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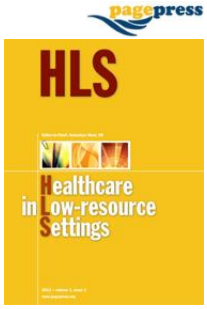


eISSN: 2281-7824
https://www.pagepressjournals.org/index.php/hls/index



Healthc Low-resour S 2024 [Online ahead of print]

*To cite this Article:*
Indah Rosdiana Narahaubun, Dian Handayani, Heri Kristianto. **Insulin injection rotation and Diabetes Mellitus nutritional management education.** *Healthc Low-resour S* doi: 10.4081/hls.2024.13065

**Review**

# Insulin injection rotation and Diabetes Mellitus nutritional management education

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**Running title:** Insulin injection rotation and diabetes mellitus

**Acknowledgment:** The authors extend their gratitude to all those who contributed to enhancing the quality of this scientific article.

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**Key words:** Diabetes Mellitus; education; injection rotation; insulin; nutritional management

**Contributions:** The content of the reviewed article is the sole responsibility of each author who

has made significant contributions. They have meticulously assessed its quality, participated in preparing the manuscript, and authorized its submission.

**Conflict of interests:** The authors declare no conflicts of interest

**Funding:** The authors receive support from the Department of Nursing, Faculty of Health Sciences, Universitas Brawijaya

**Clinical trials:** not applicable**.**

**Conference presentation:** Part of this article was presented at the 4th International Nursing and Health Sciences Symposium, from 27th-28th of October 2023, Universitas Brawijaya, Malang, East Java, Indonesia.

**Significance for public health:** The management of diabetes mellitus (DM) entails adopting a healthy lifestyle, utilizing anti-hyperglycemic medications, and administering insulin. Proper selection and rotation of injection sites are imperative to mitigate potential side effects. This research emphasizes the significance of nutritional education in enhancing overall health and averting complications in DM patients.

**Abstract**

The management of Diabetes Mellitus (DM) involves implementing a healthy lifestyle and pharmacological interventions through the administration of anti-hyperglycemia drugs. An essential aspect of treating DM patients is insulin administration, which facilitates glucose transportation into cells. This study evaluated the effectiveness of insulin injection rotation and nutritional management education for DM.

The literature search utilized the keywords "education,"AND "insulin injection," AND "nutritional management," AND "DM", ranged 2021-2023 Searches were conducted on various databases, including Proquest, NCBI, BMC, ScienceDirect, and other relevant platforms such as Google Scholar.

Ten journal articles pertinent to the subject matter were identified in the study. Findings indicate that nutritional education facilitates overall health improvement in individuals with DM, contributing to maintaining average body weight and near-normal blood glucose levels. It also enhances lipid profile and insulin receptor sensitivity while being a preventive measure against acute or chronic complications such as hyperglycemia. It is noted that selecting the appropriate injection site can significantly impact patients' blood glucose levels. While it is recommended to administer injections at consistent locations, repetitive use of the same site may pose risks of side effects, such as lipodystrophy.

After conducting a comprehensive review of ten journal articles, it has been concluded that insulin injection rotation and nutritional management education are effective for managing DM.

## Introduction

A total of 422 million Diabetes Mellitus (DM) patients were reported by the data obtained from the World Health Organization (WHO) and International Diabetes Federation (IDF) in 2019. Approximately 10.7 million patients are in the age range of 20-79 years, and the figure is estimated to increase by 11.8% in 2030 and 2045[1] due to the high incidence of the disease. According to the 2018 Riskesdas data, the prevalence of DM patients aged over 15 years remained at 2%, marking an increase compared to the figures from the 2013 Riskesdas.[2]

The management can be achieved by implementing a healthy lifestyle with pharmacological intervention and administration of anti-hyperglycemia drugs.[3-6] The management of type 2 DM restores blood glucose concentration, allowing patients to feel comfortable and healthy as well as preventing the onset of micro complications and macrovascularcomplications.[7-9] Individuals who have been diagnosed with diabetes often need to rely on insulin therapy to help move glucose from the blood into the body's cells. This essential process is critical in managing the condition and maintaining proper blood sugar levels.[10-12]

Selection of the right insulin injection site can affect the blood glucose levels of patients. Therefore, changing the injection point is important to prevent the risk of side effects. Lipodystrophy is a side effect of insulin resulting from fat tissue damage to form scars in the form of lumps under the skin. These lumps can interfere with insulin absorption and repetitive injection can cause other complications in the form of skin irritation.[13-15] A strong understanding of nutritional treatment can play a crucial role in helping to stabilize blood glucose levels and support overall health.[16-17]

Nutritional education improves the general health of DM patients, maintains normal body weight and near-normal blood glucose levels, improves lipid profiles and insulin receptor sensitivity, as well as prevents acute or chronic complications such as hyperglycemia.[17-19] Achieving success in DM management requires diligent adherence to the guidance provided by healthcare professionals, including physical exercise, pharmacological treatment, and dietary recommendations. Therefore, this research aimed to determine the effectiveness of insulin

injection rotation and nutritional management education for DM.

## Materials and Methods

### *Eligible Criteria*

The articles underwent a rigorous evaluation based on specific criteria and were managed using bibliographic software like Mendeley. The assessment was carried out meticulously through a systematic three-step review to determine their suitability for inclusion in the study. This comprehensive process involved the initial scrutiny of the title, abstract, and full text. The inclusion criteria encompassed articles published within the past three years (2021-2023), original qualitative and quantitative research, content relevant to the specified search terms, and availability as open access. The exclusion criteria included content irrelevant to the topics.

### *Search Strategy*

An extensive electronic search was conducted across five databases: Proquest, NCBI, BMC, ScienceDirect, and Google Scholar. The search period ranged from 2021 to 2023, focusing on specific keywords including "Education," AND "Insulin Injection," AND "Nutritional Management," AND "Diabetes Mellitus." Following the retrieval of articles, predefined inclusion criteria were applied to filter the results and identify relevant content for further analysis.

### *Article Selection Process*

The review article selection process employed the PRISMA method. A comprehensive search across Proquest, NCBI, BMC, ScienceDirect, and Google Scholar yielded 39,490 articles. Following filtering based on specified year criteria, the number was refined to 19,728. Subsequently, a thorough evaluation of the title and abstract and a scoping review identified 30 suitable articles. Finally, after the third stage of screening, 16 articles were selected (Figure 1).

Articles selected shown in Table 1.

## Results and Discussion

### *Optimizing the administration of insulin injections*

Insulin, a vital hormone, is pivotal in regulating the body's glucose levels. The degree of insulin sensitivity varies among individuals and is influenced by diverse lifestyle and dietary factors. Notably, approximately 40% of adults in the United States experience low insulin sensitivity, also known as insulin resistance, which elevates the risk of developing type 2 diabetes. Improving insulin sensitivity and diminishing insulin resistance can yield significant benefits for individuals with type 2 diabetes or those predisposed to the condition. Embracing positive lifestyle modifications, such as regular physical activity and a well-balanced diet, can substantially enhance insulin sensitivity and mitigate the risk of type 2 diabetes.[20]

The efficacy of diabetes therapy hinges on the accurate administration of insulin through proper injection techniques. Despite existing guidelines and evidence, it is imperative to identify barriers to this technique among patients and foster awareness among patients and healthcare professionals regarding the significance of refining insulin injection practices.[21]

Administration of insulin injections necessitates careful attention to optimizing patient care. A study by Zhang and Chen elucidated the specific requirements for this procedure. Compared to the control group, the cohort receiving consistent care and optimized insulin injection techniques demonstrated marked enhancements in health. These improvements included decreased blood glucose and HbA1c levels, fewer reported insulin-related complications and reduced pain scores. Additionally, the intervention group exhibited expedited training and achieved a higher success rate for initial subcutaneous injections. Moreover, the intervention group experienced a lower frequency of subcutaneous fat hyperplasia. Conversely, while not statistically significant, the control group displayed a higher incidence of hypoglycemia.[22] A study compared the effects of IT education on diabetes

management in two groups. Both groups had similar demographics and baseline IT behaviour. HbA1c reduction was similar in both groups in the intention-to-treat analysis but significant in the per-protocol analysis. Total daily dose (TDD) insulin changes were more important in the IT education group. Control patients showed "contamination" of IT education behaviours, decreasing HbA1c.[23] A new automatic insulin injection log device with an algorithm improved injection rotation in the abdominal area, potentially reducing lipo hypertrophy lesions and promoting better glucose control.[24]

The prevalence of lipohypertrophy among individuals with diabetes mellitus is notably high, linked to insufficient health education on proper injection techniques. Implementing a system of rotating injection sites has been shown to enhance glycemic control in both type 1 and type 2 diabetes mellitus subjects. Moreover, it has been observed that the level of education influences glucose control in type 1 diabetes mellitus subjects. However, further comprehensive research is necessary to extrapolate these findings and to establish definitive causal relationships between injection techniques and glycemic control.[25]

Proper insulin administration is paramount to avoiding serious complications. Healthcare providers must educate patients on appropriate techniques, insulin storage, injection sites, and potential complications to mitigate errors resulting from a lack of knowledge. Effective diabetes management relies on healthcare providers' assessment of patient understanding and utilization of engaging educational methods. Given time constraints, physicians require support in effectively educating and providing patient feedback. Notably, patients improved their injection technique during follow-up visits by addressing factors such as injection force and area size. Educational interventions to improve insulin injection techniques can potentially enhance glycemic control in individuals with diabetes mellitus. It is imperative to incorporate evidence-based recommendations and guidelines for insulin injection techniques and adopt technological and innovative solutions to advance this endeavour.[26-28]

***Improving Nutritional Management for Patients with Type 2 Diabetes Mellitus***

Type 2 diabetes is characterized by impaired glucose utilization and energy storage, leading to elevated blood sugar levels. Insulin resistance, a hallmark of this condition, impedes the entry of sugar into cells, while insufficient insulin production by the pancreas further contributes to the increased blood sugar levels.[29] Effectively managing type 2 diabetes necessitates lifestyle modifications, self-care practices, and medication to prevent complications associated with the eyes, kidneys, and nerves. Regular monitoring of blood sugar levels, as well as the regulation of blood pressure and cholesterol, are vital aspects of management. Adhering to a nutritious diet, engaging in physical activity, and adhering to prescribed medications are integral to diabetes management. Seeking guidance from a qualified dietitian is advantageous in formulating a personalized plan that aligns with individual needs and preferences.[8]

The preceding study elucidates the nutritional enhancements following a targeted dietary intervention.[30-35] A study focused on two individuals aged 39 and 67 with low body weights and BMIs. Their nutritional deficiencies were addressed through assessments, oral hygiene interventions, and diabetes-specific dietary education. Following the educational session, the patient's weight and BMI showed improvement.[30] Before the educational interventions, 70.5% of the patients had poor blood sugar levels, with 47.7% exhibiting moderate levels. Adherence to dietary recommendations notably impacted the blood sugar levels of individuals with type II diabetes.[31] The study involved 159 patients divided into three groups, resulting in varied outcomes. The intervention group significantly improved HbA1c levels, metabolic parameters, dietary intake, and physical activity.[34]

While healthcare providers recognized challenges in maintaining a healthy diet, patients demonstrated positive self-management indicators.[34-35] Healthcare providers hold diverse perspectives regarding patients' challenges in maintaining a healthy diet. Some patients demonstrate proactive self-management behaviours, such as consistently monitoring their blood glucose levels and displaying a strong interest in acquiring knowledge about dietary practices. Nevertheless, providers have indicated that they often lack the necessary time to

engage in extensive discussions about diet with their patients and would prefer to delegate dietary education to other individuals.[36]

Managing diabetes well involves learning about it, planning meals, staying active, taking medication as prescribed, and checking blood sugar levels regularly. Modalities encompass insulin therapy, oral medications, complementary and alternative medicine, surgical interventions, and lifestyle modifications. The rotation of insulin injections and nutritional knowledge significantly impact diabetes management and overall understanding. Healthcare professionals employ counselling techniques and provide educational resources to enhance treatment outcomes.

## Conclusions

In conclusion, the effective management of diabetes mellitus (DM) can be enhanced by implementing five key pillars: education, meal planning, physical exercise, pharmacological intervention, and blood sugar monitoring. Treatment options comprise insulin therapy, oral medications, exploration of alternative therapies, surgical interventions, and lifestyle improvements such as dietary modifications and regular exercise. The proficient rotation of insulin injections and provision of nutritional education significantly impact patients' blood glucose control and knowledge levels. Healthcare professionals deliver education through counselling and the distribution of educational materials, including booklets, leaflets, and modules, to augment treatment success.

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**Table 1. Selected articles**

| Author, Year | Title | Design | Objectives | Result |
|---|---|---|---|---|
| Zhang et al. (2022) | Evaluation of Clinical Efficacy of Continuous Care with Improved Insulin Injection Techniques on DM Patients: A Randomized Controlled Trial | • Randomized Controlled Trial<br>• The control group received regular nursing care<br>• The observation group received specialized insulin injection education and care. | To examine the clinical impact of consistent care involving enhanced insulin administration methods on patients with diabetes mellitus. | • 96 diabetic patients (48 per group) participated in the study<br>• The group receiving continuous care and optimized insulin injection techniques showed significant improvements in health, including reduced blood glucose levels and HbA1c, and reported fewer insulin-related issues and lower pain scores compared to the control group |
| Liang et al. (2021) | Study on the effect of education for insulin injection in diabetic patients with new simulation tools | • Quasi-Experimental<br>• 120 diabetes mellitus patients who required insulin therapy but had not been trained in insulin injection before<br>• Intervention group (60 patients) and a control group (60 patients)<br>• The control group was trained using traditional methods<br>• The intervention group was trained using an improved simulation tool | To examine the impact of standard training on the self-administration of insulin among diabetic patients. | • The intervention group had a shorter training time and a higher success rate for the first subcutaneous injection<br>• Higher scores for injection skills and pre-discharge scores in the intervention group<br>• Lower incidence of subcutaneous fat hyperplasia in the intervention group<br>• The control group had a higher incidence of hypoglycemia, but the difference was not statistically signifi |
| Chen et al. (2021) | Injection Technique Education in Patients with Diabetes Injecting Insulin into Areas of Lipohypertrophy : A Randomized Controlled Trial | • Randomized Controlled Trial<br>• The intervention (IT-education group) received comprehensive IT education, with a strong emphasis on injection techniques and insulin | To evaluate the effects of offering intensive education on injection techniques (IT) to patients who regularly inject insulin into areas affected by lipo hypertrophy (LH). | • A study compared the effects of IT education on diabetes management in two groups.<br>• Both groups had similar demographics and baseline IT behaviour.<br>• HbA1c reduction was similar in both groups in the intention-to-treat analysis but significant in the per-protocol analysis.<br>• Total daily dose (TDD) insulin changes were more significant in the IT education group<br>• Some control patients showed "contamination" of IT education behaviours, decreasing HbA1c. |

| Author, Year | Title | Design | Objectives | Result |
|---|---|---|---|---|
| | | dose management, ensuring thorough patient care.<br>• The control group received their usual care. | | |
| Louzolo-Kimbembe et al. (2021) | Insulin Injection A Non-Trivial Act with Sometimes Serious Consequences: Major Role of Therapeutic Education | Case Report, 2 cases | To report case involving infectious cellulitis of the abdominal wall and necrotizing fasciitis of the thigh after an insulin injection | • Negligent insulin administration can have serious consequences, and documented errors have led to complications.<br>• Proper injection techniques and education on insulin storage, injection sites, and complications are essential to prevent skin complications and infectious complications.<br>• Patients often lack knowledge of proper insulin injection procedures, leading to errors such as injecting in the same site, reusing needles, and not mixing cloudy insulins.<br>• Healthcare providers must continuously assess patients' understanding of insulin administration and use techniques like the teach-back method to confirm comprehension.<br>• Active patient engagement in insulin therapy education and ongoing support from healthcare providers can help prevent complications and ensure successful diabetes management. |
| Adhi et al. (2023) | Effectiveness of Rotation Scheme for Insulin Injection on Blood Sugar Control of Diabetes Mellitus Patients in the Polyclinic of North Lombok District Hospital | • Pre-experimental design with a static-group comparison<br>• 52 participants were selected (26 in the intervention group, 26 in the control group) using accidental sampling | To assess the efficacy of insulin injection rotation scheme for managing blood sugar levels among Diabetes Mellitus (DM) patients | • Most participants in both groups were aged between 46 and 55.<br>• The intervention group consisted of well-educated individuals, while the control group had more participants with no formal education and mostly unemployed.<br>• Both groups had a substantial history of insulin use, with all participants having used insulin for at least two years.<br>• The control group showed an average decrease of 36 mg/dl in blood sugar levels with a rotation scheme of 128 mg/dl.<br>• The research findings revealed a p-value of 0.003 ($p < 0.05$), indicating that the rotation scheme for insulin injection effectively controlled blood sugar levels. |
| Lukman et al. (2023) | Implementation Of Nutrition Management In Nursing Care For Type II Diabetes Mellitus With Nutrition Deficit Nursing Problems | • Case Study of nursing care for Type II Diabetes Mellitus patients focused on nutritional management | To conduct a comparative analysis of nursing care approaches for patients with type II diabetes mellitus, focusing on nutritional management and the issue of nutritional deficit as primary interventions | • The study evaluated two patients, aged 39 and 67 years, with body weights of 47 kg and 48 kg and BMIs of 18.3 and 18.7, respectively.<br>• Nutritional deficiencies were addressed through nutritional status evaluation, oral hygiene interventions, and education on a diabetes-specific diet.<br>• Patients experienced an improvement in body weight and BMI as a result of the intervention. |

| Author, Year | Title | Design | Objectives | Result |
|---|---|---|---|---|
| Pangaribuan & Wahyu, (2023) | The Effect Of Diet Compliance Education On Blood Sugar Levels In Type Ii Diabetes Mellitus Patients In The 7th Floor Inpatient Care, Murni Teguh Hospital, Medan | • Quasi-Experimental design with a single-group pre-post test. | To assess the impact of dietary education on blood glucose levels in individuals with Type II Diabetes Mellitus. | • 70.5% of patients had poor blood sugar levels before the educational session.<br>• 47.7% showed improvement after the session, indicating a shift to moderate levels.<br>• A significant association between dietary adherence and blood sugar levels in type II DM patients, supported by a p-value of 0.001, demonstrating an educational impact. |
| Sitorus et al. (2023) | Knowledge and Compliance of Type 2 Diabetes Mellitus Patients with Diabetic Nutrition Management. | Descriptive Analysis | To assess knowledge and adherence to nutritional management among type 2 diabetes mellitus patients. | • 75.91% demonstrated good knowledge of diabetic nutrition management<br>• 81.48% exhibited compliance with diabetic nutrition management |
| Momongan et al. (2021) | Diet Education With Booklet Media In Improving Diet Compliance And Blood Sugar Levels In Type II DM Patients | • Pre-Experimental design with one group pre-test-post-test approach. | To assess the impact of diet education using booklet media on adherence to dietary guidelines and blood glucose levels in patients with type II diabetes mellitus | • Significant differences in adherence to dietary guidelines and blood glucose levels were observed before and after the implementation of diet education.<br>• The statistical analysis using the Paired t-test demonstrated a significance level 0.000 ($p < 0.05$). |
| Isaksson et al. (2021) | Effects of nutrition education using a food-based approach, carbohydrate counting or routine care in type 1 diabetes: 12 months prospective randomized trial. | • Randomized controlled study<br>• 3 parallel: food-based approach (FBA), carbohydrate counting (CC), and routine care (RC)<br>• Primary endpoint: variance in glycated hemoglobin A1c (HbA1c) over 12 months | To evaluate the effects of different nutritional education initiatives on glycemic control, cardiovascular risk markers, quality of life, dietary habits, and food preferences among people with type 1 diabetes. | The study included 159 patients with varying distribution in three groups<br>• After three months, FBA and CC groups improved HbA1c compared to the RC group<br>• No significant differences in HbA1c at 12 months between FBA and RC, CC and RC, and FBA and CC<br>• At 12 months, FBA showed better intake of legumes, nuts, and vegetables than CC and RC<br>• FBA reported a higher intake of certain fats and dietary fibre than RC and CC No significant differences were observed in blood pressure levels, lipids, body weight, or quality of life |
| Hashim et al. (2021) | Effectiveness of simplified diabetes nutrition education on glycemic control and other diabetes-related outcomes in patients with type 2 diabetes mellitus | • Randomized controlled trial.<br>• The intervention group received weekly diabetes nutrition modules and usual care<br>• The control group | To assess the impact of Simplified Diabetes Nutrition Education (SDNE) on glycemic control and other diabetes-related outcomes in individuals with type 2 diabetes mellitus (T2DM). | • After 22 weeks, the intervention group showed significant improvement in HbA1c levels (-1.7%) compared to the control group (+0.01%) ($p < 0.001$).<br>• The intervention group significantly improved metabolic parameters more than the control group ($p < 0.05$).<br>• Significant enhancement in dietary intake and physical activity levels was observed in the intervention group compared to the control group ($p < 0.05$).<br>• Health beliefs, diabetes knowledge, and health literacy experienced significant |

| Author, Year | Title | Design | Objectives | Result |
|---|---|---|---|---|
| | | received only usual care.<br>• HbA1c and diabetes-related outcomes were rigorously measured at baseline, 12 weeks, and 22 weeks, demonstrating the rigour of our study. | | enhancements in the intervention group compared to the control group ($p < 0.05$). |
| Bross et al. (2022) | Barriers to Healthy Eating and Diabetes Diet Education: Divergent Perspectives of Patients and Their Providers | • A survey of diet self-management | To examine perceived barriers to diet self-management among low-income minority patients with type 2 diabetes and their health care providers within a single ecosystem, to test whether providers understood patient barriers | • Providers have divergent perceptions of patients' barriers to healthy eating<br>• Patients show positive indicators for self-management, such as regular blood glucose monitoring and interest in diet education<br>• Providers cited a lack of time for diet discussions and preferred others to handle teaching |
| Mehrabbeik et al. (2022) | Investigation of Association Between Insulin Injection Technique and Blood Glucose Control in Patients with Type 2 Diabetes | • A survey of insulin injection technique | To explain the correlation between proper insulin use with glycemic control in type 2 diabetes patients. | • Injective pain, needle reuse, and improper injection site rotation were common issues.<br>• Participants with lower injection scores had higher fasting blood sugar and HbA1c levels.<br>• A strong negative correlation between insulin injection scores and glycemic control markers. |
| Abujbara et al. (2022) | Effect of Insulin Injection Techniques on Glycemic Control Among Patients with Diabetes | • A survey of insulin injection practices | To evaluate insulin injection practices among diabetes patients and their impact on glycemic control.<br>. | • Rotation of insulin injection sites, absence of lipohypertrophy, and a total daily insulin dose of ≤50 units were associated with improved glycemic control.<br>• Proper insulin injection techniques are essential for managing diabetes and improving glycemic control |
| Bari et al. (2023) | Addressing Insulin Injection Technique: A Follow-up Study of Canadian Patients with Diabetes | •A survey on patients with diabetes who used insulin pens and pen needles; and physicians without support from diabetes educators | To assess the current insulin injection technique employed by patients and investigate the impact of feedback and education on enhancing their proficiency. | • Physicians need help educating and providing patient feedback due to limited time and resources.<br>• Patients improved their injection technique during follow-up visits, addressing factors such as injection force, needle retention time, needle reuse, injection area size, and injection angle.<br>• Common initial errors included selecting a smaller injection area than recommended and not paying attention to injection force.<br>• On their second visit, patients, on average, reduced one error in their injection technique. |

| Author, Year | Title | Design | Objectives | Result |
|---|---|---|---|---|
| Klarskov et al. (2021) | A New Medical Device for Improved Rotation of Insulin Injections in Type 1 Diabetes Mellitus: A Proof-of-Concept Study | • 12-week trial testing a new device for rotating insulin injections<br>• 1-week baseline data collection followed by 12 weeks of device-guided insulin rotation | To evaluate the effectiveness of the medical device in reducing the frequency of insulin injections within the same subcutaneous area compared to standard insulin injection techniques without assistance. | • A new automatic insulin injection log device with an algorithm improved most users' injection rotation in the abdominal area.<br>• The device showed potential in reducing lipo hypertrophy lesions and promoting better glucose control through enhanced rotation.<br>• Although no significant changes in HbA1c levels or hypoglycemic incidents were noted, the device helped reduce glycemic variability for better diabetes management.<br>• The device is designed to streamline insulin injections, especially for newly diagnosed T1DM or type 2 diabetes patients. |

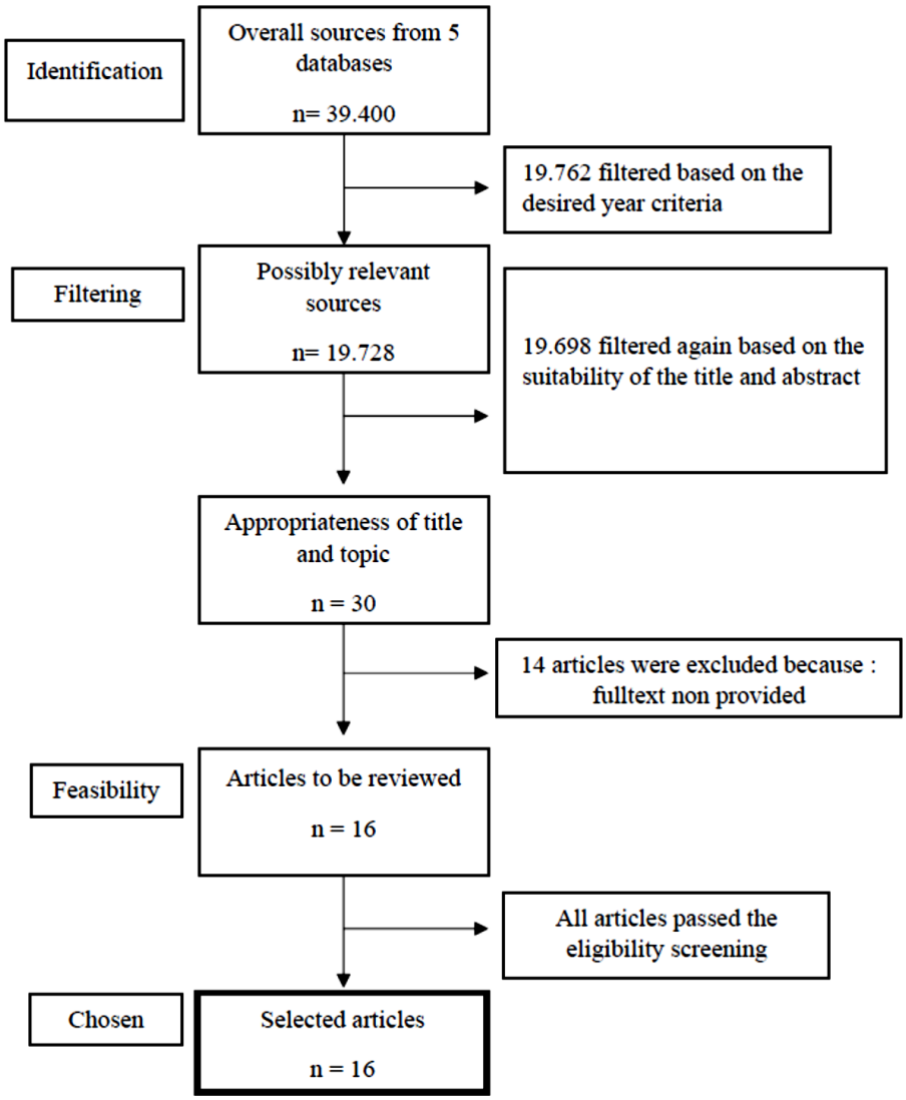


**Figure 1. Article selection process**