

Insulin Medication Trends in Diabetes Management: A Comprehensive USDDS Database Analysis

Abstract

Background

Insulin medication trends in diabetes management have evolved significantly over the past two decades, influenced by demographic factors and advancements in treatment. Analyzing these trends from 2000 to 2022 helps identify disparities and informs strategies for optimizing diabetes care across diverse populations.

Method

This retrospective, observational study analyzed United States Diabetes Data System (USDDS) data from 2000 to 2022. Adult diabetic patients were categorized by age, gender, race, and education. Insulin-only usage percentages were calculated annually, with statistical analyses conducted to identify trends and disparities across demographics. Data confidentiality was maintained, using de-identified information to ensure compliance with ethical standards.

Results

The analysis of insulin medication trends from 2000 to 2022 reveals significant changes in diabetes management. The analysis shows that the proportion of patients using pills only increased from 45.6% in 2000 to a peak of 52.7% in 2011, then slightly decreased to 49.5% in 2022. The proportion of patients using both insulin and pills increased from 11.2% in 2000, reached a peak of 16.8% in 2019, and then stabilized at 16.3% in 2022. Insulin-only usage

decreased from 25.6% to around 17-18%, indicating a shift towards combination therapies. Age-specific trends show a decline in insulin-only use among older adults and variability among younger adults. Gender-specific trends reveal an initial decline in insulin-only use, with males generally showing higher percentages in later years. Race and education-specific trends indicate varying patterns, with higher insulin-only usage among Non-Hispanic Whites and those with higher education. These trends highlight evolving diabetes management practices influenced by advancements and socio-economic factors.

Conclusion

The 22-year analysis of insulin medication trends highlights a shift towards increased use of oral medications and combination therapies in diabetes management. Significant variations in insulin-only usage were observed across different demographics, including age, gender, race, and education level, reflecting evolving clinical practices, advancements in treatment options, and socio-economic influences on diabetes care.

Keywords: insulin medication trends, diabetes management, USDDS database, demographic variations, health disparities

Introduction

Diabetes mellitus, a persistent metabolic condition marked by elevated blood glucose levels, poses a substantial global public health challenge. Managing diabetes effectively requires a comprehensive strategy encompassing lifestyle adjustments, routine blood glucose checks, and pharmacological treatment. Insulin stands as a cornerstone in managing both type 1 and type 2

diabetes among pharmacotherapeutic options. Since its inception in the early 20th century, insulin therapy has undergone significant evolution, with improvements in formulations and delivery techniques aimed at boosting effectiveness, safety, and patient compliance.[1-3].

Globally, diabetes represents a significant and escalating public health issue, with its prevalence continually rising due to factors such as urbanization, lifestyle changes, and an aging

population. Worldwide, millions are affected by diabetes, with type 2 diabetes constituting approximately 90-95% of all cases. The prevalence of diabetes has been increasing due to factors such as increased life expectancy, urbanization, and lifestyle changes that contribute to higher rates of obesity and sedentary behavior. In the United States, diabetes is a major health issue. The Centers for Disease Control and Prevention (CDC) estimate that over 34 million Americans have diabetes, and nearly 88 million adults have prediabetes. This growing epidemic imposes substantial economic and healthcare burdens, necessitating effective management strategies to mitigate its impact on individuals and society [4-5].

The global burden of diabetes is reflected in statistics from the International Diabetes Federation (IDF) Diabetes Atlas (2021), which reports that 10.5% of the adult population (ages 20-79) has diabetes, with nearly half unaware of their condition. Projections from the IDF suggest that by 2045, the number of adults with diabetes will rise significantly, underscoring the urgent need for comprehensive public health strategies and effective diabetes management programs [6].

The pathophysiology of diabetes involves a disruption in insulin production or utilization, leading to chronic hyperglycemia. Insulin therapy is central to managing diabetes, as it helps regulate blood glucose levels by compensating for the body's impaired insulin production or action. Understanding these elements highlights the importance of our study in assessing

medication trends and their impact on diabetes care. Diabetes involves complex interactions between genetic predisposition, environmental factors, and lifestyle choices. Type 1 diabetes is an autoimmune condition wherein the body's immune system attacks and destroys insulin-producing beta cells in the pancreas, leading to absolute insulin deficiency. In contrast, type 2 diabetes is characterized by insulin resistance and a progressive decline in beta-cell function. Insulin resistance impairs insulin's ability to facilitate glucose uptake in peripheral tissues, resulting in hyperglycemia. Over time, the pancreas fails to produce sufficient insulin to overcome this resistance, necessitating pharmacological intervention. Insulin therapy for both type 1 and type 2 diabetes aims to restore normoglycemia and prevent complications such as cardiovascular disease, neuropathy, nephropathy, and retinopathy [7-9].

The United States Diabetes Data System (USDDS) serves as a crucial resource for data for our study, providing comprehensive data on diabetes management trends and aligning with our data source. This extensive database allows for in-depth analysis of medication usage patterns and treatment outcomes. It also provides insights into prescribing patterns, patient demographics, treatment outcomes, and emerging trends in diabetes care. This data is invaluable for healthcare providers, researchers, and policymakers striving to understand and improve diabetes management strategies [10].

The objective of this study is to analyze and elucidate trends in insulin medication use among diabetes patients in the United States by leveraging data from the USDDS. This analysis aims to identify patterns in insulin prescribing practices, assess the impact of different insulin formulations and delivery methods on patient outcomes, and explore disparities in insulin therapy across various demographic groups. By examining these trends, the study seeks to

provide a comprehensive understanding of how insulin therapy is evolving in clinical practice, thereby informing healthcare providers, researchers, and policymakers.

Method

Study design

This study adopted a retrospective, observational design, utilizing data from the USDDS to investigate trends in insulin-only medication usage over a 22-year period, from 2000 to 2022.

This design facilitated an in-depth analysis of the influence of demographic factors such as age, gender, race, and education level on the prevalence of insulin-only therapy among diabetic patients. By examining longitudinal data, the study aimed to identify patterns and disparities in diabetes management practices.

Study population and inclusion criteria

The study population comprised adult patients diagnosed with diabetes, sourced from the USDDS database. To ensure the accuracy and relevance of the analysis, the following inclusion criteria were applied: adult patients (aged 18 and above) with a confirmed diagnosis of diabetes, and patients who used insulin-only therapy during the study period. Patients with suppressed or incomplete records or missing demographic information were excluded from the study to maintain the dataset's integrity and consistency. These comprehensive inclusion criteria ensured the study captured a broad and diverse sample of the diabetic population in the United States.

Study variables

The primary outcome variable for this study was the percentage of patients using insulin-only therapy each year. Several key demographic variables were analyzed to understand their impact

on insulin usage trends: age, gender, race, and education level. Age was categorized into four groups (18-44, 45-64, 65-74, and 75+ years) to assess variations in insulin usage across different life stages. Gender-specific trends were identified by conducting separate analyses for male and female patients. Racial differences in insulin usage were examined among Hispanic, Non-Hispanic White, and Non-Hispanic Black patients. Education level was considered by grouping patients based on their highest level of educational attainment to explore its influence on diabetes management practices.

Data extraction and analysis

Data were meticulously extracted from the USDDS database and categorized according to the defined demographic variables. The extraction process involved filtering the dataset to include only those records meeting the inclusion criteria and containing complete demographic information. Data analyses were conducted to identify trends and patterns in insulin-only usage across different demographic groups. Descriptive statistics, including percentages and confidence intervals (95% lower limit [LL] and 95% upper limit [UL]), were calculated to provide a clear and precise representation of the data. Temporal trends were assessed by examining annual changes in insulin-only usage rates within each demographic category.

Ethical considerations

This study utilized publicly available data from the USDDS database, ensuring compliance with ethical standards and privacy regulations. The use of de-identified data meant that no personally identifiable information was accessed or analyzed, maintaining patient confidentiality and data security throughout the study. The retrospective nature of the study further minimized ethical concerns as it relied on existing data without any direct patient interaction or intervention.

Results

Trends in use of diabetes medication

The analysis of insulin medication trends from the USDDS database from 2000 to 2022 reveals significant changes in diabetes management strategies among different demographics. In 2000, 45.6% of patients used pills only, peaking at 52.7% in 2011, and settling at 49.5% in 2022.

Patients using insulin only decreased from 25.6% in 2000 to 14.9% in 2016, with a slight rise to 17.8% in 2022. Those using both insulin and pills started at 11.2% in 2000, peaked at 16.8% in 2019, and remained stable at 16.3% in 2022. Patients not on any medication were 17.6% in 2000, fluctuating and stabilizing at 16.5% in 2022. Table 1 presents these trends, including 95% confidence limits (LL and UL) for each category.

Table 1: Trends in use of diabetes medication

Year	Pills Only			Insulin Only			Both Insulin & Pills			No Medication		
	Percentage	95% LL	95% UL	Percentage	95% LL	95% UL	Percentage	95% LL	95% UL	Percentage	95% LL	95% UL
2000	45.6	42.3	49	25.6	22.2	29.4	11.2	9.3	13.6	17.6	14.5	21.1
2001	49.9	46.6	53.2	19.7	17	22.7	10.4	8.6	12.5	20	17.5	22.7
2002	49.5	46	53	17.1	14.4	20.2	12.9	10.7	15.6	20.4	17.4	23.8
2003	48.6	44.7	52.4	21.6	18.4	25.3	11.6	9.7	13.8	18.2	15.3	21.5
2004	49.9	46.4	53.3	17.8	15.1	20.9	11.8	9.9	14.1	20.5	17.4	24.1
2005	49.7	46.4	52.9	17.7	14.7	21.2	12.9	10.7	15.5	19.7	17.3	22.5
2006	49.9	46.3	53.5	15.3	12.6	18.5	11.7	9.6	14.3	23.1	19.9	26.7
2007	51.3	47.4	55.2	15	11.8	18.8	11.2	8.9	14	22.5	18	27.8

2008	45.9	41.7	50.2	16	12.8	19.7	13.6	10.9	16.9	24.5	20.5	29
2009	49.5	45.6	53.4	15.7	13	18.9	11.9	9.8	14.4	22.9	19.4	26.8
2010	48.1	44.7	51.6	17.9	15.1	21	13.7	11.3	16.5	20.3	17.3	23.5
2011	52.7	49.5	55.8	17.7	15.3	20.4	12.1	10.3	14.2	17.5	15	20.4
2012	50.5	47.1	53.8	15.6	13	18.7	15.9	13.7	18.4	18	15.3	21
2013	45.8	42.6	49	19.4	16.3	22.9	14.2	12.2	16.5	20.6	17.6	24
2014	50.1	46.6	53.5	17.9	15.3	20.8	14.3	12.1	16.7	17.8	14.9	21
2015	50.6	47	54.3	17.2	14.3	20.6	15.1	12.4	18.3	17	14.3	20.2
2016	51.7	47.4	55.9	14.9	12.4	17.7	14.4	12.1	17.2	19	16.2	22.2
2017	47.6	44.2	51	16.7	13.9	20.1	15.2	12.7	18.1	20.5	17.2	24.2
2018	42.4	38.9	46	18.6	15.4	22.2	15.1	12.8	17.8	23.9	20.7	27.3
2019	48.1	44.4	51.8	18.9	15.9	22.4	16.8	14.1	19.8	16.3	13.5	19.4
2020	46.6	42.6	50.6	16	13.1	19.4	16.7	14.2	19.6	20.6	16.5	25.4
2021	47.8	44.2	51.4	17.9	14.9	21.3	16.5	13.8	19.5	17.9	14.8	21.4
2022	49.5	45.4	53.7	17.8	14.6	21.4	16.3	13.6	19.3	16.5	13.4	20.1

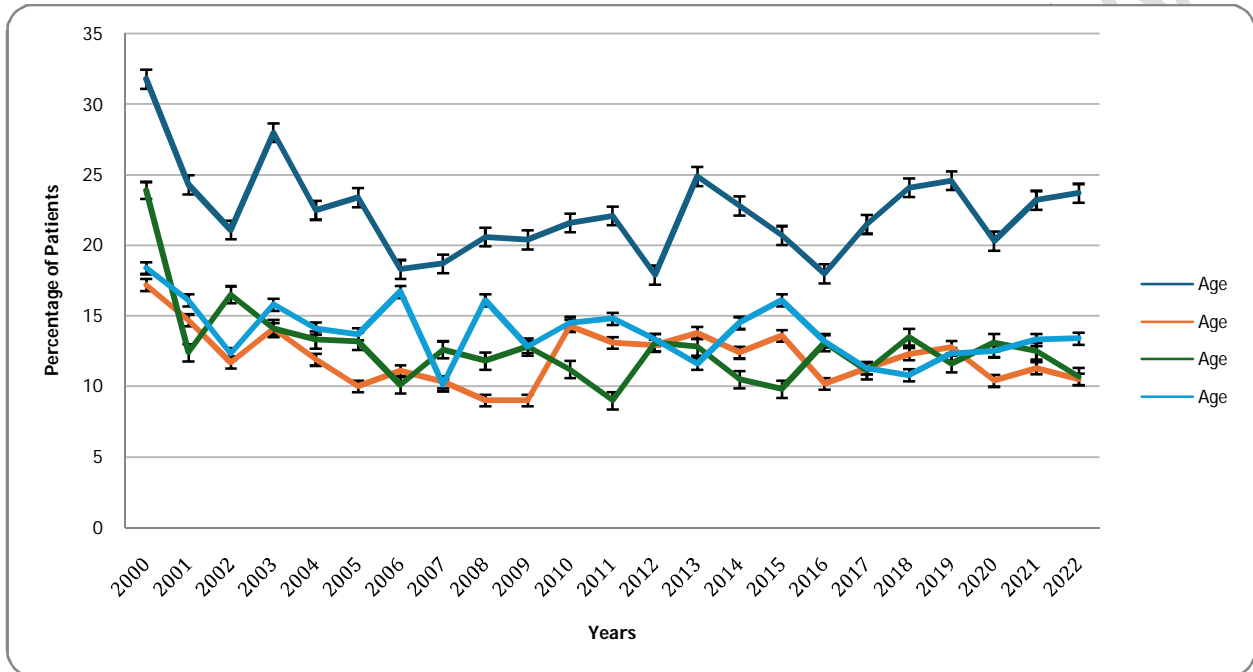
Age-specific trends: Insulin only usage

The insulin-only usage among patients aged 18-44 began at 31.8% in 2000, showing notable fluctuations over the years. It decreased significantly to 18.3% in 2006, briefly rose to 24.9% in 2013, and settled at 23.7% by 2022. This group exhibited considerable variability, reflecting evolving treatment practices or preferences among younger adults. In the 45-64 age group, insulin-only usage declined from 17.2% in 2000 to a low of 9.0% in 2008, with a slight increase to 14.3% in 2010, followed by fluctuations stabilizing around 10-13% in subsequent years. By 2022, 10.5% of patients in this age group were using insulin only, suggesting a trend towards combination therapies or newer oral medications (Figure 1).

Patients aged 65-74 showed a decline in insulin-only usage from 23.9% in 2000 to 10.1% in 2006. This percentage fluctuated, peaking at 16.5% in 2002 and dropping to 9.0% in 2011. By 2022, 10.7% were using insulin only, indicating a steady decline from the early 2000s possibly due to improved management strategies and increased use of oral hypoglycemics. In the 75+ age group, insulin-only usage was 18.4% in 2000, showing fluctuations with a peak of 18.4% in

2000, a drop to 10.1% in 2007, and a rise to 16.7% in 2006. From 2010 onwards, usage stabilized around 13-16%, ending at 13.4% in 2022 (Figure 1). This stability suggests consistent management practices among older adults with longstanding diabetes.

Figure 1: Diabetes medication pattern based on age groups

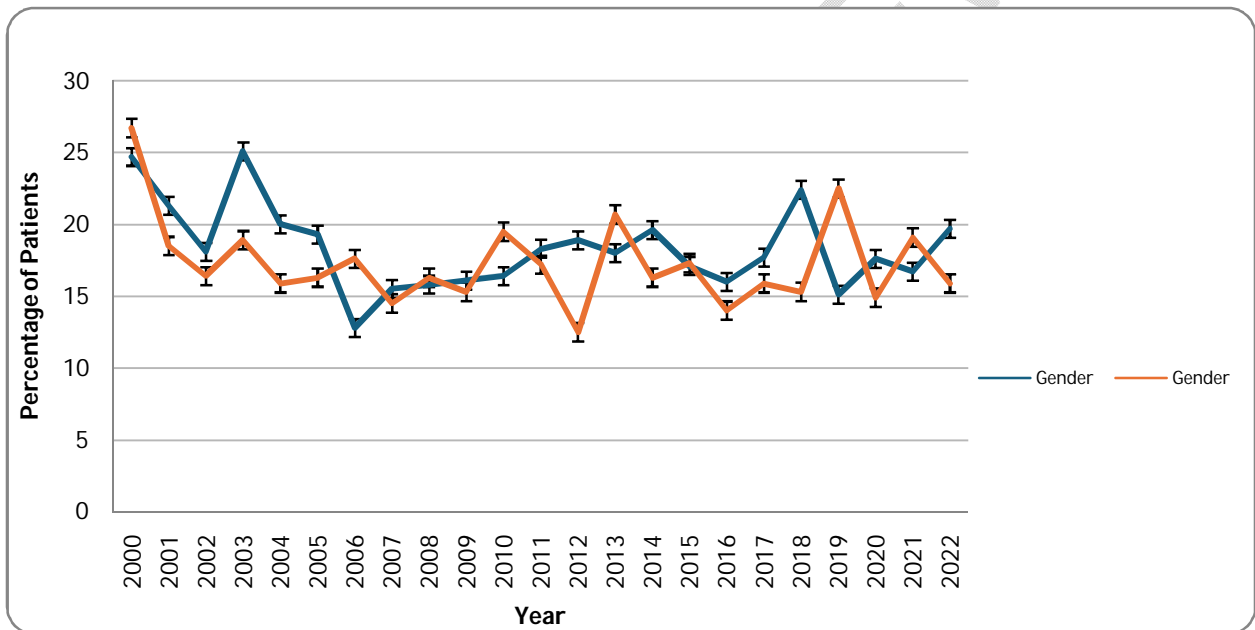


Gender-specific trends: Insulin only usage

In 2000, 24.7% of male patients used insulin only. This figure declined noticeably to 12.8% by 2006, followed by slight fluctuations over the years. The percentage peaked at 22.4% in 2018 and settled at 19.7% in 2022 (Figure 2). This overall trend reveals a general decrease in the early years, with intermittent rises in subsequent years, likely reflecting changes in treatment preferences or updates in clinical guidelines.

For female patients, insulin-only usage began at 26.7% in 2000, dropping significantly to 15.9% by 2004. After fluctuating for a few years, it reached a low of 12.5% in 2012. The percentage then increased, peaking at 22.5% in 2019, and stabilized at 15.9% in 2022. Similar to the male trend, females showed an initial decline, followed by variability and periods of increase in recent years (Figure 2). Overall, both genders exhibit an initial decline in insulin-only usage, followed by fluctuating patterns that reflect evolving treatment strategies and clinical practices.

Figure 2: Diabetes medication pattern based on gender groups



Race-specific trends: Insulin only usage

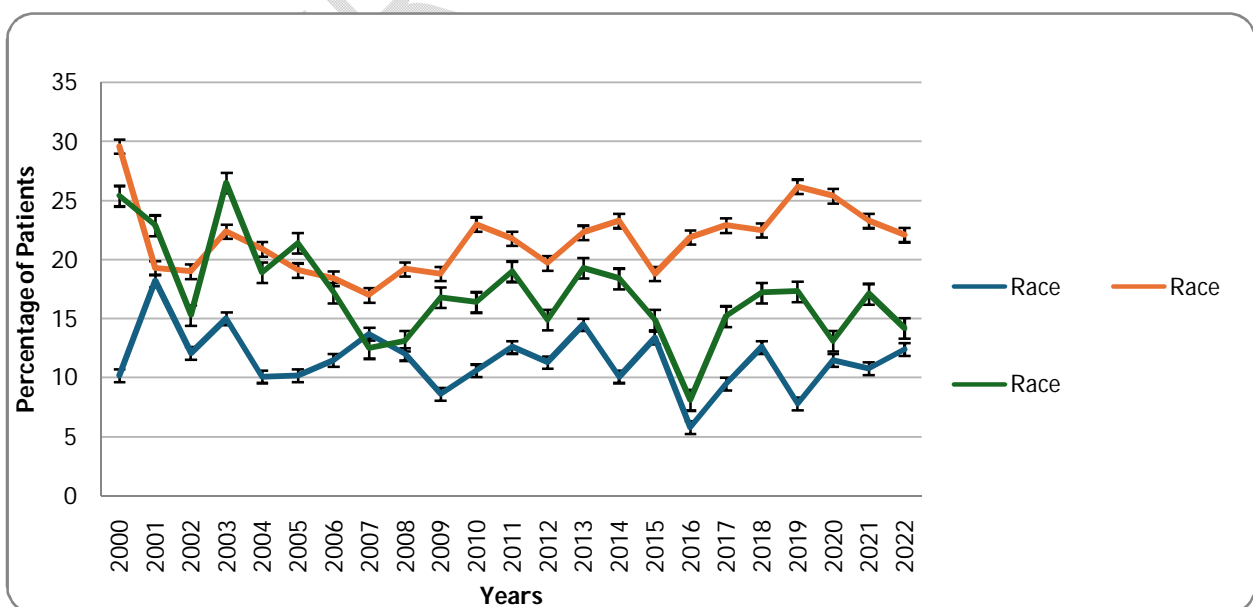
For Hispanic patients, insulin-only usage started at 10.2% in 2000. This percentage fluctuated, peaking at 18.2% in 2001. Over the subsequent years, the percentage generally trended downward, hitting a notable low of 5.8% in 2016. However, there were intermittent rises, such as 14.5% in 2013 and 12.6% in 2018. By 2022, the percentage of Hispanic patients using insulin

only was 12.4%. Overall, the trend for Hispanic patients indicates variability with occasional peaks and a general decline in the early years (Figure 3).

Among Non-Hispanic White patients, the percentage using insulin only began at 29.6% in 2000. This percentage decreased to a low of 17.0% in 2007 but saw intermittent increases in later years, peaking at 26.2% in 2019. By 2022, 22.1% of Non-Hispanic White patients were on insulin-only therapy. The trend for Non-Hispanic White patients shows an initial decline followed by variability and intermittent increases in the later years (Figure 3).

For Non-Hispanic Black patients, 25.4% were using insulin only in 2000. This percentage decreased to 12.5% in 2007, followed by fluctuations with peaks such as 26.5% in 2003 and 19.3% in 2013. By 2022, 14.2% of Non-Hispanic Black patients were using insulin only. The trend for Non-Hispanic Black patients indicates an initial decline followed by fluctuations and periods of increase (Figure 3).

Figure 3: Diabetes medication pattern based on racial groups



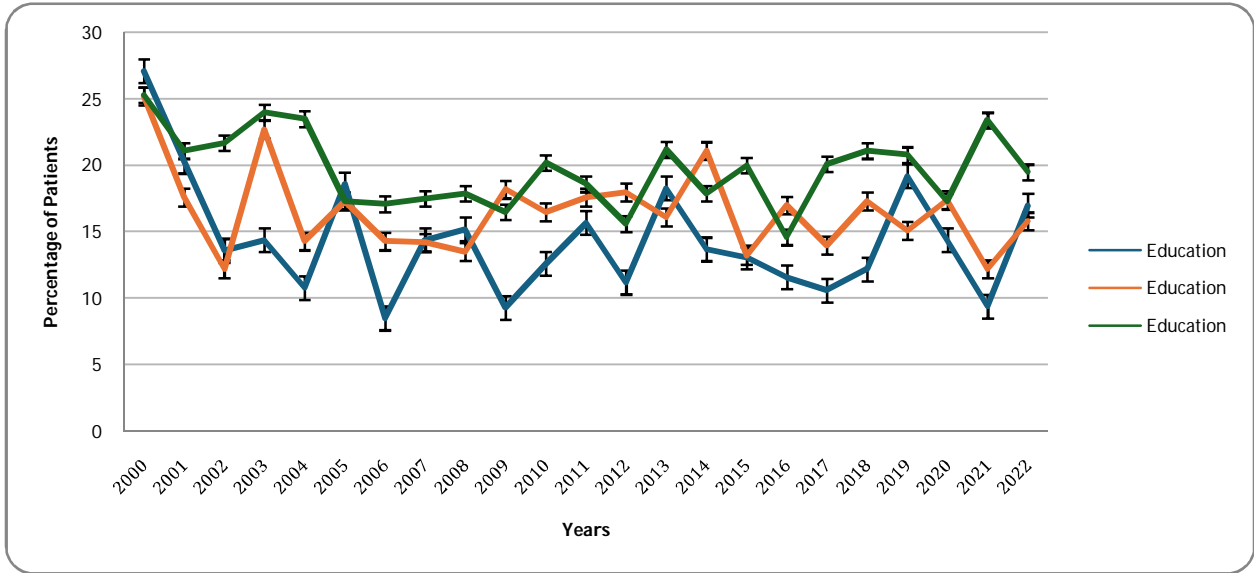
Education level trends: Insulin only usage

Among patients with less than a high school education, the percentage using insulin-only therapy started at 27.1% in 2000. This percentage saw a significant decline to 8.5% in 2006, followed by fluctuations. The percentage peaked at 19.2% in 2019 and by 2022, had increased to 17%.

Overall, the trend for this group shows an initial decline followed by variability and occasional increases (Figure 4).

For patients with a high school education, the percentage using insulin-only therapy was 25.2% in 2000. This percentage decreased to a low of 12.2% in 2002, then experienced fluctuations, peaking at 22.7% in 2003 and 21.1% in 2014. By 2022, 15.8% of patients in this group were on insulin-only therapy. The trend for high school-educated patients indicates variability with periods of increase and decrease. Patients with more than a high school education had a percentage of 25.3% using insulin-only therapy in 2000. This percentage generally remained high, with fluctuations, reaching 24.0% in 2003 and 23.4% in 2021. By 2022, 19.5% of patients with more than a high school education were using insulin-only therapy. The trend for this group shows less variability compared to the other groups, maintaining relatively higher percentages over the years (Figure 4).

Figure 4: Diabetes medication pattern based on education level



Discussion

UNDER PEER REVIEW

The analysis of insulin medication trends has provided valuable insights into how diabetes management strategies have evolved across different demographics, including age, gender, race, and education level. This section discusses the key findings in the context of existing literature and their implications for future diabetes management practices.

The increasing trend in the use of pills only suggests a growing preference for oral hypoglycemic agents. This preference is likely driven by the convenience and ease of use of pills compared to insulin injections [11]. Additionally, the introduction of new classes of oral medications, such as DPP-4 inhibitors and SGLT2 inhibitors, has provided more effective options with fewer side effects. Studies have highlighted the benefits of these newer agents, including their cardioprotective effects and reduced risk of hypoglycemia, which have likely contributed to their increased adoption [11-13].

The decline in insulin-only use indicates a shift from monotherapy to combination therapies or oral medications, with a slight increase in some years. By 2022, 17.8% of patients used insulin only, showing reduced reliance on insulin alone. This trend aligns with recommendations from clinical guidelines that advocate for a combination of therapies to achieve better glycemic control and reduce the risk of complications [15].

The fluctuating percentage of patients using both insulin and pills highlights the importance of combination therapy in achieving optimal glycemic control. This trend reflects a tailored approach to diabetes management, where healthcare providers combine different therapies to address the unique needs of each patient. Research supports the efficacy of combination therapy in improving glycemic control and reducing the incidence of diabetes-related complications [11, 15-16].

The percentage of patients not using any medication showed significant variability may indicate changes in diagnosis rates, access to healthcare, and patient adherence to treatment plans. The high percentage of patients not on medication during certain years suggests a need for improved access to diabetes care and better patient education on the importance of medication adherence. Previous studies have emphasized the critical role of education and support in enhancing medication adherence and overall diabetes management [17]. The overall trends in diabetes medication use reflect broader changes in treatment strategies and the availability of newer medications.

The variability in insulin-only usage observed across different age groups underscores the evolving landscape of diabetes management. Younger adults (18-44 years) demonstrated significant fluctuations in insulin usage, indicative of their responsiveness to evolving treatment options and clinical guidelines. This finding aligns with research suggesting that younger patients often prefer more flexible treatment approaches, such as non-insulin medications or lifestyle interventions, which may contribute to the observed variability [18-19]. In contrast, the 45-64 and 65-74 age groups exhibited a declining trend in insulin-only usage, reflecting a shift towards alternative therapies like oral hypoglycemic agents and GLP-1 receptor agonists. This shift is consistent with studies highlighting the convenience and effectiveness of these treatments in older adults [18, 20]. Among the oldest age group (75+), insulin-only usage remained relatively stable with slight fluctuations, reflecting a consistent management approach aimed at avoiding therapy changes that could lead to complications. This stability in management practices aligns with literature emphasizing the importance of established regimens in older adults with long-standing diabetes [20].

Gender-specific trends revealed that male patients generally maintained higher percentages of insulin-only usage compared to females, particularly in later years. This pattern may be attributed to higher prevalence of insulin resistance and more severe disease progression among men, leading to greater reliance on intensive insulin therapy [21]. In contrast, women showed a tendency towards non-insulin therapies, potentially influenced by concerns related to insulin-related weight gain and hypoglycemia [22-23].

Race-specific analysis highlighted disparities in insulin-only usage among Hispanic, Non-Hispanic White, and Non-Hispanic Black patients. Non-Hispanic White patients consistently exhibited higher usage rates, while Hispanic patients displayed lower and more variable rates. These disparities underscore the influence of socio-economic factors, healthcare access, and cultural attitudes towards diabetes management [24-25].

Educational attainment also played a significant role in insulin-only usage trends. Patients with higher educational attainment generally maintained higher and more stable percentages of insulin usage, reflecting better access to healthcare resources and adherence to treatment plans. Conversely, those with lower educational levels showed declines or variability, indicative of potential barriers to consistent diabetes management [26].

Overall, these findings highlight the complex interplay of age, gender, race, and educational factors in shaping patterns of insulin-only usage among diabetes patients. Understanding these dynamics is crucial for tailoring diabetes management strategies that are effective and accessible across diverse patient populations.

Strengths and limitations

This study's primary strength lies in its comprehensive 22-year analysis of insulin medication trends using a national database, providing a robust examination of long-term patterns across diverse demographics. By including factors such as age, gender, race, and education levels, the study offers a nuanced understanding of diabetes management trends and identifies disparities necessitating targeted interventions. The broad scope yields valuable insights into how different demographic groups respond to insulin-only therapy over time.

This study has several limitations that should be considered. Firstly, the research does not explore causality behind the observed trends, which restricts the understanding of the underlying factors influencing medication usage. Without examining these causal relationships, the study can only provide a descriptive analysis of trends rather than insights into why these changes occur. Secondly, the absence of qualitative data is a notable limitation; incorporating patient perspectives on insulin therapy preferences and challenges would provide a richer, more nuanced understanding of the factors affecting medication choices. Lastly, the analysis is constrained by incomplete data, as missing data points for specific demographics in certain years may impact the robustness of the findings. These limitations suggest that future research should address these gaps to offer a more comprehensive view of insulin medication trends and their determinants.

Future directions and clinical implications

Building on the trends observed in this analysis, future research should focus on collecting qualitative data to better understand the factors influencing medication choices among diabetes patients. For example, exploring patient experiences, treatment adherence challenges, and the impact of educational interventions could provide valuable comparative analysis insights. Additionally, investigating socioeconomic factors such as income disparities, healthcare access,

and insurance coverage may reveal underlying influences on medication trends. Clinically, these findings underscore the need for personalized treatment strategies that account for diverse patient backgrounds and preferences. Policymakers should consider these trends when formulating healthcare policies, ensuring that resources are allocated effectively to address the evolving needs in diabetes management. Tailoring interventions and support programs based on comprehensive data could enhance treatment outcomes and optimize care for patients across different demographics.

Conclusion

In summary, this study reveals significant demographic variations across age, gender, race, and education levels. Younger adults and those with higher educational attainment showed higher and more variable usage rates, likely linked to better healthcare access and adherence. Gender-specific trends indicate higher insulin-only usage among males recently, while race-specific disparities show Non-Hispanic White patients maintaining higher percentages than Hispanic and Non-Hispanic Black patients. These findings underscore the need for targeted interventions and personalized treatment approaches tailored to diverse demographic needs. They also reflect broader changes in diabetes care practices, emphasizing the importance of continuous monitoring and adaptive treatment strategies. Addressing these disparities and ensuring equitable access to comprehensive diabetes care can greatly enhance health outcomes. Future research should delve into the root causes of these trends to optimize diabetes management and promote health equity effectively.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

- 1.
- 2.
- 3.

References

1. NIH: Type 2 diabetes (2023). Accessed on: July 1, 2024. [Type 2 Diabetes - StatPearls - NCBI Bookshelf \(nih.gov\)](#)
2. Sapra A, Bhandari P. Diabetes. In: *StatPearls*. Treasure Island (FL):StatPearls Publishing; June 21, 2023.
3. MSD manuals: Diabetes mellitus (DM) - hormonal and metabolic disorders (2023). Accessed on July 1, 2024. [Diabetes Mellitus \(DM\) - Hormonal and Metabolic Disorders - MSD Manual Consumer Version \(msdmanuals.com\)](#)
4. CDC Diabetes: National Diabetes statistics report (2024). Accessed on: July 1, 2024. [National Diabetes Statistics Report | Diabetes | CDC](#)

5. International diabetes federation: Diabetes facts and figures. Accessed on: July 1, 2024.
[Diabetes Facts and Figures | International Diabetes Federation \(idf.org\)](https://www.idf.org/diabetes-facts-and-figures)
6. WHO: Diabetes. Accessed on July 1, 2024. [Diabetes \(who.int\)](https://www.who.int/diabetes)
7. Banday MZ, Sameer AS, Nissar S. Pathophysiology of diabetes: An overview. *Avicenna J Med.* 2020;10(4):174-188. Published 2020 Oct 13. doi:10.4103/ajm.ajm_53_20
8. Galicia-Garcia U, Benito-Vicente A, Jebari S, et al. Pathophysiology of Type 2 Diabetes Mellitus. *Int J Mol Sci.* 2020;21(17):6275. Published 2020 Aug 30.
doi:10.3390/ijms21176275
9. Cerf ME. Beta cell dysfunction and insulin resistance. *Front Endocrinol (Lausanne).* 2013;4:37. Published 2013 Mar 27. doi:10.3389/fendo.2013.00037
10. United States Diabetes Surveillance System (2024). Accessed: June 1, 2024. Available at:
<https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html>
11. Kantor ED, Rehm CD, Haas JS, Chan AT, Giovannucci EL. Trends in Prescription Drug Use Among Adults in the United States From 1999-2012. *JAMA.* 2015;314(17):1818–1830. doi:10.1001/jama.2015.13766
12. Kerr D, Rajpura JR, Namvar T. Evaluating Patient and Provider Preferences for a Once-Weekly Basal Insulin in Adults with Type 2 Diabetes. *Patient Prefer Adherence.* 2024 Feb 14;18:411-424. doi: 10.2147/PPA.S436540.
13. Ferro EG, Elshazly MB, Bhatt DL. New Antidiabetes Medications and Their Cardiovascular and Renal Benefits. *CardiolClin.* 2021 Aug;39(3):335-351. doi: 10.1016/j.ccl.2021.04.007. PMID: 34247748.
14. Scheen AJ. Bridging the gap in cardiovascular care in diabetic patients: are cardioprotective antihyperglycemic agents underutilized? *Expert Rev ClinPharmacol.*

2023 Jul-Dec;16(11):1053-1062. doi: 10.1080/17512433.2023.2279193. Epub 2023 Nov 22. PMID: 37919944.

15. American Diabetes Association. 6. Glycemic targets: standards of medical care in diabetes—2020. *Diabetes care*. 2020 Jan 1;43(Supplement_1):S66-76.
16. Mason SA, Keske MA, Wadley GD. Effects of Vitamin C Supplementation on Glycemic Control and Cardiovascular Risk Factors in People With Type 2 Diabetes: A GRADE-Assessed Systematic Review and Meta-analysis of Randomized Controlled Trials. *Diabetes Care*. 2021 Feb;44(2):618-630. doi: 10.2337/dc20-1893. PMID: 33472962.
17. Asheq A, Ashames A, Al-Tabakha M, Hassan N, Jairoun A. Medication adherence in type 2 diabetes mellitus patients during Covid-19 pandemic: a cross-sectional study from the United Arab Emirates. *F1000Res*. 2021 Jun 25;10:435. doi: 10.12688/f1000research.51729.2. PMCID: PMC8649966.
18. DeVoe JE, Wallace LS, Fryer GE Jr. Patient age influences perceptions about health care communication. *Fam Med*. 2009;41(2):126-133.
19. Uusitupa M, Khan TA, Viguioliouk E, et al. Prevention of Type 2 Diabetes by Lifestyle Changes: A Systematic Review and Meta-Analysis. *Nutrients*. 2019;11(11):2611. Published 2019 Nov 1. doi:10.3390/nu11112611
20. Arslanian S, Bacha F, Grey M, Marcus MD, White NH, Zeitler P. Evaluation and Management of Youth-Onset Type 2 Diabetes: A Position Statement by the American Diabetes Association. *Diabetes Care*. 2018;41(12):2648-2668. doi:10.2337/dci18-0052
21. McGill, J.B., Hirsch, I.B., Parkin, C.G. *et al.* The Current and Future Role of Insulin Therapy in the Management of Type 2 Diabetes: A Narrative Review. *Diabetes Ther* **15**, 1085–1098 (2024). <https://doi.org/10.1007/s13300-024-01569-8>

22. Kautzky-Willer A, Kosi L, Lin J, Mihaljevic R. Gender-based differences in glycaemic control and hypoglycaemia prevalence in patients with type 2 diabetes: results from patient-level pooled data of six randomized controlled trials. *Diabetes ObesMetab*. 2015;17(6):533-540. doi:10.1111/dom.12449
23. Chadha M, Jain SM, Chawla R, et al. Evolution of Guideline Recommendations on Insulin Therapy in Type 2 Diabetes Mellitus Over the Last Two Decades: A Narrative Review. *Curr Diabetes Rev*. 2023;19(8):e160123212777. doi:10.2174/1573399819666230116150205
24. Kamat S, Gousse Y, Muzumdar J, Gu A. Trends and Disparities in Quality of Diabetes Care in the US: The National Health and Nutrition Examination Survey, 1999-2016. *Innov Pharm*. 2019 Oct 31;10(4):10.24926/iip.v10i4.2064. doi: 10.24926/iip.v10i4.2064. PMID: 34007599; PMCID: PMC8051907.
25. Tan X, Lee LK, Huynh S, Pawaskar M, Rajpathak S. Sociodemographic disparities in the management of type 2 diabetes in the United States. *Curr Med Res Opin*. 2020 Jun;36(6):967-976. doi: 10.1080/03007995.2020.1756764. Epub 2020 Apr 29. PMID: 32297530.
26. Ekenberg, M., Qvarnström, M., Sundström, A. *et al.* Socioeconomic factors associated with poor medication adherence in patients with type 2 diabetes. *Eur J ClinPharmacol* **80**, 53–63 (2024). <https://doi.org/10.1007/s00228-023-03571-8>