

Errors in the preparation and application of insulin: an integrative review

Erros no preparo e aplicação de insulina: revisão integrativa

Errores en la preparación y aplicación de insulina: revisión integradora

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Abstract

Objective: To analyze the scientific literature on errors in the preparation and application of insulin by people with diabetes mellitus and/or their guardians. **Methods:** This is an integrative literature review, carried out between January and April 2023, in the MEDLINE via PubMed, CINAHL via Ebsco, LILACS, Embase and Scopus databases. Studies published as original articles, in Portuguese, English, and Spanish and published in the last 10 years were included, resulting in a sample of 12 articles. **Results:** The most prevalent errors in the practice of preparing and applying insulin were: incorrect preparation of doses, above or below those prescribed; incorrect application; failure to rotate application sites; inadequate storage and preservation of insulin vials. **Conclusion:** Given the errors revealed, diabetes education for patients and those responsible for this practice is a fundamental strategy for avoiding errors in insulin therapy. Nursing can contribute to planning educational actions aimed at this public, making decisions to qualify the care provided.

Descriptors: Diabetes Mellitus. Insulin. Medication Errors. Literature Review.

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Whats is already known on this?

Errors in the preparation and application of insulin by people with diabetes and their caregivers can cause harm to patients, such as uncontrolled blood sugar levels and changes to the skin.

What this study adds?

The results obtained in the study can help guide the multi-professional team, especially nurses, in detecting and correcting the main errors made in the preparation and application of insulin.



How to cite this article: Silva AKA, Lavor SF, Oliveira CJ, Cavalcante EGR, Gomes EB, Kenya Lisboa WSC, Alencar AMPG. Errors in the preparation and application of insulin: an integrative review. Rev. enferm. UFPI. [internet] 2025 [Cited: ano mês abreviado dia];14:e5657. DOI: 10.26694/reifpi.v14i1.5657

Resumo

Objetivo: Analisar a literatura científica acerca dos erros no preparo e aplicação de insulina pelas pessoas com diabetes mellitus e/ou responsáveis. **Métodos:** Trata-se de uma revisão integrativa da literatura, realizada no período de janeiro a abril de 2023, nas bases de dados MEDLINE via PubMed, CINAHL via Ebsco, LILACS, Embase e Scopus. Foram incluídos estudos publicados no formato artigo original, nos idiomas português, inglês e espanhol e publicados nos últimos 10 anos, resultando em uma amostra de 12 artigos. **Resultados:** Os erros mais prevalentes na prática de preparo e aplicação de insulina foram: preparo incorreto das doses, além ou aquém da prescrita; aplicação incorreta; não rodziamento dos sítios de aplicação; armazenamento e conservação inadequada dos frascos de insulina. **Conclusão:** Mediante os erros evidenciados, a educação em diabetes para os pacientes e responsáveis nessa prática é estratégia fundamental para evitar erros na terapia com insulina. A enfermagem poderá contribuir para o planejamento de ações educativas direcionadas a este público, tomando decisões para a qualificação da assistência prestada.

Descritores: Diabetes Mellitus. Insulina. Erros de Medicação. Revisão de Literatura.

Resumén

Objetivo: Analizar la literatura científica sobre errores en la preparación y aplicación de insulina por parte de personas con diabetes mellitus y/o sus cuidadores. **Métodos:** Revisión integradora de la literatura, realizada entre enero y abril de 2023, en las bases de datos MEDLINE vía PubMed, CINAHL vía Ebsco, LILACS, Embase y Scopus. Se incluyeron estudios publicados en formato de artículo original, en portugués, inglés y español, divulgados en los últimos 10 años, resultando una muestra de 12 artículos. **Resultados:** Los errores más prevalentes en la práctica de preparación y aplicación de insulina fueron: preparación incorrecta de las dosis, por encima o por debajo de lo prescrito; aplicación incorrecta; falta de rotación de los sitios de aplicación; Almacenamiento y conservación inadecuados de los viales de insulina. **Conclusión:** Ante los errores resaltados, la educación diabetológica de los pacientes y/o responsables de esta práctica es una estrategia fundamental para evitar errores en la terapia con insulina. La enfermería puede contribuir a la planificación de acciones educativas dirigidas a este público, tomando decisiones para brindar una asistencia cualificada a este grupo.

Descriptores: Diabetes Mellitus. Insulina. Errores de Medicación. Revisión Bibliográfica.

INTRODUCTION

Insulin is a vital hypoglycemic hormone prescribed in the treatment of diabetes mellitus. Its use requires knowledge of the technique of preparation and application by people with diabetes who use this therapy, implying the need to implement educational actions for self-care.⁽¹⁾

Despite the implementation of care models, such as the model focused on chronic diseases in Primary Health Care, with an emphasis on comprehensive care for diabetes mellitus and a focus on education for self-care,⁽²⁾ errors in the preparation and application of insulin are still evident and are a factor that interferes with the glycemic profile of people with diabetes.⁽³⁾

In this scenario, considering that the integrative review method emerges as a methodology that provides the synthesis of knowledge and the incorporation of the applicability of study results in the clinical practice of health professionals, and based on the fact that there is no current review study on the proposed theme, the research in question is justified.

Furthermore, the results of this research will provide reflections on the errors evidenced in the preparation and application techniques of insulin by people with diabetes, pointing to the need for changes in the care practices of health professionals, specifically nurses, who are most often responsible for teaching and educating patients and their families in self-care.

Recognizing possible errors in the insulin preparation and application technique and, consequently, correcting them, can effectively uncover the main difficulties during insulin therapy and are important for successful treatment.⁽³⁾ The aim was therefore to analyze the scientific literature on errors in the preparation and application of insulin by people with diabetes mellitus and/or those responsible for this practice.

METHODS

Type of study

This is an integrative literature review, carried out between January and April 2023. For its development, the stages recommended by Mendes, Silveira and Galvão (2019)⁽⁴⁾ were followed: 1) Identification of the guiding question; 2) Establishment of inclusion and exclusion criteria, data sources and search strategy and search and selection procedures; 3) Procedures for extracting, organizing and summarizing data; 4) Evaluation of the included studies; 5) Analysis/Interpretation of the results; 6) Review presentation.

Identification of the guiding question (stage 1)

The PVO (*Population, Variables and Outcomes*) strategy was used to develop the research question and select the descriptors, as shown in Chart 1.

Chart 1. Subject descriptors located in DeCS/MeSH for the components of the research question according to the PVO strategy. Iguatu, CE, Brazil, 2023.

Strategy items	Components	Subject descriptors
<i>Population</i>	People with diabetes mellitus and caregivers	Diabetes <i>mellitus</i> OR Cuidadores OR Caregivers
<i>Variables</i>	Preparation and application of insulin	Insulina OR <i>Insulin</i> OR administração & dosagem OR Administration & dosage
<i>Outcomes</i>	Errors	Erros de medicação OR Medication errors OR Segurança do paciente OR Patient safety

Source: Prepared by the authors.

Thus, the question was “What are the errors in the preparation and application of insulin by people with diabetes and/or their guardians?”.

Establishment of inclusion and exclusion criteria (stage 2)

The inclusion criteria were: studies published as original articles, in Portuguese, English, and Spanish and published in the last 10 years (2014-2023). Review studies, theses, dissertations, letters to the editor, repeated articles and those that could not be found in full free of charge were excluded.

Data sources and search strategy (stage 2)

The search was carried out in the databases *Medical Literature Analysis and Retrieval System Online* (MEDLINE) via PubMed, *Cumulative Index to Nursing and Allied Health Literature* (CINAHL) via Ebsco Information Services, *Literatura Latino-Americana e do Caribe em Ciências da Saúde* (LILACS), *Embase and Scopus*, through the advanced search method, using the descriptors of the *Medical Subject Heading* (MeSH) of the *National Library of Medicine* (NLM), *National Institutes of Health* (NIH) and the *Health Science Descriptors* (DeCS),

It should be noted that the search strategy used was to associate the variables of the PVO strategy using the *Boolean* operator AND between each of them and the *Boolean* operator OR was used between the descriptors of each variable.

To obtain a larger number of articles, two search strategies were used in the databases, as shown in Chart 2.

Chart 2. Search strategies to obtain the articles. Iguatu, CE, Brazil, 2023.

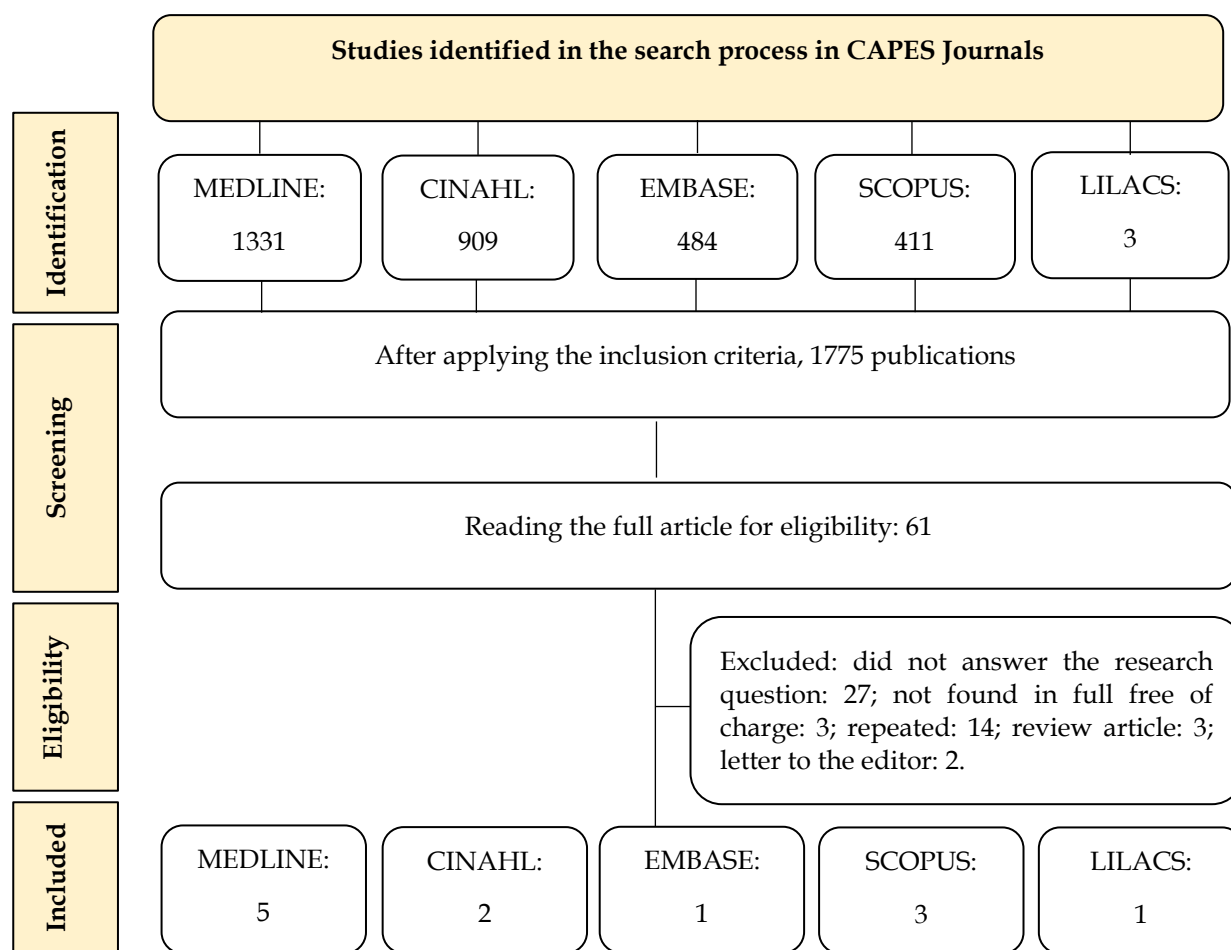
Database	Search strategy
Scopus/Embase	“Diabetes mellitus” AND “Insulin” AND “Medication errors”
Medline/Lilacs/Cinahl	“Diabetes mellitus OR Cuidadores OR Caregivers” AND “Insulina OR Insulin OR administração & dosagem OR Administration & dosage” AND “Erros de medicação OR Medication errors OR Segurança do paciente OR Patient safety”

Source: Prepared by the authors.

Search and selection procedures (stage 2)

The selection process of the publications was carried out in a paired and independent manner, using the *Preferred Reporting Items for Systematic Review and Meta-Analyses* (PRISMA)⁽⁵⁾ instrument to demonstrate the search and selection process of the studies, as shown in Figure 1.

Figure 1. Flowchart of the search process and selection of articles by cross-checking Desc/MeSH Terms via the PRISMA strategy. Iguatu, CE, Brazil, 2023.



Source: Adapted from PRISMA - ScR (2018).

Procedures for extracting, organizing and summarizing data (stage 3)

The authors created an instrument to collect/extract the data in *Word for Windows*®. The identification/characterization variables of the studies were listed (year, country, objective of the study, methodological design, level of evidence and main errors in the practice of preparation and application of insulin).

Evaluation of included studies (stage 4)

The included studies were assessed by building a chart by the authors themselves, characterizing them according to the variables described in the previous stage. The manuscripts were evaluated according to the levels of evidence based on the *Agency for Healthcare Research and Quality (AHRQ)* of the United States of America, which covers six levels: 1 - evidence from meta-analysis and systematic reviews; 2 - evidence from randomized clinical trials; 3 - evidence from non-randomized clinical trials; 4 - evidence from cohort and case-control studies; 5 - evidence from systematic reviews of descriptive and qualitative studies; and 6 - evidence based on descriptive or qualitative studies.⁽⁶⁾ From this classification, it was possible to identify that the majority of studies are at level 6.

Analysis/Interpretation of the results and presentation of the review (stages 5 and 6)

The data was interpreted using the data reduction method,⁽⁷⁾ which is a method of analysis specific to integrative reviews.

This integrative review was presented descriptively, using the strategy of grouping data according to similarity, which was organized into thematic categories and then discussed based on the scientific literature.

RESULTS

The characterization of the 12 articles included is shown in chart 3, categorized in ascending order according to the year of publication.

Chart 3. Characterization of the studies included in the final sample. Iguatu, CE, Brazil, 2023.

ID Code*	Year/Country	Objective	Type of study/LE**	Main errors
A***1 ⁽⁸⁾	2014 United States	To estimate the rates of hypoglycemia and insulin-related errors that result in emergency room visits and subsequent hospitalizations, and to identify high-risk groups and precipitating factors for insulin-related errors	Descriptive study/ Level 6	Incorrect dose, incorrect application of insulin
A2 ⁽⁹⁾	2014 Vietnam	Determine the prevalence, type and potential clinical consequences of errors in the preparation and administration of insulin in hospitals	Observational study/ Level 2	Incorrect dose, incorrect route of application
A3 ⁽¹⁰⁾	2016 United States	To examine the effectiveness of a dual subcutaneous insulin monitoring preparation intervention on insulin administration errors	Controlled clinical trial/ Level 2	Incorrect dose, incorrect route of application
A4 ⁽¹¹⁾	2016 Austria	Comparing a paper protocol with a computerized medication management system combined with clinical workflow and decision support	Clinical trial/ Level 2	Wrong dose
A5 ⁽¹²⁾	2017 United States	Describe three unique cases of patients describing incorrect administration techniques when using pen devices and the possible consequences of these errors	Case study (descriptive)/ Level 6	Failure to remove the inner needle cap before injection, dial the pen back down instead of pushing the plunger
A6 ⁽¹³⁾	2017 Ireland	To determine the knowledge and practice of district nurses regarding insulin	Descriptive study/ Level 6	Vial stored in the fridge for more than a month, lack of knowledge of the action of each type of insulin
A7 ⁽¹⁴⁾	2018 Italy	To estimate the prevalence of lipohypertrophy among patients treated with insulin, to identify its association with errors in the insulin injection and storage technique and the correlation between lipohypertrophy, risk of hypoglycemia and glycemic control	Qualitative study/ Level 6	Not checking for air bubbles and removing them if there were any, application of the drug through clothing, incorrect storage of the insulin vial in the fridge before application, vial stored in the fridge for longer than a month, not rotating

				the insulin injection site, not keeping the needle under the skin for at least five seconds after injecting insulin, reusing syringes and needles
A8 ⁽¹⁵⁾	2020 United States	Educate and inform healthcare professionals about the importance of providing adequate education about injectable antidiabetic agents and drawing attention to common medication errors related to diabetes care observed in outpatient practice	Case study (descriptive)/ Level 6	Not removing the inner needle cap before injection, not pressing the plunger to administer insulin, not rotating the insulin injection site
A9 ⁽¹⁶⁾	2021 Brazil	Assessing the quality and individual and collective safety of insulin use by the elderly population in a large municipality in southern Brazil	Cross-sectional study/ Level 2	Incorrect disposal of sharps, reuse of syringes and needles
A10 ⁽¹⁷⁾	2021 Australia	Analyze the interventions carried out by hospital pharmacists associated with the prescription of insulin to inpatients with diabetes	Qualitative study/ Level 6	Wrong dose
A11 ⁽¹⁸⁾	2022 Austria	To examine the views of patients with type 2 diabetes <i>mellitus</i> on their experiences with medication errors, overall satisfaction with treatment and their perceptions of how a medication error was dealt with in the daily routine of the hospital.	Qualitative study/ Level 6	Wrong dose
A12 ⁽¹⁹⁾	2022 Pakistan	To explore doctors' perceptions, experiences and expectations of medication errors when dealing with patients with type 2 diabetes mellitus	Qualitative study/ Level 6	Wrong dose

*Identification; **Level of evidence; ***Article.

Source: Prepared by the authors.

Characterization of the studies included in the final sample

Among the 12 articles included, it was noted that there were few publications on this topic between 2018 and 2020, as only two studies were included.⁽¹⁴⁻¹⁵⁾ Regarding the country in which these studies were carried out, the United States stood out, with the highest number of publications. In terms of levels of evidence, the majority were classified as level six, that is, descriptive or qualitative studies.

Errors regarding the storage/conservation of insulin

The errors relating to the storage of insulin vials include incorrect storage of the insulin vial in the fridge before application, that is, the insulin was stored at the top (near the freezer) or on the fridge door⁽¹⁴⁾ and storage of the vials in the fridge for more than a month.⁽¹³⁻¹⁴⁾

Errors in insulin preparation technique

Incorrect preparation technique has been cited in some studies, such as incorrect dosage, below or above the dose prescribed by the doctor,^(8-11,17-19) not checking for air bubbles and removing them if there were any⁽¹⁴⁾, incorrect insulin application, that is, confusion between the types of insulin (rapid-acting agents versus long-acting agents).⁽⁸⁾

In addition to the lack of knowledge about the action of each type of insulin, patients were unable to distinguish the time taken for the insulins used to take effect⁽¹³⁾ and the reuse of syringes and needles.^(14,16)

Errors in insulin application technique

Regarding the application of insulin, it was observed that the main errors were related to applying the drug through clothing,⁽¹⁴⁾ not removing the inner cap of the needle before injection,^(12,15) dialing the pen back down instead of pushing the plunger,⁽¹²⁾ not pressing the plunger to administer insulin⁽¹⁵⁾ and application in the incorrect route, that is, in intramuscular tissue.⁽⁹⁻¹⁰⁾

Also noteworthy regarding insulin application is the lack of care taken with the patient's skin, such as applying insulin to areas of altered skin (lipodystrophy), which interferes with insulin absorption, not rotating the insulin injection site⁽¹⁴⁻¹⁵⁾ and not keeping the needle under the skin for at least five seconds after injecting the insulin.⁽¹⁴⁾

Errors in the disposal of sharps

Regarding the disposal of sharps, only one article mentioned that people discarded them directly in the general garbage.⁽¹⁶⁾

DISCUSSION

Considering the importance of insulin therapy in the treatment of diabetes mellitus, the errors in the preparation and application technique of insulin found in this study are worrying, as they can cause health risks for people with diabetes. In fact, failures in the management of the disease occur due to a lack of knowledge of basic procedures, which contribute to the improvement of skills in the application of insulin, thus leading to uncontrolled blood sugar levels.⁽²⁰⁾

In fact, the practice of preparing and applying insulin is complex and requires knowledge on the part of health professionals and, especially, attention on the part of people with diabetes and their families/caregivers, as it requires care before and after application. Its stages consist of storage, transportation, drug application technique and disposal of sharps waste.⁽²¹⁾

The results of this review regarding the incorrect conservation and storage of insulin vials are worrying, as they are essential factors for the success of insulin therapy. Temperature fluctuations can alter the protein structure of this drug and subsequently compromise its effectiveness in treatment. In view of this, health professionals should advise insulin users and/or their caregivers on the correct conservation and storage of insulin vials.

Insulin (vial, refill or disposable pen) should be stored according to its use. If it is sealed, it should be refrigerated between 2°C and 8°C, with a shelf life of 2 to 3 years, depending on the manufacturer, from the date of manufacture. If the insulin is being used, it must be refrigerated between 2°C and 8°C or up to 30°C at room temperature, with a shelf life of 4 to 6 weeks after the date of opening and start of use, according to the manufacturer. It should be noted that application to the person must be at room temperature.⁽²²⁾

With regard to insulin storage, it should be noted that some places in the fridge are not suitable, such as the door, due to constant opening, or near the freezer, as this can cause the medication to freeze. Insulin should therefore be stored on the shelves from the middle downwards, next to or in the vegetable drawer, thus preserving its effect.⁽²³⁾

It should also be noted that incorrect aspiration of the insulin dose, under or over, was the most prevalent error in the insulin preparation stage in the studies surveyed, which can have a direct impact on the patient's glycemic control, with risks of the occurrence of hyperglycemia and hypoglycemia. According to the Institute for Safe Medication Practices⁽²⁴⁾, misinterpretation of syringe graduation scales, as well as prescription labels and abbreviations, are the main factors that cause errors in the administration of prescribed insulin doses.

The capacity of the syringe can vary according to the manufacturer: 30 and 50-gauge syringes, where each mark represents one unit; and 100-gauge syringes, graduated in two units. These changes in

syringe units, associated with reduced near visual acuity, are directly related to the occurrence of insulin dose preparation errors.⁽²⁵⁾

It is inferred that the occurrence of errors in the storage, preparation and application of insulin is, in most cases, due to a lack of guidance from health service professionals, since insulin users, as well as family members and caregivers, do not have adequate knowledge about safe practices in the use of this medication.

This highlights the importance of educational interventions, carried out mainly by nurses and pharmacists, on the correct use of insulin and adherence to treatment, with the aim of reducing errors and harm to patients and, consequently, providing a better quality of life.⁽²⁶⁾

Still regarding the insulin preparation stage, studies included in this review found that the reuse of syringes and needles for insulin application is recurrent among the sample studied, and is a practice not recommended by National Guidelines, such as the Brazilian Diabetes Society (BDS), since it can cause damage such as elimination of lubrication, loss of sharpness and changes in the bevel of the cannula, causing blockage of the flow in the needle, waste of insulin with the needle in the pen and breakage of the needle during injection.⁽³⁾

In clinical practice, it can be seen that the supplies needed to prepare and administer insulin are not regularly made available to users in Primary Health Care, implying, as an alternative to this shortage, the reuse of instruments (syringe/needle) by them. Authors⁽²⁷⁾ have found that patients with diabetes stop using insulin due to a lack of supplies and financial difficulties in paying for them. In this sense, it is important to emphasize the responsibility of the public authorities to provide qualified care to the needy population, so that everyone has equal access to the medicines and supplies needed to treat diabetes.

The errors found in the studies in this integrative review regarding the rotation of insulin application sites, with an emphasis on applying insulin in the same area, are worrying, as they can contribute to the appearance of skin lipodystrophy. This is considered to be an alteration in the subcutaneous tissue, the main manifestation of which is lipohypertrophy, with the accumulation of fat and the formation of hardened tissue in the places where insulin is most applied, with direct repercussions on the inadequate absorption of insulin and consequent impairment of the patient's blood sugar levels control, with the occurrence of hyperglycemia.

Studies have found an association between lipohypertrophy, the failure to rotate or the incorrect rotation of insulin application sites, as well as an association with the reuse of needles.⁽²⁸⁻²⁹⁾ In this scenario, the role of health professionals in the continuing education of insulin users stands out, aiming to guide them regarding the errors shown, through the individualization of care and encouraging their participation in the planning of actions to be taken.

A recent study carried out in PHC with 451 people with diabetes, with 23.9% of the sample using insulin, found that these people do not receive individualized treatment with dialogue and discussion to establish and achieve goals, and are not prepared for self-care of their health condition.⁽³⁰⁾

Therefore, health professionals must keep up to date and be trained to promote health education, individually or collectively, for insulin users, their guardians and/or caregivers, with the aim of ensuring safe treatment.

A limitation of the study is the time frame and the search strategies, since there may be other publications outside the stipulated period. However, based on the errors highlighted, this review has made it possible to reflect on the need to implement diabetes education for patients and those responsible for this practice, as a fundamental strategy to avoid errors in insulin therapy.

Based on the results obtained in this review, nurses can direct their care for people with diabetes taking insulin to reduce the occurrence of errors and promote a better quality of life through educational actions.

CONCLUSION

This analysis of errors in the preparation and application of insulin by people with diabetes and their guardians showed that these errors continue, especially aspiration of the wrong dose, less than or more than prescribed, and failure to rotate application sites. These errors go against safe practices for administering this drug and contribute significantly to the uncontrolled blood sugar levels of these people, which can lead to skin changes.

In this context, Nursing can contribute to the planning of educational actions aimed at this public, making decisions to qualify the care provided.

CONTRIBUTIONS

Conception or design of the study: Silva AKA, Lavor SF, Alencar AMPG; Data collection: Silva AKA, Lavor SF, Alencar AMPG; Analysis and interpretation of the data: Silva AKA, Lavor SF, Alencar AMPG; Writing of the article or critical review: Silva AKA, Lavor SF, Oliveira CJ, Cavalcante EGR; Gomes EB, Lisboa KWSC, Alencar AMPG.; Final approval of the version to be published: Silva AKA, Lavor SF, Oliveira CJ, Cavalcante EGR; Gomes EB, Lisboa KWSC, Alencar AMPG.

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Conflicts of interest: No
Submission: 2024/04/01
Revised: 2024/11/12
Accepted: 2024/11/21
Publication: 2025/03/24

Editor in Chief or Scientific: José Wicto Pereira Borges
Associate Editor: José Cláudio Garcia Lira Neto

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