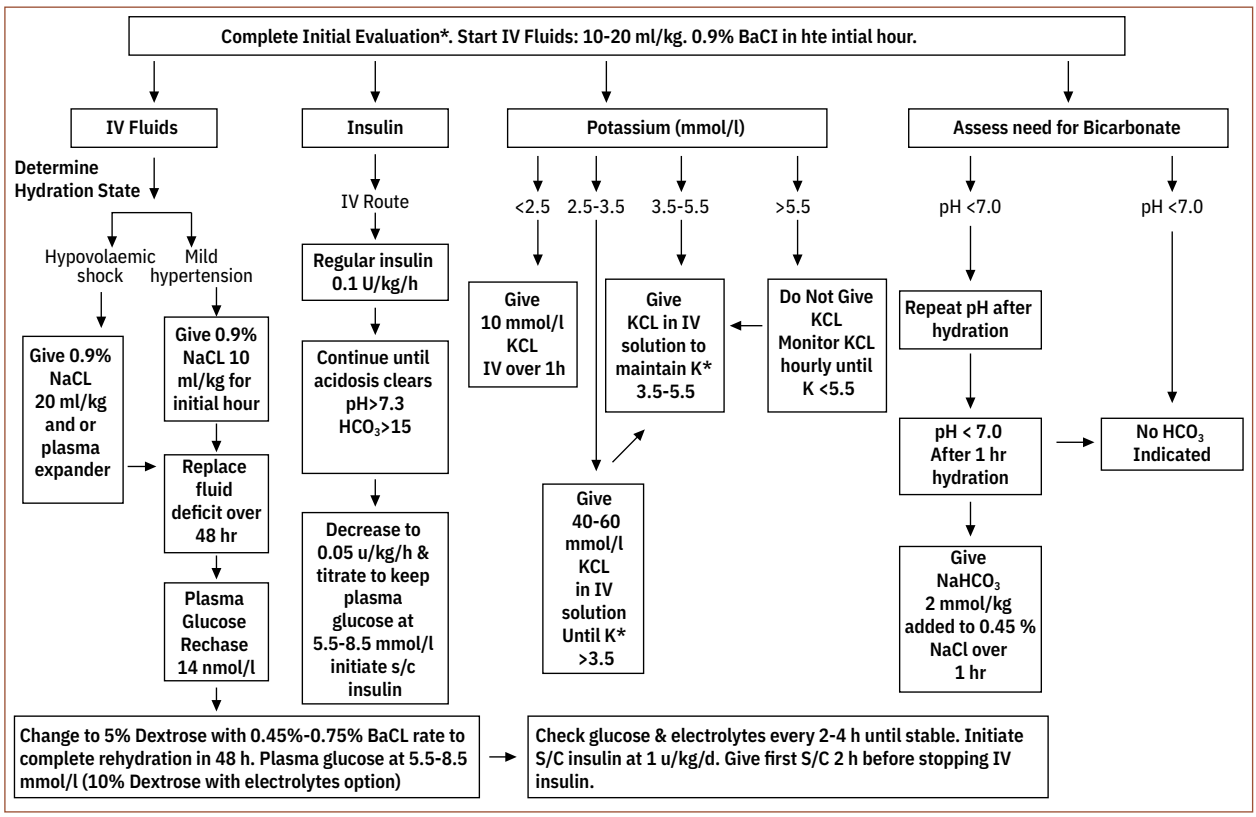


Fig 16: Protocol for the management of patients with diabetic ketoacidosis (DKA)
*After the initial history and physical examination, obtain blood glucose, venous blood gasses (where available), electrolytes, BUN, creatinine, calcium, phosphorous, and urine analysis STAT.

- In DKA patients with severe hypokalaemia, potassium deficit can reach 10 mmol/kg. Profound hypokalaemia (<2.5 mmol/l) in untreated DKA is extremely rare [23], but serious.
- Do an electrocardiogram (ECG) to rapidly estimate whether hypokalaemia or hyperkalaemia is present (high peaked T-waves in hyperkalaemia; low T-waves with U-waves in hypokalaemia).
- Levels < 2.5 mmol/l, necessitate urgent replacement and delay of insulin therapy until potassium serum levels are > 2.5 mmol/l to avoid the risk of cardiopulmonary and neuromuscular compromise.
- Insulin infusion rate of 0.05–0.1 units/kg/h is suggested and lower doses in hypokalaemia
- When hypokalaemia is present, potassium supplementation should be given promptly and insulin infusion rate lowered or delayed.
  - Start potassium replacement once serum value is available or if patient is passing urine.
  - Add KCl to IV fluids at a concentration of 40 mmol/l (20 ml of 15% KCl has 40 mmol/l of potassium)
  - If IV potassium not available, replace by giving the child fruit juice (coconut juice if available or bananas).
  - If rehydrating with oral rehydration solution (ORS), no added potassium is needed
  - Monitor serum potassium 6-hourly, or as often as possible
  - In sites where potassium cannot be measured, **consider transfer of the child to a facility with resources to monitor potassium and electrolytes.**
  - **If potassium chloride is not available give Darrow's solution**
- Where serum electrolyte testing is not available, potassium should be added to the intravenous fluid at the commencement of insulin administration and once the child passes urine.

Hyperchloremic metabolic acidosis

Hyperchloremic metabolic acidosis is commonly observed during the treatment of DKA. The main mechanism is loss of ketoanions in the urine. Ketoanions are necessary for bicarbonate regeneration. Other mechanisms include 1) intravenous fluids containing chloride concentrations exceeding that of plasma, 2) volume expansion with bicarbonate-free fluids, and 3) intracellular shift of sodium bicarbonate during correction of DKA. These abnormalities are transient and are not clinically significant except in patients with acute renal failure or severe oliguria [34 32].

Hyperchloremia with high anion gap (AG)

- Characterized by high anion gap (AG). Anion Gap = $(Na^+ + K^+) - (Cl^- + HCO3)$. Normal: 3–11 mmol/l. The tricky part about DKA is that the gap is not necessarily related just sodium, potassium, chloride and bicarbonate. The metabolism of fats and acids produce ketoacids, which are not directly measured. A low sodium level may also affect the anion gap.
- Retards the increase in bicarbonate and pH; [35 33]
- Consequently, tends to prolong IV insulin infusion time and ICU stay
- Management:
  - Continuous infusion of intravenous (IV) insulin.
  - Correction of water and electrolytes deficits.
  - Treatment of the underlying precipitating factors.

Non-anion gap hyperchloremic metabolic acidosis [36 34]

- Continuous isotonic fluid therapy in paediatric patients was is associated with an increased risk of a non-anion gap hyperchloremic acidosis.
- *Hyponatremia*
- Serum sodium concentration $[Na^+]$ <107 mmol/l is clinically significant and serious
- The major goal in hyponatremia correction is osmotic demyelinating syndrome (ODS) prevention
- Can be corrected with the predominant infusion of potassium [37 35].
- Similarly, volume expansion with relatively isotonic KCl solution is as effective as NaCl.
- During the treatment of hyponatremia, transient aquaresis may arise for various reasons and must be anticipated and immediately treated to avoid rapid overcorrection

Cerebral oedema

- Rare but associated with a very high mortality
- Often unpredictable
- Related to severity of acidosis, rate and amount of rehydration, severity of electrolyte disturbance, degree of glucose elevation and rate of decline of blood glucose
- Causes raised intra-cranial pressure
- Presents with
  - Change in neurological state (restlessness, irritability, increased drowsiness or seizures)
  - Headache
  - Increased blood pressure and slowing heart rate
  - Decreasing respiratory effort
  - Focal neurological signs
- Diagnosis of cerebral oedema is based on the presence of 2 major or 1 major and 2 minor criteria
- Major criteria for diagnosis of cerebral oedema
  - Altered mental state/fluctuating level of consciousness
  - Sustained heart rate deceleration (decrease more than 20 bpm) not attributable to improved intravascular volume or sleep state

  - Age-inappropriate incontinence
- Minor Criteria for diagnosis of cerebral oedema
  - Vomiting
  - Headache – 2–12 hours before event
  - Lethargy or being not easily aroused from sleep
  - Diastolic blood pressure > 90 mmHg
  - Age < 5 years
- Management of cerebral oedema
- Check blood glucose
- Reduce the rate of fluid administration by one-third
- Give Mannitol 0.5–1 g/kg IV over 20 minutes
- Give hypertonic saline (3%), 5 ml/kg over 30 minutes - may be an alternative
- Elevate the head of the bed
- Nasal oxygen
- Intubation may be necessary for a patient with impending respiratory failure.

Other complications of DKA include venous thrombosis, rhabdomyolysis, pneumomediastinum and pulmonary oedema.

Infection in DKA

- Infection can precipitate the development of DKA
- Often difficult to exclude infection as the white cell count is often elevated because of stress
- Suspect infection if there is fever, lethargy, etc
- If infection is suspected, treat with broad-spectrum antibiotics while waiting for culture results.

DKA prevention

- Before Diagnosis
- High level of awareness among health care providers and school teachers
- Increased public awareness of diabetes in children.
- After Diagnosis
- Proper insulin administration during sick days
- Good insulin compliance
- Patient education

Diabetes Self-Management Education

Diabetes self-management education is an ongoing process that provides a platform for T1DM patients and their families / carers to acquire the necessary information, skills and capability to effectively manage their own diabetes care. The process should incorporate the needs, goals, and life experiences of the person with diabetes, guided by the evidence-based standards. The overall objective of the diabetes self-management education in both type 1 and type 2 diabetes is to support informed decision-making, self-care behaviours, problem-solving and active collaboration with the health care team and to improve health status and outcomes, and overall wellbeing and quality of life.

General Recommendations on Self-Management Education

- The education must focus on the management of T1DM and not a modified version of insulin requiring type 2 diabetes
- Education is delivered by the multidisciplinary diabetes team, who must deliver clear, relevant and consistent messages - hence should be structured
- Structured diabetes education should be offered to all T1DM patients or their families / carers with the teaching strategy and learning environment modified to suit each patient and /or their carer (s) as appropriate, and must take into account learning styles and learning ability.
- Education strategies /aids, in particular, the increasing use of technology and social media should be encouraged bearing in mind that very young patients may need additional support to these approaches.
- Education should be individualised, including goal setting and focus on safety, risk management, and complication prevention.
- All patients with T1DM require individualized plans that include:
  - Insulin regiment
  - Blood glucose and blood ketone monitoring
  - Hypoglycaemia treatment and prevention
  - Sick day management.
- Appropriate decision aids and cues to action should be developed with the individual and their family caregivers as appropriate
- Education strategies focusing on monitoring blood glucose and / or blood ketones and administration of insulin by others must be considered as an integral component if patient not able to self-care or self-care deficits exist.

Evidence Base and Reasoning

Diabetes self-management education should be a mandatory approach to achieving the clinical outcomes for all patients with T1DM. It has been shown to be associated with a wide range of benefits in both type 1 and 2 diabetes such as improved glucose control, increased quality of life, reduced weight, and lower costs of healthcare costs [36]. Improved health care have been achieved when programmes were culturally appropriate and age-specific. The following key areas should be addressed:

- The pathogenesis of type 1 diabetes and its natural history in simple way
- Living with diabetes
- The role of nutrition
- Physical activity
- Medications
- Goal setting
- Monitoring

- Acute and chronic complications
- Psychosocial support.

It has been long recognised that as a chronic and complex disease, type 1 diabetes places a substantial and often relentless burden of treatment demands on the person with diabetes and their family. This burden can lead to reduced participation in diabetes self-care and contribute to self-management burnout.

The opportunities for learning and engagement with others with T1DM include camps, age-specific-education, peer educators and social media activities.

Usual Clinical Practice

Local healthcare and diabetes teams should receive support and funding to offer structured diabetes educational approaches for all adults with T1DM. In particular, a focus on diabetes self-management education is desirable that allows diabetes care to be individualized to the person's unique medical, cultural and social situation.

Close liaison between healthcare and diabetes teams with social services may improve the level of support required by the more disadvantaged to participate in educational sessions. Programmes of education should be available for both formal and informal carers and concentrate on basic diabetes knowledge and skills, but provide opportunities for more advanced learning. This may be particularly important in adolescents with T1DM who may require help with because of other social factors that emerge during adolescence.

Local educational programmes should also allow for T1DM patients having other disabilities to access specific specialist educators and services if available.

Diabetes Self-Management Tutelage

Providing **effective support** for patients in using **insulin effectively** is essential for **good diabetes care**. For that support to be effective it must reflect and attend to the needs of the patients. Diabetes education as conventionally given looks at knowledge, skills and abilities and has little capacity on support. Aimed to support patients in using insulin effectively and adhering to a prescribed lifestyle, this diabetes self – management tutelage takes the form of **M**entoring, **M**anaging and **M**onitoring (MMM) while reflecting and attending to the needs of the patients and their families.

Self-management support goes beyond simply supplying patients with information. It includes a commitment to patient-centred care, providing clear and useful information to patients, helping patients set goals and make plans to live a healthier life, creating a team of clinicians and administrative staff with clearly understood roles and responsibilities, using office systems to support follow up and tracking patients.

Self-management support includes the following:

- Providing compassionate, patient-centred care
- Involving the whole care team in planning, caring out, and following up patient visits.
- Involving the patient in goal setting
- Providing customized education and skills training, using materials appropriate for the cultures and health literacy levels
- Making referrals to community-based resources, such as programs that help patients quit smoking, alcohol abuse or other substance abuse or follow an exercise plan.
- Follow up with patients with email, phone, text messaging, or mailings to support them taking good care of themselves.

In this guideline, we recommend that each health facility caring for patients with type 1 diabetes puts more emphasis on collaborative care planning, improved patient choice in the use of

health technology, more resources for self-management support; and more explicit format for the process of care in the clinic [7, 25, 3638, 37 39].

The health facility will need to design services that are responsive to patient and family needs, and are efficient in the use of limited health care resources because in most areas it is the families which pay out of pocket for insulin and associated technologies. The need for explicit format for the process of care should be understood by health authorities, patients and their families. **Because most health care units in SSA do not have a multidisciplinary paediatric diabetes team (Paediatric Endocrinologist, Paediatric Diabetes Nurse Educator, Dietician, Psychologist, Social Worker) which is the ideal for designing the program for diabetes self-management, it is important that a team composed of the administrators and the core team looking after T1DM right from the outset of starting a T1DM clinic sit together, design a feasible Diabetes Tutelage Program, and request for input from the EADSG or other centre that give assistance. In this way the care for T1DM in SSA will begin to network and improve.**

The development of a productive relationship between a prepared patient and health care professional, here takes the form a Diabetes Self-Management Tutelage (DSMT). The DSMT is patient–family centred and emphasizes putting in place enabling support structures which include family, patient/caregiver, health care providers and the community to achieve pre-defined goals of care. During the DSMT, the health care team should support the patient and family in developing their self-management skills so that at the completion of the **intensive phase of their treatment, they are well equipped to maintain their control. It is recommended that an assessment of adequacy to maintain control is done and this is documented on a DSMT card.** The patient and family should understand why monitoring blood glucose is an essential component of care. Patients and their families should understand the implications of poor control and the need to achieve good control as soon as the diagnosis is done. Patients and/or their families should give ample time to understand that delay in getting to good control may be associated with irreversible diabetes complications.

The DSMT should be explicit about the interaction with the health care professional and ensure the following are in place:

(i) Continuity – in both dimensions – health care professional and continuity of care in terms of information and planning
(ii) Access to health care professionals (psychosocial support)
(iii) Patient involvement, and
(iv) Care planning.

Clinic notes should document this and the patient given a reward of a card (DSMT-Card) to show they have been mentored successfully. The DSMT should be tailored to the age groups: pre-school (0–5 years), primary education (6–9 years), adolescents (10–19 years) and adults (20+ years). A clear written plan of care at the end of each visit should be produced and understood by the patient and family.

To avoid breakdown of continuity, a formal hand over of a patient to another health care professional should be arranged and become a norm in the clinic practice, when a health care professional is “taking leave” of the patient.

Self-management support should look at technology support; telecare, educational resources; psychosocial support; and social support.

The Chronic Care Model (CCM) approach is recommended for setting up a health facility at the primary health care level. The CCM aims to improve and optimize six key, interrelated elements of the health system: Organization of health care, self-management support, decision support, delivery system design, clinical information systems and community resources and policies. Table 10 below gives the monitoring component, Table 11 the CCM approach components [28] and Table 12 a suggested tutelage curriculum [38 40].

Assessment and Clinical Audit Measures

Evaluation should focus on the extent by which a healthcare organisation delivering diabetes care for patients with T1DM has invested time and resources to ensure that education and other support materials are 'fit for purpose'. This will include the extent of promoting individualised education plans, making education materials sensitive to the presence of conditions that influence learning such as visual health or other sensory impairments, and the appropriate insulin regimen / self-monitoring of blood glucose and blood ketone. Audits should also focus on the level of knowledge, ability to problem solve and degree of confidence that the individual with T1DM and their care giver(s) have.

General Recommendation

- All patients with T1DM should have a written management plan that reflects the outcome of a comprehensive and integrated assessment of need, including the type of support they will get
- Structured diabetes education should be offered to all T1DM and their families / carers, including *diabetes tutelage*
- Education should be individualized, include goal setting and focus on safety, risk management and complication prevention
- Monitoring of blood glucose should aim at getting a pattern that scans over the day than aiming at fasting blood glucose - the frequency is individualized
- Education strategies focusing on monitoring blood glucose and / or blood ketones and administration of insulin by others must be considered as an integral component until the patient self-cares.
- There should be a regular review of self-care behaviours and abilities that may influence goal attainment by the management plan.
- All T1DM require individualized plans that include:
  - Insulin regime;
  - Blood glucose and blood ketone monitoring;
  - Hypoglycaemia treatment and prevention;
  - Sick day management.

Table10: Template for the diabetes tutelage

Name:					**Date of Birth:**			**Sex:**	
Health Facility:					**Reg No.:**				
Visit Date	**Values**	**Weight (Kg)**	**Height (cm)**	**BP (mm/Hg)**	**Last Month Average**		**HbA1c (%)**	**CHOL (mmol/L)**	**Physical Activity (minutes/ day)**
					FBG	**RBG**			
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
	This Visit								
	Target Next Visit								
MEDICATIONS									
Visit Date	Insulin Dose Prescribed					Other Medication			
	Morning	Afternoon		Evening					
Level of understanding of diabetes:					◻ Poor		◻ Satisfactory		◻ Good

Table 11: Key Elements in the setting up a clinic for Type 1 Diabetes

Element of care	Implementation of Care Element
Organization of Health Care	• Health facility directly accessed by community • Linkage of community facilitated by community health workers (CHW) • Health facility refers to higher level and this link should be formalized with log book of out and report back
Self-Management Support	• Education programs • Tele-support from diabetes nurses and other professionals • Psychosocial interventions: psychology and psychiatry with targeted behaviour change interventions • Support from patient organizations, schools, community
Care Delivery Design	• Multidisciplinary input (diabetologist, diabetes nurse specialist and dieticians). As these are not easily available, we suggest mentorship from the higher centre using interception and perception visits
Clinical Information Systems	• The goal should be to use Electronic Health Care Records. When not available, clear clinical records to be kept at facility, and every visit patient to go home with clear summary of the current visit management plan
Clinical Decision Support Systems	• Technology for assessing blood glucose performance. SMBG in patient's log book and HbA1c records should be entered in patient's log book and in clinic files. Multidisciplinary review
Patient/ Health Professional Interface	• Patient given care objectives by clinical team documented in a summary form of the management plan that is retained by patient and reflected in patient's clinical notes. More in depth management details where appropriate- like pumps/ complications

Table 12: Curriculum of insulin dose adjustment training program

Time	Day 1	Day 2	Day 3	Day 4	Day 5
09:00–10:30	Introduction to the course: What is diabetes Diagnosis Signs & Symptoms Natural History	Part II: Meal planning Carbohydrate portion / insulin ratio. Counting grams of carbohydrate in local foods	Discuss blood glucose levels. Practice adjusting insulin.	Friends invited. Discuss blood glucose levels. Friends discuss the meals.	Discuss blood levels. Healthy eating. Sweets and Entertainments.
10:30–10:45	Break	Break	Break	Break	Break
10:45–12:00	Part I: Meal Planning Types of Food Introduce insulin / carbohydrate relationship using Food Records	As a group discuss individual blood glucose levels. Insulin: Actions, timings and types	Diabetes and long-term health	Hypoglycaemia. Social issues. Poster display	The future. Discuss school packs. Recap weeks learning objectives.
12:00–13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00–14:30	Monitoring diabetes control (Blood glucose, Urine Ketones, HbA1c), Other Process Measures Recapping days objective All participants to return following week with a week's food record	Practical session using the Lunch example for dose adjustment Recap objectives of the day	Parents, Peers, Mentors invited on day basis. Sick day rules	Exercise, theory and practical	Parents' discussion. Evaluation Children's Presentations
14:30–14:45	Break	Break	Break	Break	Break
14:45–16:00	Parents, Peers, Mentors invited on day basis for mentoring. Evaluation. Return after 1 week.	Hypoglycaemia Plan evening insulin dose. Evaluation Return after 4 weeks	Correction doses. Planning of evening insulin dose. Evaluation Return after 4 weeks	Guest speaker (Mentor) invited on day basis. Plan insulin dose. Evaluation Return after 4 weeks	Parents' discussion. Children's Presentations continued. Finish

Sick Day Rules

Management of Children with Type 1 Diabetes Admitted in Hospital

- Close monitoring is required in all children admitted to hospital with a concomitant illness. Insulin requirements may increase as a result of infection or change in diet. There is a tendency to give a lot of juices for patients admitted, which result in hyperglycaemia.
- Hypoglycaemia is common, as patients may have no appetite and consume little food and would have taken the shots of insulin prior.

Sick with fever

- Acute illness and fever raise stress hormones including cortisol, glucagon
- Stress hormones promote insulin resistance and gluconeogenesis and lead to raised blood glucose and even DKA if insulin dose is not adjusted
- Management:
- Drink more to prevent dehydration
- Sugar free fluids if BG is > 10 mmol/L
- Sugar containing fluids if BG is < 10 mmol/L
- Fever 38°C: give 10–20% more insulin per 24hrs (TDI)
- Fever > 39°C: may require as much as 50% more of TDI
- Start with the normal dose of insulin
- A child in the honeymoon period may need to increase the dose up to 1 unit/kg/day
- Check BG every 2–4 hour and ketones in urine or blood 1–2 times per day
- Do not increase the insulin dose more than0.1u/kg

Sick with gastroenteritis

- Vomiting and/or diarrhoea
- Have lower blood glucose levels due to:
- Decreased food intake
- Poor absorption
- Slower emptying of the stomach
- Management:
- Monitor BG carefully (2–4hrly, or at shorter intervals if concerned)
- Check for ketones (starvation)
- Vicious circle with ketones (nausea – eat less – more ketones)
- BUT NEVER OMIT INSULIN
- If 2 – dose daily injections is used, exclude the regular insulin
- NPH dose might also be decreased to prevent hypoglycaemia
- If MDI, exclude the rapid acting insulin (or reduce the pre-meal dose by 1–2 units)
- Reduction of total daily insulin dose by 20–50%

Management in Hospital for Surgery

The objective of glycaemic management during surgery are to maintain normal glucose levels and normal metabolism. Insulin resistance and gluconeogenesis will increase during stress. For this reason, the customary basal insulin dosage is the minimum requirement during the perioperative period. Additional insulin also will be needed to prevent excessive hepatic glucose release and decreased peripheral utilization while maintaining normal glucose levels and normal fluid and electrolyte balance. Perioperative hyperglycaemia will delay healing and increase the risk of infection and ischaemia. Plasma glucose levels between 5.5–8.5 mmol/l during and after the operation may be a reasonable target range for patients who are less critically ill.

Surgery

- Surgery is more complicated when the patient has diabetes
- Need to monitor continuously
- Risks for hypoglycaemia (because of missing meals) or hyperglycaemia (because of taking a lot of juices)
- Presence / absence of ketones
- Elective surgery only at a centre with expertise in treating children with diabetes

General principles

- Correct DKA/ketosis before surgery
- First on a surgical list (ideally morning)
- Maintain blood glucose of 5.5 –8.5 mmol/l during and after surgery
- Frequent monitoring (2hourly)
- May need repeated doses of short-acting insulin and maintenance IV fluids
- No solid food for 6 hours before general anaesthesia

Minor procedures

Rapid recovery anticipated

- Early morning procedure
- Delay insulin and food until completion of the procedure
- Check blood glucose 0–1 hour pre-operatively
- After surgery, check glucose, give full dose of insulin and food

Rapid recovery and/or early feeding may not occur

- Give 50% of usual insulin dose
- Monitor glucose 2 hours pre-operatively
- If glucose above 10 mmol/l: Give dose of short-acting insulin (0.05 U/kg) OR Start insulin infusion at 0.05 U/kg/hour
- If glucose <5 mmol/l, start IV dextrose (5 or 10%) infusion

Post-operative care

- Check blood glucose hourly
- Start oral intake or continue IV glucose
- Give small doses of short-acting insulin for hyperglycaemia or for food intake
- Give the dinner time or evening dose of insulin as usual
- Because of post-op DKA possibility, more overnight blood glucose monitoring at home or admit to hospital(2hourly)

Major surgery

- For emergency major surgery
- Consider transfer to a centre with expertise in treating children with diabetes
- If unable to transfer to a centre with appropriate expertise take the child to operating theatre and start DKA protocol

Elective surgery

- First on surgical list (ideally morning)
- If control is uncertain or poor, admit for stabilisation of glycaemic control
- If diabetes is well controlled, admit to hospital on the day before surgery
- Only consider surgery once diabetes is stable

Pre-operative management

In the evening before surgery

- Frequent blood glucose monitoring
- Usual evening insulin(s) and snack
- Short-acting insulin to correct high blood glucose values every 3–4 hours
- Keep nil by mouth from midnight
- If the child develops hypoglycaemia, start an IV infusion of dextrose (5–10%)

Intra operative; post-operative

- On the day of surgery
- Omit usual morning fast or rapid insulin
- Consider decreasing or omitting intermediate or long-acting morning insulin
- Instead give insulin by IV insulin infusion at 0.05 U/kg/hour
- OR Repeated doses of short-acting insulin every 3–4 hours
- Give IV fluids (half normal saline with 5% dextrose).
- Check blood glucose and electrolytes (2 hourly)
- DKA can occur during or after surgery
- Monitor glucose1–2 hourly before surgery
- Every 30 minutes during surgery
- Hourly post-operatively
- Aim for 5–10 mmol/l
- Adjust rate of insulin and dextrose-saline
- Feed and start regular doses of insulin once awake
- Monitor ketones if glucose is >15 mmol/l

Children who undergo religious and cultural practices

- In some religious and cultural practices (eg male or female circumcision, induction ceremony for puberty) alcohol, traditional drinks or herbal combinations should be restricted.
- Male circumcision should be done in a health facility and all precautions taken to have this done when blood glucose control is adequate and sterile conditions prevail. Female circumcision (genital mutilation- FGM) is strongly discouraged. Alcohol and other drinks of unknown content and composition are strongly discouraged.

Psychosocial Support

It takes a '*village to raise a child*' is an African proverb which means that it takes an entire community of different people interacting with children in order for a child to experience and grow in a safe environment. For a child or adolescent with T1DM to achieve the glycaemic targets and prevent complications, he or she needs the support of every individual that interacts with him or her for prolonged period of time.
The team includes:

a) The child or adolescent
b) Caregivers and family members:
c) School: Teachers, School nurses
d) Community: Friend's, religious or community institutions, social clubs

The Child or Adolescent with Diabetes

The diagnosis of T1DM has an immediate impact on both the child and family. It is not uncommon for both the child and the family to find themselves in *a state of shock*. It takes approximately 6–9 months for children to adjust to the diagnosis. However, each age requires different interventions to assist with acceptance and adjustment to the diagnosis and management.

Infancy and toddlers

Infancy and toddler stages are characterized by more rapid changes in behaviour and development. Although insulin administration and careful monitoring of blood glucose are a necessity, these should be carried out with the least discomfort possible to ease the psychological adjustment to invasive and potentially uncomfortable procedures.

School children and adolescents

Children and adolescents with diabetes must contend with a range of issues and feelings that vary with each developmental stage. Feeling different from their peers is the most issue they face. HCP must acknowledge these feelings and refer for counselling. Positive reinforcement by parents/caregivers and peer support groups are interventions that support the motivations.

Caregivers and Family Members

In several parts of SSA, families live amongst the extended community/relatives. Research has shown that families play the key role in the adjustment of children to diabetes, to their level of care, and to their specific management regimens. The impact of diabetes depends on children's and families' perceptions and knowledge of self-care and self-management, as well as on the background, structure, and functioning of families as a whole.

Recommendations

1. HCP should involve the family and family members in diabetes education and management. They should emphasize the critical role they play in achieving glycaemic targets.
2. Parents/carers should be connected with volunteer parent mentors in the community at diagnosis. The parent mentor should then follow up with the parent for the 1st year after diagnosis.
3. HCP should guide in the transition of roles through the various phases:

Infants and children 0–5 years

Parents are encouraged to take on management completely and to let children help with tasks when they are interested.

School aged children

Parents should remain in the management as much as possible. Studies have shown greater parental involvement is associated with better outcomes. Children should be educated on basics of diabetes management especially how to recognize and treat hypoglycaemia. They should be encouraged to take up more responsibility with the management of TIDM.

Adolescents

Positive family support and involvement with decreased diabetes-related family conflict is associated with improved adherence to adolescent diabetes self-care.

The HCP should guide the parent in renegotiating the role of the adolescent in diabetes management.

1. Parents/carers should be encouraged to participate in support groups for the various age groups
2. Parents should be assessed for diabetes related distress or depression biannually. If the parents are noted not be adjusting, they should be referred to mental health department for evaluation.

Diabetes in Schools

Children and adolescents spend approximately 8 hours a day for two thirds of the year during which time they will be under the care and support of the school personnel. It is the time where they learn, make friends, have fun and find peer groups. However, in SSA children and adolescents with diabetes find themselves excluded, isolated or stigmatized. HCP together with the family, the community and the school authorities should create a safe environment for children with T1DM, so that they receive the same education opportunities as other children in the community. Most schools in SSA do not have a school nurse; and therefore, a need to train teachers in the school, to have some basic skills in the management of T1DM. Diabetes at school is explained in more detail later.

Recommendations:

1. At diagnosis the parents or caregivers should communicate with the school administration concerning the diagnosis of diabetes.
2. The family together with the HCP team should train both the school administration and teachers on basic management of diabetes: The training should include:
   a) What is Diabetes?
   b) Signs and symptoms of diabetes
   c) Insulin and Insulin administration
   d) Blood glucose testing and interpreting the blood sugar readings according to the diabetes management plan (DMP)
   e) Hyperglycaemia symptoms and management of hyperglycaemia
   f) Hypoglycaemia symptoms and management of hypoglycaemia
   g. Physical activity and its effect on blood sugar reading.
3. The HCP should submit an individualized DMP for the child as guide for the teacher to follow for the day to day at school activities.
4. The school should provide a safe place to store medication and supplies especially during the hot seasons
5. A safe place with adequate privacy should be identified for both blood sugar testing and insulin administration

Community

Educating the community that the child or adolescent interacts with on diabetes and its management creates a conducive and supportive environment for the management of diabetes. They should be educated on the signs and symptoms of diabetes and its management. The child or adolescent should be encouraged to share the diagnosis with close friends. He/she should educate them on diabetic emergencies: (hypoglycaemia/hyperglycaemia and their management)

Physical Activity, Exercise and Life Style Modification

Physical Exercise

Definitions

Aerobic (cardiovascular) fitness is one of the most important components of physical fitness. The other components are muscular strength and endurance, and flexibility and low-back function. Muscular fitness and cardio-respiratory fitness are independently associated with metabolic risk of insulin resistance and therefore of type 2 diabetes. Adolescents with T1DM have insulin resistance on par with obese non-diabetic peers and children and adolescents with T1DM are less fit than their non-diabetic peers, particularly if they are in poor glycaemic control [39 41].

Aerobic exercise (also known as cardio) is any type of physical activity that uses the large muscle groups, is rhythmic in nature, and can be sustained for at least 10 minutes. Walking, jogging, rowing, swimming, cycling, and aerobic dancing are all examples of aerobic exercise that stimulate and strengthen the heart and lungs, thereby improving the body's utilization of oxygen and maintaining health. During aerobic exercise the body must supply fuel for working muscles. The muscles will require more oxygen during this phase. The heart beats faster and the lungs breathe deeper to deliver oxygen through the small blood vessels to muscles. Generally, light-to-moderate intensity activities that are sufficiently supported by aerobic metabolism can be performed for extended periods of time. Vigorous activities, however, can be performed only for a short time and depend on anaerobic respiration, without oxygen. During aerobic respiration, carbon dioxide, water, and energy are produced whereas during anaerobic respiration, lactic acid, ethanol and energy are created.

Aerobic exercise can help lower cholesterol, reduce risk of type 2 diabetes, improve immune function, lower blood pressure, help lose, control or maintain weight, improve the fitness of the heart and lungs and can help to alleviate muscle pain and soreness. Physical activity continues to be the most effective way to combat coronary heart disease.

Anaerobic exercise is a physical exercise intense enough to cause lactate to form and is used to promote strength, speed and power. Any exercise that consists of short exertion, high-intensity movement is anaerobic. Examples include heavy weight training, sprinting (running or cycling) and jumping. Heavy weight training is an excellent way to build strength and muscle mass.

Muscular Strength is "The maximum force that can be generated by a muscle or group of muscles in one single contraction". Muscle strength is necessary for all daily movement and to build and maintain strong bones, regulate blood sugar and blood pressure, and help maintain a healthy weight. Examples of muscle-strengthening activities include: carrying or moving heavy loads, such as groceries, doing exercises that use your own body weight for resistance (e.g. push-ups and sit-ups), activities that involve stepping and jumping (e.g. dancing), working with resistance training using elastic bands, heavy gardening, such as digging and shovelling, climbing stairs, hill walking and cycling. Muscle-strengthening exercises are counted in repetitions and sets. A repetition is 1 complete movement of an activity, like a sit-up. A set is a group of repetitions. For each strength exercise, try to do at least 1 set with 8 to 12 repetitions in each set. To get health benefits from strength exercises, you should do them to the point where you struggle to complete another repetition.

Moderate activity will raise your heart rate, and make you breathe faster and feel warmer. One way to tell if you're working at a moderate level is if you can still talk, but you can't sing the words to a song.

Vigorous activities (jogging or running, swimming fast, riding a bike fast or on hills, football, skipping rope) makes you breathe hard and fast. If you're working at this level, you won't be

able to say more than a few words without pausing for breath. One minute of vigorous activity provides the same health benefits as 2 minutes of moderate activity.

Recommended physical activity for children and young people

- **All children and young people should planned engage in moderate to vigorous intensity physical activity for at least 60 minutes and up to several hours every day, with at least 20 minutes daily of vigorous activity.** Moderate intensity physical activities will cause children to get warmer and breathe harder and their hearts to beat faster, but they should still be able to carry on a conversation (e.g.,. bike riding and playground activities)
- **Vigorous intensity activities, including those that strengthen muscle and bone, should be incorporated at least three days a week.** Vigorous intensity physical activities will cause children to get warmer and breathe much harder and their hearts to beat rapidly, making it more difficult to carry on a conversation (e.g.,. fast running and sports such as swimming or football). Physical activities that strengthen muscle and bone involve using body weight or working against a resistance (e.g.,. swinging on playground equipment, hopping and skipping, and sports such as gymnastics or tennis).
- **All children and young people should minimize the amount of time spent being sedentary (sitting) for extended periods.** This may involve reducing time spent watching TV, using the computer or playing video games and breaking up sedentary time such as swapping a long bus or car journey for walking part of the way. Sedentary behaviour is now considered an independent risk factor for ill health, no matter how much exercise one does and sedentary time is linked to elevated HbA1c levels.

Note:

- Moderate exercise should be in addition to daily activities such as casual walking, shopping, cooking or housework, or taking out the rubbish because their effort isn't enough to raise the heart rate. Brisk walking that raises the heart rate, for 10 minutes at a time, can be accumulated toward the 60-minute minimum.
- Daily activities however, are still important, as they break up periods of sitting.
- Muscle-strengthening exercises are not an aerobic activity, so they will need to be done in addition to the 60 minutes of aerobic activity. Some vigorous activities count as both an aerobic activity and a muscle-strengthening activity. Examples include: running, football, rugby, netball.

These activities should become habitual i.e. including activities performed during leisure time plus structured activities like regular exercise, sports, and some specific school-related activities such as physical education lessons.

Some of the benefits of exercise include weight control, reducing the amount of fat and increasing the amount of lean tissue: muscle, fibres, and bone, increased bone mineral content, reduced cardiovascular risk, and improved sense of wellbeing. This increases the metabolic rate, reduces blood pressure and Low-Density Lipoprotein (LDL) cholesterol, and increases HDL, reducing the risk of cardiovascular morbidity and mortality.

- For people with T1DM, evidence suggests a beneficial effect of exercise on HbA1c, especially in youth:
- A twice-per-week 16-week resistance training program significantly increased insulin sensitivity in overweight adolescents independent of changes in body composition.
- Regular exercise performed at least two times a week for at least 8 weeks was associated with a significant absolute reduction in HbA1c.
- The frequency of regular physical activity was associated with lower HbA1c without increasing the risk of severe hypoglycaemia.

- The overall effect on HbA1c ranges from -0.5% - -0.8%, an amount that should decrease the risk of diabetes complications.

Exercise physiology

The normal physiological responses to moderate intensity aerobic exercise in the non-diabetic individual include:

- **A reduction in insulin secretion** and an increase in glucose counter-regulatory hormones (catecholamines, growth hormone, cortisol) facilitating an increase in liver glucose production that matches skeletal muscle glucose uptake during exercise.
- An increase in non-insulin dependent glucose uptake into muscle, even when insulin levels are low and remain high during recovery of exercise.

This autonomic and endocrine regulation is precise and blood glucose levels remain stable under most exercise conditions.

In T1DM, **the pancreas does not regulate insulin levels** in response to exercise and as a result, hypoglycaemia or hyperglycaemia commonly occurs during or soon after exercise. Under conditions of intense exercise, counter regulatory hormones rise, as does circulating lactate, all of which are associated with increases in glucose production by the liver relative to muscle glucose uptake. This can result in a transient rise in glucose levels even in non-diabetic children. The rise in blood glucose can be protracted in youth with T1DM unless insulin is administered.

The impact of exercise on blood glucose levels

The **duration, intensity, and type** of exercise are all known to affect blood glucose response to exercise. Overall, there appears to be an inverted U-shape in the relationship between aerobic exercise intensity and muscle glucose disposal, with the highest risk for hypoglycaemia likely occurring at about 50% of the individuals' maximal aerobic capacity.

- In adolescents with T1DM exercising in the late afternoon, insulin sensitivity is elevated during and immediately after exercise and from 7 to 11 hours during recovery. In contrast, exercise performed earlier in the day results in heightened insulin sensitivity throughout 11 hours of recovery, without an obvious biphasic response in sensitivity.
- In practice, exercise for >1 hour appears to lead to increased insulin sensitivity during recovery and therefore an increased risk for hypoglycaemia for the next 12 to 24 hours, often occurring during evening after exercise. This means that adolescents who only exercise on occasion can have difficulty in managing their basal insulin. If hypoglycaemia is frequent, then it may be better to limit vigorous exercise to every other day rather than daily, if possible. If not, a strategy for altering basal insulins to cope with the widely varying insulin sensitivity is needed.
- In general, aerobic exercise is associated with decreasing glucose values both during (usually within 20–60 minutes after the onset) and after the exercise.
- However, when plasma insulin is at near basal levels, blood glucose level often remains stable or fall at a low rate in response to exercise of moderate intensity
- Intense aerobic exercise under basal or near basal insulinaemic conditions is associated with a rise in blood glucose level.
- Brief very high intensity or anaerobic exercise, particularly if performed under basal insulin conditions, is associated with increasing glucose values.
- However, if plasma insulin levels are elevated, all forms of exercise are likely to cause a fall in blood glucose levels, and most activity lasting >30 minutes is likely to require a reduction in insulin delivery, or some adjustment to carbohydrate intake to preserve euglycaemia.
- Real-world physical activity for many children and adolescents consists of spontaneous play, and/or team and field sports, all of which may be characterized by repeated bouts of relatively intense activity interspersed with low to moderate intensity activity or rest. This

type of “interval” or intermittent activity has been shown to result in a lesser rate of fall in blood glucose level compared to continuous moderate intensity exercise, both during and after exercise.

- Intense efforts, such as cycling or running sprints performed after moderate-intensity exercise (approximately 40% of VO2 max) prevents a further decline in blood glucose for at least 2 hours after exercise when exercise is performed under mildly hyperinsulinaemic conditions. Team games may last up to 90 minutes and typically these kinds of sports include repeated bouts of sprints, blood glucose responses therefore may be as described above.
- Anaerobic efforts lasting only a short time (seconds to minutes) may increase blood glucose levels. In general, the rise in blood glucose is transient, lasting typically 30 to 60 minutes during and after a sprint performed in a basal insulinaemic state. Importantly, it may be followed by hypoglycaemia in the hours after finishing the exercise, especially where over-aggressive post-exercise correction boluses are given.
- Timing of the exercise influences the results:
  - Morning activity before breakfast and bolus insulin administration reduces the risk of acute hypoglycaemia as circulating insulin levels are typically low.
  - Furthermore, timing exercise earlier in the day may be an adequate strategy to avoid nocturnal hypoglycaemia.

Prevention of Exercise-Induced Hypoglycaemia

In people with diabetes, hypoglycaemia is the most feared side effect of exercise: it compromises both exercise performance and cognitive function. Hypoglycaemia may be anticipated during or shortly after exercise but is also possible up to 24 hours afterward due to increased insulin sensitivity.

- Glucose requirements for maintaining stable glucose levels in adolescents with diabetes are elevated during and shortly after exercise, as well as from 7 to 11 hours after exercise.
- Hypoglycaemia is less likely with high intensity exercise than with moderate intensity effort.
- There is minimal data to support an increased risk of hypoglycaemia with less than 30 minutes of activity: glucose monitoring is recommended at 30-minute intervals to detect risk of alternatively existing hypoglycaemia.
- Exercising in a high insulin state (e.g. postprandial) increases the risk of hypoglycaemia. In this situation carbohydrates supplementation may be needed to reduce hypo risk.
- In adults, repeated episodes of hypoglycaemia in a sedentary state result in an attenuated counter-regulatory response to subsequent exercise and increases the risk for hypos. Hence, two to three times more exogenous glucose may be needed to maintain euglycemia during exercise following a previous exposure to hypoglycaemia.
- Blood glucose level less than 6.6 mmol/l (120 mg/dl) at the start of exercise is associated with high risk of hypoglycaemia that frequently needs more than 15 g carbohydrate to restore to normal.
- Exercising for 60 or more minutes without adjusting the insulin dose for the activity is associated with high occurrence of hypoglycaemia preventable by consuming additional carbohydrate at a rate equal to carbohydrate utilization during exercise (approximately 1 g of carbohydrate per kilogram body mass per hour).

Late hypoglycaemia

- Hypoglycaemia may occur several hours after exercise, especially when this has been prolonged and of moderate or high intensity due to:
  - the late effect of increased insulin sensitivity
  - delay in replenishing liver and muscle glycogen stores and
  - attenuated glucose counter-regulatory hormone responses, especially during the night.

- A single bout of exercise can increase glucose transport into skeletal muscle tissue for at least 16 hours post-exercise in non-diabetic and diabetic subjects.
- Without altering the basal overnight insulin, twice as many people may get a hypoglycaemic event on the night after an exercise day compared to the night after a sedentary day.
- Late hypoglycaemia is still common after intermittent high intensity exercise, even when hypoglycaemia occurs during exercise, perhaps due to the greater need for glycogen replenishment for the next 24 hours. The likelihood of late hypoglycaemia may be greater after intermittent high intensity than lower/moderate intensity exercise.
- The amount of automatically delivered nocturnal basal insulin to maintain euglycemia is approximately 20% lower after an exercise session compared with a sedentary day.
- If using multiple daily injections, a similar 20% reduction in basal analogues is similarly effective in reducing the risk of delayed post-exercise nocturnal hypoglycaemia.

Prevention of post-exercise hypoglycaemia

- Risk of post exercise nocturnal hypoglycaemia is high, and care should be taken if bedtime blood glucose level is <7.0 mmol/L (126 mg/dl). However, no specific bedtime glucose value guarantees that nocturnal hypoglycaemia will be avoided.
- Extra carbohydrate after the activity may be the best option to prevent post-exercise hypoglycaemia when short duration and high intensity anaerobic activities are performed under hyperinsulinaemic conditions but is less likely to prevent delayed nocturnal hypoglycaemia without appropriate insulin adjustment.
- Short sprints added to aerobic exercise can reduce the risk of hypoglycaemia early (<2 hours) after exercise if the person is mildly hyperinsulinaemic.
- No person with diabetes should exercise alone, or “decide” not to have regular snacks when they are needed. If young people with diabetes are together on holiday, they should stay in groups of at least four, so that two can accompany each other if they need to alert adult helpers to the occurrence of an accident or hypoglycaemia.
- Glucose tablets, glucose gel or some form of rapidly absorbed sugar should always be carried by young people who exercise or, at a minimum, kept within a reasonable distance of the activity.
- To treat hypoglycaemia with a rise in blood glucose of approximately 3 to 4 mmol/L (55–70 mg/dl), approximately 9 g (0.3 g/kg) of glucose is needed for a 30 kg child and 15 g for a 50-kg child.

Insulin regimen should be tailored to activity

- Most activity lasting >30 minutes is likely to require a reduction in insulin delivery, or some adjustment to carbohydrate intake to preserve euglycaemia.
- When exercise is planned at a time of peak insulin action, typically after a meal with rapid acting bolus insulin administered, a marked reduction in insulin dose should be made.
- Insulin should not be injected in a site that will be heavily involved in muscular activity. A cyclist may achieve more consistent response by choosing to inject in an arm or the abdomen rather than a leg before an event.
- The rise in blood glucose level during or after intense exercise may be treated by giving a small additional dose of rapid-acting insulin - for example, 50% of the usual correction bolus when levels are >14 mmol/l (252 mg/dl).
- The risk of nocturnal hypoglycaemia is increased after afternoon exercise. Similarly, morning exercise tends to lower insulin needs in the early afternoon. Two or more activity sessions in a single day promotes increased risk for hypoglycaemia, and in particular nocturnal hypoglycaemia. Hypoglycaemia should be mitigated by basal insulin dose reduction on the day of exercise together with a carbohydrate snack at bedtime, corresponding to 0.4 g carbohydrates/kg.

- Bolus insulin dose reductions after prolonged aerobic exercise may be needed if post-exercise hypoglycaemia typically occurs.
- Exercise with duration <90 minutes could easier be balanced by extra carbohydrate intake.
- Interrupting insulin therapy or omitting insulin doses may result in very low insulin levels and marked rise in plasma glucagon/insulin ratio, a potent activator of hepatic ketogenesis and gluconeogenesis. The resulting severe hyperglycaemia and ketoacidosis can be further aggravated by exercise thus increasing the risk of ketoacidosis-mediated complications.
- All patients should receive specific education regarding time of active insulin, time of peak insulin effect, and total duration as this is important information regarding exercise-related glucose fluctuations. When regular (soluble) insulin has been injected prior to exercise, the most likely time for hypoglycaemia will be 2 to 3 hours after injection, when insulin levels peak. However, rapid-acting insulin analogues peak earlier, at around 60 to 90 minutes, and thus hypoglycaemia risk is earlier when this peak effect coincides with an exercise-mediated glucose reduction. This is particularly so regarding early postprandial exercise, which is common in children and adolescents who by nature exercise mostly later in the day or after school.
- Exercise increases skin and systemic blood flow, along with insulin and glucose delivery to skeletal muscle. Exercise increases the rate of rapid-acting insulin absorption, thereby likely hastening the peak insulin action. Basal insulin absorption, on the other hand, is not significantly increased by exercise. Thus, hypoglycaemia prevention during prolonged aerobic or mixed type exercise typically requires reductions in bolus and basal insulin. Usual recommendations include to reduce rapid-acting analogue exposure prior to exercise lasting longer than 30 minutes.
- High altitude tends to increase the risk for exercise associated hyperglycaemia possibly because of increased stress hormone release, despite the increased activity demands.

Type and timing of food

- Carbohydrate intake may not be required prior to moderate intensity exercise if of short duration (<30 minutes).
- For children and adolescents undertaking daily activities associated with health (60 minutes of moderate and vigorous physical activity daily), daily food intake should be sufficient to meet the demands of the activity provided meals are distributed regularly across the day and an age appropriate amount of carbohydrate and energy are consumed.
- Adequate fluid intake is essential to reduce the risk of dehydration. In most situations water or sugar-free fluids are most suitable for maintain hydration.

Pre-exercise

- When circulating insulin levels are high (postprandial) and pre-exercise insulin doses are not decreased, up to 1.5 g of carbohydrate per kilogram of body mass is recommended per hour of strenuous or longer duration exercise.
- For low to moderate intensity/aerobic exercise of >30 minutes duration under basal insulin conditions, 0.2 to 0.5 g/kg/h may be required to maintain euglycemia, but in some circumstances, or for optimal performance, 1 g/kg/h may be required.

During exercise

- For activities that last 60 minutes or longer, additional carbohydrate may be needed during exercise dependent on blood glucose responses but also on the goal of the exercise. Up to 1.5 g of carbohydrate per kilogram of body mass per hour of exercise can be tolerated.

Post exercise

- Post-exercise ingestion of both carbohydrate and protein maybe beneficial for both hypoglycaemia prevention and muscle recovery. Insulin sensitivity remains elevated for

hours post-activity and early replenishment of glycogen stores helps to reduce the risk of late onset hypoglycaemia. Reductions in basal insulin, low-glycaemic-index snacks (with no bolus), or reduced boluses at post-exercise meals will usually reduce the problem.
- Meals with appropriate carbohydrate and protein content should be consumed within 1 to 2 hours of exercise, taking advantage of the period of heightened insulin sensitivity to help replenish glycogen stores and limit post-exercise hypoglycaemia risk.
- Adding protein to the post-exercise meal increases the glucose uptake and enhances glycogen synthesis in healthy individuals. Added protein will also stimulate muscle recovery post-exercise.
- Children with diabetes should consider consuming a source of dietary protein after physical activity to enhance whole-body anabolism.
- Alcohol inhibits gluconeogenesis, increasing the risk of hypoglycaemia (especially night time) and is best avoided when participating in exercise, especially as alcohol may also impair performance. After exercise if alcohol is to be consumed it should be combined with a high glycaemic index carbohydrate meal.

At bed-time

- A carbohydrate, fat, and protein snack (avoiding high saturated, high sugar items) at bedtime may limit nocturnal hypoglycaemia caused by daytime exercise.

Summary recommendations for avoiding hypoglycaemia in physically active people

- At start of exercise, consider several factors that can affect glucose control
  - time since most recently given bolus dose/insulin, and possible adjustments of basal/long-acting dose
  - previous and more recent trends in glucose concentration
  - experience the individual has from previous occasions of the same kind of physical activity.
- Start in target metabolic control (no hyperglycaemia, no elevated ketones), and measure glucose before start of exercise
- Always have a carbohydrate during exercise
- Increase the intensity and/or the duration of the exercise progressively
- In the few hours preceding the exercise, ingest slowly absorbing carbohydrates
- In the case of unforeseen physical activity decrease the insulin dose during and after intense muscular activity
- Do not inject insulin at a site that will be heavily involved in muscular activity
- When physical activity is planned at a time of peak insulin action, a marked reduction of the insulin dose should be made
- If the activity is prolonged, add glucose sweetened water or carbohydrates before, during and after the exercise
- Measure the blood glucose value before bedtime on the evening after major physical activity and make sure to add extra carbohydrates and/or reduce long-acting/basal dose to reduce the risk of nocturnal hypoglycaemia
- Evaluate the effect after every modification in insulin dose and every change regarding carbohydrate supplementation or change in nutritional status
- Make the people accompanying you aware of the procedures and treatment of severe hypoglycaemia.
- Participation in almost any sport or exercise is likely to be safer in company, but for the person with diabetes this is even more important. At very least, one companion should know something about diabetes and how to recognize and manage hypoglycaemia. Every participant in a sports team should be aware of a person with diabetes and know where to find the person's hypoglycaemia remedies.

- It is good practice to have a "Diabetes ID" somewhere on the body—preferably in the form of a durable bracelet or necklace.
- The signs and symptoms of exhaustion and hypothermia could easily be confused with hypoglycaemia. It is always safer to assume that the latter is making some contribution and to check blood glucose or treat expectantly.

Hyperglycaemia

Hyperglycaemia might occur due to the following

- stress release of catecholamines (during exercise of high intensity or competition in sports)
- after excessive carbohydrate intake
- too large insulin dose reductions

In these situations, consider a lesser reduction of insulin dose pre-exercise.

Ketones

- It is a relatively common misconception that no insulin is needed when prolonged exercise is to be undertaken.
- Blood ketone levels >0.5 mmol/l are abnormal in children with diabetes.
- Patients can be reassured that reducing insulin down to 25% of pre-exercise doses does not make later ketosis more likely.

Contraindications to exercise

- Patients who have proliferative retinopathy or nephropathy should avoid resistance-based exercise or anaerobic exercise that results in high arterial blood pressure (systolic pressure >180 mm Hg), such as lifting heavy weights (or any tasks in which a Valsalva manoeuvre is involved) or performing high-intensity sprints or a cold bath after a sauna.
- Patients with peripheral neuropathy should be careful to avoid blisters and cuts and should avoid running and other sports that involve excessive wear of legs and feet.
- Moderate to vigorous physical activity should be withheld in the following situations:
  - High glucose (>14 mmol/l) and high ketone levels (ketonuria or ketonemia> 0.5 mmol/l). Give an insulin bolus using half the usual correction factor (or 0.05 U/kg) and postpone exercise until evidence of ketonemia has cleared.
  - Severe hypoglycaemia (blood glucose ≤2.8 mmol/l [50 mg/dl]) or an event including cognitive impairment requiring external assistance for recovery within the previous 24 hours. Hypoglycaemia (blood glucose <4.0 mmol/l), occurring recently before planned exercise carries an increased risk for recurrent hypoglycaemia, and calls for careful glucose monitoring and avoiding risky activities.

Planning the initiation of exercise in sedentary people with Type 1 Diabetes

- Identify barriers that might reduce chances of success (fear of hypoglycaemia, knowledge gaps, parental barriers, personal fears of embarrassment, body image concerns)
- Set a specific goal (improved fitness, better glucose control, weight loss, safety vs performance)
- Plan the schedule of exercise where possible (e.g., every day, 3 days per week)
- Discuss:
  - the type of exercise and how this affects glucose levels differently
  - time of day, especially if exercise will be close to meals or in the evening
  - delayed glycaemic excursions and plan to avoid post-exercise nocturnal hypoglycaemia
  - specific glucose monitoring plan (when to check glucose before, during and after exercise
- Plan:
  - pre-exercise meal and insulin dose (timing and any dose adjustment)

- basal injected insulin dose adjustment, or pump basal rate adjustment so that it is active during the desired period
- post-exercise meal and insulin dose (timing and any dose adjustment)
- time to review glucose data around exercise with care team such that modifications can be made
- review of overall insulin doses after 1–2 weeks as insulin sensitivity changes (3 months later at the next clinic visit is not soon enough) [39 41]

School activities and diabetes camps

- For many, all that will be required for a 30-minute recess break is a small snack of 10 to 15 g carbohydrate, for example, a fruit, dried fruit, a cereal, fruit or sports bar. Chocolate contains fat which will cause the sugar to be absorbed more slowly.
- For longer periods of physical activity (>60 minutes), a reduction in basal insulin by 30% to 50% should be considered, along with carbohydrate snacks being provided.
- Camps for children with diabetes that include counselling on nutrition and insulin adjustments for exercise can result in improved glycaemic control. Insulin doses may have to be reduced substantially to prevent hypoglycaemia in a camp setting, especially in children not accustomed to physical activity, and it is wise to begin with a 20% to 25% reduction in total daily dose.
- When being physically active for a prolonged period, on an outdoor camp, for example, insulin sensitivity will increase after 1 to 2 days which will probably call for substantially lowered insulin doses (decreased by 20% or sometimes even 50%, especially if not used to hard physical exercise). The increased insulin sensitivity will continue for at least a couple of days after returning home [39 41].

Establishing an effective exercise program

- Adhering to the following helps in establishing an effective exercise program:
- Sedentary lifestyle behaviours should be routinely screened for and discouraged in the diabetes clinic
- Children, adolescents, and relevant family members should be provided with user-friendly evidence-based guidelines focusing on blood glucose management in exercise
- Written advice about exercise and sports should be included within the school management plan for carers/teachers.
- Careful advice and planning on exercise and management is essential
  - Type and amount of carbohydrate required for specific exercise.
  - Percentage reductions in insulin before exercise
  - When best to exercise safely
- Patients should be encouraged to keep careful notes of:
  - what they do (timing, duration and intensity of physical activity)
  - strategies used to maintain glucose concentrations in the normal range including what carbohydrate was taken
  - blood glucose responses before, during, after and several hours after the end of exercise and at bedtime with attention paid to the direction of change in glycaemia.
- These records are important for blood glucose management and clinical advice and accurate record keeping will allow individualized and fruitful consultation.
- High glycaemic index snacks should be readily available during any form of physical activity. High glycaemic index snacks and hyperglycaemia remedies should always be readily available at school.
- Advice about safety should be given: children and adolescents should be encouraged to wear or carry diabetes identification when exercise is performed in the absence of a responsible

adult. Counselling should include consideration of access to a mobile or alternative communication method in case urgent help is required [39 41].

Exercise monitoring

Many applications for smartphones and wearables are freely available for monitoring and encouraging adoption of healthy lifestyles. Health practitioners should be aware of them and encourage their use [39].

Hypoglycaemia In Type 1 Diabetes

Assessment and Monitoring

Definition

Hypoglycaemia is a blood glucose level of **3.9 mmol/L or less**. Symptoms occur around <3.5 mmol/l but awareness of symptoms depends on background values; confusion may occur with rapidly dropping blood glucose but also with only modest hypoglycaemic values. Counter regulation in individuals without diabetes begins at <4 mmol/l and the symptoms are due to the bodies' self-correcting hormonal responses (adrenalin).

Hypoglycaemia is one of the most common acute complications of diabetes; may cause severe symptoms (coma or seizures) and limit adequate management of diabetes. Its effective treatment and prevention are therefore key to effective diabetes management.

Worldwide, severe hypoglycaemic events requiring treatment assistance from another person occur at rates of 16–20 per 100 person-years; hypoglycaemic events leading to loss of consciousness or seizure occur at a rate of 2–8 per 100 person-years. Hypoglycaemic events are associated with adverse effects on cognitive function and are associated with 4–10% of type 1 diabetes-related deaths. In resource limited regions, these rates are much higher.

Note that in some patients, symptoms of hypoglycaemia may occur at much higher levels than 3.9 mmol/l. The Whipple triad is characteristically present: documentation of low blood glucose, presence of symptoms, and reversal of these symptoms when blood glucose level is restored to normal. Recent studies show hypoglycaemia is common in T1DM, and knowing underlying cause helps to avoid future hypoglycaemia (Pirie, F.J., et al., *High frequency of hypoglycaemia in patients with type 1 diabetes mellitus attending a tertiary diabetes clinic in Durban, South Africa. Diabetes Res Clin Pract, 2019. 155: p. 107783. doi: 10.1016/j.diabres.2019.107783.;* Woldaregay, A.Z., et al., *Data-Driven Blood Glucose Pattern Classification and Anomalies Detection: Machine-Learning Applications in Type 1 Diabetes. J Med Internet Res, 2019. 21(5): p. e11030. doi: 10.2196/11030.;* Lindner, L.M.E., W. Rathmann, and J. Rosenbauer*, Inequalities in glycaemic control, hypoglycaemia and diabetic ketoacidosis according to socio-economic status and area-level deprivation in Type 1 diabetes mellitus: a systematic review. Diabet Med, 2018. 35(1): p. 12–32. doi: 10.1111/dme.1351*).

Risk factors for hypoglycaemia

- Too little/late food
- Impaired food absorption - diarrhoea and vomiting
- Insulin regimen is changed: too much insulin (dose error or timing)
- Age (younger children, adolescents, long duration diabetes)
- Low HbA1c levels
- Frequent low blood glucose levels
- When awareness of hypoglycaemia is reduced
- During sleep
- Increased activity or exercise

After alcohol - makes it nearly impossible for body to self-correct.

Signs of hypoglycaemia

- Trembling
- Rapid heart rate
- Pounding heart (palpitations)
- Sweating
- Pallor
- Hunger and/or nausea
- Irritability
- Difficulty concentrating
- Blurred or double vision
- Disturbed colour vision
- Difficulty hearing
- Slurred speech
- Poor judgement and confusion
- Dizziness and unsteady gait
- Tiredness
- Nightmares
- Inconsolable crying
- Loss of consciousness
- Seizures
- Irritability

Classification of severity

Mild and moderate hypoglycaemia

- Recognition and self-treatment still present; blood glucose usually <3.9 mmol/l, but > 2.5 mmol/l
- Aware of symptoms: Needs **assistance** to take care of themselves usually

Severe hypoglycaemia

- Loss of consciousness (coma); convulsion, marked confusion; Usually <2.5 mmol/l

Management of Mild Hypoglycaemia

- Treat with sweets, glucose/sugar/honey (1 tablespoon), ½ glass (i.e. 125 mls) of juice or soda (not diet soda). A glass is usually 220–250 mls. In SSA a glass of 500 mls is usually referred to a *mug*.
- Follow up with regular meal or snack
- Immediate and long-term interventions at different levels to manage hypoglycaemia

Management of Severe Hypoglycaemia

- IV glucose (3 ml/kg of 10% dextrose; 1 ml/kg of 50% dextrose) using a large vein.
- Glucagon (0.5 mg for age <12 years, 1.0 mg for ages >12 years) if available
- If able to eat, give oral rapid acting foods - glucose, sugar or honey

In all cases of hypoglycaemia, the health worker should explore and look for the cause of hypoglycaemia which may include; missed meals, wrong injection techniques etc (refer to the list above).

Prevention

- Hypoglycaemia is best prevented by regular, consistent monitoring of blood glucose
- Awareness of the symptoms and signs of hypoglycaemia by the patient, family, peers, school, community and their continuous reminder about these symptoms.
- Education on management of hypoglycaemia
- Recognising hypoglycaemia
- Appropriately treating hypoglycaemia: fast acting glucose, followed by a meal
- Looking for the causes of hypoglycaemia
  - Missing meals
  - Walking, unplanned exercises
  - Higher insulin doses, etc.
- Repeated episodes of hypoglycaemia should result in specific advice to prevent recurrences
- Re-involve adults and caregivers/direct supervision
- Often some psychological issues
- During illness know the levels of blood glucose
- Perform blood glucose level prior to exercise

Management of Chronic Complications

Introduction

- Children with T1DM develop the same long-term complications as adults with type 1 and type 2 diabetes, if their blood glucose control is poor.
- These complications may take many years to develop, and may not be obvious till adulthood. However, if diabetes developed when the child was very young or if diabetes control has been very poor, diabetes complications can appear in childhood and adolescence, about 3–5 years after diagnosis.
- Major long-term studies show that improved glucose control (as measured by HbA1c) will reduce the incidence and progression of these long-term complications. Early control is important as poor control early on can also cause complications despite improved later control. This is the concept of '***metabolic memory***' or the '***legacy effect***'. In the long term, these complications are a major cause of mortality in people with diabetes. Thus, good early control of diabetes and maintenance of a low HbA1c as possible is required to prevent occurrence of complications and early mortality.
- Diabetes can result in a wide range of serious complications, such as damage to the eyes (retinopathy) that will eventually lead to blindness, damage to the kidneys (nephropathy) that will lead to kidney failure and damage to the peripheral nerves (neuropathy) causing reduced pain perception.
- There is also damage to blood vessels. When these occur in small vessels in the limbs, the patient may have peripheral vascular disease. When these occur in the vessels around the heart there is an increased risk for heart attacks and when it occurs in the brain there is an increased risk for strokes.
- The combination of neuropathy and peripheral vascular disease is the cause of abnormalities in the limbs that lead to amputations.
- Limited joint mobility is the simplest screening method for long term complications. It is an indicator of poor glycaemic control.
- An additional noteworthy complication of type 1 diabetes is the patient-reported burden of adverse effects on quality of life. This affects not only the person with type 1 diabetes, but also their family, friends, and caregivers. Fear of hypoglycaemia is a prevalent issue, particularly for the families of very young children with type 1 diabetes. Furthermore, poor quality of life is predictive of subsequent poor glycaemic control [40 42].

Peripheral Neuropathy

- This includes painful neuritis, loss of sensation, and reduced reflexes
- Most commonly presents in a typical 'glove and stocking' distribution in the hands and lower legs, involving pain, hyperesthesia and/or loss of sensation to pinprick or plastic filament testing. Reflexes can be absent or reduced in the lower extremities, and vibratory sensation decreased or absent. Most such changes affect both sides of the body.

Autonomic Neuropathy

- May include alteration in gastric function (gastro paresis), bloating with decreased appetite, constipation, diarrhoea, palpitations, urinary retention and impotence, abnormal sweating, and absent or abnormal pupillary responses. These children need referral for assessment and management.

Nephropathy (Kidney Complications)

- Damage to the kidneys will result in an increase in the protein excreted in the urine. Early in the development of nephropathy, trace amount of protein in the urine will be detected. This is called microalbuminuria. Treatment can be started at this stage to slow down the progression of kidney disease.
- Later on, a larger amount of protein will be excreted in the urine. This is called macro albuminuria, and further progression of kidney damage will result in kidney failure.
- It is therefore important to detect signs of kidney damage as early as possible and to start treatment to prevent the progression to kidney failure.
- Progression to end-stage stage renal failure will require dialysis or kidney transplantation. Without one of these treatments, early death will occur. Poor glucose control, worsened by smoking, hypertension or hyperlipidaemia will increase the risk of this occurring.
- Urinary protein should be screened annually using urinary microalbumin tests or protein dipsticks. On diagnosis, as a part of screening, the urinary protein / microalbuminuria test must be done and then screened annually.
- Blood pressure should be checked at least annually and compared to age- and sex-matched standards. Watch out for those with a family history of hypertension, kidney, stroke or heart problems. A chart of normal ranges for blood pressure in included in the manual.
- Treatment with ACE inhibitors (e.g. enalapril) can help, and reducing total protein intake can reduce microalbuminuria. Hypertension can be treated with any blood pressure-lowering medication (diuretics, beta blockers, or ACE inhibitors). Improvement of glucose control remains the single most important factor for reducing microalbuminuria. Smoking should stop.

Eye Complications: Retinopathy

- Retinopathy is caused by bleeding and new blood vessel formation in the retina of the eye. It is associated with poorly controlled diabetes.
- Screening should start immediately on diagnosis and then annually. Screening is done by **retinoscopy** or by fundus photography.

Co-Morbid Conditions

- Type 1 diabetes is associated with other metabolic disorders. These disorders are not caused by having diabetes or by poor diabetes control. Instead, they reflect the common genetic predisposition shared by these autoimmune diseases and the autoimmune type of type 1 diabetes.
- It is not usually possible to identify exactly which children or adolescents are most susceptible to these conditions, so clinical laboratory screening is recommended if available. Many cases of co-morbid metabolic disorders will be identified by simple measures such as recording the child's detailed medical history, charting growth and comparing it with expected ranges, looking for an abnormal increase or decrease in pigmentation, and looking for a goitre.
- Thyroid dysfunctions, including euthyroid goitres, (underactive thyroid) and (overactive thyroid), can affect 20–40% of people with type 1 diabetes. They may be detected with thyroid function tests and thyroid antibodies, their treatment is easy and cheap, and will make a lot of difference to the child.
- Coeliac disease is caused by intolerance to gluten, a protein found in wheat and wheat products, which causes bowel dysfunction. Coeliac disease may result in poor growth and sometimes poor glycaemic control. It is more common in people with type 1 diabetes. Many affected children do not show any symptoms or only have non-specific symptoms such as vague abdominal complaints (flatulence, dyspepsia, diarrhoea, non-specific abdominal pains), increased hypoglycaemia, slowed growth rate and/or delayed puberty. The disease

does occur in the African population [41 43]. Avoiding gluten will reverse many of the symptoms and effects of the disease.

- Adrenal insufficiency may occur in children and adolescents with type 1 diabetes. It should be suspected if there is an unexpected or unexplained decrease in insulin requirement, with unexplained or severe hypoglycaemia. Slowed growth, weight loss, unexplained fatigue and/or increasing skin pigmentation should suggest adrenal insufficiency. Refer to a specialist if this is suspected.
- Limited joint mobility is often a result of long-term poor blood glucose control. It is painless, but is a marker for poor glycaemic control. It can be assessed by having the patient place his/her hands in a 'prayer' position.
- Osteopenia. Chronic vitamin D insufficiency and/or deficiency is increased with poorly-controlled type 1 diabetes, and this could contribute to osteopenia. Adequate exposure to sunlight, or vitamin D supplementation and adequate calcium intake in the childhood years are needed to ensure good bone quality.
- Necrobiosis lipoidica diabeticorum, a condition of itchy or painful hardened skin patches which can become infected or ulcerated, occurs in adolescent girls and young women with diabetes. Most often they occur on the anterior shins and usually on both legs.
- Lipohypertrophy occurs when insulin is injected in the same sites time after time causing localized subcutaneous scarring; small or large mounds of fatty deposit at the site of injections, and can occur at any injection site. It may hamper or cause erratic insulin absorption. Rotation of injection sites will prevent the problem. Avoid injecting into a lipohypertrophic areas, as the absorption of insulin cannot be predicted.
- Lipoatrophy is the occurrence of a localized loss of subcutaneous fat so that the skin has the appearance of a small or large indentation.
- Refer all children who present with these conditions for further diagnosis &management.

Hypertension and Dyslipidaemia

Coronary heart disease, peripheral arterial disease, and cerebrovascular disease all occur more commonly, at an earlier age, with a more diffuse distribution and with greater severity and mortality in people with diabetes compared to patients without diabetes. Diabetes itself has been elevated in status from a risk factor for cardiovascular disease, to a coronary heart disease (CHD) risk equivalent in the National Cholesterol Education Panel Adult Treatment Program III (NCEP ATP III) guidelines. These guidelines focus on the necessity of aggressive preventive strategies for all patients with diabetes.

Hypertension and cigarette smoking are major cardiovascular risk factors. Because of the high prevalence of cardiovascular risk factors in patients with diabetes and the effect of hyperglycaemia to magnify the impact of these risk factors, physicians should consider all patients with type 1 diabetes to be at risk for developing macrovascular disease. They should systematically assess patients for risk factors for CVD, question them about the symptoms of CVD, and be alert for signs of atherosclerosis. Lifestyle and pharmacologic treatments for modifying specific risk factors should be started. All patients with type 1 diabetes need to understand the critical importance of following a healthy lifestyle from childhood onward.

Dyslipidaemia in a patient with diabetes may result from poor metabolic control; use of certain drugs, including high – dose ß-blockers (other than Carvedilol), high-dose diuretics, systemic corticosteroids, or other immunosuppressants, protease inhibitor antiretroviral agents, androgens, progestins (other than micronized progesterone, despironone), or oestrogens; obesity; associated conditions such as hypothyroidism, the frequency of which is increased in type 1 diabetes; or inherited dyslipidaemia. Each cause must be considered in assessing patients with diabetes and abnormal blood lipids.

In adults with low-risk lipid values (LDL <1.3 mmol/l; HDL > 1.6 mmol/l, triglycerides 1.7 mmol/l, repeat lipid assessment may be done every two years. In children > 2 years of age, lipid assessment should be done after the diagnosis of diabetes once glucose has been established. If values are of low risk and there is no family history of dyslipidaemia, assessment should be repeated every 5 years until the age of 21 years, then every 2 years. If abnormalities are identified, more frequent testing is warranted. Children with a family history of dyslipidaemia should be assessed annually.

If dyslipidaemia is present, the patient should be assessed for factors that aggravate dyslipidaemia. Insulin treatment should be intensified in poorly controlled patients, but retesting will be necessary to be sure that additional that therapy will be provided if abnormalities persist. Optimal LDL cholesterol for adults with diabetes are < 2.6, acceptable HDL cholesterol levels are >1.0 mmol/l for men and > 1.3 mmol/l for women and desirable triglyceride level higher < 1.7 mmol/l. Patients with diabetes with non-optimal values should institute medical nutritional therapy (MNT) and exercise. Regarding pharmacological therapy, it is suggested that subjects with type 1 diabetes and clinical CVD or an LDL cholesterol level > 2.6 mmol/l after lifestyle intervention, be treated.

Statin therapy is the initial treatment of choice for most patients, because of the robust evidence for their benefits in terms of CVD events and mortality. For children with type 1 diabetes over the age of 10 years, life time modification should be considered for LDL > 2.6 mmol/l, and statin considered for children with LDL >4.1 mmol/l, or over 3.4 mmol/l in the presence of other CVD risk factors such as family history of premature CVD.

Blood pressure should be measured in all patients with type 1 diabetes, including children and adolescents, at each physical examination, or at least every 6 months. If hypertension develops, treatment should be initiated to reduce the risk of macrovascular and microvascular disease. To the extent possible, blood pressure should be maintained at levels <130/80 mmHg in adults or below the 90th percentile for age – and sex-adjusted norms. When prescribing pharmacologic

therapy, the clinician should consider adverse effects of various antihypertensive drugs on hyperglycaemia and hypoglycaemia, electrolyte balance, renal function, lipid metabolism, CVD status, and neuropathic symptoms including orthostatic hypotension and impotence. Table 13 summarizes the management of hypertension and dyslipidaemia.

Table 13: Screening parameters for CVD and type of intervention

HTN and Lipid Classification	Children aged 1–12 years (percentile based)	Everyone ≥ 13 years (mm Hg based)	Type of intervention
Normotensive	<90th percentile	< 120/<80	
Elevated blood pressure	≥90th percentile or ≥ 120/80 mm Hg (lower) to <95th percentile	120–129/ < 80	Lifestyle intervention: exercise, less screen time and diet
Stage 1 Hypertension	≥95th percentile to < 95th percentile + 12 mm Hg or 130/80 to 139/ 89 (lower	130–139 / 80–89	ACE inhibitor or other BP lowering agents If microalbumin is present: ACE inhibitors or ARB
Stage 2 Hypertension	≥ 95th percentile + 12 mm Hg or ≥ 140/ 90 (lower)	≥ 140/90	Lifestyle intervention and ACE inhibitor or another BP lowering agent If microalbumin is present: ACE inhibitors or ARB
LDL cholesterol >2.6 mmol/L (100mg/dL)			Dietary and lifestyle intervention
LDL cholesterol >3.4 mmol/L (130mg/dL)			Statins*

*Note: Statins should be started at the age of eleven years

Diabetes in Adolescents

Adolescence

Adolescence is the phase of life stretching between childhood and adulthood. WHO defines an adolescent as any person between ages **10** and **19** years. It is a phase in which significant physical, pubertal, neural, cognitive and socio-emotional growth occurs.

The onset of puberty and pubertal growth spurt causes insulin resistance requiring higher doses of insulin up to 2 units/kg/day. In addition to the hormonal changes of adolescence that cause insulin resistance and the corresponding need for larger doses of insulin, adolescent rebellion/experimentation results in reduced adherence to the treatment regimen.

Adolescence is also marked by feelings of ambivalence, impulsiveness, and mood swings; the struggle to separate from parents; and the need to be accepted by peers. Adolescents typically engage in experimentation and risk-taking behaviours that may adversely affect self-care and clinical outcomes. Metabolic control tends to deteriorate in adolescence and young adults with type 1 diabetes and puts them at risk for acute diabetes complications, chronic macrovascular and microvascular complications, psychosocial challenges, and early mortality.

Recommendations

- The diabetes care team should develop a trusting relationship with the adolescent. The team should maintain familiarity and continuity of care.
- Parents should be encouraged to maintain a partnership with the adolescent for diabetes decisions important for optimal diabetes control.
- Peer led support groups should be formed for additional psychosocial support.

During the clinic visits

1. The diabetic team should be adolescent friendly
2. Routine biannual psychosocial assessment using HEEADSSS (Table 14) screening for all ≥10 years of age with type 1 diabetes
3. Mental health/eating disorders should be screened at each visit and treated.
4. The diabetic team should help clarify priorities and have a target driven or goal oriented approach.
5. The Educator should provide well directed education to help understand the physiological changes of puberty, their effect on insulin dose and diet.
6. The adolescent should gradually assume greater responsibility for diabetes management tasks.

Risk Behaviours

Management of Type 1 Diabetes in youth remains imperfect, requiring unending vigilance and behavioural intervention. When adolescents seek independence, caregivers must carefully balance autonomy with supervision. Caregivers should not delegate all diabetes care to the youth, as adolescents often need more, not less, support during this challenging developmental period.

Adolescents with diabetes frequently experiment with diabetes mismanagement through non-adherence. They may also engage in other risky behaviours, including use of tobacco and recreational drugs and unprotected sexual intercourse. Many of these behaviours can also interfere with diabetes self-management. Females are more likely to participate in diabetes mismanagement, whereas boys are more likely to engage in risky behaviours. Alcohol use is a particular problem, as it can be associated with severe hypoglycaemia several hours after drinking, if adequate food is not ingested. Adolescent risk behaviours should be routinely

assessed by the diabetes team and counselling provided. All adolescents should be informed of the effects of drugs and alcohol on diabetes.

Many adolescents experiment with sexual behaviour, which may lead to pregnancy. Before initiating sexual activity, all adolescent girls should be given preconception counselling, including the risk of diabetes complications and the risk of any medications and poor glycaemic control to the foetus. Prevention of pregnancy is desirable in the adolescent age-group.

Adolescents should receive regular counselling about sexual health and contraception. Unplanned pregnancies should be avoided, as pregnancy in adolescent females with type 1 diabetes with suboptimal metabolic control may result in higher risks of maternal and foetal complications.

All adolescents should have an assessment of risky behaviour using HEEADSSS and be counselled accordingly.

Table 14: HEEADSSS assessment for risk behaviours

Home environment	Where do you live? Who do you live with? Has anyone recently moved in or moved out? Is there any adult at home that you are able to share your secrets with? Is there anyone who assists you with the management of the diabetes? If yes who?
Education/ Employment	Which school do you go to? Is it boarding or day school? What class/grade/form are you in? What is your average grade? How do you feel about your academic grade? How many school days have you missed because of diabetes in the last month? Does the school provide an area for you to check blood sugar and give insulin? If yes, Where? Once done with school, what would you like to do once you grow up? Do you work? What do you do and how many hours per week/per day do you work?
Eating	How many meals do you eat in a day? Are there any meals that you skip eating? If yes, which ones and why? Are there any foods that you avoid or are not allowed to eat?
Activity	What do you do for fun? How do you spend time with family? With friends? Are you involved with any sports, clubs at school, neighbourhood or other social gatherings e.g., religious activities? Does diabetes affect your participation in activities? If yes how?
Drugs	Do you have friends or family members who take any drugs, tobacco or alcohol? Do you take any drugs, tobacco or alcohol? (If the adolescent responds yes to history of drug taking, administer the ASSIST questionnaire) If yes, ask-where do you get the money to buy drugs, tobacco or alcohol? If yes, ask them if they know the effects of drugs, tobacco or alcohol. Educate them on the effects of the above.

Sexuality	For girls- Have your periods or menses started? If yes, when was your last period? Have you ever missed school due to your periods and if yes, for how many days? Are you involved in a romantic relationship? If yes, how long have you been involved in this romantic relationship? Has your romantic partner-boyfriend or girlfriend ever been violent with you? Are you sexually active? If respondent answers yes to sexual activity, ask if the adolescent uses any form of contraceptive with each sexual encounter. Have you ever been pregnant or had an abortion? Provide preconception counselling if sexually active -For boys, have you ever impregnated a girl? Have you ever been treated for a sexually transmitted infection or worried that you have an infection?
Suicide/ Depression	Are there days in the week you wake up feeling low? If yes, how many days In a week do you feel low? Have you ever tried to hurt yourself or kill yourself? Are there any family members, friends that have tried to hurt themselves or kill themselves? What time do you sleep and what time do you wake up? Do you have any difficulties getting to sleep or waking up in the morning? Are there any activities you used to enjoy that you do not enjoy anymore? If yes, could you tell me which ones?
Safety	Have you ever been seriously injured? If yes, how? Have you ever been involved in a car/motorbike accident? When in a car, do you wear a safety belt? When on a motorcycle do you wear a helmet? Have you ever been driven by a person who is drunk or high? Have you ever gotten into any physical fights in school and /or your neighbourhood?

Transition Clinic

Poorly arranged transition from paediatric to adult diabetes care may contribute to fragmentation of health care and increased risk for adverse outcomes. Challenges include gaps between paediatric and adult care, suboptimal transition preparation, deterioration of glycaemic control and increased hospitalizations.

Preparation should include patient counselling on diabetes self-management, the differences between paediatric and adult care systems, the coordination of transfer, direct communication with receiving adult providers, and a written care summary.

Transition to adult care providers should be planned and negotiated among the patient, the family, the paediatric diabetes team, and the adult care providers. However, in most set up within sub-Saharan Africa it is the same health care provider that will continue to provide care, but it is important that after the age of 18, a specialized T1DM adult clinic be created on different day. It should not be mixed with adult T2DM clinic.

Special Situations

Hyperglycaemia in Pregnancy

Hyperglycaemia in pregnancy is a big challenge in adolescents, with increased risk of complication from conception to after delivery.

Risk to the mother

- Recurrent Urinary tract infections
- Increased risk of hypertension in pregnancy
- Preterm delivery
- Increased rate of Caesarean section due to macrocosmic babies
- Increased risk of diabetic ketoacidosis
- High risk of progression to microvascular complications

Risk to the baby

- Hypoglycaemia
- Intrauterine death (still birth)
- Trauma during delivery (Erb's palsy, fracture limbs)
- Respiratory Distress syndrome
- Prolonged neonatal jaundice
- Polycythaemia

Counselling on pregnancy in adolescents with diabetes

Adolescents should be counselled about pregnancy during the pubertal period and should be told to avoid unplanned pregnancy altogether. **Pregnancy is not an emergency so it should wait until the patient has achieved good control.** Counselling should include:

1. Abstinence
2. Contraception if abstinence fails
3. Effect of diabetes on pregnancy and the effect of pregnancy on diabetes control
4. Risk of congenital malformations if conception takes place amidst poor glycaemic control

Monitoring should be done prior to conception and throughout pregnancy by an experienced multidisciplinary team and women should seek medical help as soon as they know they are pregnant.

Fasting in Type 1 Diabetes

Children and adolescents with medical illness including diabetes are not recommended to fast. However, Ramadan and other religious fasting are feasible for type 1 diabetes patients who wish to fast. Clinicians should advise them about the importance of adequate glycaemic control before Ramadan and frequent glucose monitoring during fasting. Expert consensus recommends reducing total daily dose of insulin by 20 -30% to reduce the incidence of hypoglycaemia. Most hypoglycaemic episodes occur before *ifter* as expected. Hypoglycaemic occurs less with continuous subcutaneous insulin infusion (CSII) than with conventional insulin, with Lispro than regular insulin, with basal bolus than premixed insulin and with Humalog Mix 50 than with Human Mix 30. Severe hypoglycaemia can also be avoided by frequent monitoring of capillary glucose during fasting. Patients at high risk of hypoglycaemia such as those with advanced renal or hepatic impairment, severe comorbid diseases and those with frequent hypoglycaemic episodes or hypoglycaemia unawareness should be actively discouraged from fasting [42 44]. Patients with type 1 diabetes therefore need to know:

1. Insulin is required when eating and when fasting
2. During fasting, meals are not consumed at the same time so insulin dosage needs to be adjusted
3. It is important to increase amount of insulin given before breaking the fast and for meals with extra glucose and fat
4. Patient should test blood glucose just before breaking the fast, before retiring to bed, just before the pre-dawn injection is given for those taking dawn meal, and again when they are feeling faint, ill or they have polyuria.

Dosage adjustment

Most people will take the same amount of food they usually take when they are not fasting. Hence the total insulin dose should remain the same, unless the patient feels he/she is eating less, she/he may reduce up to 20–30%. Adjust the dosages as using the scenario below:

Children on twice daily injection

Switch the morning dose to evening, and the evening one to the morning. For example:

When not fasting	During fasting
Morning: Intermediate Acting Insulin (NPH) 16 Units, Regular Insulin: 8 Units	Morning: Intermediate Acting Insulin (NPH) 8iu, Regular Insulin: 8 Units (Omit Regular Insulin: if no meal is being taken)
Evening: Intermediate Acting Insulin (NPH) 8 Units, Regular Insulin: 8 Units	Evening: Intermediate Acting Insulin (NPH) 16 Units, Regular Insulin: 8iu

Children on Multiple injections

If a person is usually on 3–4 injections a day: calculate the total dose then give half as long acting and half as short acting, twice daily. For example:

When not fasting	During fasting
Intermediate Acting Insulin (NPH) 8 Units twice daily + Regular Insulin 4 Units at three meals (total is 16 Units Insulatard and 12 Units Regular Insulin)	Morning: Intermediate Acting Insulin (NPH) 8 Units, Regular Insulin 4 Units (Give Intermediate Acting Insulin (NPH) only if no meal is being taken)
	Evening: Intermediate Acting Insulin (NPH) 8 Units, Regular Insulin 5 Units

Diabetes and Tuberculosis

In developing countries where tuberculosis is common, the 10-year actual risk of acquiring tuberculosis may be as high as 25% for Type I diabetes mellitus. However, the literature is scanty on the prevalence of comorbid type 1 diabetes and tuberculosis infection [43 45]; with some indication that there may be a negative correlation [44, 46].

Associations between Tuberculosis and Diabetes

- For people with TB infection and no risk factors, the risk for TB disease is about 5% in the first two years after infection and about 10% over a lifetime.
- For people with TB infection and diabetes, the risk for TB disease is 3 times as high, or about 30% over a lifetime.
- Diabetic patients are 3–4 times more likely to have tuberculosis than people without diabetes.
- TB in people with diabetes is more severe than in people without diabetes, and they present with more advanced disease than the general population.
- Patients with tuberculosis and diabetes do not respond as well to tuberculosis therapy as those who are non-diabetic. Uncontrolled diabetes lowers the immune system, making

diabetics more prone to infection and slower to heal particularly for patients with chronically high blood sugar.

Recommendations

- Screen for TB in people with diabetes and screen for diabetes in people with TB to detect and prevent diabetes or tuberculosis-related complications.
- Aggressively treat diabetes to improve the outcomes of patients receiving tuberculosis therapy.
- Review insulin doses for good blood glucose control
  - Isoniazid impairs insulin action, so consider insulin dose increment.
  - Marked weight loss and higher insulin and caloric needs in tuberculosis are important indications for reviewing dosages.
- Eat a healthy diet rich in low glycaemic foods, such as vegetables, whole grains and fish
- Be more physically active
- Avoid chronic stress - get enough sleep and maintain weight.

Diabetes and Human Immunodeficiency Virus (HIV) Infection

Diabetes as a human immunodeficiency virus (HIV) infection co-morbidity is increasing in both incidence and prevalence. This follows from the increase in early HIV testing and early start of highly active antiretroviral therapy (HAART) that has markedly improved life expectancy of persons living with HIV. Unfortunately, long-term therapy on HAART has been associated with cardiometabolic complications, including development of type 2 diabetes [45, 46] , but also children with vertically transmitted HIV can develop type1 diabetes, and those with type 1 diabetes do contract HIV infection.

Classification of HIV in children with diabetes

Three subgroups of patients with HIV and diabetes can be identified:

a) Patients with pre-existing diabetes who contract HIV.
b) Those who are diagnosed with both HIV and diabetes mellitus at the same time.
c) Those who develop hyperglycaemia post-HAART initiation.

Screening for HIV in patient with diabetes

- All children and adolescents with T1DM should be screened for HIV.
- Sexually active youth who have been tested negative should be screened yearly, if with risky behaviour.

Evaluation of a patient

Initial evaluation of a patient with both HIV and diabetes mellitus includes a detailed history which amongst others includes a detailed search for infections which are common in both conditions such as:

- tuberculosis
- fungaemia
- sexually transmitted infections
- urinary tract infections

In addition, the evaluation should search for other chronic conditions that need to be aggressively managed and that will also influence the choice of anti-HIV drugs and diabetic drugs: -

- hypertension,
- renal impairment
- any form of dyslipidaemia

- thyroid dysfunction
- cardiac dysfunction.

Initial investigations should include:
a) Full blood count
b) Urinalysis
c) Urea and creatinine with estimated GFR
d) Liver function with hepatitis screen
e) CD4 count
f) Viral load for HIV
g) Fasting blood glucose (HbA1c may be used but the readings may be low in HIV infection and HAART)
h) Serum lipids
i) Thyroid function test (Serum TSH)
j) ECG
k) Serum uric acid.

Treatment of diabetes in HIV infected individuals

General measures

a) Appropriate treatment of opportunistic infections.
b) Lifestyle modification, which includes physical exercise, smoking and alcohol cessation and dietary advice, and comorbidities.
c) Psychosocial support of patients and both family and community
d) Reinforce compliance at every visit.
e) Treatment of other cardiovascular risk factors such as dyslipidaemia and hypertension

Glucose lowering agents

All patients with type 1 diabetes mellitus and HIV should be managed with insulin therapy.

Diabetes and Mental Health

Good mental health helps in glycaemic control. Children with T1DM are at risk for adjustment problems during the initial period of adaptation after diagnosis and have a high risk of continued adjustment difficulties. When adjustment problems exist, females are more likely than males to have a diagnosis of mental health. Even after the adjustment period, children and adolescents with T1DM have increased prevalence of psychiatric disorder (depression, anxiety, psychological distress, and eating disorders) compared to their peers without diabetes; higher frequency being in those with chronic poor metabolic control, and recurrent DKA. These problems are exacerbated by parental distress associated with the child having diabetes.

Poor glycaemic control is one of the factors leading to depression and anxiety and adherence to treatment is affected by depression.

Children with depression are more likely to be poorly controlled and more likely to have DKA and frequent hospital admissions

Diabetes distress

Another common form of psychiatric disorder in children with diabetes is *diabetes distress*, which is among the factors that are associated with decreased regimen adherence and poor health outcomes.

Youth who are under distresses are also at an increased risk for disordered eating behaviours (e.g., restricting food intake and insulin omission; and binge eating).

There is evidence that adolescents with diabetes, especially girls, have a higher incidence of eating disorders. It is estimated that 7% of adolescent girls with T1DM have an eating disorder which is twice the rate in the general population

Even at subclinical levels, glycaemic control has been observed to worsen with increasing symptoms of eating disorder.

Without intervention, disordered eating and insulin manipulation may worsen over time and increase the risk of serious health complications.

Recommendations

Interdisciplinary team with expertise in mental health (psychologists, social workers, and psychiatrists) and behavioural health are needed in the diabetes health care team.

Mental health professionals should be available to interact with patients and families at clinic visits to conduct screening and more complete assessments of psychosocial functioning, but also to support the diabetes team in the recognition and management of mental health.

Training the mental health expertise on diabetes and its management is important. Mental health assessment [i.e., physical, intellectual, academic, emotional and social development, overall psychosocial well-being, diabetes specific quality of life and psychiatric disorders (e.g., depression, eating disorders, diabetes distress)] should be planned and conducted routinely by appropriate mental health specialists.

These assessments are particularly important in young people not achieving treatment goals or who exhibit chronically poor metabolic control

The interdisciplinary team should aim to provide preventive interventions for patients and families (including training parents in effective behaviour management skills) at key developmental times, particularly after diagnosis and prior to adolescence.

Organisation of Diabetes Care

Goals of Diabetes Care

The ultimate goal of diabetes care in children is to provide care that results in high quality of life, normal growth and development, and lowest possible risk of acute and long-term diabetes complications. This is best accomplished by helping children and families become proficient in self-management, remain motivated throughout childhood and adolescence and allow for children to develop into independent, healthy adults.

Diabetes Care Teams

For optimal outcomes, people with diabetes should be cared for by a multidisciplinary care team, including diabetes educators, nurse practitioners, nurses, nutritionists, physician assistants, exercise physiologists, social workers, psychologists and community health workers. This has so far not been possibly in sub-Saharan Africa. The goal should, however, be to work towards achieving this. Three levels of care have recently been suggested by Ogle and co-workers: minimal care, intermediate care and comprehensive (guideline-based) care [1]. Clearly the minimal care is associated with profoundly high risk of developing metabolic and long-term diabetes complications and all efforts need to spent to have comprehensive (guideline-based) care or at worst intermediate care.

The team should provide:

- Hospital and comprehensive ambulatory care for diabetes and associated conditions
- Comprehensive education for the young person and his/her caregivers on day to day management of diabetes including insulin therapies, nutrition and psychosocial support
- Expert advice for the child and the family on issues related to daily diabetes management including hypoglycaemia, exercise, sick day management, travel, fasting, festivals and other special occasions
- Anticipatory guidance on age and developmentally appropriate goals and life events (including alcohol consumption, contraception and risk taking behaviour)
- Advice for care at school, camps, and other venues where children with diabetes require care when away from home
- Screening for co-morbid conditions, complications and risk for complications
- Emergency telephone or other support 24 hours a day to patients and families
- Psychosocial evaluation and support for all patients and families and especially for children with suboptimal glycaemic control, frequent health utilization of emergency departments/ hospital, other social considerations and/or mental health needs
- Advice and support to physicians and health care professionals who provide diabetes care where immediate access to a diabetes care team is not possible

Processes of diabetes care should include

Routine visits, at least every 3 months

- Ongoing evaluation of diabetes management and review of home management records, as well as evaluation of growth, development, and general health
- Physical examination with inspection of glucose monitoring sites and injection/insertion sites

Options to communicate between visits

- insulin dose adjustments, including text, phone call

An annual visit that includes

- expanded physical assessments (such as pubertal staging, foot exam)
- additional self-management assessments, including dietary knowledge (ability to estimate carbohydrate consumption and accurately determine insulin doses), self-management skills and behaviours, psychosocial needs
- screening for co-morbidities and risk factors for long-terms complications, and identification of barriers to care

A planned, purposeful transition to adult diabetes care, to facilitate continuity of care during this critical time.

Culturally sensitive communication, counselling, and encouragement for altering preconceptions or negative and unhealthful beliefs about diabetes

Contact with other families of children with diabetes (planned meetings, camps, patient support groups, patient associations)

Assistance to access care: outreach services, transport allowance, clinics on non-school hours/days for school children, nurse led clinics.

Diabetes Education and Support

Children and their care givers need to be taken through the education process of knowledge, skills and abilities for diabetes self-management (DSME). Some children develop at different rates and successfully transition at different rates and ages. Inappropriate transition of care before the child is ready and demonstrates competency can lead to metabolic decompensation.

- Level 1: (Age: 0–5 years); child and parents educated together - parent is administrator and child is the observer.
- Level 2: (Age: 6–10 years); child takes over the administration and the parents oversee the administration
- Level 3: (Age:11–18 years); adolescent clinics. Patient encouraged to manage monitoring and change of insulin
- Level 4: (Age: 19 years onwards); Transition to adult clinics. The patient should be able to manage the diabetes together with the health professional and with family support.
- The diabetes educator / HCP must evaluate the process of conversion from Level 1 to Level 2 by assessing knowledge and skills of the child (use simple tools to assess self-care) in the following aspects:
- Goals of care– is the child able to state what has been agreed
- Dose measurements
- Injection technique
- Self-monitoring of blood glucose with appropriate change in insulin dose
- Sick day rules: continue with medication, frequent monitoring and intake of fluids
- Addressing hypoglycaemia (day and nocturnal): state symptoms of hypoglycaemia and what measures to take, also inquire if they have some simple sugar (glucose) in the bag at every visit, in case hypoglycaemia arises.

Community, school and family support

- M-health
  This can be useful for training communities, the school staff and families living with a child who has diabetes. If facilities are available, the care centre can organize for scheduled webinars and send invitations for the concerned. It will only be practical if the concerned

have smart phone /computers and internet access. It is a cost-effective way of delivering diabetes information.

- Social media
  Social media can be used to forward general tips and prompts on diabetes care.
  Although, social media for consultation is discouraged due to issues related to litigation however it is often an easy way to prompt/ follow-up on set education goals.

Format of education

Diabetes self-management education for type1 Diabetes can be offered in various formats, however it must be structured. This allows for a systematic way of delivery.

- Use of templates enables documentation of the process: each topic discussed should be signed against by the educator and the client or their care giver if they are under age
- Use of standardized tools e.g., *conversation maps*, flip charts, food models is encouraged to enhance learning by engaging several senses of the client and the family.

Different types of education

Education sessions can be organized in the formats highlighted below

- Individual (one to one)
- Group Education- small or large groups
- Periodic gathering e.g., monthly, quarterly or half yearly to allow clients to air their concerns
- Social media- WhatsApp, twitter, Short Message Service (SMS) and Facebook groups to convey general care tips
- Information, Education and Communication (IEC)materials – Posters, flyers
- Diabetes camps

Target population

The educator needs to engage the following:

- Children with diabetes
- Parents, siblings of concerned child
- Care givers e.g., children's home staff
- School nurse, teachers, staff, students– school members are best engaged in the school setting

Who executes the communication (DSME)?

Diabetes self-management education can be facilitated by:

- Nurse educators
- All other health professionals
- Peer educators
- Community health workers

Contents of education (DSME) process

- Basics of diabetes - what it is, what causes it
- How to manage diabetes- the various components key to diabetes care- diet, medication, physical activity and its chronic nature
- Insulin administration, injection sites, insulin transportation and storage – ensure parents inject themselves at education session so that the child may not "manipulate" them at home.
- Acute complications: Hypoglycaemia, hyperglycaemia, DKA
- Chronic complications: Eye, dental, renal, cardiac, foot, sexual complications of long-standing diabetes and how to prevent them
- Annual risk assessment and what the target numbers are, what they mean and what is to be done in case of any anomaly

- Sick day management, stress and school examination days
- Importance of regular follow up
- Foot care
- General hygiene, dental hygiene
- Emotional/ psychosocial issues related to diabetes and the need to seek help early if one has an issue
- Diabetes and travel
- Diabetes at school
- Self-monitoring of blood glucose (SMBG), good control parameters and making sense of the numbers

Structured blood glucose testing is probably the most important single component of care

Current situation

- Test strips are very expensive, and therefore blood glucose measurements be purposeful
- Test strip quantities are limited, but patient should be given sufficient to monitor care
- Time for education on what to do with blood glucose data is limited, **BUT** must not be compromised
- Most patients are on premixed insulins or fixed dose basal bolus regimen, and this should be changed if not achieving the predefined HbA1c goal
- Few patients are using carbohydrate counting or corrective doses, and it is time to change and time spent to take them through carbohydrate counting. This is the support patients require to achieve good control.

What we know about testing

- SMBG testing is required to balance insulin dose with food, exercise, and other diabetes routine behaviours.
- SMBG data that is not collected at the right time and for the right reason is of limited benefit.
- People with type 1 diabetes have too much intra- and inter-day blood glucose variability to be able to use 1 test per day spread across various time points over various days. This testing approach also fails to provide any insights into blood glucose patterns; in particular how one blood glucose level leads to the next and how short-term inputs such as food types, portions, snacking, exercise and dose could be affecting the blood glucose levels.
- A blood glucose target needs to be actively set and aimed for.
- Structured blood glucose data collection has proven benefit.

What is structured testing?

- Structured testing is a method of using the fewest number of test strips for the maximum reward.
- The testing regimen can match the medication regimen.
- Experience has shown that 4 blood glucose tests per day (before breakfast, before lunch, before dinner and at bedtime, for 3 consecutive days) provides adequate data for analysis to generate a pattern that can be used safely for the remaining days of the week in stable patients.
- Consecutive days are chosen to evaluate the overnight periods.
- The sequential collection of blood glucose data allows for patterns to be recognized and for correlations to be made about how each input variable may be influencing the blood glucose levels.

Advantages of structured testing

- Fewer test strips can be used but still enough data can be collected for interpretation

- For example, with 50 test strips per month the patient can do a structured testing sprint every week, they then analyze the data, make appropriate adjustments and remain on the revised dose for the rest of the week and re-measure the effect the following week.
- If fewer test strips are available, they should be saved up and used in 1 sprint per month (12 strips), however we do not advocate for this extreme level.
- The collection of the data makes the patient aware of cause and effect influences on their blood glucose levels - *how did my blood glucose get here and how do I get it to target by the next test.*
- The collection and presentation of data provides the health care provider with usable data and forces them to act upon it.
- The structured data collection allows patients to follow self-titration algorithms
- Structured data allows for remote monitoring and consultations.

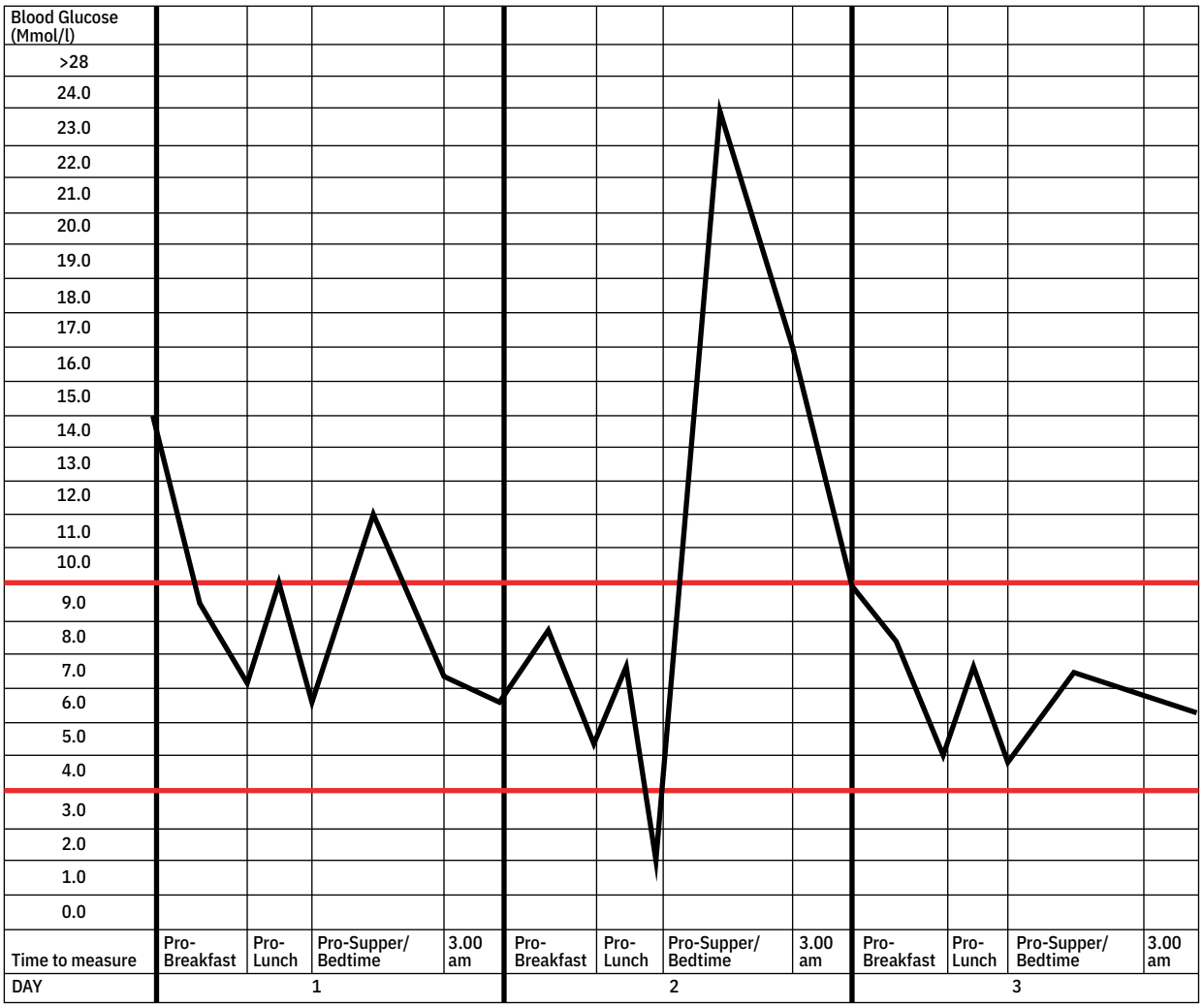
Case Study

John is 12 years and has recently been going through Diabetes Tutelage and is quite keen to improve his HbA1c. He is on NPH insulin 10 Units morning and 5 Units evening; and injects 6 Units of regular insulin before the main meals. His weight is 35 kg and height is 135 cm. Below are his recordings, in mmol/l.

Name...John Tindimwebwa				**Insulin doses .....NPH –10 Units Pre-Breakfast; 5 Units Pre-supper; Regular Insulin 6 Units Pre-Breakfast, 6 Units Pre-Lunch and 6 Units Pre-Supper**					
DAY	**DATE**	**Breakfast**		**Lunch**		**Supper**		**Night**	
		Before	**2-hrs After**	**Before**	**2-hrs After**	**Before**	**2-hrs After/ Bedtime**	**3:00 am**	**Comments**
1	21/2/2019	15.0	9.8	7.0	10.0	6.5	12.0	7.4	*
2	22/2/2019	6.5	8.7	5.3	7.6	2.0	24.0	17.0	**
3	23/2/2019	10.0	8.3	5.0	7.6	4.9	7.4	6.9	***

* On 21/2/2019 he added 4 units to regular insulin before Breakfast. That is he injected NPH 10 Units and Regular 10 Units and has his usual breakfast. He noted he had missed his dose of NPH on 20/2/2019 at supper and was not going to miss his shots again.
** On 22/2/2019 he noted the low glucose level before supper because he went exercising and did not take a snack and had not checked his glucose level. He drank two bottles of orange juice and proceeded to take his dinner. He was worried about the subsequent glucose levels of 24.0 and 17.0 mmol/l and called the health worker. She told him not to panic but take his usual dose of NPH insulin, and since it was late already in the night, not to inject the regular insulin. She advised him to check glucose before exercise, and to take a snack before vigorous exercise. The following day John followed the rules and his glucose levels were excellent. He plotted the graphs and was ready to continue the same the following week.
*** On 23/2/2019 he increased his dose of regular insulin by 2; that is he injected NPH 10 units and Regular insulin 8 Units before breakfast. He decreased the pre-lunch regular insulin to 4 Units as he had planned to have exercise in the evening.

As he was going to have regular exercise every evening, he planned out his dosage for the week to be as follows:
Morning: NPH 10 Units and Regular 6 Units; Lunch 4 Units; Supper NPH 5 Units and Regular 6 Units.



Graph of the blood glucose monitoring done over the 3 days. Note the range is between the red lines in day 3. John got the pattern of glucose excursion he was looking for by adjusting the meals, exercise and insulin doses.

A structured pattern would allow one to assess the efficacy of this regimen matched against their dietary intake.

- Bolus insulin is adjusted (every 2–3 days) based on **post-meal** glucose values if using **rapid-acting analogs**
- Bolus insulin is adjusted (every 2–3 days) based on **glucose values prior to the next meal** if using **regular insulin** until the desired blood glucose targets are achieved.
- Basal insulin is adjusted (every 3–5 days) based on **fasting glucose values**, for **long-acting insulin analogs**
- Basal insulin is adjusted (every 3–4 days) based on **fasting glucose values**, and **3.00 am** glucose levels for NPH.
- Fasting hyperglycaemia may occur due to either over – or under- insulinization overnight. If SMBG between 2:00 and 3:00 a.m. reveals nocturnal hypoglycaemia, rebound hyperglycaemia (Somogyi effect) may be operative, although blood glucose levels > 11.1 mmol/l usually do not occur unless food is given to treat the hypoglycaemia.

The breakfast to lunch pattern provides information on the adequacy of the short acting component to cover breakfast, and the longer acting component to cover mid-morning snack.
The lunch to dinner pattern provides information on the match between the basal component and its ability to cover the carbohydrate content of the lunch (which is not covered by short acting insulin) and perhaps an afternoon snack if there is one.

The dinner to bedtime pattern provides information of the adequacy of the dinner short acting component to cover the dinner carbohydrates and the ability to get to bed with an adequate level.

The bedtime to breakfast pattern provides potential information on the requirement for a bedtime snack, and the ability of the basal component to manage hepatic glucose output during the overnight period such that one can get to breakfast within the target blood glucose range.

This testing pattern allows one to experiment with different carbohydrate choices and loads at all meals, and assesses whether or not the lunch needs to be covered with short acting insulin or not (i.e.. whether a regimen adjustment is required).

Other tips

It is really important that patients keep a food diary for the duration of the testing sprint.

It is also helpful for them to be educated about the variables that are influencing their blood glucose pattern such as:

- Type of carbohydrate consumed
- Quantity of carbohydrate consumed
- Snack content and frequency
- Dose of insulin
- Type of insulin
- Injection sites
- Exercise

Audit (evaluation) of DSME

- At the end of each year, the education process needs to be evaluated for effectiveness e.g.
- % of children educated fully or not
- % achieving desired outcomes e.g., Target HbA1C
- % of session and topics covered
- Ability to administer insulin appropriately
- Also evaluate each client regularly and endeavour to repeat the education process from time to time and also to update them on new trends/recommendations

Important factors in education process

The educator needs to take note of the following and encourage

- Consistency in who brings/ accompanies child to clinic for education sessions. Essentiality it would be advisable for both parents or at least the same caregiver/s at each education session
- Siblings to attend sessions
- Ask about myths, other socio-cultural issues and address them
- Test for readiness for change, so that changes are recommended at the appropriate time
- Small changes
- Graduated transfer of responsibility as child grows
- Document process at each visit and ensure **parents sign attendance** to each session
- Use of age appropriate tools that appeal to the particular age group
- Develop service charter and issue to clients for accountability

Important factors in diabetes education

- Provide a hotline in case of emergency (or mobile)
- Regular (scheduled) sessions
- Set goals of care together with the clients and care givers, often not more than 2 goals at a time
- Gender sensitivity especially in adolescents
- In pre-adolescence: ensure education covers lifestyle issues such as sex, drug and substance abuse (alcohol, cigarette use, peer pressure, eating disorders, initiation rites etc

Communication process

How education is done is as important as even the content

- Ensure the setting is well lit, quiet and with minimal disturbance
- Appropriate tools and language (simple language, preferably what the patient and caregivers are comfortable with) depending on context
- Always endeavour to use the second voice… e.g. you should, you will, you can….,it is recommended that you…
- Assess knowledge on diabetes for both parents and children as the session begins and state what you will be discussing
- If they have a great concern in a particular area, it is always wise to deal with it first and then come back to your topic as per the schedule: at times, you may need to re- schedule.
- Explore their feelings about diabetes and let them feel comfortable to air even what may be considered negative without judgement
- Let the parent and child verbalize their concerns, challenges and fears
- Recommend supplies that parents/ caregivers can afford and is accessible to them locally e.g., when you recommend food, monitoring supplies, etc… endeavour to provide a resource list with contacts of where to get supplies if they are not provided in the care setting
- Schedule

Referral

- It is here emphasized that referral arrangements are best discussed in advance. Primary care facilities should be aware of their referral options if they have a child with diabetes receiving care at their facility. **A referral should not be a way of getting off responsibility.**
- Where possible, the health care worker at a primary care facility should be encouraged to contact the higher-level facility by telephone in order to prepare them to receive the patient and also for the possibility of receiving advice on appropriate care prior to referral.

- The receiving facility should provide a written feedback on the patient's presentation, management, outcome and future recommendations
- Both facilities should maintain a register of all referrals for record

Camps for Children with Diabetes

Diabetes camps provide an ideal setting to help youth and children manage and cope with the disease; and thus, develop a positive impact on health-related quality of life for children and adolescents.

Diabetes camps aim to offer participants opportunity to:

- Enjoy a camping experience in a safe environment
- Experience a setting where caring for diabetes is a shared experience with other campers who also have diabetes.
- Meet other children with diabetes and learn healthy ways to manage diabetes.

The benefits include:

- Getting to know and bond with others with diabetes
- Learning new tips and tricks for diabetes management
- Jump starting an activity program
- Enable health care workers to meet and identify children who need specialized diabetes care
- Enable them to form friendship, boost self-esteem and increase self-acceptance
- Improved glycaemic control
- Increased awareness about diabetes care and complications through various educational activities of the camp
- Benefits from peer education of self-management
- Learning new ways to relax and meditate to decrease stress
- Possibility of continued support once they return home
- Offer them the opportunity to have unfettered access to their health service provider (nurse, doctor, etc)
- Improved psycho-social well-being of children and their knowledge about diabetes throughout the duration of the camp

Camps should have:

- Adequate professionals trained to manage children with diabetes including:
  - knowledge of insulin dose adjustments for the increased levels of activity that are usual at camps
  - an understanding of how to adjust settings and maintain insulin pumps if they are used at the camp
  - identifying and treating early ketosis and decide when referral to a medical facility should be initiated
  - at least one staff member with knowledge of medical nutrition therapy, carbohydrate content of meals, and the principles of adjusting insulin doses for variable carbohydrate content of meals
  - all staff trained to recognize and treat hypoglycaemia.
  - Staff should also be familiar with management of intercurrent diseases such as asthma, sore throat, diarrhoea and vomiting.
  - Other staff may include peer educators, diabetes educators, diabetes clinical nurses and exercise specialists to engage to children in joyful activities.

- Insulin to meet the needs of the children
- Ability to test glucose and ketones, and have adequate facilities to manage emergencies. These should include IV cannulas, giving sets, dextrose solution, bag and mask resuscitation kit, stethoscope, glucosemeters and test strips, glucagon, anti-histamines, pain killers, sharps disposal boxes, and gauze.
- A plan to maintain a log of each camper's glucose levels and insulin doses. It is usual practice to provide a parent or guardian with a copy of this log at the end of camp.

For a successful camp, the preparation should include

- Budget for the camp
- Setting up the date and venue for the camp
- Sending out invitations to the parents
- Transport to and from the camp
- Meals for the attendees
- Emergency medical set
- The camp activities for engaging all the children throughout the camp duration.

Most camps provide some education in diabetes management through:

- Planned, formal sessions
- Helping campers 'learn by doing'
- Discussing one-on-one or in a group issues related to diabetes care and outcomes.

Other out of clinic activities in which the diabetes team may be involved include the following:

- Local (and national) support groups
- Advanced education sessions (e.g., advanced insulin pump classes, use of CGM)
- Resources (information leaflets/books, equipment, informational websites, etc.)
- Discussion groups, activity days, visits, lectures, holiday events, family camps, etc.

Monitoring for Quality of Care

The ultimate aim of T1DM care is to alleviate the consequences of T1DM and maintain a healthy person in mind and body: no sickness and well psychologically and socially. A well- managed child will have a good quality of life, normal growth and development and will perform well in school, assuming that all resources required for care are available and an enabling environment is in place to enable the child to avail him/her self to that care. Table 15 summarizes the aspects which need to be consider while monitoring quality of care.

Table 15: Monitoring quality of care

Aspect of Wellbeing	Possible Indicators	Selected Indicator
Quality of life		
a) Reduced mortality b) Reduced sickness c) Reduced disability	a) Blood Glucose b) Not exceeding 10 mmol/l c) Not less than 4 mmol/l d) HbA1c less than 7 mmol/l e) Hospitalizations f) Episodes of hypoglycaemia g) Reduced complications	a) Number of deaths b) Episodes of hypoglycaemia since last visit/yearly c) Number of hospitalizations since last visit/yearly
Normal growth and development		
a) Height b) Weight c) Puberty	a) Height for Age b) Weight for age and for height	
Optimal school performance		
Uninterrupted learning	a) Episodes of hypoglycaemia b) Missed classes due to sickness, hospital attendance, hospital admissions c) Environment conducive to self-care: injecting insulin, snack d) Reasonable adjustments in schools to facilitate prescribed medical care to allow for children with type 1 diabetes to participate in education on the same basis as their peers	Number of missed school attendances since last visit/yearly
Availability of resources		
	a) WHO lists of essential medicines for children and adults: Different types of insulin, glucagon, and metformin b) Blood glucose meters and test strips c) Syringes, needles, etc d) Waive export/import taxes e) No administrative obstacles so that resources can reach patients as quickly and efficiently as possible: availability of services close to community	a) Days child/facility missed insulin b) Days child/facility missed glucose test strips c) Travel costs to health facility d) Cost of insulin
Enabling environment		
	a) All people are educated on diabetes b) Active patients associations	At least yearly general meetings of associations

Non-Insulin/Adjunctive Therapies

Introduction

Many patients with T1DM and caregivers enquire about alternative therapy to the exogenous insulin. It is therefore appropriate that some discussion is given to other available therapies. It is emphasized from the outset that the current standard-of-care for type 1diabetes mellitus (T1DM) world over, including SSA, is exogenous insulin replacement therapy. Recent developments in this field include the hybrid closed-loop system for regulated insulin delivery and long-acting insulins. However, even with this computer-assisted insulin delivery, achievement of desired glycaemic control targets remains challenging. The most prominent reason is the variable pharmacokinetics and absorption rates of traditional insulin analogues. Currently available insulin analogues have relatively restricted onset and prolonged duration of action, with onset time of 10 to 15 minutes, with peak glucose excursion of 40 to 60 minutes and an overall duration of action of 4 to 6 hours (Table 6). As such the inherent pharmacokinetic profile of insulin remains a hindrance for preventing episodes of hypoglycaemia. This challenge presents T1DM patients and healthcare providers with limited options for intensification of the insulin therapy, and thus a tendency to use suboptimal dosing of insulin due to fear of hypoglycaemia with possible consequent keto-acidosis, variability of blood glucose levels not easily managed by current insulin formulations (similar doses of insulin can lead to different and unpredictable responses) and long-term micro-and macro-vascular complications. These episodes of hypoglycaemia and variability pose the danger of making patients feel they are not in control of their diabetes [47 49]. These unmet needs have led to the development of dual-hormone artificial pancreas system, where glucagon can also be administered simultaneously, thereby providing tight glucose regulation as well as mimicking the physiological action of the endocrine pancreas; exploration and use of adjunctive therapy in the management of type 1 diabetes. A summary of adjunctive therapies being explored in specialized centres is given here to broaden the knowledge of the healthcare worker, as they are unlikely to apply in the SSA region in the very near future.

Adjunctive Therapies

Pramlintide, Metformin, Glucagon-like-peptide agonists (GLP-1) agonists, Dipeptidyl peptidase (DPP4) and Sodium glucose co-transporter -2 inhibitors (SGLT2)

Pramlintide is the only non-insulin medication approved for improved glycaemic control in patients with type 1 diabetes. Metformin, Glucagon-like peptide-1 receptor (GLP-1) agonist, Dipeptidyl peptidase-4 inhibitors, and Sodium-glucose co-transporter-2 (SGLT2) inhibitors have also been used off-label; however, fewer than 5% of patients use these medications [49 51].

Studies evaluating the sodium-glucose co-transporter 2 (SGLT2) inhibitors or dual inhibitors of sodium-glucose co-transporter -1 (SGLT1) and SGLT2 as adjunct to insulin therapy in specific adult patient populations with T1DM [47 49, 49 51, 50 52] have shown a limited role. The benefits include improved glycaemic control, weight reduction, and reduced insulin dose requirement. However, the risk of diabetic ketoacidosis (DKA) with SGLT2 inhibitors is significant and the diagnosis may be delayed due to absence of significant hyperglycaemia. Currently there is little role of SGLT2 inhibitors in T1DM in SSA.

Pramlintide, an amylin analog, can improve glycaemic control, primarily through lowering postprandial blood glucose levels. Patients may experience weight loss and an increased risk of hypoglycaemia. It is licensed for use in the United States.

Metformin would provide an inexpensive, oral treatment option but the use in T1DM has not yielded useful outcomes [51 53]. In summary, Pramlintide and metformin have very limited roles in the adjunctive therapy of T1DM [52 54], and currently may have no role in SSA.

There have been many preliminary clinical studies exploring the therapeutic utility of GLP-1 receptor agonists as adjunct to insulin therapy in T1DM patients. Findings demonstrate significant reduction of postprandial glucose excursions, decreased glucagon production, and delayed gastric emptying in patients taking insulin in combination with GLP-1 receptor agonists exenatide and liraglutide as compared with patients on insulin monotherapy (47 49). Therefore, the use of GLP-1-based agonists appears beneficial as an add-on therapy in patients with uncontrolled HbA1c and mild obesity. However, the impact of GLP- based drugs on long-term glycaemic control and on secondary complications remains to be explored and its option in the management of T1DM in SSA still unlikely in the very near future.

Immune Therapies

The rise in the number of cases with T1DM cannot be explained solely by genetic predisposition. It is accepted that an interplay between genetic susceptibility and environment influences is responsible for activating self-reactive immune cells. Accordingly, the pathogenesis of T1DM involves a complex interaction between the β cells and the components of both innate and adaptive immune systems. The activated immune system then destroys the β cells through many cell types and multiple pathways. Therefore, there are many immunomodulatory strategies that have been proposed for the treatment of T1DM but none is yet proven satisfactory for clinical use. Many trials are still ongoing and some promising to be of clinical benefit in the very near future (47 49).

Transplantation

Transplantation of whole pancreas and islets from humans offers an alternative for providing lifelong insulin independence; however, there are practical challenges pertaining to donor shortages. To alleviate the scarcity of donors, islet xenotransplantation has been tried but is not available for clinical application.

Islet transplantation has been tried with some success in several centres but remains still under intensive investigation.

Stem Cell-Based Therapies

Stem cells have gained attention due to their potential for providing a limitless source of glucose responsive insulin-producing β cells as well as their ability to enhance the survival function of transplanted islets. This holds the potential to solve the problem of limited availability of suitable donor islets, and can also enhance therapeutic outcome of islet transplantation in T1DM.

Use of Technology in Diabetes Management

The management of type 1 diabetes has changed substantially in the past 25 years with respect to the adoption of intensive insulin therapy as the standard of care following publication of the landmark Diabetes Control and Complications Trial in 1993. Technological advances in glucose monitoring and insulin delivery have greatly enhanced the ability to optimise glycaemic control with intensive therapy. Self-management support is enhanced by the use of cellular phones and platforms. All members of the local diabetes team should become aware of the newer automated injection devices such as insulin pens and pumps, as well as the latest durable insulin delivery devices for patients with T1D so as to be able to discuss this topic with confidence with patients who enquire about them. They are unlikely going to be routinely used in SSA in the majority public health facilities.

Prevention of Type 1 Diabetes

While it is possible to identify individuals, who are at an increased risk of developing type 1 diabetes through autoantibody and genetic testing, this is currently done in research settings only. There is no evidence-based strategy for preventing type 1 diabetes.

Policy Implications

The Rights and Welfare of the Child

In drawing up the guidelines for management of type 1 diabetes in sub-Saharan Africa (SSA), we have noted that many SSA countries have already committed themselves to putting children first by signing the Convention on the Rights of the Child [53 55], and the African Charter on the Rights and Welfare of the Child. In addition, many countries' constitutions pay special attention to the Rights of Children. Furthermore, many countries have signed numerous other International Conventions, Documents, and developed legislation, policies, and programs that protect and promote the health of children. With this background, we are reminded that:

- The purpose of the above legislations was to ensure that the child is healthy thus resulting to a healthy adult, the future workforce.
- The lack of a national policy on child health may result in uncoordinated approaches to child health, duplication of effort, waste of scarce health resources and sub-optimal community level impact.
- Health care financing has historically provided inadequate resource allocation to children.
- Children with special health needs have double financial weight and some remain dependent throughout their lives thus making care of the other children even more difficult.

Right to Life

- Every person has the right to life.
- The life of a person begins at conception.
- A person shall not be deprived of life intentionally.

Access to Insulin and Associated Technologies

Insulin is the only definitive treatment for type 1 diabetes mellitus and is required to keep persons with the disease alive. Therefore, the availability of insulin and associated technologies should be embedded into the National Policies of Governments and should have high-level priority. Hence:

- To deny a child or other dependent person with type 1 diabetes access to insulin and blood glucose monitoring supplies is to condemn them to death and is tantamount to a breach of the fundamental right to life.

Insulin should therefore be provided to all children who require it irrespective of their ability to pay as part of government responsibility to protecting the right to life.

Cost of Care and Cost Benefit Analysis

In 2015, the total health care expenditure was estimated to be greater than USD$ 775 billion dollars and equivalent to ~11.6% of all global health expenditure, excluding lost quality of life, lost opportunity and productivity as well as burden of care on the families.

~80% of all expenditure is associated with treatment of complications from diabetes and only ~20% in primary care. The annual health costs per person with T1DM increases by~400% if a person develops micro-/macro- vascular complications. Thus, a disproportionate amount of resources are consumed by diabetes complications [54 56, 55 57] which have modifiable risk factors early in life. Prevention of complications through improved early care of diabetes could significantly reduce health costs globally [54 55, 56 58].

In 2015, only19% of global diabetes health expenditure was spent in low- and middle- income countries where 75.4% of people with diabetes live.

Hence an investment in gold standard care particularly during childhood and adolescence should be advocated for globally and is likely to be of significant economic benefit.

Improved glycaemic control through adequate education and regular glucose monitoring can decrease the risk of complications. Regular home glucose monitoring is cost effective, decreasing costs of diabetes care by decreasing emergencies. Care in an emergency department or a short hospital admission for hypoglycaemia or ketoacidosis exceeds the cost of several weeks of home glucose and ketone testing. Moreover, safe intensive diabetes management aimed at near-normal glycaemia is impossible without frequent and consistent glucose monitoring.

The cost of diabetes care has increased dramatically in the past 20 years with the introduction of insulin analogs, increased use of insulin delivery technologies (pumps), and glucose monitoring modalities. As continuous glucose sensor technology and closed loop system use increases, this will also add to the cost of care.

Countries and health care systems are adapting differently to the increased cost of diabetes care. Some countries or health insurance systems are considering or have already restricted use of newer insulin analogs and newer technologies requiring those choosing these technologies to bear up to 100% of the cost.

Advocacy for broad access and affordability of optimal therapies is needed, for most equitable delivery of care [57 59].

In conclusion, current therapies hold greater promise to prevent acute and long-term complications, thus with potential to reduce future health care expenditures and improve wellbeing. Therefore, whenever possible, all children with diabetes should be offered the most effective care currently available

Essential Considerations in Resource Limited Settings

Identification of the child's and family's resources and challenges, is essential for successful management their diabetes. Major limitations that can contribute to suboptimal care in resource limited settings include:

- Limited access to care
- Shortages of providers with diabetes expertise
- Limited access to insulin, food and supplies
- Financial burdens
- Psychosocial instability
- Lack of awareness of diabetes
- Detrimental health beliefs.

The following considerations should be useful:

- Champions in the health care arena need to be identified and supported in their advocacy roles. Lack of awareness means death before diagnosis, or soon after diagnosis. Increasing awareness and education among health care personnel can help.
- Families can be put in touch with each other and can offer peer support and education
- Health care providers working with children with diabetes and their families need to provide self-management education with regular follow up. Communication between visits may rely more heavily on telephone calls
- Community health workers may serve as an extension of the specialized diabetes care team, meeting with families and identifying areas that require attention outside of in-person follow up
- Treatment prescribed from the onset should be appropriate for the family's economic and educational status. Where costs are borne by the family, options to reduce costs should be explored, e.g.:
  - conventional rather than analog insulins

  - syringes rather than pen devices
  - careful use of syringes and lancets (syringes not more than 5 times)
  - meters with inexpensive strips
  - families forming groups to enable bulk purchase of diabetes care supplies
  - obtaining supplies from donor organizations, etc.
- Safe disposal of "sharps" (needles, syringes, lancets) must take into account local conditions: parents can be asked to collect all sharps in a thick-walled metal or plastic container (e.g., shampoo bottle) and bring them on each visit to the clinic for safe disposal
- Food can be in scarce supply, and not all children have food on a daily basis. In such situations multi-dose modified basal bolus regimens are very useful. The child can take small doses of NPH insulin once or twice a day, and regular insulin only when food is eaten; the dose depending on the amount of food available.
- Pictorial educational materials and simple instructions are essential for illiterate families. Providing pre-marked syringes (wrapped with coloured tape to mark the dose), and using colour coding to designate doses of insulin based on proximity of glucose reading to target range. Educational and instructional materials may not be available in the local language. In these circumstances, self-help support groups can be of great value when available.
- Many developing countries have robust family structures. Support may come from the extended family or community.

Diabetes and School

Children and adolescents with T1D spend much of their waking time in the school environment. However, there is limited empirical understanding of the challenges youth face in managing their T1D at school. There is even less literature focused on potential interventions to improve health or psychological outcomes in youth with T1D in this milieu. Moreover, in SSA, there are no legislative mandates to guide the school and parents over the management of T1D in school. It should be noted that optimal management of diabetes at school is a prerequisite for optimal school performance, including learning, and for the avoidance of diabetes-related complications. Apart from the well-known traditional diabetes complications of micro- and macrovascular complication, there is considerable evidence that children with diabetes may experience lasting neuropsychological impairments and neuroanatomical changes brief episodes of hypo- or hyperglycaemia. Therefore, maintaining normoglycaemia during school hours is important and day-to-day glycaemic targets should not differ from any other setting. Without adequate training and education, school personnel will have difficulty understanding and applying the correct principles of diabetes management and ongoing lack of knowledge and misconceptions will undermine the core objectives of achieving optimal BG control. Furthermore, irrespective of age and ability, all students with T1D at school must receive the support, encouragement, and supervision of school personnel.

There is also no specific age at which children with T1D should be expected to take on full responsibility for the diabetes self-management at school. While many children will achieve a level of maturity and ability to self-care by the age of 12 years, some children may have other underlying issues (e.g., neurocognitive / learning / psychosocial) or circumstances (e.g., war, famine financial constraints) that might preclude them from this. Furthermore, while many children may become technically skilled at an early age, all young patients, irrespective of their age, cannot be expected to be wholly responsible for their diabetes management at school. Encouragement, supervision, and support with diabetes self-management are required through their school years. Non-adherence with diabetes self-management particularly with blood glucose monitoring, bolus insulin delivery, and insulin dose calculations, are particular issues with adolescents.

Insulin administration at school must be delivered safely for every child with T1D. Preferably, and where possible, designated school personnel should have the responsibility to assist with insulin administration, or at least, to supervise the process being performed by the child. Education and training of the school personnel by the health care team (or by the parent if appropriate) is required and the explicit informed consent and authorization by the parents/guardians for the school personnel to give insulin to their child must be in place in advance.

School personnel responsible for supporting students with T1D should, ideally, also be trained to make insulin dose adjustments at school. This is achieved by matching the premeal insulin dose to the planned carbohydrate intake and by taking into consideration the premeal blood glucose (BG) level, as well as the physical activity that may have preceded the meal and any physical activity anticipated to occur after the meal. Postmeal BG excursions are often a concern but can be mitigated by adjusting the timing of the premeal insulin bolus to occur 10 to 20 minutes before eating; however, guidance on optimal timing may be required depending on individual circumstances noting that in some schools in SSA, the optimal timing for a premeal bolus can be difficult to apply as the meals are unpredictable, both in terms of their timing and expected content of food. Thus, in general, all recommendations for meal insulin dose administration in school need to be individualized. Specific instructions regarding insulin administration and insulin dose adjustments at school should be incorporated into the students' individualized diabetes management plan (IDMP).

Self-monitoring of blood glucose (SMBG) is an essential component in the optimal management of diabetes in children and adolescents with T1D. Capillary BG values should be checked by fingerstick testing using a portable BG meter (glucometer). The minimum frequency of SMBG testing during the school day is before each meal, as well as before and after physical activity. Because both high and low BG may adversely affect exam performance, BG should be checked before a school test/exam. The degree of physical activity, and the insulin sensitivity of the child, influence insulin dosage. School personnel should be made aware that BG levels outside the normal range (4–10 mmol/L) are risk factor for below-average school performance and increased absenteeism.

In SSA we have the following categories of school set up:

- Day School:
  - child goes to and from school; stays with parents at home; walks on foot, and variable distance
  - child goes to and from school; stays with relative; walks on foot, and variable distance
  - any of the above but uses motorized means to go to and from school
- Boarding School:
  - school in near the patient's home
  - the school is a distance away (over 50 km away)
- College/University
  - the student is now an adolescent and may be staying in a hostel in a room alone or with a colleague or staying at the College /University campus.

Successful management of T1D requires daily balancing of insulin administration, blood glucose monitoring, dietary tracking, and exercise with the goal of achieving blood glucose levels as near normal as possible. For children, the school environment is a critical component of their daily routine and a milieu in which they spend much of their waking time during the school year. Consequently, successful management of diabetes at school promotes good overall diabetes control. The template of the **Individual Diabetes Management Plan** (IDMP) provided in this guideline addresses all the scenarios and should be used for all children going to school. The IDMP is a formal document about the child's specific diabetes management requirements at school. The document summarizes the important areas of managing diabetes: insulin availability and storage, injection techniques, food quality and quantity at school, exercise etc. Time should be taken to develop the **IDMP** which should be revised regularly, as the settings change.

General Recommendations T1DM at School

- In all countries, even where laws do not exist, children with T1D should be able to enjoy the same benefits of school attendance as their peers and should not be excluded because of their medical needs.
- A written **Individual Diabetes Management Plan (IDMP)** developed by the child's health care provider and the family specifically for the child's school setting should be discussed with the school nurse and teacher and revised where necessary.
- The type of insulin regimen used at school should be tailored to the needs, ability and wishes of the child / family and should not be dictated by the school resources.
- It is important to have an ongoing and individually tailored training of school staff, including nursing, teaching, coaching, and administrative staff, to support the child with diabetes in their daily diabetes care tasks.
- Schools should make "all reasonable adjustments" to facilitate prescribed medical care to allow for children with T1D to participate in children education on the ***same basis as their peers***. "Reasonable adjustments" include school personnel support with insulin

administration, as well as understanding and knowledge of diabetes technologies (including continuous glucose monitoring [CGM] devices and insulin pump settings.

- Blood glucose (BG) monitoring is central to achieving optimal glycaemic control at school and must be familiar to school personnel.
- The need to promote a gradual transition to the child's diabetes self-management in the school setting that is both developmentally and appropriate and individually tailored.
- School personnel should be able to manage appropriately the effects of low and high BG levels according to parent and health care team instructions.
- It should be appreciated that school exams or other assessment situations are associated with stress and increased risk of acute transient episodes of hypoglycaemia or hyperglycaemia that can affect performance.
- Parents cannot be expected to "fill the gap" of school resources and attend to their child's medical management during school day.
- The value of communication and close collaboration between the child with diabetes and all the stakeholders including the school nurse, other trained school staff members, diabetes health care provider, and the child's family. Indeed, successful diabetes management at school heavily depends on effective communication and problem-solving with the family and schools should clarify expectations and coordinate communication.
- A need to address the perception of what the child has with regard to managing diabetes at school - young people with diabetes have a significantly increased risk of being exposed to issues of discrimination, which may impact on self-esteem and cause feelings of stigmatization.
- A need to address the perception of what the parents have with regard to managing diabetes at school: nursing competency, hypoglycaemia management, stigma etc.
- A need to address the perception of what the teachers and other school staff have with regards to managing diabetes at school.
- With. A mutually supportive, collaborative approach between parents and the child's health care team and schools, and with advancements in communication technology, for example sending data of glucose checks by SMS (or the advanced sensor glucose data in real time) to parents, there is a real opportunity for a truly cooperative approach.

Contextualized Recommendations T1D at School

While school is a time of learning, making friends, having fun, and finding peer groups, this may be difference in the low resource setting environment where the child with T1D may be excluded purely because the school authorities feel T1D will become an "endless burden", the student is isolated or stigmatized. As health professionals caring for these vulnerable young people, we must ensure as best as we can that they receive the same educational opportunities as other children in their community, providing the potential for fruitful employment and the chance for further education. It is important, therefore, that ample time is spent in developing individualized diabetes management plan, which will should be reviewed regularly as the school settings are also bound to change. The following areas need special attention:

- The school has no school nurse and is remotely away from a health facility - suggest more intensive education of the teacher and try to establish a phone communication with the family or caretaker
- Children walking to and from school - ensure the child is with a peer all time who will be educated about hypoglycaemia and its management
- School does not provide meals and the child packs the meals for school from home - while this may appear absurd, it is a frequent occurrence. This works well if the food is sufficient and does not lost/stolen while at school. Planning should put in place a peer to help and

inform the family and avert the hypoglycaemia likely as the family prepares to deliver a supply of food.

- A child taking a lunch-time injection at school, should have a safe and private place to give the injection.
- It may take a whole day for the child to attend regular scheduled medical appointments. Teachers and school authorities should try to assist the student fulfil this obligation and probably arrange for the child to go through the work missed when the student returns from the medical appointment.

Community Initiatives

Community initiatives to improve the care of type 1 diabetes in an important option, especially where health services are poorly developed as in sub-Saharan Africa. This requires training of health professionals to start such initiatives [58, 59]. Such programs should identify low cost, effective, and easily implementable primary and secondary prevention approaches, as well as tertiary strategies that delay disease progression, complications, and associated deterioration in function of patients with diabetes. The Chronic Care Model provides a well-accepted framework for improving diabetes and chronic disease care in the community and primary care medical home. Diabetes programs must offer accessible information and support throughout the community and must be delivered in a format that is understood, regardless of literacy and socioeconomic status [59 61].

Strengthening Delivery of Health Services

Good health service delivery can be challenging in low-resource settings where human and health system resources are scarce; yet delivery of high-quality efficient health services is a cornerstone of the global agenda to achieve universal health coverage. According to the World Health Organization, health service delivery is considered good when equitable access to a comprehensive range of high-quality health services is ensured within an integrated and person-centred continuum of care [62 64]. The success of maintaining patients within the continuum of care through follow-up visits or referrals of patients from one health facility to another is very much dependent on the health service delivery system; directly impacting on the quality of health care services delivered. Therefore, it is imperative that health care professionals take up the challenge to improve the health service delivery. Two particular areas, digital health-enhanced referral coordination and mobile clinical decision support systems, demonstrate considerable potential to improve the quality and comprehensiveness of care received by patients, but they require a greater level of standardization and an expanded scope of health worker engagement across the health system in order to scale them up effectively.

When this formal approach is not feasible, it is emphasized that simple basic protocols of referral should be developed within each health facility that ensure the patients' safety on referral to another centre. A patient should not be referred as a way of getting rid of a problem from a health facility- exhibiting **strategic incompetence**. All efforts should be taken to ensure the patients safety.

Devices, Needle Choice and Injection Technique

Insulin therapy remains the cornerstone of type 1 diabetes mellitus (T1DM) management. This section has been extensively elaborated on in the EADSG Guidelines: Insulin Therapy in Diabetes [10] and EADSG Guidelines: Insulin Storage and Optimisation of Technique [62]. In brief, insulin is the primary treatment in all patients with T1DM. Typically, patients with T1DM will require initiation with multiple daily injections at the time of diagnosis. In the majority of sub-Saharan Africa (SSA), the available devices to use will be the traditional insulin syringe and needle to be used with human insulin. Health workers should give sufficient time of training on insulin injections and techniques including rotation of sites and recognition of lipohypertrophy. Analogue insulin is as effective as human insulin but is associated with less post-prandial hyperglycaemia and delayed hypoglycaemia, but is more expensive and not easily available in most parts of SSA. An insulin syringe has three parts: a needle, a barrel, and a plunger. The needle recommended should be 6-mm in length i.e., short and thin and covered with a fine layer of silicone to allow it to pass through the skin easily and lessen pain. The recommended needles are those that are not detachable. The shortest needles (currently the 4-mm pen and 6-mm syringe needles) are safe, effective, and less painful and should be the first-line choice in all patient categories; intramuscular (IM) injections should be avoided, especially with long-acting insulins, because severe hypoglycaemia may result; lipohypertrophy is a frequent complication of therapy that distorts insulin absorption, and therefore, injections and infusions should not be given into these lesions and correct site rotation will help prevent them. Many patients in SSA reuse syringes for various reasons, including financial. This is not recommended by the manufacturer and there is an association between needle reuse and lipohypertrophy. However, patients who reuse needles should not be subjected to alarming claims of excessive morbidity from this practice. When insulin syringes are reused, it should not exceed five times. Special considerations may be made for the patient who is very thin and even ‘pinching’ the skin to give an injection is difficult. In such a patient it may be advisable to use the 4-mm pens until the patient has improved and there

Training in the use of insulin pumps is available in some centres in SSA and this should be availed for the patients who require them. Similarly, the use of continuous glucose monitoring is available in some centres and this should be availed should the patient opt for it and can afford it.

Setting up an Emergency Plan

Identification in Emergency Situations

Diabetes is a serious condition that can cause life-threatening dips in blood glucose (hypoglycaemia). Patients should be guided on how to obtain a medical identification either in the form of Jewellery or a wrist band or a simple card bearing the name and what to do in emergency situations. Patients should be instructed on carrying with them a glucose meter and an emergency supply of insulin and glucagon if available; to always pack carbohydrates for low blood sugar, to communicate health needs with people who are in a position to help out in an emergency (friends, roommates, teachers, coaches, etc. An up-to-date emergency health care plan for those at school should be reviewed.

Health Insurance

Health insurance is extremely important for people with diabetes. Insulin and glucose/ketone monitoring supplies, glucagon, insulin pumps, physician visits, etc are expensive. Plan for the future, as good health insurance coverage is critical to good diabetes management. While most countries in SSA have no national insurance coverage, every opportunity should be taken where an insurance cover can be obtained. Health workers should guide parents and patients on insurance coverage. A little investigation can help find and keep the best insurance plan for the diabetes.

Limited Insulin Supply

Not very often patients and their caregivers will report not being able to get to the clinic or other place to secure further supplies of insulin for a couple of days and sometimes even weeks. While this is very undesirable and may precipitate diabetic ketoacidosis when the insulin runs out entirely, the best option in this circumstance is to reduce the dosage of insulin injected to half the dose, so that ketoacidosis is avoided and 'buys' time to get further supply of insulin. Giving an extra vial of insulin to the one likely to fall into this mishap may obviate this danger. Discussing this situation with patients and their relatives should be part of the diabetes education and self-care.

Away from Home with Limited Supervision

During holidays especially, children return to the ancestral homes or go to visit their grandparents where the meals will vary and the supervision is less. These situations should be covered in the *diabetes tutelage*. The parents or caregivers should be given information on such scenarios and be aware how to plan them. It should not be left to the simple solution of the patient should not go to the parents because it may lead to stigma and loss of self-esteem. Adequate training of the caregiver who travels with the patient avoids this situation. Older patients who have already taken charge of their diabetes need only discussion to enhance their skills.

Severe Acute Respiratory Syndrome Corona Virus-2 (SARS-CoV-2)

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is poised to disrupt healthcare delivery in low- and middle-income countries. SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19) was first reported by Dr. Li Wenliang on the 30 December 2019 in an online chat group WeChat, in Wuhan, China. Since its report in China, the COVID-19 has spread to almost all countries in the world in unprecedented speed. There are adverse reports of the severity of this infection in type 2 diabetes; although not reported in type 1 diabetes. However, the effects of the preventive measures to stop the spread of COVID-19 e.g., lockdown, transport restrictions, fear contracting the SARS-CoV-2 from a health facility, may adversely affect access to health care and monitoring of glucose at home. Delayed hospital admissions for diabetic ketoacidosis (DKA) in children and adolescents have been reported during the COVID-19 pandemic. These experiences reinforce the importance of continued attentiveness to standard diabetes care to avoid the need for hospitalization and emergency or urgent care visits during the COVID-19 pandemic. The message to the patients has been “Keep calm and mind your diabetes care”. Self-monitoring should continue and if possible, more frequently. If a person with type 1 diabetes gets infection, insulin should be continued, more frequent monitoring done and patients to seek health care as soon as possible.

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Appendix

EADSG Guideline Development Task Force (EADSG-GDTF)

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Appendix 1: SMBG CHART - Write Actual Figures

Name.....		Insulin doses							
DAY	DATE	Breakfast		Lunch		Supper		Night	
		Before	2-hrs After	Before	2-hrs After	Before	2-hrs After/ Bedtime	3:00 am	Comments
1									
2									
3									

Blood Glucose (Mmol/l)	Draw Graph using data from recordings of blood glucose																				
>26																					
25.0																					
24.0																					
23.0																					
22.0																					
21.0																					
20.0																					
19.0																					
18.0																					
17.0																					
16.0																					
14.0																					
14.0																					
13.0																					
12.0																					
11.0																					
10.0																					
9.0																					
8.0																					
7.0																					
6.0																					
5.0																					
4.0																					
3.0																					
2.0																					
1.0																					
0.0																					
DAY	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Time to Measure	Fasting or Pre-Breakfast			2-hrs Post Breakfast			Pre-Lunch			2-hrs Post Lunch			Pre-Super			2-hrs Post Supper / Bedtime			3:00 am		

Appendix 3: Draw Graph Using Data of Appendix 1 (if checking 4 times a day)

Blood Glucose (Mmol/l)												
>26												
24.0												
23.0												
22.0												
21.0												
20.0												
19.0												
18.0												
17.0												
16.0												
15.0												
14.0												
13.0												
12.0												
11.0												
10.0												
9.0												
8.0												
7.0												
6.0												
5.0												
4.0												
3.0												
2.0												
1.0												
0.0												
Time to measure	Pre-Breakfast	Pre-Lunch	Pre-Supper/ Bedtime	3:00 am	Pre-Breakfast	Pre-Lunch	Pre-Supper/ Bedtime	3:00 am	Pre-Breakfast	Pre-Lunch	Pre-Supper/ Bedtime	3:00 am
DAY	1				2				3			

Appendix 4: Initial Form

Date of Visit	
Clinic/Identity Number	
Name	
Date of birth:	
Sex	
Address	
Next of Kin	
Ten cell leader	
Mobile Phone	
No. of 1st Degree relatives with Diabetes	
Average No. of Cigarettes / Day	
No. of Days/month you take alcohol?	
No. of Minutes/day you walk to school	
What sports do you participate in?	
Date Symptoms Started	
Main Presenting Symptoms (Choose: DKA, Classical, or Others)	
Height (cm)	
Weight (Kg)	
BMI	
% Weight for Height	
% Weight for Age	
Blood Pressure (mm/Hg)	
Any other finding on Physical Exam	
1.	
2.	
3.	
Biochemistry	
Fasting Blood Glucose	
Random Blood Glucose	
HBA1C	
Total Cholesterol	
Serum Creatinine	
Urine Proteins	
Amount of Insulin Prescribed	
Short Acting Insulin (units/day)	
Long Acting Insulin (units/day)	
Mixed Insulin (units/day)	
Other Medication	
1.	
2.	
3.	

Appendix 5: Follow up Form

Name	
Mobile Phone	
Clinic Number	
Present Symptoms: Choose: DKA, Classical, Others)	
Since Last Visit:	
No. of Episodes of Hypoglycaemia	
No. of Hospital Admissions	
No. of Days missed Classes	
Minutes of Physical activity per day	
Average No. of Cigarettes / Day	
No. of days/month you take alcohol	
Anthropometry	
Height (cm)	
Weight (Kg)	
BMI	
% Weight for Height	
% Weight for Age	
Blood Pressure (mm/Hg)	
Injection Sites	
Other Physical Exam Findings	
1.	
2.	
3.	
Biochemistry	
Fasting Blood Glucose	
Random Blood Glucose	
HBA1C	
Urine Proteins	
Amount of Insulin Prescribed	
Short Acting Insulin (units/day)	
Long Acting Insulin (units/day)	
Mixed Insulin (units/day)	
Other Medication	
1.	
2.	
3.	
Annual Review	
Pubertal Status	
Fundus Examination	
Foot Examination	
Total Cholesterol	
Serum Creatinine	

EADSG Guidelines Contributors

THE VISION OF EADSG

The vision of EADSG is an East Africa where health care professionals and persons with diabetes are fully empowered to effectively manage diabetes.

THE MISSION STATEMENT

The EADSG is committed to contribute towards the current and future measures of addressing the challenges posed by an increasing burden of diabetes and other non-communicable diseases (NCDs) in East Africa and beyond.

The EADSG will provide health care professionals with scientific information and educational initiatives (training) designed to translate research into effective clinical practice. These include short courses in epidemiology and translational research, scientific conferences and practical guidelines for patient education and management.

The EADSG encourages and supports research into practices appropriate for situations in the region that would ensure good diabetes control and advocates for wide dissemination and action on research findings.

The EADSG aims to lead and deliver national activities in the region and co-operate with the East African Community and other international organisations to share knowledge and resources so as to add value to the lives of people with diabetes.

THE VALUES

The EADSG upholds the well-being of people affected by diabetes and the pursuit of excellence in professionalism, quality and ethics. In everyday interactions EADSG will exhibit and expect fairness, honesty, openness, confidentiality and integrity from all and will in addition respect the diversity and roles of individual members of the EADSG.

TRAINING PROGRAMS

EADSG adopts a broad, integrative approach to diabetes care and the management of associated diseases and complications, tailoring its endeavours to the East Africa conditions and bearing relevance to countries facing similar challenges and concerns. EADSG focuses on broad dimensions of diabetes care that encompass promotive, preventive and therapeutic services, many of which are frequently lost sight of, in policy planning as well as in popular understanding, but are contributing immensely as barriers to quality diabetes care in the region. EADSG recognises the fact that meeting the shortfalls of health professionals is imperative to a sustained and holistic response to the public health concerns of the country which in turn requires health care to be addressed not only from the scientific perspective of what works, but also from the social perspective of who need it the most. To achieve this important of objective, the EADSG initiated five overarching, but integrated, set of activities that address diabetes education, training, research, health systems support, advocacy and communications; and policy development: - (i) the EADSG Academy which aims at capacity building of health workers; (ii) the EADSG Congresses & Scientific Sessions; (iii) the E-Diabetes education; (iv) the Certificate course in diabetes care and (v) the Evidence Based Clinical Practice Guidelines.

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