

A Review on Insulin Errors and It's Prevention among Diabetic Patients

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ABSTRACT

Diabetes mellitus (DM) is a heterogeneous complex metabolic condition characterised by hyperglycemia with a degenerative potential resulting from changes in the production, secretion and/or inability of insulin to adequately exercise its effects. Diabetes mellitus (DM) is currently a leading cause of morbidity and mortality. Insulin errors refer to mistakes or inaccuracies that occur in the administration, dosage, or management of insulin, a hormone used in the treatment of diabetes. These errors can happen in various healthcare settings, such as hospitals, clinics, or even in self-administration by individuals with diabetes. Insulin errors can occur at any stage of the medicine administration procedure, including prescribing, transcribing, dispensing, and administration. The vast majority of these mistakes occur during administration. Incorrect administration of insulin (e.g., too little, too much, or at the wrong times) can result in both transient and serious hypo and hyperglycemia, wide glycemic excursions, severe hypoglycemia, and DKA. These errors can have serious consequences, as insulin is a crucial hormone for regulating blood sugar levels, and both too much and too little insulin can lead to health complications. The aim of this article is to provide a review of insulin errors in various health settings, identify risk factors associated with insulin error as well as effective strategies to prevent errors and manage their consequences. Insulin errors in various health settings represent a critical concern for patient safety. To mitigate insulin errors, healthcare organizations should prioritize ongoing training and education for their staff, focusing on proper dosing, administration techniques, and the recognition of hypoglycemic and hyperglycemic symptoms and also individuals with diabetes and their caregivers should receive proper education about insulin administration, dosing, and safety measures. Regular communication, patient education, and adherence to standardized protocols

are key components of a successful strategy to minimize insulin errors and promote safe and effective diabetes management.

Keywords : Insulin, Errors, Diabetes

I. INTRODUCTION

Diabetes mellitus (DM) is a heterogeneous complex metabolic condition characterised by hyperglycaemia with a degenerative potential resulting from changes in the production, secretion and/or inability of insulin to adequately exercise its effects.^[1] DM is currently a leading cause of morbidity and mortality. The increasing number of adult diabetics worldwide is placing a significant burden on the healthcare system.^[9] Among the many people who have diabetes, approximately 6 million use insulin to control their blood glucose.^[2] The most common classifications include Type 1 DM and Type 2 DM.^[3] Type 2 DM is characterized by insulin resistance and a relative deficiency of insulin secretion which progressively worsens over time.^[4,5] Type 1 DM results in an absolute deficiency in beta-cell function with autoimmune destruction of beta-cells a common origin.^[6] Current estimates suggest more than half a billion adults live with DM worldwide, a rise of 16% since previous estimates in 2019.^[7] This is predicted to escalate to almost 800 million by 2045. In Ireland, in the absence of a national DM registry, the current approximate projection is 5.6%.^[8] The majority of this increase occurs in developing country, including Malaysia.^[10] It was found from National Health and Morbidity Survey III (NHMS III) that the prevalence of diabetes in population aged more than 30 year has escalated by 80% within 10 years duration.^[11]

In 1921, two youthful Canadian scientists made the initial discovery of insulin. Since its discovery, insulin has been the greatest medical marvel ever. It is the most effective agent to reduce high sugar. Insulin commencement in type 2 diabetes has shown encouraging outcomes on endogenous insulin secretion as well as metabolic

control.^[14] Furthermore, it is also preventing the damage; not only to the beta cells in the pancreas but also to the endothelial lining.^[15] Since insulin has a significant therapeutic effect in establishing optimal glycemic control in type 2 diabetes, it has become the cornerstone of diabetes management.^[13] When used improperly, insulin has a greater risk of serious patient injury. Anecdotal research indicates that insulin is responsible for a significant number of medication errors, despite the lack of available Irish statistics and the lack of local incidents.^[12]

Incorrect administration of insulin (e.g., too little, too much, or at the wrong times) can result in both transient and serious hypoglycemia, wide glycemic excursions, severe hypoglycemia, and DKA. When glycemic control is poor, patients and providers commonly assume that this is because of poor behavioral adherence (e.g., insulin omission), dietary indiscretions, difficulties using carbohydrate counting (6), or sedentary lifestyle.^[16] The proper delivery of insulin is crucial since using the wrong method can result in a serious hypoglycemia or hyperglycemia crisis that requires ED visits. Insulin errors can occur at any stage of the medicine administration procedure, including prescribing, transcribing, dispensing, and administration. The vast majority of these mistakes occur during administration.^[17] Unfortunately, insulin errors are not uncommon, with the 2017 British National Diabetes Inpatient Audit (NaDIA) reporting that two-fifths of those treated with insulin (40% with type 1 diabetes and 37% with type 2 diabetes) experienced an insulin error whilst in hospital.^[18] Prescribing insulin is complicated by its narrow therapeutic window, the variety of insulin products available, including concentrated and biosimilar insulins, similar sounding brand names, and the varied terminology used to describe them (e.g. long-acting, human, cloudy, biphasic). Inter-individual variation in insulin doses, regimens, and lack of knowledge or experience can further obscure the prescribing process.^[19,20] This may also be compounded by a culture of reluctance to contest unclear insulin prescribing.^[20]

WHAT IS INSULIN ERRORS?

Insulin errors refer to mistakes or inaccuracies that occur in the administration, dosage, or management of insulin, a hormone used in the treatment of diabetes.^[21] These errors can happen in various healthcare settings, such as hospitals, clinics, or even in self-administration by individuals with diabetes. Insulin errors can have

serious consequences, as insulin is a crucial hormone for regulating blood sugar levels, and both too much and too little insulin can lead to health complications.^[22]

SOME COMMON TYPES OF INSULIN ERRORS INCLUDE:

Dosage Errors: This occurs when the prescribed insulin dose is not administered accurately. It can involve giving too much or too little insulin, which can lead to fluctuations in blood sugar levels. This involves administering the wrong amount of insulin. This could be due to miscalculations, misunderstanding of insulin dosing instructions, or misreading labels on insulin vials or pens and misinterpretation of dosing instructions, or confusion about insulin concentration (e.g., U-100 vs. U-500 insulin).^[23]

Overdosing: Administering too much insulin can lead to severe hypoglycemia (low blood sugar), which can cause unconsciousness and, if left untreated, can be life-threatening.^[24]

Double Dosing: Accidentally taking a second dose of insulin due to forgetfulness or confusion can cause hypoglycemia.^[25]

Wrong Insulin Type: Insulin comes in different types, such as rapid-acting, short-acting, intermediate-acting, and long-acting. Using the wrong type of insulin can result in inappropriate blood sugar control.

➤ **Mixing Insulin Types Incorrectly:** Some people with diabetes use a combination of short-acting and long-acting insulins. Mixing these insulins inappropriately or injecting them in the wrong order can affect blood sugar control.^[26]

➤ **Confusion between Insulin Types:** There are different types of insulin with various onset, peak, and duration times. Confusing one type with another can lead to unexpected changes in blood sugar levels.

Administration Technique Errors: Injection technique errors refer to mistakes or improper practices during the administration of injections, which can lead to various adverse effects, complications, or reduced treatment efficacy. Proper injection technique is essential to ensure the safety and well-being of patients. Errors in injection depth, angle, or site can affect how the insulin is absorbed and its effectiveness.^[27] The location of insulin injection matters. Injecting insulin into a muscle instead of subcutaneously

(under the skin) can lead to faster absorption and potential hypoglycemia. Rotating injection sites is important to prevent lipohypertrophy (localized fat accumulation) that can affect insulin absorption.^[28]

Injecting insulin into the wrong site (e.g., muscle instead of subcutaneous tissue) or failing to rotate injection sites properly can affect insulin absorption and lead to inconsistent blood sugar levels.^[29]

Timing Errors: "Insulin timing errors" refer to mistakes or issues related to the timing of insulin administration for individuals with diabetes. Taking insulin at the wrong time can lead to fluctuations in blood sugar levels. Insulin should be administered according to a person's prescribed schedule, which may involve taking different types of insulin at different times of the day. Following a prescribed dosing schedule is crucial to maintain stable blood sugar control. Forgetting to take insulin doses can result in high blood sugar levels, which can be dangerous over time and also skipping insulin doses can lead to high blood sugar levels, increasing the risk of complications in the long term. Proper insulin timing and adherence to the recommended schedule are crucial for controlling blood sugar and preventing complications.^[30]

Misinterpretation of Orders: Healthcare providers may misinterpret or miscommunicate insulin orders, leading to incorrect dosages or insulin types being administered.

Labeling and Storage Errors: Mishandling insulin, storing it improperly, or confusing different insulin vials can lead to insulin errors. Insulin needs to be stored properly, usually in the refrigerator or at room temperature, depending on the type. Improper storage can degrade the insulin and affect its effectiveness. Improper storage of insulin, such as exposing it to extreme temperatures or direct sunlight, can degrade the insulin's potency. Specific storage recommendations provided by the insulin manufacturer should be strictly followed. Insulin pens, unused cartridges and vials should preferably be refrigerated. If kept between 2°C and 8°C, stored insulin can be used till the expiration date provided by the manufacturer. It is emphasized that insulin should never be allowed to be frozen and if frozen, it should be discarded. We usually ask our patients to keep insulin in a place within the refrigerator which is distant from the deep freezer compartment. We had experienced insulin losing its bioavailability when vials were stored in the topmost part of the refrigerator door and getting exposed to the very low temperature of the deep freezer due to the malfunction and/or broken door of the deep freezer.

Pens should not be stored with needles on to avoid potential air-clogging and leak in thermoinsulation. Using insulin that has passed its expiration date can result in unpredictable blood sugar levels due to reduced potency.^[31]

Patient Education and Compliance: Patients may make errors in self-administration due to a lack of understanding of their insulin regimen or non-compliance with prescribed instructions. Insufficient understanding of insulin therapy, including proper administration and blood sugar monitoring techniques, can contribute to errors.^[32]

Insulin Pump Errors: For individuals using insulin pumps, programming errors, infusion set issues, or pump malfunctions can lead to incorrect insulin delivery.^[33]

Language and Labeling Errors: Proper labeling and clear communication are essential to ensure the safe and effective use of insulin. Misunderstanding insulin labels, dosing instructions, or communication barriers can lead to incorrect insulin use. Confusing the names of different insulin products can lead to patients receiving the wrong type of insulin. For example, confusing "Novolog" and "Lantus" could result in dosage errors. Inconsistent or unclear labeling of insulin products can make it difficult for patients or healthcare providers to identify the type, concentration, and dosage of insulin.^[34]

Patients with diabetes should also be vigilant and ask questions if they encounter any unclear or confusing information regarding their insulin therapy. Clear communication and attention to detail are critical to preventing language and labeling errors in insulin use and also individuals with diabetes and their caregivers should receive proper education about insulin administration, dosing, and safety measures. Insulin errors can have serious consequences, ranging from hypoglycemia (low blood sugar) to hyperglycemia (high blood sugar), diabetic ketoacidosis, and long-term complications of uncontrolled diabetes. To minimize insulin errors, it is crucial for healthcare providers to follow standardized protocols, educate patients on proper insulin administration, and regularly monitor and adjust insulin regimens as needed. Using insulin delivery devices like insulin pens and pumps can also help reduce the likelihood of errors. Regular communication between patients and healthcare providers is essential for maintaining effective blood sugar control and preventing complications related to insulin errors. Patients with diabetes should also receive proper education and training

on insulin administration and adhere to their prescribed treatment plans.

CONSEQUENCE OF INSULIN ERRORS

Insulin errors can have serious consequences for individuals with diabetes. Insulin is a hormone that regulates blood sugar levels, and when it is not administered or managed properly, it can lead to both immediate and long-term health problems. Here are some of the potential consequences of insulin errors:

Hypoglycemia (Low Blood Sugar):

Administering too much insulin or not eating enough after taking insulin can lead to hypoglycemia. Symptoms of hypoglycemia can range from mild shakiness and confusion to severe cases that can result in seizures, loss of consciousness, and even death if not treated promptly.^[35]

Hyperglycemia (High Blood Sugar): Not taking enough insulin, missing doses, or using expired insulin can cause high blood sugar levels. Prolonged hyperglycemia can lead to complications such as diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic state (HHS), both of which can be life-threatening.^[36]

Glycemic Variability: Inconsistent insulin dosing can result in unpredictable fluctuations in blood sugar levels, making it challenging to maintain stable glycemic control. This can impact a person's quality of life and increase the risk of both short-term and long-term complications of diabetes.^[37]

Diabetic Complications: Prolonged insulin errors and poor blood sugar management can lead to long-term complications such as neuropathy, retinopathy, nephropathy, and cardiovascular problems. These complications can be debilitating and reduce overall life expectancy.^[38]

Weight Gain: Overcompensating for low blood sugar by consuming excessive calories can lead to weight gain, which can exacerbate insulin resistance and make blood sugar management more difficult.^[39]

Mental Health Issues: The stress and anxiety associated with managing insulin errors and the fear of hypoglycemia or hyperglycemia can lead to mental health issues such as depression and anxiety.^[40]

Reduced Quality of Life: The constant fear of insulin errors and the need for meticulous monitoring can reduce the quality of life for individuals with diabetes, impacting their physical and emotional well-being.^[41]

Increased Healthcare Costs: Frequent hospitalizations and medical treatments for acute complications of insulin errors can result in high healthcare costs. It's not only a burden on individuals but also on healthcare systems.^[42]

Fatal Outcomes: In severe cases, insulin errors can lead to fatal outcomes, such as death due to severe hypoglycemia, DKA, or other diabetic complications.

To minimize the risk of insulin errors, it is crucial for individuals with diabetes to receive proper education and support in managing their condition, and for healthcare providers to prescribe appropriate insulin regimens and dosages. It's also essential for individuals with diabetes and their caregivers to be vigilant, monitor blood sugar levels regularly, and have a clear plan in place for managing both high and low blood sugar events.

FACTORS AFFECTING INSULIN ERRORS

Insulin errors can be influenced by a variety of factors that can contribute to mistakes in the administration or management of insulin. Some of these factors include:

Lack of Education: Insufficient understanding of diabetes, insulin therapy, and proper administration techniques can lead to errors in dosing, timing, and other aspects of insulin management.^[43]

Complex Insulin Regimens: People with diabetes who require multiple types of insulin with different dosing schedules can find it challenging to keep track of their regimen, leading to potential errors.^[44]

Communication Barriers: Language barriers or inadequate communication between patients, caregivers, and healthcare providers can result in misunderstandings and errors.^[45]

Cognitive Impairment and Fear of Hypoglycemia: Cognitive decline, memory issues, or confusion can lead to mistakes in insulin dosing and administration. Some individuals may intentionally skip or reduce insulin doses due to a fear of hypoglycemia (low blood sugar), which can lead to poor blood sugar control.^[46]

Injection Site Issues: Insulin absorption can vary depending on the injection site. Repeatedly using the same site or injecting into muscle instead of subcutaneous tissue can affect insulin absorption.^[47]

Medication Interactions: Certain medications can interact with insulin, altering its effectiveness or absorption and potentially leading to dosing errors.^[48]

Patient Non-Adherence and Misinterpretation of Instructions: Patients not adhering to prescribed insulin regimens, missing doses, or discontinuing treatment can result in uncontrolled blood sugar levels. Misunderstanding dosing instructions, insulin labels, or other written or verbal information from healthcare providers can lead to dosing errors.

Equipment and Device Errors: Malfunctioning insulin pens, needles, or pumps can lead to incorrect dosing or delivery.

Stress and Lifestyle Changes: Stress, changes in routine, illness, or changes in physical activity levels can affect insulin requirements and lead to dosing errors.^[49]

Insulin Storage Issues: Improper storage of insulin, including exposure to extreme temperatures or direct sunlight, can affect insulin potency and lead to dosing errors.

Health Literacy: Limited health literacy can make it difficult for individuals to understand insulin dosing instructions, leading to errors.

Transitions in Care: Moving from one healthcare provider to another, or transitioning between healthcare settings, can lead to changes in insulin regimens that are not communicated accurately.^[50]

To mitigate these factors and reduce the risk of insulin errors, individuals with diabetes should receive proper education about insulin therapy, maintain open communication with healthcare providers, adhere to prescribed insulin regimens, monitor blood sugar levels regularly, and seek guidance when faced with changes in their health or routine. Healthcare providers play a vital role in educating patients, addressing concerns, and helping to minimize the risk of insulin errors.

PREVENTION OF INSULIN ERRORS

Preventing insulin errors is crucial to ensure the safe and effective management of diabetes. Here are several strategies to help prevent insulin errors:

Education and Training: Healthcare providers should educate patients and their caregivers about diabetes management, including insulin administration, dosing, and insulin types. Provide clear and written instructions on how to use insulin pens, syringes, or pumps. Ensure patients and caregivers understand the importance of monitoring blood sugar levels and how to interpret the results.^[51]

Standardized Protocols: Implement standardized protocols and guidelines for insulin administration

and management within healthcare facilities to reduce variability and errors.^[52]

Double-Checking: Healthcare providers should double-check insulin orders and prescriptions to ensure accuracy. Pharmacy staff should double-check insulin products before dispensing them to patients.^[53]

Clear Communication: Promote open and clear communication between healthcare providers, patients, and caregivers. Encourage patients to ask questions if they are uncertain about their insulin regimen.^[54]

Labeling and Identification: Ensure insulin vials, pens, and syringes are clearly labeled with the insulin type, concentration, and dosage. Patients and caregivers should verify the insulin's identity and check for any discrepancies in labeling.^[55]

Patient Involvement: Encourage patients to actively participate in their insulin management, including keeping a record of insulin doses and blood sugar levels. Provide patients with tools like insulin dosing calculators or apps to help with accurate dosing.^[56]

Simplify Regimens: When possible, simplify insulin regimens by using fewer types of insulin and minimizing the number of daily injections.^[57]

Medication Reconciliation: During transitions of care (e.g., from the hospital to home), ensure that patients' insulin regimens are accurately documented and communicated.^[58]

Regular Monitoring: Encourage patients to monitor their blood sugar levels regularly and adjust insulin doses based on these measurements.^[59]

Medication Reviews: Conduct regular medication reviews to evaluate the need for insulin and adjust regimens as needed, especially for patients taking multiple medications.^[60]

Patient Alerts and Reminders: Use patient alerts and reminders, including mobile apps and alarms, to help patients remember their insulin doses and scheduled monitoring.^[61]

Annual Reevaluation: Annually reevaluate the patient's insulin regimen and overall diabetes management plan to ensure it is still appropriate for their needs.

Preventing insulin errors requires a collaborative effort between healthcare providers, patients, and caregivers. Regular communication, patient education, and adherence to standardized protocols are key components of a successful strategy to minimize insulin errors and promote safe and effective diabetes management.

II. CONCLUSION

In conclusion, errors in self-administration of insulin are common in ambulatory adults with diabetes is of concern. These results strongly suggest that more attention to periodically reviewing and re-educating patients concerning proper insulin self-administration should be considered, and this may be particularly important for those with lower income and education levels. It's important to note that many insulin errors go unreported or are not documented in a systematic way. Consequently, the true prevalence of insulin errors is likely underreported. The frequency of insulin errors can also vary depending on the population studied, the healthcare setting, and the level of diabetes care available. Healthcare systems can implement protocols and safety measures to minimize insulin errors, such as double-checking insulin orders, using computerized order entry systems, and ensuring clear communication between all parties involved in diabetes care. Patient engagement and awareness are also essential in preventing insulin errors. To reduce the occurrence of insulin errors, it is critical for healthcare providers to educate patients and their caregivers on proper insulin management, including dosage calculations, injection techniques, and recognizing the signs of hypoglycemia and hyperglycemia.

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