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A Review of Type 1 Diabetes (T1D): To Assist Patients' and Carers' Understanding of This Condition

Eileen O'Donnell
Technological University Dublin, eileen.odonnell@TUDublin.ie

Liam O'Donnell
Technological University Dublin, liam.odonnell@tudublin.ie

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A Review of Type 1 Diabetes (T1D):
To Assist Patients' and Carers' Understanding of This Condition

Eileen O'Donnell, Technological University Dublin, Dublin, Ireland
Liam O'Donnell, Technological University Dublin, Dublin, Ireland

ABSTRACT

The diagnosis of Type 1 Diabetes (T1D) will come as an unwelcome surprise to most people. Within a short period of time, the person will have to come to understand and manage this chronic illness. The terminology associated with the T1D condition will also be totally new to the person: diabetes mellitus, pancreas, hyperglycaemia (hyper), hypoglycaemia (hypo), bolus (fast acting insulin), basal (slow acting insulin), ketones and blood glucose levels. The purpose of this article is to assist newly diagnosed patients' understanding of T1D, people who are already living with T1D, carers of people with T1D, partners and family members of someone with T1D, work colleagues, and friends who participate in the same sporting activities or go on holiday with a person who has T1D. In addition, this article reviews how people living with T1D can still enjoy exercise and maintain the best quality of life possible; whilst controlling the blood glucose levels in their body for the rest of their lives to prevent the onset of complications associated with diabetes.

KEYWORDS

Basal, Blood Glucose Levels, Bolus, Diabetes, Glycaemic Control, HbA1c, Hyperglycaemia, Hypoglycaemia, Insulin, Ketones, Lancets, Oral Glucose Tolerance Test, Pancreas, Sharps Bucket, Sharps

INTRODUCTION

The diagnosis of T1D at any age can be quite shocking. Particularly to an individual or parent who has had no close previous contact with anyone with the condition. "85% of newly-diagnosed patients have no family history of the disease" (Atkinson & Eisenbarth, 2001, p. 224). The diagnosis of T1D, a debilitating autoimmune disease (Wen et al., 2008), has increased substantially over the last thirty years (Atkinson & Eisenbarth, 2001), and continues to increase (Ang et al., 2017; O'Hara et al., 2017), to the extent that it is now considered to be a global epidemic (Ahmed et al., 2018; Noor, Khan, & Ahmad, 2017; O'Loughlin, McIntosh, Dinneen, & O'Brien, 2010).

T1D is a life-long medical condition requiring frequent monitoring of blood glucose levels throughout the day, constant vigilance of every morsel the patient consumes and other lifestyle choices are necessary to effectively manage this condition (Dinneen, 2010). In addition, the patient or carer must have an appreciation of the effect that personal exercise choices may have on blood glucose levels and how to manage the precise dose of insulin administered to cover for the possible reduction in blood glucose levels experienced during exercise.

Even if a person with Type 1 Diabetes takes great care and manages to keep their blood glucose levels as close to normal as possible, there is still no guarantee that they will not suffer from

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complications due to diabetes later on in life. Basically, the person has the power to control/modify all of the risk factors through tight monitoring of blood glucose levels, diet, exercise, life style choices, etc. The only factor that is non-modifiable is the fact that a person diagnosed with T1D has it for life, everything else that effects blood glucose levels are modifiable. The pancreas of a person with Type 1 Diabetes no longer produces insulin or produces insufficient doses of insulin to control the amount of glucose in the blood. Therefore, the challenge is to balance insulin doses and everything else (food and drink intake, exercise, sleep, stress, illness, and so forth) to maintain blood glucose levels as near to normal as possible.

T1D is challenging to manage as so many different variables influence the level of glucose in one's blood at any single point in time. "Crucial to achieving glycaemic control is an understanding of the effect of diet, physical activity, and insulin on blood glucose levels" (Jackson et al., 2015, p. 1959). The administration of the most suitable dose of insulin to cover the amount of carbohydrates consumed and the level of activity in which the person engages is paramount to achieving good glycaemic (blood glucose level) control in order to avoid other medical complications in the future. The administration of the most suitable dose is also crucial to ensure that the person who has T1D does not experience a severe hypoglycaemia episode (hypo).

"Type 1 diabetes is a chronic disease in which individuals are unable to produce insulin, which is essential for regulating blood sugar" (Byrne et al., 2012, p. 3), that is characterised by hyperglycaemia and the harm it may cause to the body (Fowler, 2008). Hyperglycaemia means that there is too much glucose in the person's blood stream, which can, if left untreated, lead to other medical complications in later life. Hyperglycaemia can also lead to Diabetic Ketoacidosis (DKA) in the short term. DKA is a life-threatening condition that may affect people who are diagnosed with Type 1 or Type 2 diabetes. Alternatively, a person may present at a Hospital's Accident and Emergency Department with DKA, this being the first sign that they are in fact suffering from diabetes. DKA happens when the levels of glucose (sugar) in the blood rise to dangerous levels because the pancreas is unable to produce sufficient insulin to regulate the level of glucose in the blood. Therefore, the body cannot access glucose from the blood for energy, tissue production and repair, instead the body starts to breakdown stores of fat that are present in the body. This process leads to the production of ketones. The presence of ketones can turn the blood acidic. Acidic blood can make a person feel very unwell, and subsequently if untreated can lead to DKA, a diabetic coma or even death.

The background section discusses the worldwide incidence of T1D and some of the symptoms experienced during the sudden onset of T1D. The section on the diagnosis of T1D includes brief explanations of the following: Self-Monitoring of Blood Glucose (SMBG); blood glucose levels; HbA1c; the use of insulin to control the blood glucose level; acceptable blood glucose level; unique treatment plan required for each patient; pancreas; and the honeymoon phase. The next section covers some factors which may influence the onset of T1D: genetics; environmental; deficiency in Vitamin D; stress; and the use of statins. The following section introduces the equipment, disposables, medication, and the monetary costs required to manage T1D. The responsible administration of insulin is explained in the next section, followed by sections on hypers and hypos. The subsequent section includes some recommendations for the successful management of T1D. Succeeded by some tips for patients with T1D. Then there is a section that briefly mentions medical complications association with diabetes, foot ulceration and nephropathy. The contraindications of administering insulin are noted in the next section. Followed by a section on the positive impact of a diagnosis of T1D, several options worthy of further research, the conclusion, and references.

BACKGROUND

Initially, a diagnosis of T1D may sound very daunting and the requirement to self-manage this complicated condition may seem insurmountable or at least very challenging. "While there has been a focused shift away from the traditional medical models of practice where the clinician is perceived

as the expert who holds a position of authority over the patient, some clinicians still struggle with the shift to shared control" (Hurley et al., 2017, p. 1958). A person with T1D must take personal responsibility for injecting themselves with insulin several times a day and also for deciding how many units of insulin to inject at each meal because they may only have a consultation with the clinician once or twice a year.

Type 1 Diabetes Mellitus (T1DM), also known as Type 1 Diabetes (T1D) accounts for 5-10% of the total number of cases of Diabetes Mellitus worldwide (Voltarelli et al., 2007), or approximately 20 million people globally (Thrower & Bingley, 2014). "The term diabetes mellitus describes a metabolic disorder of multiple aetiology characterized by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both" (Alberti et al., 1998, p. 2). "Hyperglycemia is associated with increased mortality in critically ill patients" (Griesdale et al., 2008, p. 821). "Type 1 diabetes has historically been considered a disorder predominately of children and young adults (the disease is commonly referred to as juvenile diabetes because it has peak expression between ages 10-14 years)" (Atkinson & Eisenbarth, 2001, p. 223). The onset of T1D usually occurs before the age of thirty years (Hex, Bartlett, Wright, Taylor, & Varley, 2012). Young adults with T1D struggle to manage blood glucose levels leading to poor glycaemic control and suboptimal clinical outcomes (Byrne et al., 2017; O'Hara et al., 2016), therefore, "effective interventions to improve self-management and outcomes for young adults with T1DM are needed" (Byrne et al., 2017, p. 2). "The precise incidence of new-onset type 1 diabetes in those over 20 years of age is unknown" (Chiang, Kirkman, & Laffel, 2014, p. 2034). "Half of people with type 1 diabetes are diagnosed as adults" (Gilbert, Millard, & Flynn, 2012, p. 2). "The clinical diagnosis is often prompted by symptoms such as increased thirst and urine volume, recurrent infections, unexplained weight loss and, in severe cases, drowsiness and coma" (Alberti et al., 1998, p. 4). Symptoms can also include difficulty breathing, vomiting and a general sense of feeling unwell. Please see Figure 1.

DIAGNOSIS OF T1D

The determination of the presence of T1D in a patient can be assessed through various different medical tests: (i) Fasting blood glucose level, (ii) Oral Glucose Tolerance Test (OGTT), (iii) HbA_{1c} test which provides an average of glycated haemoglobin over approximately the last two to three months, (iv) a random blood glucose level greater than or equal to 11.1mmol/L (200mg/dL).

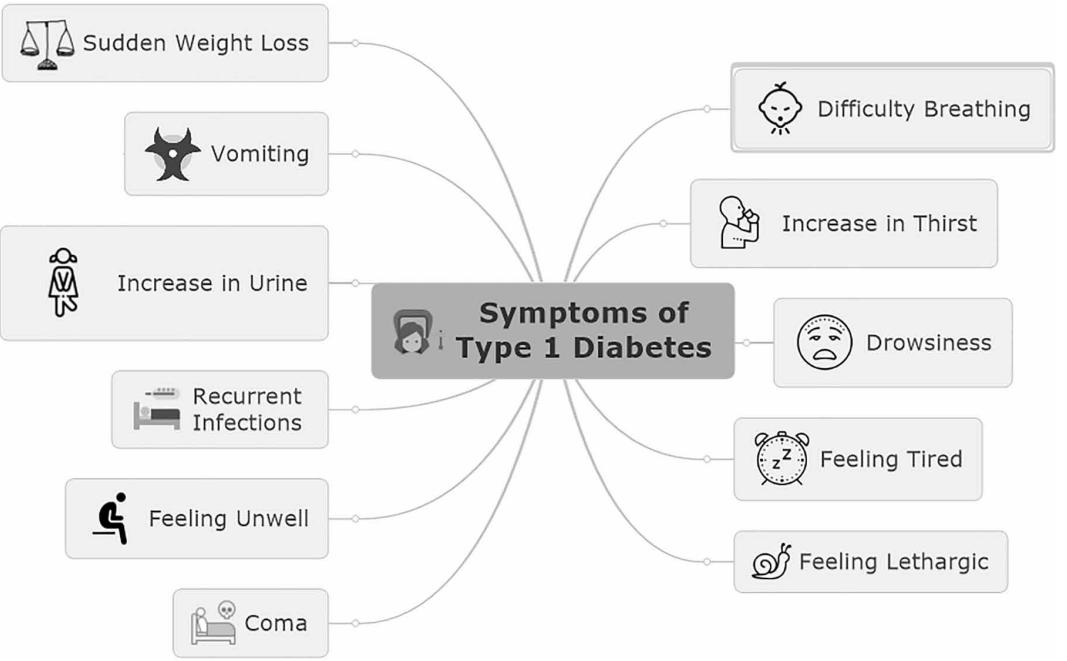
Self-Monitoring of Blood Glucose (SMBG)

A person who has recently been diagnosed with T1D can broaden and enhance their understanding of this condition by (i) following the advice of the medical professionals on the assigned diabetes care team, (ii) getting the opportunity to discuss the experiences of others who have lived with diabetes and how they have managed their condition, and (iii) reading books, journal articles and online forums. One of the main responsibilities of a person diagnosed with T1D is to avoid experiencing hypos and hypers through regular Self-Monitoring of Blood Glucose (SMBG) (Deiss et al., 2006; Garg, Shah, Akturk, Beatson, & Snell-Bergeon, 2017), and by improving their understanding of the condition by engaging with Structured Education Programmes (SEPs) (Lawton & Rankin, 2010). Unfortunately, Diabetes Self-Management Education (DSME) does not receive the same level of funding as "drugs and devices (which are associated with financial gain)" (Hurley et al., 2017, p. 1958). Achieving near to normal blood glucose levels is challenging (Russell et al., 2014), but very important, as hyperglycaemia is associated with many negative cardiovascular and immunological effects (Egan & Dinneen, 2016). Cardiovascular disease affects the heart, blood vessels and arteries.

Blood Glucose Levels

T1D can be diagnosed from a fasting blood glucose level greater than or equal to 7 mmol/L (126 mg/dL) (Atkinson, Eisenbarth, & Michels, 2014; Chiang et al., 2014; Daneman, 2006; Egan & Dinneen,

Figure 1. Some of the symptoms of type 1 diabetes



2014). "The cut-off point used to define a normal plasma glucose differs between the USA (where the American Diabetes Association (ADA) recommends a concentration of 5.6) mmol/L and the rest of the world (where the World Health Organisation (WHO) recommends 6.1 mmol/L)." (Dinneen, 2010, p. 589). OGTT is the abbreviation for the Oral Glucose Tolerance Test. A Glucose Tolerance Test (GTT) result of 11.01 mmol/L (200mg/dL) or greater (Atkinson et al., 2014; Chiang et al., 2014; Egan & Dinneen, 2014) signifies the presence of diabetes. "The diagnostic cut off points of 7.0 mmol/L (fasting) and 11.1 mmol/L (OGTT 2-hour value) are based on the concentrations at which retinopathy begins to appear in a population" (Egan & Dinneen, 2014, p. 680). Retinopathy is the medical term for damage to blood vessels in the eyes due to high blood sugar levels. The diagnostic cut off point of haemoglobin A1c > 7.0% is associated with patients who are at increased risk of developing Cardiovascular Autonomic Neuropathy (CAN) (Spallone et al., 2011). Neuropathy is the medical term for damage to peripheral nerves resulting in weakness, numbness, and pain. The risk of developing retinopathy and other complications associated with diabetes depends on the duration and severity of the hyperglycaemic episodes experienced (Fowler, 2008). Malone, Pavan, Morrison, & Cuthbertson (2001) suggest that dilated eye examinations that are performed to detect retinopathy should be conducted within the first year after the onset of T1D; as their study found that 20% of the volunteers who lived with diabetes for 1 year tested positive for retinopathy.

HbA_{1c}

People with poor glycaemic control have haemoglobin HbA_{1c} levels in excess of 7% (Davis, 2016). "The American Diabetes Association currently recommends an A1c goal of less than 7.0%, while other groups such as the American Association of Clinical Endocrinologists recommend a goal of less than 6.5%" (Davis, 2016, p. 4). A HbA_{1c} test of 6.5% or higher indicates the presence of diabetes (Egan & Dinneen, 2014). A HbA_{1c} test provides an average of glycated haemoglobin (Byrne et al., 2012) in the blood over the past two to three months (Atkinson et al., 2014). In Dinneen et al.'s (2013)

study one of the inclusion criteria to participate in the study was to have "an HbA_{1c} level below 13 percent at recruitment" (Dinneen et al., 2013, p. 30). Dinneen et al. (2013) in their study "Based on pre-study audit data from Irish centres estimated that approximately 20 percent of participants would have a baseline HbA_{1c} below 7.5 percent (59 mmol/mol)" (Dinneen et al., 2013, p. 31).

The Use of Insulin to Control the Blood Glucose Level

"In patients with classic symptoms of hyperglycemia or hyperglycemia crisis, a random plasma glucose ≥ 200mg/dL (11.1 mmol/L)" (Chiang et al., 2014, p. 2036). A person with a random plasma glucose test result of less than 11.1 mmol/L (200mg/dL) is considered not to have diabetes. In a person with normal blood glucose control, their pancreas will deliver the appropriate quantity of insulin to bring their blood glucose level down to normal levels in a short period of time after the consumption of food or drink. Whereby, the pancreas of a person with T1D is incapable of producing sufficient insulin to bring their blood glucose level down in a short period of time or even in a long period of time. Therefore, the person with T1D has to decide whether to administer insulin to reduce their blood glucose level or to engage in some sort of physical activity to reduce their blood glucose level. A 5km walk could reduce blood glucose level by 3/4 mmol/L (54/72 mg/dL), alternatively, hoovering the house could have the same impact. Everybody is different. Therefore, blood glucose levels should be taken before and after exercise until the person knows roughly what blood glucose level to expect. "The endocrine pancreas makes insulin so that the body can use glucose (sugar) for energy. The exocrine pancreas makes enzymes that help the body digest food" (Gilbert et al., 2012, p. 37). Further research is required to investigate if insulin inhibits the release of glucose into the blood from the liver (Manninen, 2004), or if insulin enables the body to use glucose for energy or perhaps both.

Acceptable Blood Glucose Level

A person with diabetes should aim for a glucose goal of 3.9 to 6.7 mmol/L (70 to 120 mg per decilitre) before meals and a blood glucose level of no more than 10 mmol/L (180 mg per decilitre) after meals (Nathan et al., 2005). Nathan et al. suggest that a postprandial (2 hours after the meal was consumed) blood glucose level of no more than 10 mmol/L (180 mg per decilitre) while others would suggest that a postprandial blood glucose level of no more than 11mmol/L (200 mg per decilitre) is acceptable.

Unique Treatment Plan Required for Each Patient

"Type 1 diabetes seems to represent a heterogeneous disease whose pathogenic processes, genetics, and phenotypic characteristics show marked variation" (Atkinson et al., 2014, p. 70). The challenge to diabetes care teams is that each person with diabetes requires an individual treatment plan. Each person requires a specific treatment plan based on their individual lifestyle choices ((food consumption, engagement in various different exercise activities (including housework and paid work), insulin dosing regimen, stress levels, sleep patterns, and many other variables)). Unlike other medical conditions, whereby people can simply follow the dosage plan set out by their medical team, people with T1D need to plan their meals and insulin dosage numerous times a day depending on the activities with which they engage. It is important for people with diabetes to tailor the administration of insulin to suit their exercise plan to avoid episodes of hypoglycaemia (Chiang et al., 2014). Therefore, the successful treatment of people with T1D substantially depends on the person's mindfulness in medicating with insulin to reflect all that they consume, and all that they do every hour of every day. Byrne et al. (2012) suggest that people with higher educational attainment benefit more from attending the Dose Adjustment for Normal Eating (DAFNE) course when compared to people with lower educational attainment. O'Hara et al. (2016) suggest that people without skills will struggle to successfully self-manage T1D even with diabetes education and support. Leelarathna et al. (2011) speculated "that those patients with T1D who do not have access to structured education may be systematically over-insulinised" (Leelarathna et al., 2011, p. e36). Over-insulinised means the administration of too much insulin. The use of excessive insulin can lead to the patient experiencing too many hypos and severe hypos which can lead to hypo unawareness.

Pancreas

The pancreas of a person with T1D has substantially or totally lost the ability to produce insulin. The pancreas of some people after diagnosis of T1D still produce some insulin, known as residual insulin secretion (Alberti et al., 1998), this is known as the honeymoon period, but generally insufficient insulin is produced to maintain good glycaemic control. Therefore, the administration of some exogenous insulin is required, but possibly not as much insulin as would be required by a person whose pancreas no longer produces any insulin at all. Once the pancreas has lost the ability to produce insulin (after the honeymoon period), the level of glucose in the blood may rise to dangerous levels. "Diabetes mellitus is a chronic disorder of glucose metabolism with serious clinical consequences" (Forouhi & Wareham, 2010, p. 602). The most important event in the history of T1D was the discovery of insulin in 1921-22 (Atkinson et al., 2014) by Frederick G. Banting and Charles H. Best (Rotenstein et al., 2012). The discovery of insulin was not a solution to cure or prevent the onset of T1D, but the administration of exogenous insulin was an effective way to control T1D. The perennial hope that islet transplantation would alleviate the need for exogenous insulin has failed to materialise (Shapiro et al., 2000). Further research is required on islet transplantation.

Honeymoon Phase

When a patient is newly diagnosed with T1D, initially a honeymoon phase may be experienced. During the honeymoon period the body may continue to produce some insulin, therefore, less injected insulin is required to self-manage diabetes. Exercise can reduce the need for insulin as the body uses up the sugar in the blood during activity. People with T1D who engage in regular exercise may prolong the honeymoon period, maintain good glycaemic control (control of the level of glucose in the blood), and require less injected insulin for longer than newly diagnosed patients who do not engage in regular exercise. Exercise increases the body's sensitivity to insulin. Therefore, less insulin is required by people with T1D who exercise regularly, however, blood sugar levels must be monitored regularly as blood glucose levels can be very hard to predict. The extent to which the engagement in exercise can extend the honeymoon phase requires further investigation.

FACTORS THAT MAY INFLUENCE THE ONSET OF T1D

At present, there are no known ways to prevent the onset of T1D and the factors which may influence the onset are not clearly defined. Some of the factors that may influence the onset of T1D are reviewed in this section. Please refer to Figure 2.

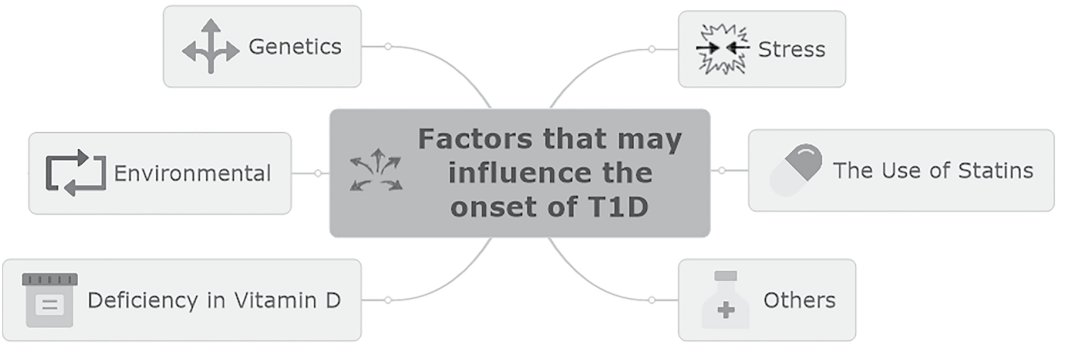
Genetics

"Type 1 diabetes (T1D) is a common autoimmune disorder that arises from the action of multiple genetic and environmental risk factors" (Barrett et al., 2009, p. 703). Genetics can have an impact on β-cell dysfunction and death (Eizirik & Darville, 2001). "Results from linkage and association studies in T1D have long supported a model in which the major risk factor for T1D resides in the HLA region on Chromosome 6p21" (Barrett et al., 2009, p. 703). Further research is required to determine factors that trigger the onset of T1D.

Environmental

"The mechanisms underlying these enigmas in geographical incidence and increased incidence rates of type 1 diabetes are unknown but have largely been attributed to environmental influences" (Atkinson et al., 2014, p. 69). Thrower and Bingley (2014) also suggest that environmental factors could play a role in the rapid increase in the diagnosis of type 1 diabetes mellitus (T1DM). Type 1

Figure 2. Factors that may influence the onset of T1D



Diabetes is also known as Type 1 Diabetes Mellitus. Samuelsson and Lofman (2013) suggest that there is a possible link between the incidence of T1D and some geological factors. Further research is required to identify the specific environmental factors with possible links to the onset of T1D.

Deficiency in Vitamin D

"Vitamin D deficiency increases the risk of many common cancers, multiple sclerosis, rheumatoid arthritis, hypertension, cardiovascular heart disease, and type 1 diabetes" (Holick, 2005, p. 1024). Vitamin D is necessary in the human body to ensure that the immune system is in excellent working order. The immune system protects the body by defending it against viruses and infections. A weakened immune system can leave the body in a very vulnerable state. One such state is the diagnosis of T1D due to an immune-mediated depletion of β-cells. "Type 1 diabetes is characterised by an immune-mediated depletion of β-cells that results in lifelong dependence on exogenous insulin" (Chiang et al., 2014, p. 2034). Exogenous insulin is the insulin injected with a needle or an insulin pump. Endogenous insulin is the insulin made in the pancreas. "Type 1 diabetes (T1D) is an autoimmune disease in which immune cells, notably T Lymphocytes, target and kill the insulin secreting pancreatic beta cells" (Mahaffy & Edelstein-Keshet, 2007, p. 915). Once a large enough percentage of the beta cells have been destroyed, the pancreas stops or greatly reduces the amount of insulin produced, therefore, the glucose levels in the blood rise uncontrollably and the person is left with full blown T1D (Mahaffy & Edelstein-Keshet, 2007). From that point in time onwards, the daily administration of insulin is required for survival "to prevent the development of ketoacidosis, coma and death" (Alberti et al., 1998, p. 17). Ketoacidosis means too much sugar and ketones in the blood which may lead to DKA.

"Numerous observational studies indicate that deficiencies in vitamins A, D, E and zinc can adversely impact immune function, particularly T-cell responses" (Kau, Ahern, Griffin, Goodman, & Gordon, 2012, p. 6). "Type 1 diabetes is a T-cell-mediated disease that is associated with loss of immunological tolerance to self-antigens" (Lindley et al., 2005, p. 92).

Although some trials have shown that the incidence of T1D in people taking Vitamin D supplements is lower than people who do not take Vitamin D supplements "Randomised controlled trials of vitamin D supplementation as a means of primary disease prevention have shown mixed results" (Thrower & Bingley, 2014, p. 682). In a study conducted by Hyppönen, Laara, Reunanen, Jarvelin, and Virtanen (2001) they concluded that their results suggested "that development of type 1 diabetes is associated with low intake of vitamin D and signs of rickets during the first year of life" (Hyppönen et al., 2001, p. 1502). The best way for the body to obtain Vitamin D is through direct contact with sunlight. During exposure to sunlight previtamin D_3 penetrates the skin, wearing sunscreen reduces the skins ability to absorb Vitamin D (Holick, 2005). The lack of vitamin D and its connection with the onset of T1D is clearly unresolved from previous studies conducted, but this interesting hypothesis is worthy of further investigation.

Stress

"As early as the beginning of the 17th century, the onset of diabetes was linked to "prolonged Sorrow" by an English Physician" (Lloyd, Smith, & Weinger, 2005, p. 121). The use of the term "Prolonged Sorrow" could possibly imply that the person may have suffered from depression. "Stress augments many hormonal and neuronal pathways, possibly over-loading pancreatic beta cells" (Butalia, Kaplan, Khokhar, & Rabi, 2016, p. 590). "Some studies have suggested that stressful experiences might affect the onset and/or the metabolic control of diabetes, but findings have often been inconclusive" (Lloyd et al., 2005, p. 121). Stressful experiences such as a difficult marriage, experiencing the grieving process alone, family breakdowns, and other circumstances may lead to the onset of T1D.

The Use of Statins

Sattar et al. (2010) found that "statin therapy was associated with a 9% increased risk for incident diabetes" (Sattar et al., p. 735). Crandall et al. (2017) also suggest that the use of statins was associated with an increased risk of developing diabetes. Casula et al. (2017) recommend rigorous monitoring of pre-diabetes patients taking statins. Further research is required to establish what causes this increased risk and how to address the risk.

EQUIPMENT, DISPOSABLES, MEDICATION, AND MONETARY COSTS

Test Strips and Lancet Devices

Blood glucose test strips are used to monitor the current level of glucose in the patients' blood. Blood glucose test strips are inserted into a meter, a lancet device is used to prick the finger to obtain a blood sample. The sample of blood is then held up to the blood glucose test strip connected to the meter which displays a number on the screen. This number indicates the level of glucose in the blood at that point in time only. The metre provides no indication to the patient whether or not the blood glucose level is increasing or decreasing. If tested ten minutes later, the result of a blood glucose test could be very different depending on what the person with T1D has consumed, how much insulin was administered, or the level and intensity of exercise the body has undertaken in that time. At times, a person may get an unexpected result, the blood level may be far higher or lower than expected, if this happens, the person should take a fresh sample of blood to place on a blood glucose test strip to confirm the initial level, before taking action to treat a hypo or correct for a hyper.

Ketone test strips are used to monitor the current level of ketones in the patient's blood. Ketone test strips are used with the meter in the same way as blood glucose test strips. After a blood sample has come in contact with the test strip the meter displays the level of ketones in the blood at that point in time only. After checking the blood/ketone level, the lancet (sharp) should be placed in a sharps bucket. Once a sharps bucket is full it can be dropped into a pharmacy or health clinic for safe disposal (incineration), at the same time the patient can collect an empty sharps bucket for future use. A large sharps bucket will take months to fill.

People diagnosed with T1D need to carry a diabetes medical supplies bag with them at all times. The contents of a diabetes medical supplies bag may include: insulin pens (basal and bolus), needles, meter, blood glucose test strips, lancets, diabetes diary, pen, glucose tablets, small red apple, small plastic bottle for used sharps, and whatever else is appropriate. Please refer to Figure 3.

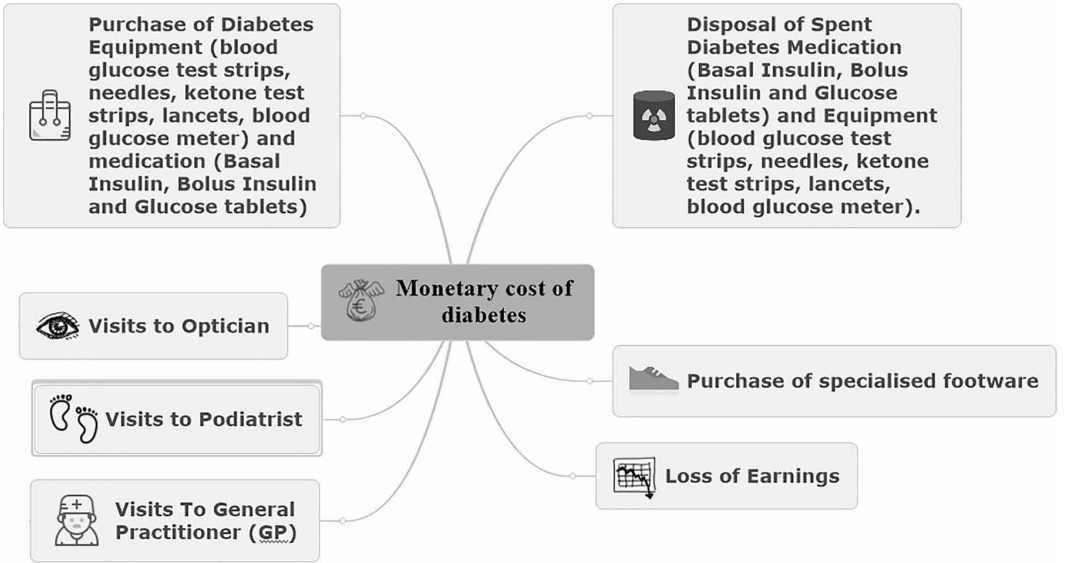
It is always useful to carry a small plastic bottle (for the safe collection of used sharps) and for the safe storage of sharps until the sharps can be deposited in the sharps bucket. It is the responsibility of the person to safely dispose of sharps, the doctor or diabetes care team will be able to guide the patient in this matter. Some pharmacies and health centres provide empty sharps bucket and take them back for safe disposal when full.

Figure 3. Diabetes medical supplies bag

Monetary Costs

"Unlike their counterparts in the UK, Irish GPs are currently not reimbursed for delivering diabetes care" (O'Donnell et al., 2013, p. 3). The onset of T1D can be an expensive condition please see Figure 4. In some countries, the cost of disposable testing and treatment equipment, and medication is paid for by the health services. In other countries, the person or the family of the person has to pay for the disposable testing equipment, treatment equipment, and medication (which can be quite expensive). Regular visits to the General Practitioner (GP) are required to obtain prescriptions (every six months) to treat this life-long condition, Yearly visits to podiatrists have to be paid for in person. Expensive specialist footwear may be required to avoid complications of the feet associated with diabetes. Glasses/spectacles/contact lenses may need changing as they may no longer be suitable as the eye prescription may have changed substantially on diagnosis or may change over the years due to diabetes. Salary/wages may not be paid for the time spent in hospital or visits to medical practitioners or the diabetes care team. There may possibly be more ongoing expenses.

Figure 4. Monetary cost of diabetes



THE RESPONSIBLE ADMINISTRATION OF INSULIN

At present, there are no known ways to prevent the onset of T1D or to cure the condition of T1D, but it is possible to manage the condition through insulin dose adjustment and the responsible administration of insulin.

The responsible administration of insulin includes:

- Adjusting the insulin dose if necessary.
- Checking that the correct insulin pen is used: basal or bolus.
- Ensuring that the injection site is clean.
- Monitoring the injection site for changes in the skin texture or colour.
- Shoot some insulin up into the air to remove air bubbles prior to injecting insulin.
- Record the quantity of units administered.
- Confirming hypo treatments are on one's person at all times.

Basal and Bolus Insulin Injections

From the point in time of diagnoses and onwards for the rest of one's life "An immediate need for exogenous insulin replacement is also a hallmark of type 1 diabetes, for which lifetime treatment is needed" (Atkinson et al., 2014, p. 69). Insulin is generally delivered in basal (insulin is active in the body for up to 24 hours or more), and bolus (insulin is active in the body for up to four hours depending on the medication administered and the persons response to the medication) doses. A basal dose of insulin is administered to act in the background for a specific number of hours. The bolus dose of insulin is administered to cover the consumption of meals and the resulting spike in blood glucose levels over several hours. Each form of medication will have its own timeframe for dosing, and each person may respond differently to the medication, therefore, each person will have to take responsibility to monitor their blood glucose levels and discuss changes to their insulin regimen with their diabetes care team.

Basal Insulin

A basal dose of insulin is administered to act in the background all the time, while the bolus dose of insulin is administered to cover the consumption of meals and the resulting spike in blood glucose levels. The more carbohydrates in a meal; the more the blood glucose levels will rise for a number of hours after the meal has been consumed. Snorgaard, Poulsen, Andersen, and Astrup (2016) found that the more that carbohydrates were restricted in the diet the greater the reduction in blood glucose levels in a study of people with type 2 diabetes. The restriction of carbohydrates in the diets of patients with type 1 diabetes also has the effect of reducing blood glucose levels.

Bolus Insulin

A bolus dose of insulin is a rapid acting insulin which is administered at meal time (Neupane & Evans, 2014). The quantity of insulin required will depend on the carbohydrate content of the meal and the activity planned for the hours after the meal. People with T1D require training in accurately counting carbohydrates to enable them to effectively administer the correct dose of bolus (quick acting insulin). Bolus insulin should continue to lower blood glucose levels for approximately four hours after injection, depending on the brand of insulin administered. Bolus insulin is injected prior to eating, to prevent a spike in blood sugars after the consumption of food and drink. The diabetes care team should ensure that each patient understands the medication (insulin) that they are given. As with any medication: each one has individual properties and dosing schedules which should be clearly explained.

HYPERGLYCAEMIA (HYPER)

Hyperglycaemia means that the person is experiencing a high blood glucose level, which if left untreated could lead to hospitalisation, complications associated with diabetes, or death. “Current carbohydrate recommendations are based on 1) preventing ketosis, and 2) providing glucose beyond minimal needs” (Manninen, 2004, p. 9). “Ketones in the blood can lead to a condition called Ketoacidosis, also known as DKA, which just stands for diabetic ketoacidosis” (Gilbert et al., 2012, p. 21). Diabetic ketoacidosis (DKA) is life threatening, some undiagnosed, and diagnosed diabetics experience DKA to various degrees of severity. Accident and Emergency medical staff are primed to recognise the signs of DKA, and treat the patient accordingly to safely reduce the levels of glucose and ketones in the blood, and rehydrate the body.

Hyperglycaemia Episodes (Hypers)

Almost everything one consumes is converted into glucose which is released into the blood stream by the liver. Should too much glucose or sugar be consumed, this could lead to the patient going into a hyperglycaemic episode (hypers occurs when a patient’s blood glucose level gets to abnormally high levels). “New hyperglycemia was defined as an admission or in-hospital fasting glucose level of 126 mg/dl (7 mmol/liter) or more or a random blood glucose level of 200mg/dl (11.1 mmol/liter) or more on 2 or more determinations” (Umpierrez et al., 2002, p. 978). Newly diagnosed hyperglycaemic patients were associated with a higher admission rate to Intensive Care Units (ICU), longer length of hospital stay, a higher in-hospital mortality rate and a lower functional outcome than previously diagnosed patients and patients with normoglycaemia (Umpierrez et al., 2002). Patients with normoglycaemia have blood sugar levels within the accepted range for the normal population (Pickup, Mattock, & Kerry, 2002). Hyperglycaemia (above normal blood sugar levels) is a dangerous medical condition which can go undetected for quite some time. “It has been thought that chronic high blood glucose levels in the body (hyperglycemia) due to diabetes could be the main cause that leads to nerve damage and thereby diabetic neuropathy” (Abdel-Motal, Abdelalim, Abou-Saleh,

& Zayed, 2017, p. 172). Neuropathy can cause the feet to feel unrelenting pain (Archer, Watkins, Thomas, Sharma, & Payan, 1983). Hyperglycaemia has a key role to play in the development of diabetic neuropathies (Pop-Busui, 2010).

Treatment of Hypers

A waking blood glucose level greater than 7 mmol/L (126 mg/dL) or a two-hour postprandial blood glucose level greater than 11.1 mmol/L (200 mg/dL) could signify that the person is at risk of a hyper. A person who is experienced in managing diabetes may have the confidence to reduce their blood glucose levels by taking a correction dose of insulin, drinking plenty of water, or engaging in exercise/manual labour. Constant monitoring of the level of glucose in the blood is required over the next few hours, regardless of which option or combination of options are chosen to treat the high blood glucose levels. People with diabetes should consult with their diabetes care team on the treatment of hypers. A person with diabetes who is not confident to deal with a hyper themselves, should contact their Doctor/General Practitioner, diabetes care team, or attend an Accident and Emergency (A&E) Department for treatment and guidance.

HYPOGLYCAEMIA

Calculating the correct dose of insulin to administer with a meal is a very difficult process. Please see Figure 5. Should too much bolus insulin be administered this could lead to the patient having a hypoglycaemic or severe hypoglycaemic episode over the coming hours. “The diagnosis is made by measuring the blood glucose level. If the glucose level is below 2.5mmol/l, you have hypoglycaemia” (Eldemir & Eldemir, 2011, p. 3). Hypoglycaemia is a low blood glucose level that mainly affects patients with diabetes who take insulin. Immediate consumption of glucose tablets, a piece of fruit, fruit drink, honey, or anything high in sugar is required to bring the blood glucose to a normal level and to avoid severe hypoglycaemia. Abnormally low blood glucose levels can result in hypoglycaemia which can pose a serious health threat (Byrne et al., 2012), if not effectively dealt with immediately. Should a patient with T1D on insulin not adequately treat hypoglycaemic in a relatively short time scale, this may lead to a severe hypo. “Severe hypoglycaemia was self-reported and defined as an episode of hypoglycaemia requiring the assistance of another person for treatment” (Dinneen et al., 2013, p. 31). Severe hypos should be avoided if at all possible, as a patient’s ability to drive, operative

Figure 5. Balancing insulin administration with food consumption

machinery, or perform many other daily activities may be impaired with serious consequences should he/she suffer from a severe hypo. "Overly tight control, however, puts patients at risk of hypoglycaemic episodes (hypos) which may lead to seizures or periods of unconsciousness which may require emergency treatment" (Lawton & Rankin, 2010, p. 486). In a study conducted by Garg, Shah, Akturk, Beatson, and Snell-Bergeon (2017) one significant finding was that men had less fear of suffering from hypos than women.

Hypoglycaemic Episodes (Hypos)

Symptoms of a hypoglycaemic episode may include some or all of the following: lack of concentration, confusion, clumsiness, intense hunger, agitation, irritability, sweating, palpitations, shaking, and pallor. Please note Figure 6. The body is basically fighting for survival as the brain feels threatened by the lack of glucose in the blood. The administration of too much insulin can inhibit the body's access to its regular glucose supply. Once the patient realises what is happening they can easily treat the hypo by taking some fast-acting glucose, for example, orange juice, a piece of fruit, or 2/3 glucose sweets. The natural instinct of a person who has just experienced a hypo is to overcompensate by the excessive consumption of sugary foods, which will invariably result in high blood glucose levels. Then the person has to decide how to deal with the high blood glucose levels. This can lead to glycaemic excursions (Deiss et al., 2006), a yo-yo effect as the blood glucose levels go up and down from one extreme to the other, as the person tries to control blood glucose levels that are uncontrollably fluctuating. People need to control the quantity of carbohydrates (carbs) consumed in the treatment of hypos which can prove to be a very challenging task.

The first experience of a hypo can take a person with diabetes on insulin by surprise, they should be alerted to this fact in advance and instructed to always carry some fast acting glucose tablets, sweets, chocolate, a piece of fruit, or fruit juice on their person. Please refer to Figure 7 for some more options for treating hypos. In addition, it is advisable to leave some glucose tablets or some other form of hypo treatment in every room of the house, including the garden shed. Gardening can

Figure 6. Symptoms of a hypo

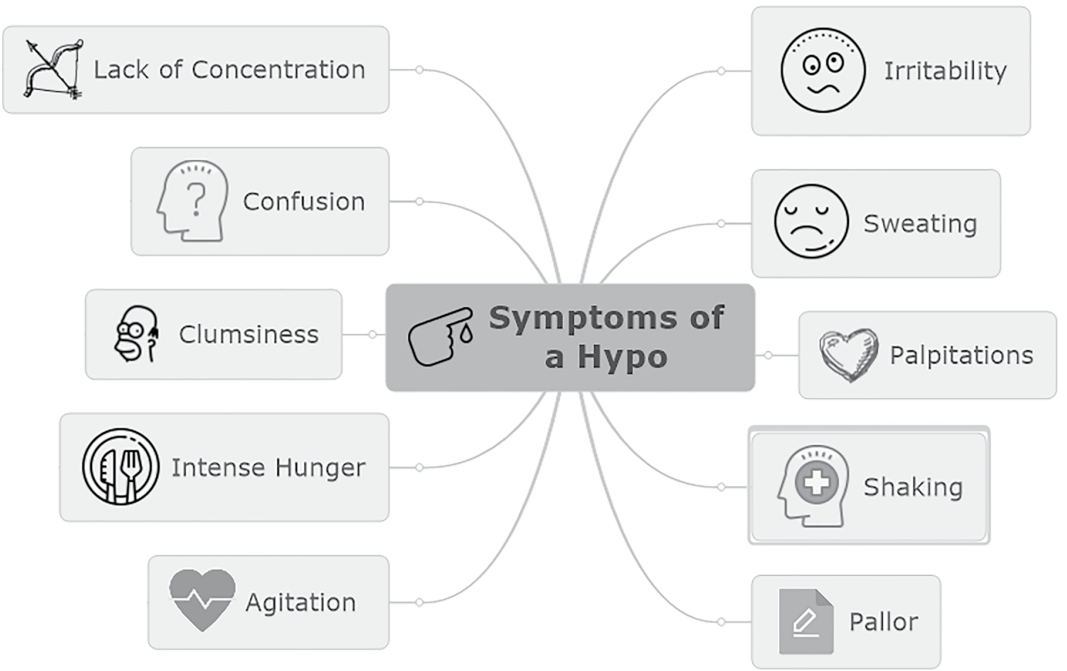
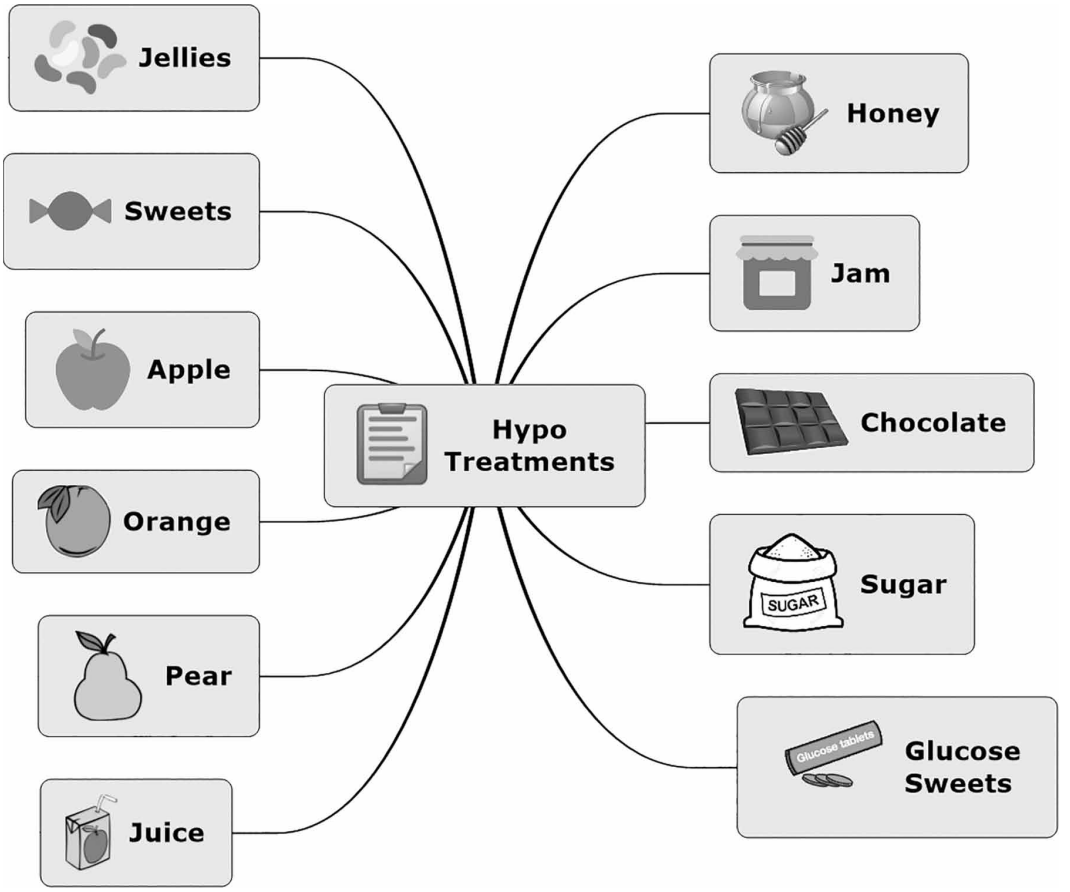


Figure 7. Hypo treatments



be a strenuous activity that consumes the glucose in the blood which could lead to a hypo, therefore hypo treatments should always be available in the garden.

It is very easy to get locked out of the house, consequently, it is necessary to carry glucose tablets on your person everywhere. Glucose tablets should be stored in an accessible place in the car and also at the work station in the place of employment. See Figure 8 for more important locations to store hypo treatments.

RECOMMENDATIONS FOR THE SUCCESSFUL MANAGEMENT OF T1D

Some individuals with type 1 diabetes mellitus (T1DM), or T1D may be initially treated with diet alone but generally require the administration of daily doses of insulin within months of the initial diagnosis (Thrower & Bingley, 2014). The types of food and beverages consumed by the person, and the volume of activity in which the person regularly engages will influence the daily doses of insulin required to maintain good glycaemic control. The challenge with managing T1D is that every person is unique and therefore requires a unique treatment plan.

Figure 8. Storage locations for hypo treatments

Self-Management of Diabetes

"Despite broad organisational, intellectual, and fiscal investments, no means for preventing or curing type 1 diabetes exists, and, globally, the quality of diabetes management remains uneven" (Atkinson et al., 2014, p. 69). The self-management of T1D requires careful planning and goal planning strategies (Fredrix, McSharry, Flannery, Dinneen, & Byrne, 2018). The quality of the self-management of diabetes may depend on the educational attainment of the patient, the guidance provided by the diabetes care team, the patient's willingness to take control of the condition, diet and exercise. Not only does the quality of diabetes management remain uneven globally, but global disparities in access to insulin also must be addressed (Atkinson et al., 2014). T1D, although it predominantly affects younger members of the population, it can affect anyone at any age of their life. At present, the factors that may influence the onset of T1D are not clearly defined.

Glycaemic Control and Excursions

Some people with T1D can manage their own treatment plans, while others require substantial input from diabetes care teams to maintain good glycaemic control. People with T1D should be educated on the impact that the consumptions of fats and proteins have on glycaemic excursions. "Calculation of insulin to carbohydrate ratios (i.e. the amount of insulin needed to limit glycaemic excursions after meals) allows for increased flexibility in meal planning without sacrificing glycaemic control"

(Daneman, 2006, p. 852). The Mean Amplitude of Glycaemic Excursion (MAGE) (Bando, Ebe, Muneta, Bando, & Yonei, 2017; Fritzsche, Kohnert, Heinke, Vogt, & Salzsieder, 2011; Hill et al., 2011; Syafa, Tjokroprawiro, Indra, Sargowo, & Muladi, 2014) is a method used to analyse fluctuations in the blood glucose levels of a person with diabetes. Complications associated with diabetes may be caused by glycaemic variability (Hill et al., 2011).

Glycaemic Control

Glycaemic control refers to the management of glucose levels in the blood. "Glucose control is facilitated by tracking glucose levels, care with food intake, and judging the correct does of insulin to take" (Ryan et al., 2017, p. 33). The administration of too little bolus insulin with a meal could lead to the patient's blood glucose levels reaching too high a level to be considered as good glycaemic control. The administration of too much bolus insulin with a meal could lead to the patient experiencing a hypoglycaemic episode.

HbA_{1c} Value

A HbA_{1c} value of greater than 8.5% (69 mmol/mol) would suggest that the current management of treatment by bolus and basal injections have failed the patient and other treatment methods should be considered (Neupane & Evans, 2014). The HbA_{1c} value indicates the average blood glucose level over the past two to three months, but it provides no information on the amount of time a patient may have spent in hypoglycaemic, severe hypoglycaemic, or hyperglycaemic episodes. Two patients with the same HbA_{1c} value may have experienced a wide variation in the standard deviation of blood glucose levels over the past two to three months. Fear of hypos may impede patients' ability to achieve near-normal glycaemic control. Hypos can cause death or serious injury in the immediate future. The HbA_{1c} test provides information on the probability of long-term complications. Good glycaemic control alongside avoidance of hypoglycaemic episodes would be the safest way for people with diabetes to manage their condition. "When basal-bolus routines are fastidiously applied in conjunction with the other aspects of management, many individuals with type 1 diabetes are able to maintain near-normal glycaemic control" (Daneman, 2006, p. 850).

Educational Programmes for T1D

Byrne et al. (2012) in their study of patients with T1D who participated in the DAFNE structured education programme, used several questionnaires including (i) Diabetes-Specific Quality of Life Scale (DSQOLS), (ii) Problem Areas in Diabetes Scale (PAID), and (iii) the Hospital Anxiety and Depression Scale (HADS). The conclusions to this study were that "Patients with higher baseline levels of anxiety, higher levels of diabetes related distress and higher baseline levels of HbA_{1c} are most likely to experience quality of life gain from participation in self-management programmes such as DAFNE" (Byrne et al., 2012, p. 243). Lower HbA_{1c} levels were significantly associated with adolescents who rated better Quality of Life (QOL) and lower perceived levels of family burden (Hoey et al., 2001).

Health Informatics

Fang, Pouyanfar, Yang, and Chen (2016) discuss the potential use of Big Data, Machine Learning, and Health Informatics to improve the quality of patient care. Privacy issues, ethics, validity of the data used, accessibility, security, are all relevant considerations and challenges to overcome in the use of Health Informatics. Wireless body sensor networks can be used to monitor patients' biometrics (calculation and analysis of body measurements) including blood glucose levels in healthcare (Chen, Lee, Chen, Huang, & Luo, 2009). Data mining applications can be used to analyse large volumes of data that are stored electronically in hospitals to identify trends or patterns and extract useful knowledge from the files of patients. Zaveri and Joshi (2017) suggest that data mining could be used to predict disease in advance. Patterson et al. (2009) suggest that the ability to predict potential new cases of

patients with T1D over the coming years would enable European centres for diabetes treatment to plan in advance for funding requirements and health care resources to cater for the future burden of childhood diabetes. Further research is required to ascertain if the use of Big Data, Machine Learning, and Health Informatics can improve the quality of patient care.

Intensive Diabetes Therapy

"Controlled clinical trials of patients with type 1 or type 2 diabetes have not demonstrated a reduction in the occurrence of cardiovascular disease with long term intensive diabetes therapy" (Nathan et al., 2005, p. 2644). Long term intensive diabetes therapy may possibly lead to an increase in the occurrence of hypos, therefore, without substantial evidence to support the use of long-term intensive diabetes therapy, patients may be advised to keep tight control but not too intensive. "Adolescents having at least one severe hypoglycemic episode in the previous 3 months were more worried than those without" (Hoey et al., 2001, p. 1926). People should avoid having hypoglycaemic or severe hypoglycaemic episodes if at all possible; to avoid experiencing undue worry and stress, as worry can interfere with quality of life and stress can elevate blood glucose levels. Hypoglycaemic or severe hypoglycaemic episodes can be avoided by reducing the amount of insulin administered. All people with diabetes controlled by insulin should keep a diary of everything they consume in order to monitor the effects that particular foods and drinks have on their blood glucose levels. Overtime, the person will begin to know and understand their own body's response to the consumption of different foods and drinks. This knowledge should inspire confidence in the management and control of blood glucose levels and doses of insulin.

Psychosocial Outcomes

Nicolucci et al. (2013) conducted a study of diabetes-related psychosocial outcomes, 8596 adults with diabetes from 17 different countries participated in this study, a significant finding of this study was that "Approximately 40% of participants (18.6 – 64.9%) reported that their medication interfered with their ability to live a normal life" (Nicolucci et al., 2013, p. 767). Further research is required to ascertain why 40% felt that their medication interfered with their quality of life. Possibly, improved education on the condition would assist people in controlling their medication so that it does not interfere with their ability to live a normal life. Living in fear of hypoglycaemia, hyperglycaemia, and the possibility of diabetes related complication in the future, can be daunting.

Exercise/Physical Activity

Perhaps, if people could try to improve their understanding of diabetes, how insulin works, and how to manage exercise and general living, their quality of life may improve. Kevin Nolan (2018) a successful Gaelic Footballer with T1D hoped to inspire other people with T1D to enjoy sports. "Exercise confers remarkable benefits to those with diabetes; however, the challenge to compelling patients with diabetes to exercise are formidable" (Jenkins & Jenks, 2017, p. 968). Frequent exercise is key to controlling blood glucose levels. "Contrary to popular belief, insulin is not needed for glucose uptake and utilization in man" (Manninen, 2004, p. 7). Physical activity is one of the things that can greatly impact on glucose uptake and utilization. Therefore, patients on insulin should carefully monitor their use of insulin and blood glucose levels before, during, and for some time after physical exercise, as physical activity can increase the risk of hypoglycaemia (Seaquist et al., 2013). Patients must always reduce their insulin dose prior to engaging in exercise (Lawton & Rankin, 2010), even if it is only going for a walk or hoovering the house, as these activities can quickly consume the glucose in the blood and leave the patient at risk of experiencing a hypoglycaemic episode due to low blood glucose levels. Family members, care givers and staff should be educated on the proper surveillance and treatment of hypoglycaemia (hypos) (Seaquist et al., 2013).

Involvement in physical activities (walking, gardening, hoovering, jogging, cycling, and so forth) lowers the blood glucose levels and also has the added advantage of keeping the person away from

Figure 9. Picture of flowers growing in the garden

food. Gardening may increase absorption of Vitamin D, provide valuable exercise, and reward with a beautiful display of colour as per Figure 9. Controlled consumption of food and drink alongside regular movement of the body are key to the management of blood glucose levels. Further research is required to target the formidable challenge to compel people with diabetes to participate in more exercise.

Restricting the Consumption of Carbohydrates

Feinman et al. (2015) suggest that restricting the consumption of carbohydrates has the greatest effect on reducing blood glucose levels and can lead to the reduction or elimination of medications used in the treatment of diabetes. By cutting out or substantially reducing the consumption of foods that are high in carbohydrates (rice, pasta, white flour, potatoes, sugary drinks, cakes, biscuits and confectionery). Instead, by consuming foods that are high in nutritional content but low in carbohydrates (chicken, fish, eggs, beef, pork, full fat cheese, nuts, berries, fruit and vegetables). A person with T1D can substantially reduce the units of basal and bolus insulin administered. It would be in the interest of people living with T1D to keep a record of everything that they eat and drink for as long as it takes for them to realise the effects that different food and drink combinations have on their specific blood glucose levels. During this time, the blood glucose levels should be taken at least six times a day and recorded. Hence, the patient will be able to see exactly what effect each meal is having on their blood glucose levels. Everybody is different, therefore, it is imperative that the patient themselves or parents/carers (Silverstein et al., 2005) take responsibility for managing diabetes tailored to the patient's individual needs. "No need for an insulin head start. Low-carb, high-fat breakfasts usually allow for dosing insulin right as I start eating (or not at all)" (Brown, 2017a, p. 31). Before reducing carbohydrate consumption, the patient must reduce the units of insulin administered. "It should be recognized that the use of low-carbohydrate diets is not a recent experiment and may well approximate the diet used by much of humanity for tens of thousands of years before the rise of agriculture" (Feinman et al., 2015, p. 11). People with T1D have to be prepared to experiment with their foods,

to see the effects that every morsel consumed has on blood glucose levels. The best approach is to have a low carbohydrate satisfying meal, tidy up, and walk away from the kitchen, no snacking or grazing, as this will impact on blood glucose levels. If a snack is required consume a small piece of fruit, a bag of nuts, coffee and cream, or some strawberries and cream. The consumption of full fat cream will slow down the release of natural sugars in the strawberries.

Low Carbohydrate Diet

Patients should also reduce the amount of insulin administered before commencing a low carbohydrate diet (Feinman et al., 2015). Some patients who reduced the amount of insulin administered discovered that as a result of taking control by reducing the units of insulin administered that they had also achieved much better glycaemic (blood glucose) control (Lawton & Rankin, 2010).

The Consumption of Fat and Protein Before Carbohydrates

"The temporal sequence of carbohydrate ingestion during a meal has significant impact on postprandial glucose regulation" (Shukla et al., 2017, p. 4). Shukla et al. (2017) suggest that the order in which one consumes food: fat and protein first followed by carbohydrate (carbohydrate last instead of carbohydrate first) has an impact on the absorption of the food and the resulting blood glucose level, patients that consumed carbohydrates last in a meal were found to have improved postprandial glycaemia. Postprandial glycaemia is the level of glucose in the blood two hours after consuming food.

The consumption of fat and protein with every meal provide satiety (Feinman et al., 2015), therefore, there should be no need for snacking between meals. Were a person with T1D to eat a scone with jam as a snack, the result would be a spike in blood glucose levels because there was insufficient protein and fat to slow down the release of glucose to the blood stream. As the spike in blood glucose levels begins to fall, the person with T1D would feel hungry again. People with diabetes should possibly avoid the consumption of scones and jam, a much healthier option would be to enjoy some fresh strawberries/blueberries/raspberries with full fat cream. Full fat cream should be consumed in moderation, as excessive consumption of full fat cream could increase total cholesterol and the amount of lipids circulating in the blood stream, which could lead to other complications.

Need to "Feed" Their Insulin

"Patients who are on insulin or insulin secretagogues are able to reduce their doses on carbohydrate-restricted diets and find they are less likely to need to "feed" their insulin" (Feinman et al., 2015, p. 6). When a person with T1D administers bolus insulin before a meal, the insulin works in the body (reducing blood glucose levels) for approximately up to four hours (everybody is different), and every medication will have a different impact on blood glucose levels. Should the quantity of insulin administered be insufficient to cover the carbohydrate content in the food consumed blood glucose levels will be higher than what is required for good glycaemic control. Should the quantity of insulin administered be in excess of what is needed to cover the carbohydrate content in the food consumed blood glucose levels will drop to a level where the patient may experience a hypoglycaemia or a severe hypoglycaemia episode. On experiencing a hypoglycaemia episode the body immediately craves food and it is difficult for the patient to restrain themselves to eating just a sufficient amount of carbohydrates to return to a safe blood glucose level. Generally, people with T1Ds will over compensate by eating too many carbohydrates after experiencing a hypoglycaemic episode. This behaviour results in the blood glucose levels escalating, feelings of guilt, and the probability that the person may then have to inject more bolus insulin to bring the blood glucose levels back down again. Frequent use of bolus insulin throughout the day can leave a person in a position whereby they are unsure as to whether their blood glucose levels are going up or down. "When blood sugars are out of range, people with diabetes are made to feel like failures" (Brown, 2017b, p. 342). Out of range blood glucose levels do not signify that the person is a failure. Possibly more information and education may be required for the person to better manage this challenging condition.

Triglycerides (TG)

"The lower carbohydrate diets were associated with significant decreases in body weight, body mass index, TG levels, and blood pressure; additionally, they showed improvement in several other metabolic and lipid indicators" (Feinman et al., 2015, p. 7). In fact, Accurso et al. (2008) suggest that "carbohydrate restriction improves all of the features of metabolic syndrome" (Accurso et al., 2008, p. 1). Triglycerides (TG) are a type of fat/lipids found in the blood. A normal level of triglycerides found in the blood is less than 1.7mmol/L (150 milligrams per decilitre). There are many benefits to lower carbohydrate diets. There is no reason why people with T1D should not try a low carbohydrate diet for a few months while closely monitoring blood glucose levels and reducing the amount of insulin administered if they are experiencing too many hypoglycaemic episodes. People can always revert back to their normal eating patterns and insulin doses if the low carbohydrate diet does not suit them or their lifestyle. "More than a dozen additional studies, have failed to show an association between dietary lipids and risk for cardiovascular disease (CVD)" (Feinman et al., 2015, p. 7). Medina-Bravo et al. (2012) suggest that children with type 1 diabetes have higher levels of Total Cholesterol (TC) when compared to healthy subjects. "The TG-to-HDL cholesterol ratio may be related to the processes involved in LDL size pathophysiology and relevant with regard to the risk of clinical vascular disease" (Boizel et al., 2000, p. 1679). High-Density Lipoproteins (HDL) are classed as the good cholesterol in the blood, as HDL transports cholesterol from all over the body back to the liver for disposal. Low-Density Lipoproteins (LDL) are classed as the bad cholesterol in the blood; as LDL can build up in the walls of blood vessels and arteries causing blockages which have the potential to cause heart attacks or strokes. The association between the consumption of dietary lipids and the risk for cardiovascular disease is very relevant to the health of people living with diabetes and the normal population, therefore, this association requires further research.

TIPS FOR PATIENTS WITH T1D

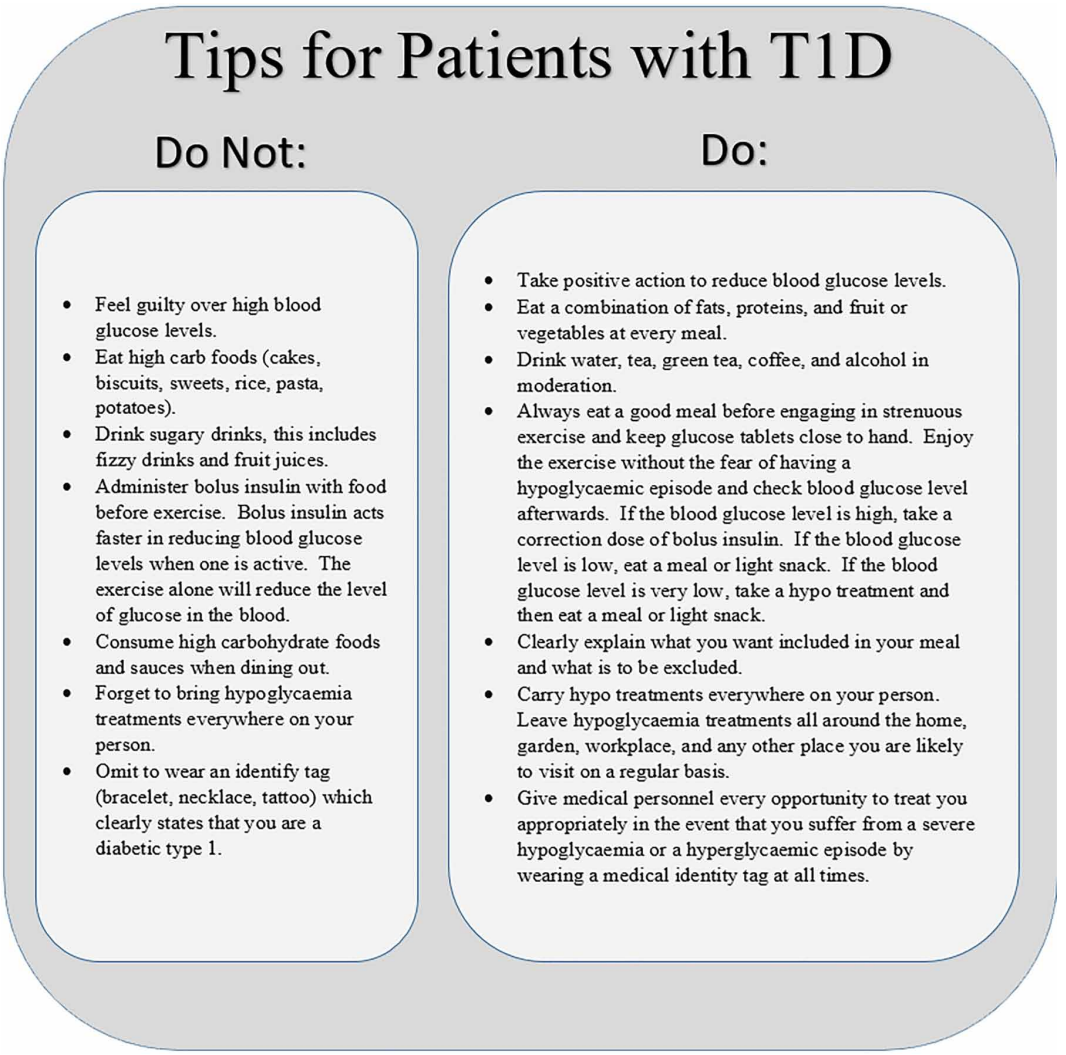
Presented in Figure 1.

MEDICAL COMPLICATIONS ASSOCIATION WITH DIABETES

In the treatment of this chronic condition the person diagnosed with the condition or the parent of a child diagnosed with the condition must take immediate responsibility for administering the medication (insulin); while having limited knowledge or understanding of how diabetes and the medication works. Tight glycaemic control is required on a daily basis to avoid complications associated with diabetes in later life (Byrne et al., 2012).

Complications association with diabetes may include some or all of the following: retinopathy (Fredrix et al., 2018; Hammes, 2018; Raymakers, Gillespie, O'Hara, Griffin, & Dinneen, 2018), neuropathy (Young, Boulton, Macleod, Williams, & Sonksen, 1993), nephropathy (Andersen, Christiansen, Andersen, Kreiner, & Deckert, 1983; Chiang et al., 2014; Fowler, 2008), renal damage (O'Loughlin et al., 2010), foot ulcers (Ahmad, 2016; Fredrix et al., 2018; Noor et al., 2017), blindness, amputation (Cousart & Handley, 2016), stroke (Lawton & Rankin, 2010), cardiovascular disease (Fredrix et al., 2018; Gerstein et al., 2001; Nathan et al., 2005), myocardial infarction (heart attack), angina (chest pain or obstruction) (Nathan et al., 2005), ingrown nails (Vural et al., 2018), decrease in Bone Mineral Density (BMD) (Vestergaard, 2007), impaired ability to heal wounds (Loomans et al., 2004), immunological effects (Egan & Dinneen, 2016), proteinuria (Kiire, Horak, Lee, Klein, & Klein, 2017; Raymakers et al., 2018), anxiety and depression (Raymakers et al., 2018), and an increased risk of infection (O'Loughlin et al., 2010).

Figure 10. Tips for patients with T1D



"The prevalence of each complication is generally lower with a more recent diagnosis when adjusting for duration of diabetes" (Kiire et al., 2017, p. 11). The sooner the condition is diagnosed and appropriately treated the better the prognosis (future outcomes) for the person.

Foot Ulcerations

Kelly et al. (2010) found that 30% of patients with diabetes who had been screened for foot complications tested positive for pedal neural dysfunction and 17% tested positive for vascular impairment. "Diabetic foot problems are responsible for nearly 50% of all diabetes-related hospital bed days" (Ahmad, 2016, p. 48). Therefore, it is in the patient's best interest to learn to understand how diabetes works and how best to manage the administration of insulin to control blood glucose levels; in order to avoid diabetes complications later on in life and to avoid hypoglycaemic, severe hypoglycaemic episodes, and DKA in the short term. The leading cause of hospitalisation due to diabetes is foot ulceration, foot ulcerations can adversely impact on a persons' quality of life which may lead to depression (O'Loughlin et al., 2010). "Conservative management of foot problems has

dramatically reduced the risk of amputation by simple procedures, such as appropriate foot wear, cleanliness, aggressive surgical debridement, … and ulcer management" (Ahmad, 2016, p. 48). Preventative measures can be undertaken to avoid the risk of foot infection associated with diabetes and the potential for amputation (Noor et al., 2017). Comfortable appropriate footwear is necessary to avoid damage to the foot which may lead to ulceration. Frequent changing of socks during the day may be necessary to ensure that the feet are free from sweat or dampness, which could lead to fungal infections or other avoidable conditions of the feet.

People living with diabetes should monitor their feet on a daily basis by checking for dry skin, cuts, ingrown toenails, redness, swelling and/or any other abnormalities. If anything unusual is noted they should visit a podiatrist/chiropodist or their diabetes care team for a consultation and to receive advice on treating the condition. "It is concluded that acute painful diabetic neuropathy is a distinct syndrome, occurring in insulin or noninsulin dependent patients of any duration, and unrelated to other diabetic complications" (Archer et al., 1983, p. 491).

People with diabetes are advised to undergo a comprehensive examination of the feet every year to identify any risk factors that may lead to neuropathy or ulceration (O'Loughlin et al., 2010). Peripheral neuropathy (PN) is more common in people with type 1 diabetes who have had the condition for a longer duration (Abdel-Motal et al., 2017) and mainly affects lower limbs (Zhang et al., 2017). Diabetic peripheral neuropathy (DPN) is more likely to injure small rather than large nerve fibres (Zhang et al., 2017). "In some patients diabetic foot infection is the first presentation of diabetes and they will require diabetology input into the initial blood glucose control and ongoing diabetes management" (Sohrabi & Russell, 2017, p. 500).

Nephropathy

"There are strong associations between glucose control (as measured by haemoglobin A1c [A1C]) and the risk of developing diabetic nephropathy" (Fowler, 2008, p. 78). Nephropathy means damage or disease of the kidney which may lead to renal failure (Alberti et al., 1998). "Our study shows convincingly that diabetes nephropathy is a very severe complication of Type 1 diabetes and that survival after the onset of proteinuria is poor" (Andersen et al., 1983, p. 500). Hb is an abbreviation for haemoglobin. HbA_{1c} is an abbreviation for a blood glucose test that tells the average glycated blood glucose level over the past two to three months, there is no need for a patient to fast for a HbA1c blood test (Saudek et al., 2008). "Normal ranges for haemoglobin A1c in people without diabetes is about 4% to 5.9%" (Davis, 2016, p. 1). A HbA_{1c} of 6.5% has been recommended by an international expert committee as a cut-off point for defining overt diabetes (Dinneen, 2010). A HbA_{1c} level of 6.5% or greater has been recognised as an unmistakeable sign that the patient has diabetes.

THE CONTRAINDICATIONS OF ADMINISTERING INSULIN

"Dead in Bed" Syndrome

"Type 1 diabetes mellitus increases the risk for sudden unexplained death (SUD), generating concern that diabetes processes and/or treatments underlie these deaths. Young (<50 yrs) and otherwise healthy patients who are found dead in bed have been classified as experiencing "dead in bed" (DIB) syndrome" (Secrest, Becker, Kelsey, LaPorte, & Orchard, 2012, p. 293). Not all people with diabetes wake up on experiencing a hypoglycaemic episode during sleep, this can be dangerous as an untreated episode of hypoglycaemia can very quickly progress to an episode of severe hypoglycaemia, if a severe episode of hypoglycaemia is left untreated this could turn into a diabetic coma. Sudden Unexplained Deaths occur up to ten times more frequently in people who have been diagnosed and treated for diabetes mellitus type 1 (Secrest et al., 2012). "SUD in Type 1 DM seems to be increased 10-fold and associated with male sex, while DIB individuals have a high HbA_{1c} and insulin dose, and low BMI. Though sample size is too small for definitive conclusions, these results suggest specific sex

and metabolic factors predispose to SUD and DIB" (Secrest et al., 2012, p. 293). Further research is required to establish why people with type 1 diabetes are more likely to experience SUD or DIB syndrome than people who have normal glycaemia.

Severe and Nocturnal Hypoglycaemia

There is a possibility of hypoglycaemia occurring when the level of glucose in the blood drops to ≤ 3.9 mmol/L (≤ 70 mg/dL) (Seaquist et al., 2013). Hypoglycaemia can be fatal, therefore, people who are treated with insulin should closely monitor the level of glucose in their blood on a regular basis throughout the day and always carry on their person treatments for hypoglycaemia (glucose tablets, orange juice, or a piece of fruit). Severe hypoglycaemia can be fatal (Seaquist et al., 2013). In a study conducted by Dinneen et al. (2013) 24% of respondents had experienced episodes of severe hypoglycaemia in the previous year.

People with diabetes should aim to avoid hypoglycaemia and more importantly severe hypoglycaemia episodes if at all possible during waking hours and more critically during sleep (nocturnal hypoglycaemia). "Type 1 diabetes mellitus increases the risk for sudden unexplained death (SUD), generating concern that diabetes processes and/or treatments underlie these deaths. Young (<50 yrs) and otherwise healthy patients who are found dead in bed have been classified as experiencing "dead in bed" (DIB) syndrome." (Secrest et al., 2012, p. 293).

Blood glucose concentration reduces when insulin is administered to fasting patients because it is assumed that glucose uptake into tissues is increased when insulin is administered, both Sonksen (2001) and Manninen (2004) suggest that this is just another metabolic legend and that in fact insulin lowers blood glucose levels through inhibiting hepatic glucose. The suggestion that insulin lowers blood glucose by inhibiting the livers production of glucose rather than lowering blood glucose levels by increasing glucose access into tissues, is an interesting suggestion that warrants further research.

POSITIVE IMPACT OF A DIAGNOSIS OF DIABETES

The diagnosis of T1D can initially be very confusing. Once familiar with this life-long condition, the patient then has the opportunity to take control of their condition and manage their blood glucose levels to suit their lifestyle and also to maintain good health for as long as possible.

Opportunity to Lead a Very Healthy Life

The consumption of too many sugary foods can have detrimental effects on everybody whether they suffer with diabetes or not. Through regular finger pricking, people with diabetes can see the impact that all foods and drinks have on their blood glucose levels. Therefore, they have the choice to consume foods and beverages which will not spike their blood sugars, and hence live a much healthier life by cutting out the consumption of foods and beverages that have high sugar content and little nutritional value.

Weight Loss

The sudden onset of T1D can lead to weigh loss. Some people struggle with their weight for years and never lose weight for long. Many attend various different classes to lose weight, lose a stone or two over a period of time, and then put it all back on (and frequently more weight). So, when a person who is newly diagnosed with T1D has lost weight as a result of their condition, they then have the opportunity to keep the weight off, by managing the condition, exercising, and eating good nutritious food.

Frequent Access to Excellent Medical Professionals

Once diagnosed as a person with T1D, depending on the country of domicile, the patient will be assigned to a diabetes care team. As with everything in life, some diabetes care teams will be better funded and resourced than others. But still the opportunity is there for the patient to tap into the knowledge base of the medical professionals to ensure that they effectively manage their condition while maintaining an excellent quality of life. The diabetes care team perhaps see each patient twice a year. Therefore, blood testing would be conducted twice a year. The results of the blood tests, (analysed by the diabetes care team), give a very clear picture of the overall general health of the patient. Hence, patients with diabetes have access to excellent medical professionals on a regular basis to guide them to a healthier lifestyle. People who are not diagnosed with diabetes, do not get regular blood tests and access to medical teams to guide them on how to improve their overall health, unless, they pay for these regular health check-ups.

Constant Reminder to Eat Well and Be Active

Even though the excessive consumption of carbohydrates and sugars may not spike the blood glucose levels of people without diabetes this may still lead to other unhealthy medical conditions, for example, obesity. "As a guide for the patient with diabetes, the prescription of many agencies to "eat to the meter" seems like a good one" (Feinman et al., 2015, p. 11). The blood glucose reading on the meter can be a wake-up call to the patient; if the reading is higher than the patient would like perhaps they have not engaged in sufficient exercise or work to expend the glucose created from their last meal, so perhaps they should go for a walk, do some housework or gardening prior to the consumption of more food or drink (with the exception of water). Many members of the world's population currently eat more calories per day than their bodies require.

Some people continually graze (eat and drink unconsciously), the effective management of diabetes depends on one's ability to control every morsel of food or drink consumed. Or, at least to record everything consumed, measure the impact on the blood glucose levels and manage the blood glucose levels to bring them to an acceptable level by engaging in exercise or through the administration of an appropriate dose of insulin.

Self-Management of Condition Unlike Other Conditions

In a study conducted by Nicolucci et al. (2013) a notable finding was that "27.7% of respondents reported a positive impact of diabetes on at least one aspect of their life" (Nicolucci et al., 2013, p. 772). Of all the diseases or conditions to get, T1D is possibly one of the easiest to self-manage, providing the patient is sufficiently informed to manage the condition, willing to monitor every morsel consumed, check blood glucose levels regularly, and take responsibility for altering the doses of (basal and bolus) insulin to suit their lifestyle. The management of T1D in babies, children, adolescents, disabled people, and the elderly is totally different to self-management of the condition; as the person responsible for the administration of insulin has no feedback from their own body to warn in advance of hypos. The management of T1D in babies, children, adolescents, disabled people, and the elderly, is deserving of further research.

FUTURE RESEARCH DIRECTIONS

A number of interesting questions have arisen during this review of T1D which deserve further investigation:

- To investigate if insulin inhibits the release of glucose into the blood from the liver (Manninen, 2004), or if insulin enables the body to use glucose for energy or perhaps both.
- Islet transplantation.

- The extent to which engagement in exercise can extend the honeymoon phase.
- The determination of factors that trigger the onset of T1D.
- The identification of environmental factors with possible links to the onset of T1D.
- The lack of vitamin D and its connection to the onset of T1D.
- The use of statins linked to an increased risk of developing diabetes.
- To ascertain if the use of Big Data, Machine Learning, and Health Informatics can improve the quality of patient care.
- To investigate why people diagnosed with T1D felt that their medication interfered with their quality of life.
- To target the formidable challenge to compel people with diabetes to participate in more exercise.
- The association between the consumption of dietary lipids and the risk for cardiovascular disease.
- To establish why people with T1D are more likely to experience SUD or DIB syndrome than people who have normal glycaemia.
- The management of T1D in babies, children, adolescents, disabled people, and the elderly.

CONCLUSION

The diagnosis of T1D, a debilitating autoimmune disease, is now considered to be a global epidemic. The self-management of T1D is a challenging ongoing process requiring daily focus to maintain good glycaemic control. For the successful treatment of this life-long medical condition the patient or carer requires an understanding of this condition. Self-management of diet, engagement in physical activity, and the daily dosage of insulin administered, are necessary to avoid complications associated with diabetes in the future. One of the main challenges to people with T1D is to avoid hypers and hypos. Hypers occur when the blood glucose levels get too high and hypos occur when the blood glucose levels get too low. Both conditions are potentially dangerous to the patient. Therefore, the successful management of diabetes is for the patient to keep their blood glucose levels under tight control at all times.

A HbA_{1c} result between 4% and 5.6%, a fasting blood glucose level less than 7 mmol/L (126 mg/dl), and an Oral Glucose Tolerance Test (OGTT) below 11.1 mmol/L (200mg/dL) are the levels expected for normoglycaemia (members of the population not affected by diabetes). A person diagnosed with T1D should aim for blood glucose levels near normoglycaemia while avoiding hypos. The quality of the self-management of the condition may depend on the educational attainment of the patient, the expertise of the diabetes care team, and by the patient attending and engaging with diabetes educational programmes. An awareness of simple facts, such as, the consumption of fats and proteins before carbohydrates can delay the release of glucose into the blood and result in a lower postprandial (2 hours after food consumption) blood glucose level. People with T1D are 10 times more likely to suffer from Sudden Unexplained Deaths (SUD) and Dead-in-Bed (DIB) syndrome. It is possible for a person with T1D to control their condition to suit their lifestyle, and therefore possibly avoid complications associated with diabetes in later life.

CONFLICTS OF INTEREST

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Eileen O'Donnell was conferred by Dublin City University with an Honours (2.1) BSc Degree in Information Technology and a First-Class MSc in Information Systems for Managers. While lecturing on the Post Graduate Diploma in Business Information Systems in the Dublin Institute of Technology a research interest in Technology Enhanced Learning (TEL) commenced. This interest evolved into the pursuit of a PhD through research conducted with the Knowledge and Data Engineering Group, School of Computer Science & Statistics, College of Engineering, Trinity College Dublin, Ireland. Her research interests include: Type 1 Diabetes (T1D), the use of ICT in higher education, instructional design, e-learning, technology enhanced learning, personalised e-learning and human computer interaction.

Liam O'Donnell worked for ten years in the computing industry before commencing employment as a lecturer in the College of Business, Dublin Institute of Technology, Ireland. Liam has lectured in Information Systems for over twenty-five years. He also has responsibility for the management of the computer network for the College of Business. Liam received his BSc in Computer Applications from Dublin City University and his MSc in Computing from Sligo Institute of Technology. Liam's research interests include: Management Information Systems (MIS), Enterprise Information Systems (EIS), cloud technologies, virtualisation, computer networks, Perl and Java programming, fuzzy logic, expert systems, genetic algorithms, Type 1 Diabetes (T1D), instructional design, personalised e-learning, and technology enhanced learning.