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Review article

A Literature Review on Proper and Safe use of Insulin

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ABSTRACT

The aim of this study is to determine the safe and proper utilization of insulin therapy. Insulin therapy is crucial in saving countless lives and improving the quality of life for many individuals. This literature review covers around 30 research articles from 1990-2024. The study shows that some diabetic patients abuse needles, reusing them 2-20 times. Moreover, needles are discarded in a dangerous manner by some patients. In the methodology section of the study, it was found that only a small percentage of patients mixed their insulin before injection. However, most patients cleaned their hands and injection site before insulin delivery. Also, insulin delivery techniques varied among patients. The utilization of insulin pumps is statistically different in glycemic control. Most participants in the study were over 46, married and female. The optimization of insulin delivery could reduce hyperglycemia, intramuscular injections, and lip hypertrophy. Proper diabetes insulin storage and delivery safety training may also have a significant impact.

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1. INTRODUCTION

1.1 Insulin

The pancreatic islets of Langerhans contain the beta cells that release insulin. Insulin belongs to the class of peptide hormones. Mitosis promotes cell division and proliferation, regulates carbohydrate, lipid, and protein metabolism, and aids glucose uptake by cells; all of these contribute to appropriate blood glucose levels. Insulin primarily regulates food-induced energy expenditure by maintaining a steady concentration of micronutrients in the fed state. Insulin is essential for the uptake of glucose from the intracellular space by insulin-dependent cells and tissues, including the fat, muscles, and liver. [1].

2. HEALTHCARE ENVIRONMENTS AND INSULIN SAFETY AND EFFICACY: PHARMACISTS ROLES

It is regarded as a pharmaceutical that demands a high degree of vigilance since insulin is a medicine that has a low therapeutic index and has a greater chance of causing severe patient damage when it is delivered wrongly [2]. In addition, insulin has a lower therapeutic index than other medications. At the same time, adverse outcomes may be associated with inadequate insulin delivery and excessive insulin administration. Using standard insulin order sets to give subcutaneous insulin on a specified schedule and average concentrations for intravenous insulin are both proposed to guarantee the safe usage of this medication. Both methods are intended to ensure that the medication is used in a manner that is not harmful to the patient. Before administering the drug, it is recommended that any unclear insulin treatment instructions be clarified in writing. It is required that all insulin injections be produced inside the pharmacy facilities alone, without any help from other sources. Pharmacists should know potential pharmaceutical errors due to incorrect acronyms, such as the letter U for units. It is essential for them to be concerned about this possibility. By lowering the possibility of medication errors connected with prescribing, transcribing, dispensing, administration, storage, and communication, chemists may help guarantee that hospitalized patients get insulin appropriately. This is one way that pharmacists may contribute. To reduce the possibility of insulin mistakes happening, it is recommended that proper protocols for storing insulin be followed [3]. Possible insulin pen delivery systems utilized in hospitals; however, the safe use of these devices is contingent upon continuous monitoring by a committee comprised of professionals from a variety of fields, the introduction of a single nursing education, both initial and ongoing, for all nurses (even those who work in agencies or part-time), and for each device individually. Furthermore, it is essential to check the situation continuously to guarantee its safety. Because it is unclear and easy to make mistakes, sliding-scale insulin is not advised. It might cause high blood sugar and low blood sugar levels. There is a very high potential for damage from the improper use of some drugs, which are called high-alert medicines 1. Insulin is one of the drugs that is considered to be a high-alert drug, which is something that is considered to be standard information [4].

A low therapeutic index is one of the features of high-alert drugs, which include insulin, parenteral chemotherapy, opiates, intravenous potassium chloride, and other pharmaceuticals. Other medications that fall into this category include intravenous potassium chloride. Insulin therapy can save lives in the hospital setting [5]. Still, if provided inappropriately, it may produce a potentially life-threatening scenario. Insulin errors can inflict twice as much harm to patients as other forms of errors compared to mistakes with other prescriptions The damage from insulin errors might be twice as severe. There were 4,764 complaints of insulin errors received by the MEDMARX

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volunteer reporting initiative. These errors were documented in the US Pharmacopoeia during a two-year period.

An estimated 6.6% of them resulted in harm to the patient. The Institute for Healthcare Improvement's 5 million Lives Campaign has proposed twelve therapies. One such program's stated goal is to "Prevent Harm from High-Alert Medications." This approach first focuses on insulin, sedatives, opioids, and anticoagulants. Reducing the risks associated with high-alert medications by half is one of the several objectives of the campaign [6].

In the following paragraphs, we will cover a variety of various methods in which clinical chemists may be of service in ensuring the safe and effective utilisation of insulin within the context of a hospital setting. Omission errors, which may lead to hyperglycemia, and improper dose or quantity, which can either lead to hyperglycemia or hypoglycemia, are the two kinds of mistakes that are most often reported in connection to the administration of insulin. Both of these types of errors include the potential to cause hyperglycemia. Both of these specific kinds of mistakes are associated with the administration of insulin. These two categories of mistakes have the potential to have very detrimental effects on the situation. According to the information that can be found in their medical records, hyperglycemia that is not treated is associated with adverse outcomes in persons who have been diagnosed with diabetes mellitus as well as in those who do not have any type of diabetes for any reason. When it comes to both groups of individuals, the situation is exactly the same [7].

A diabetic patient can have unpleasant consequences such as ketoacidosis if they are given an insufficient amount of insulin or if they do not take the quantity that they have been prescribed. Several symptoms may be brought on by insulin-induced hypoglycemia. Some of these symptoms include nausea, falls, and an increased likelihood that the patient would have cardiac ischemia.

Insulin delivery has the potential to result in eight distinct kinds of errors, including transcription and prescription errors. The following are examples of mistakes that may occur: prescriptions that are not legible, zeros and decimal points that are missing or misplaced, potentially hazardous acronyms, and the ordering of an unexpected formulation. Insulin usage is also associated with the potential for serious consequences. The errors that are made throughout the transcription process are also included in this category at this point. The usage of medications comparable to one another in terms of look or sound, as well as the preparation of injectable doses in an inappropriate manner, both have the potential to result in dispensing errors. An incorrect dosage, medicine, or infusion rate, as well as a lack of pharmaceutical monitoring or double-checking, are all mistakes that may occur throughout the delivery procedure. Other examples include a need for more surveillance or double-checking. A further kind of administrative error is when a patient gets the wrong drug rather than the one that was intended for them to take. Using medical acronyms that are not safe to use increases the likelihood of making substantial errors while purchasing insulin. This also increases the possibility of making mistakes. According to the National Patient Safety Goal 2B established by the Joint Commission, every hospital must compile a rundown of the unacceptable symbols, acronyms, abbreviations, and dosage designations utilized inside the structure. This list needs to be standardized [8]. An excellent instance of this is the fact that the abbreviation "U" for "unit" is placed on the official list of abbreviations that persons are not authorized to use. This is an excellent example of this. In the process of placing an order for insulin, it is of the utmost importance to specify the units of measurement. For insulin infusions, the units of measurement should be mL/hr rather than cc/hr since cc might be mistaken with U. This is because the mL/hr measurement is more precise.

3. INSULIN ADMINISTRATION APPARATUSES

Picking the proper insulin syringe is crucial. Several nurses have introduced nine units of insulin into patients' systems by mistakenly administering 0.9 mL [90 units] of insulin via a tuberculin syringe rather than an insulin one. It was the Pennsylvania Patient Safety Reporting System that documented these details. Some healthcare institutions have reduced mistakes by using insulin pens tailored to each patient. Several potentially harmful medical applications exist for pen injectors. Insulin pens should not be used like vials, including needle removal and reuse.20 Despite needle replacement frequency, ISMP data shows the FDA advised healthcare practitioners against recycling insulin pens and cartridges for many patients. Hepatitis and HIV may spread. 21 A multidisciplinary committee must monitor the installation of insulin pen delivery devices in hospitals; only one device should be introduced at a time, and agency and part-time nurses must be trained on their usage. Safety requires frequent monitoring. Risk-management systems must continually check this. Glass pen instruments may decrease dosage mistakes in the number of units administered. After learning them, nurses may educate patients to use pens at home [9]. Insulin pens may save money for brief hospital stays or minimal insulin needs since they contain less than vials. Lilly distributes a 3-milliliter vial of ordinary human insulin to keep expenses.

Figure 1: Insulin administration apparatuses

Nurses mistake insulin pen devices for vials because they prefer needle and syringe insulin delivery. Changes in pressure dynamics and air entering the cartridge may weaken a pen as a vial. Aspirating insulin from insulin pen injector cartridges revealed large air pockets. Failure to dispose of the pen injector or cartridge and vacuum out the air before a second dosage increases the risk of subcutaneous air injection and insulin insufficiency. Pens as vials may result in unlabeled insulin syringes in the nursing unit [10]. Nursing personnel may accidentally stab themselves if the pen is not held at 90 degrees to the skin pinch. An improper angle causes the needle to pass the skin pinch and enter the nurse's finger, causing a dirty needle poke. A pen device used on several patients may be contaminated, increasing infection-control issues. Each pen is patient-specific. Healthcare practitioners struggle to use pen injectors due to their variability. Especially nurses.

A multidisciplinary committee should introduce insulin pen devices one at a time with nurse education. Require initial and recurrent proficiency and competence testing. The research found that insulin pen devices do not increase needlestick injuries or nurse time teaching patients to self- inject insulin [11]. Insulin pen users also report higher patient satisfaction and the ability to use the same insulin administration route at home as hospitalized insulin vials and syringe users.26 Although many people with diabetes leave hospitals, this researcher has to remember this when improving their long-term glycemic control.

4. CHEMICAL COMPOSITION OF INSULIN

There is a hormone known as insulin that may be used to assist in the management of glucose levels in the blood. As well as in other species, the pancreas is responsible for the production of this substance in mammals, including humans. Insulin is generally composed of carbon, hydrogen, nitrogen, oxygen, and sulphur, which are the components that go into its composition. Insulin is a hormone that regulates blood sugar levels [12]. Fifty-one amino acids comprise one monomer of human insulin, which has a molecular weight of 5808 Da. The formula for human insulin at the molecular level is $C_{257}H_{383}N_{65}O_{77}S_6$. This is a combination of two peptide chains, also known as a dimer, referred to as an A-chain and a B-chain. Two disulfide bonds connect these chains.

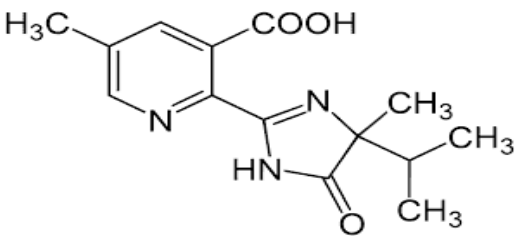

Figure 2: Insulin Structures

5. HUMAN REGULAR INSULIN

Relying on ordinary human insulin was the predominant technique of insulin treatment for type 1 diabetes in children and adolescents up until the early 2000s. This was the case over the majority of the time period. On the other hand, with the exception of intravenous injection, the use of regular human insulin in children and adolescents has been almost eliminated as a consequence of the introduction of rapid-acting insulin analogues. This is the case with the very exception of intravenous injection. The delayed absorption and longer duration of effect of the high premeal bolus doses of daily insulin that adolescents with type 1 diabetes require in order to overcome the insulin resistance that occurs during puberty were the cause of the problems with hyperglycemia and hypoglycemia that were observed in this age group [13]. These problems were observed in relation to adolescents who were diagnosed with type 1 diabetes. Both hypoglycemia and hyperglycemia are signs that diabetes is present in a person. A total of 305 items Regular insulin is still the insulin of choice for intravenous infusion therapy when it comes to the treatment of diabetic ketoacidosis (DKA), which is associated with the condition. Patients with substantial insulin resistance and need massive daily insulin doses may utilize a unique formulation of regular insulin called U-500 (500 units/mL). This formulation is a unique formulation of regular insulin. Patients can avail themselves of this formulation since it is readily available.

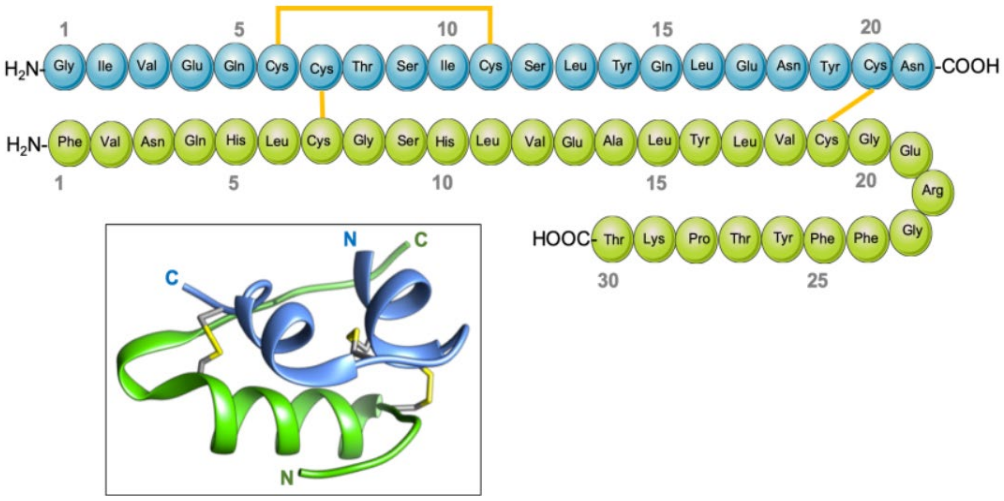

Figure 3: 3D structure of Human Insulin [23]

6. INSULIN DELIVERY

The primary care physicians are often the ones who are responsible for monitoring diabetic patients who are receiving therapy via injections or infusions. Written guidance for these treatments has been difficult for both the professionals working in this area and the patients they treat. This is true for both parties [14]. In this section, we provide answers that are up-to-date, based on truth, and thorough concerning the injections and infusions used in treating diabetes. This suggestion is based on the findings of a comprehensive study conducted all around the globe that looked at the several methods that are currently being used. It was the workshop's responsibility to create and evaluate the criteria. The disciplines of technology, psychology, anatomy, physiology, and pathology lay down the rules used to organize themes. The shortest needles, currently defined as pen needles measuring 4 millimeters and syringe needles measuring 6 millimeters, should be the first-line option for all patient groups since they are safer, more effective, and cause less discomfort than longer needles. This is easily one of the most crucial pieces of advice [15].

Instead of injecting insulin intramuscularly, it is recommended that you avoid doing so to prevent severe hypoglycemia. When insulins with a long expiry period are being used, this is very important to remember. It is crucial to avoid injecting or infusing into these lesions and to rotate injection sites properly to prevent lipo hypertrophy, a common side effect of medication that changes insulin absorption [16]. To prevent lipohypertrophy, it is vital to avoid it. It is possible, however, to mitigate this danger by ensuring enough training is received, implementing effective disposal processes, and using safety equipment. Although there is a potential for infection with blood-borne pathogens when used sharps are disposed of improperly, this risk may be reduced with appropriate disposal practices. It is vital to address psychological hurdles throughout the process, even before insulin is provided, to achieve effective long-term insulin therapy. This is required to achieve diabetes treatment success. It is anticipated that applying these new

guidelines would result in better treatments, improved results, and lower expenditures for individuals with diabetes. To keep diabetes under control in an acceptable way, it is very vital to inject insulin in a suitable method. This article presents innovative injection and infusion techniques for insulin users, which follows a review of the most current research conducted in the appropriate area. The year 2010 saw the publication of injectable guidelines, and the purpose of this paper is to expand and improve upon existing suggestions.1. The findings of the fourth injection technique questionnaire (ITQ) survey, which served as the basis for our most recent ideas, are the basis for our most recent proposals, which are based on those results. The most current suggestions that we made were based on these results. We have described the results of our investigation in a different part of this subject, which may be found someplace else. Participants in the ITQ research included a total of 13,289 diabetes patients who inject insulin. This study has the distinction of being one of the most comprehensive investigations of its kind that has ever been carried out anywhere in the world. The patients in this group hailed from 42 different nations, which are spread out over the whole world. Between the months of February 2014 and June 2015, the questionnaire was filled out by their respective respondents. During the same time period that the Infusion Technique Questionnaire research was being conducted, a more constrained version of the questionnaire was distributed in four different countries. In all, there were 356 participants who were participating in the trial. These participants were receiving continuous subcutaneous insulin infusion (CSII). The updated infusion recommendations were developed with this research serving as the foundation for their formulation. In all, the survey was conducted in four different countries throughout the world. The workshop that took place on October 23 and 24, 2015 and was known as the Forum for Injection Technique and Therapy: Expert Recommendations (FITTER) was attended by 183 medical experts from 54 different nations. The session was hosted in the United States. In the course of this conference, they examined the outcomes of the ITQ survey, which was done for injection and infusion, as well as the initial text of these suggestions.

7. SECURE ADMINISTRATION OF INSULIN PENS AT HEALTHCARE FACILITIES

Using the joint efforts of twelve experts ranging from a broad variety of areas, the implementation of the Delphi method was successfully completed. Included in the group of specialists who participated in this endeavour were medical professionals, including physicians, chemists, and nurses, among other types of professionals. Over four hundred and fifty replies were received from individuals during the first round of comments that were received by the panel. Every single one of those remarks put in a considerable level of work in order to ensure that insulin pens are used in a manner that is absolutely risk-free. Because of the information that was supplied, about 1,520 practice statements were developed [17]. This was accomplished by making use of the information. Seventy-six of the 98 statements that were given to the panellists in the second round and received consensus from them were examined in the third round and deemed to be either highly critical for the safety of patients or likely to have a beneficial impact on patient safety. This was determined by the panellists when they were asked to evaluate the statements. Before then, they had already been prepared for usage and were ready to go. During the fourth round of the discussion, the panel was able to arrive at a decision about the 35 best-practice statements concerning the secure use of insulin pens at healthcare facilities. This was the result of the panel's thorough examination of the situation, which led to this outcome. There was not a single individual on this list who was opposed to the idea of passing it, according to the information that was gathered. The disease known as hyperglycemia, which is very rare, is often seen in patients who are admitted to the hospital. The individuals who have been diagnosed with diabetes mellitus as well as those who have not yet been given that diagnosis is included in this group. This group is responsible for fifty percent of the circumstances that are associated with diabetes mellitus. Since hyperglycemia is associated with an increased risk of morbidity and mortality, hospitals have been begun to focus a larger emphasis on the treatment of their patients who are afflicted by this illness. This is because hyperglycemia is connected to an increased risk of those two outcomes. When it comes to the management of hyperglycemic patients who are hospitalised, the use of insulin therapy is considered to be the golden standard (gold standard). It is possible that the vast majority of patients may take advantage of the guidance that is being provided here. 3–5 Based on the outcomes of the research that Wu and Ballantyne carried out in the year 2020, it can be deduced that this led to the widespread use of insulin in healthcare institutions. Insulin is administered and either intravenously or subcutaneously to the vast majority of diabetes patients. This is the most prevalent method of therapy for diabetic individuals. It is feasible to use an ever-expanding assortment of insulin formulations and delivery strategies when administering insulin in an inpatient environment. This is something that is conceivable. The injection of insulin that has been extracted from a vial may be performed with the help of a syringe that has been particularly created for the administration of insulin. Considering the circumstances of this specific scenario, the administration of insulin using the method of subcutaneous injection is a viable option. One study found that nurses believed it was easier to teach patients how to self-administer insulin doses by utilising pens rather than vials and syringes. This was the conclusion reached by the researchers over the course of their training. In conclusion, this was the conclusion that the nurses arrived to. After conducting their examination, the researchers arrived at this conclusion as a consequence of themselves. Not only did the nurses observe that the use of an insulin pen resulted in a reduction in the amount of time required to prepare and give an insulin dose, but it also resulted in a reduction in the hazards that were associated with dosing errors and unintended needlestick injuries. According to the findings of a second poll, the majority of nurses believe that insulin pen devices are more convenient and simpler to use than conventional insulin bottles and syringes. This was the conclusion that the majority of the nurses who responded to the survey arrived at. Based on the findings of the investigation, it seems that this particular facet with respect to the circumstance is the most significant one. According to White and Kahn (2021), the use of insulin pens is beneficial for nurses when it comes to the administration of insulin since they are more convenient to use than vials and syringes [18]. This is also the case when it comes to the administration of insulin. As a last point of consideration, it is important to understand that there is a correlation between insulin pens and increased levels of patient satisfaction. Because insulin pen devices minimise the amount of waste that occurs during the process of giving insulin, a dozen hospitals could be able to save money in the long term if they decide to move from using vials and syringes to utilising insulin pen devices. This is because insulin pen devices reduce the amount of waste that occurs during the process of delivering insulin. The findings of one piece of research indicate that the use of insulin pens has the potential to reduce the amount of

money spent on medical treatment by a total of $36 for each individual patient each time they were hospitalised.

Despite the fact that there have been suggestions given, this was the conclusion reached. The first thing that we wanted to do was make a list of the procedures that are advised for the safe administration of insulin injection pens in healthcare facilities. The fundamental objective that we set out to accomplish was to do this. In order to assist in making this strategy a reality, it was decided to bring in a group of specialists that are knowledgeable in a broad variety of fields. This was done in order to make the implementation of a difficult technique for reaching a consensus easier to do. Using a gadget that is analogous to an insulin pen is yet another alternative that may be used for the purpose of dosing and monitoring the dose [19]. This is an option that can be utilised for those who have diabetes. Insulin pen devices have been shown to improve patients' adherence to their treatment regimen, in addition to their ease of use and convenience when it comes to patient care that is provided outside of a hospital setting. In addition, it has been shown that patients who use these devices have improved control of their glucose levels. Several pieces of evidence support this assumption.

There is a high probability that patients may have terrible outcomes in the event that insulin prescription mistakes are not handled in an acceptable manner. There was research that shown that 61% of insulin-related mistakes occurred during the process of giving the medicine, 27% occurred during the process of writing the prescription, and 10% occurred during the process of filling the drug. These findings were based on the findings of the respective processes. Thirteen in total in total the use of an improper insulin product, the administration of an erroneous dosage, and the lack of or delay in providing doses were some of the mistakes that were identified to be the source of a substantial percentage of the errors that were noticed. A totally new and unique risk has been identified, and it has been shown that insulin pens are connected with this risk. It is possible to raise the risk of contamination and the spread of blood-borne infections by using the same insulin pen for several patients, even after the needle has been changed. This is because the needle has been replaced. Even after the needle has been adjusted, there is still a possibility that this risk may grow. In spite of the fact that you have replaced the needle, this will not be affected in any way, shape, or manifestation. At that moment, the time is fifteen minutes and fourteen seconds. Even though each insulin pen is only intended to be used by a single patient at a time, there have been instances in which many patients have reused insulin pens. This is despite the fact that each pen is used by only one patient at a time. The fact that each pen is intended for use by a single patient does not change the fact that this is the case. As a result of the fact that the individuals who took part in this research could have been exposed to diseases that are transmitted by blood, it is feasible that these results would be seen as somewhat alarming in the years 2016 and 2017. There were 1,141 patients at a community hospital in New York and 2,141 patients at a national hospital in Texas who were impacted by instances involving pen-sharing in the year 2013. Both of these healthcare facilities are located in the state of Texas. According to the most recent year, there have been 3,149 patients in the state of Connecticut who have been affected by incidents involving pen-sharing. These patients have been affected by the incidences. Galindo et al. (2023) indicate that the incident that took place in a federal institution in the state of New York in 2014 had an effect on 716 patients [20]. This information comes from the study that was conducted. The year 2014 was the year that all of these occurrences occurred, and it was also the year that they were reported to the authorities that were responsible for dealing with them. Following the occurrence of these occurrences, a number of organisations, including as the International Society for the Prevention of Poverty (ISMP), the Food and Drug Administration (FDA), and the Centres for Disease Control and Prevention (CDC), published cautions about the potential risks associated with this practice. When it comes to the concept of the Only Campaign, the Safe Injection Practices Coalition and the Centres for Disease Control and Prevention (CDC) collaborated in order to come up with the idea. The strategy of working together was successful in achieving this goal. The purpose of the campaign was to increase the level of awareness among medical professionals and the patients that they serve about the significance of using insulin pens in a manner that is in accordance with the standards that have been established for safety. In accordance with what Wu and Ballantyne (2020) have indicated, the idea of "one patient, one pen" acts as the driving force behind this educational attempt [21]. In spite of the fact that there have been recommendations made to assist with the safe administration of insulin in the setting of hospitalisation, guidelines for the most efficient use of insulin pens have not yet been developed.

8. CONCLUSION

This is the conclusion that can be drawn from the findings of the study. A hospital with 214 beds was able to achieve a savings of sixty thousand dollars after making the switch from insulin bottles and syringes to pen devices. This transition took place six months after the hospital introduced the new system. The year 2022 will see Heinemann and his colleagues [22]. Although insulin pen devices have the potential to bring about major advantages, it is important to keep in mind that they are also associated with a number of risks that should be taken into account. In spite of the fact that insulin is used in the treatment of diabetes in a variety of different ways, the Institute for Safe medicine Practices (ISMP) continues to consider it to be a medicine that requires a high level of alertness. There is a possibility that insulin prescription mistakes might occur at any stage of the procedure of taking the medication, despite the fact that such errors are very out of the ordinary. It is quite probable that these errors might result in illnesses that are associated with a significant degree of severity owing to the possible repercussions that they could have. In a way that is comparable to the point that came before it, the use of these technologies within the confines of a medical setting has the potential to bring about a wide range of positive outcomes.

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