# Literature Survey on Diabetes Treatment

## Introduction

Diabetes mellitus, particularly type 2 diabetes mellitus (T2DM), represents a major global health challenge due to its rising prevalence and associated complications, including cardiovascular disease, renal impairment, and neuropathy. Effective diabetes treatment aims not only to achieve glycemic control but also to reduce comorbidities, improve quality of life, and prevent long-term complications. Recent advances in pharmacotherapy, personalized medicine, lifestyle interventions, and technological innovations have transformed diabetes management. This literature survey synthesizes findings from recent studies and reviews to provide a comprehensive overview of current and emerging approaches in diabetes treatment, emphasizing pharmacological developments, precision medicine, drug delivery innovations, lifestyle and behavioral strategies, and management of diabetes complications.

## Advances in Pharmacological Treatments and Personalized Medicine

Pharmacological management of diabetes has evolved significantly, with new drug classes offering improved glycemic control alongside cardiovascular and renal benefits. Sodium-glucose co-transporter 2 (SGLT2) inhibitors and glucagon-like peptide-1 (GLP-1) receptor agonists have emerged as cornerstone therapies in T2DM treatment, especially for patients with cardiovascular or kidney disease risks (Chong et al., 2024; Garg et al., 2023, 2024, 2025). These agents not only lower blood glucose but also reduce heart failure hospitalizations and renal events, partly through anti-inflammatory mechanisms that modulate key signaling pathways and reduce systemic inflammation (Zhang et al., 2024).

Recent pharmacological innovations include dual and polyagonists targeting multiple incretin receptors. Tirzepatide, a dual agonist of glucose-dependent insulinotropic polypeptide (GIP) and GLP-1 receptors, has demonstrated superior glycemic and weight loss effects compared to traditional GLP-1 receptor agonists, with ongoing trials evaluating its long-term safety and cardiovascular outcomes (Min and Bain, 2020; Dissanayake and Somasundaram, 2023). Polyagonists that simultaneously activate GLP-1, GIP, and glucagon receptors represent promising therapies addressing multiple diabetes pathophysiological pathways for enhanced efficacy.

Personalized medicine approaches are increasingly emphasized to optimize diabetes treatment. Tailoring therapies based on genetic profiles, comorbidities, patient preferences, and lifestyle factors improves adherence and outcomes (Sugandh et al.,

2023; Williams et al., 2022). Genome-wide association studies (GWAS) have identified genetic variants influencing glucose regulation and drug response, notably in the GLP1R gene, suggesting potential for genotype-guided therapy to maximize efficacy of GLP-1 receptor agonists (Lagou et al., 2021, 2023). Pharmacogenomics also informs drug choice, such as metformin response linked to OCT1 gene variants (Sugandh et al., 2023).

Consensus guidelines from endocrinology associations underscore individualized treatment algorithms incorporating novel agents, lifestyle modifications, and continuous glucose monitoring (CGM) to balance glycemic control with cardiovascular risk reduction and hypoglycemia prevention (Garber et al., 2019, 2020). Early insulin therapy in newly diagnosed T2DM patients has shown cardiovascular benefits, reducing stroke and heart failure risks, potentially by preserving β-cell function and improving endothelial health (Luo et al., 2024).

# Innovations in Drug Delivery and Monitoring Technologies

Advances in drug delivery systems and glucose monitoring technologies have enhanced diabetes management by improving treatment precision and patient adherence. Nanotechnology and novel biomaterials enable glucose-responsive insulin delivery and sustained drug release. Janus particles, characterized by dual compartments with distinct properties, facilitate co-delivery of multiple agents such as immunosuppressants and insulin secretagogues, offering targeted, controlled, and prolonged therapeutic effects while minimizing drug dosages (Tan et al., 2023). These multifunctional platforms also hold potential as biosensors for glucose monitoring, integrating diagnosis and therapy.

Nanotechnology-based glucose sensors using carbon nanotubes, metal nanoparticles, and graphene have improved the sensitivity and rapidity of glucose detection, enabling minimally invasive continuous monitoring (Disanto et al., 2015). Closed-loop insulin delivery systems, combining glucose sensing with automated insulin release, represent a significant leap toward precision diabetes care, although challenges remain in enzyme stability and immune compatibility.

Continuous glucose monitoring (CGM) technologies, including real-time CGM and flash glucose monitoring (FGM), have demonstrated benefits in glycemic control and hypoglycemia reduction, particularly in insulin-treated patients (Moe et al., 2023; Garg et al., 2022; Carlson et al., 2022; Aronson et al., 2022). CGM facilitates individualized insulin dosing and lifestyle adjustments, contributing to improved patient engagement and quality of life. Cost-effectiveness analyses support broader adoption of CGM, especially when initiated early in insulin therapy (Isitt et al., 2022). Integration of CGM data with behavioral and mental health assessments enables precision monitoring, allowing tailored interventions that address psychological and self-care factors influencing glycemic outcomes (Hermanns et al., 2022).

# Lifestyle Interventions, Patient Education, and Holistic Management

Lifestyle modification remains a foundational component of diabetes treatment, with evidence supporting its efficacy in preventing or delaying T2DM onset and improving glycemic control in diagnosed patients. Intensive lifestyle interventions focusing on diet, exercise, and weight management reduce diabetes risk by nearly half in individuals with impaired glucose tolerance (Gillies et al., 2007). Multidisciplinary programs delivered in-person or virtually achieve comparable improvements in weight, glycemic control, and cardiovascular risk factors, demonstrating scalability and accessibility benefits (Al-Badri et al., 2022).

Patient education, particularly nurse-led and online programs, enhances insulin therapy adherence and glycemic outcomes by fostering positive attitudes and self-management skills (Huang et al., 2021). Addressing behavioral and psychosocial dimensions, including mental health and sleep quality, is critical, as poor sleep adversely affects glycemic control and cardiovascular risk (Henson et al., 2024). Incorporating sleep assessment and management into diabetes care may optimize treatment effectiveness.

Despite advances, social determinants of health and disparities in healthcare access influence diabetes outcomes. Many clinical guidelines lack comprehensive social care recommendations, and rural populations remain underrepresented in clinical trials, limiting the generalizability of findings (Aceves et al., 2022; Weeda et al., 2021). Enhancing patient education on diabetes complications correlates with better treatment compliance, underscoring the need for improved awareness campaigns (Alhammadi et al., 2022). Multidisciplinary care teams, including nurses, play vital roles in guideline adherence and patient-centered management (Alshammari, 2020; Mcintosh et al., 2017).

# Management of Diabetes Complications and Complementary Therapies

Effective diabetes treatment encompasses prevention and management of complications such as nephropathy, neuropathy, retinopathy, and cardiovascular disease. Targeting pancreatic β cells through preservation, regeneration, or replacement strategies holds promise for restoring endogenous insulin secretion and improving glycemic control (Jain et al., 2022). Early insulin therapy may also mitigate cardiovascular risks by preserving β-cell function (Luo et al., 2024).

Pharmacological agents, including oral hypoglycemic drugs, exhibit effects beyond glycemic control. Some oral agents reduce depression symptoms associated with diabetes by modulating brain oxidative stress and inflammation, while DPP-4 inhibitors may lower depression risk in T2DM patients (Soliman et al., 2020; Akimoto et al., 2019). Oral hypoglycemic agents also influence vascular calcification markers, though their effects on vascular function require further study (Schinzari et al., 2019).

Traditional Chinese medicine approaches combining Yiqi Huoxue prescriptions with acupuncture and moxibustion show potential in alleviating diabetes complications by improving microcirculation, reducing inflammation, and promoting tissue repair, representing valuable complementary therapies (Li et al., 2024). Targeting aldose

reductase, an enzyme implicated in diabetes-related oxidative stress and inflammation, is another emerging therapeutic avenue for managing complications (Maccari and Ottanà, 2015).

# Conclusion

Diabetes treatment has advanced considerably through the integration of novel pharmacological agents, personalized medicine, innovative drug delivery systems, and comprehensive lifestyle interventions. SGLT2 inhibitors, GLP-1 receptor agonists, and dual/polyagonists offer multifaceted benefits addressing glycemic control and comorbidities. Precision medicine guided by genetic insights and continuous glucose monitoring enhances individualized care, while nanotechnology and smart drug delivery platforms improve therapeutic efficacy and patient adherence. Lifestyle modification and patient education remain indispensable, supported by multidisciplinary and technology-enabled approaches. Addressing social determinants and expanding clinical trial inclusivity are essential for equitable diabetes care. Complementary therapies and targeted management of complications further enrich treatment options. Continued research and clinical integration of these advances promise improved outcomes and quality of life for individuals living with diabetes.

# References


Aceves, Ben and Gunn, R. and Pisciotta, M. and Razon, N. and Cottrell, E. and Hessler, D. and Gold, R. and Gottlieb, Laura (2022). Social Care Recommendations In National Diabetes Treatment Guidelines. *Current Diabetes Reports*.

Akimoto, Hayato and Tezuka, Kotoe and Nishida, Yayoi and Nakayama, T. and Takahashi, Yasuo and Asai, S. (2019). Association Between Use Of Oral Hypoglycemic Agents In Japanese Patients With Type 2 Diabetes Mellitus And Risk Of Depression: A Retrospective Cohort Study. *Pharmacology Research & Perspectives*.

Al-Badri, M. and Kilroy, Cara and Shahar, J. and Tomah, Shaheen and Gardner, Hannah and Sin, Mallory and Votta, Jennie and Phillips-Stoll, Aliza and Price, Aaron and Beaton, J. and Davis, C. and Rizzotto, JO-ANNE and Dhaver, Shilton and Hamdy, O. (2022). In-Person And Virtual Multidisciplinary Intensive Lifestyle Interventions Are Equally Effective In Patients With Type 2 Diabetes And Obesity. *Therapeutic Advances in Endocrinology and Metabolism*.

Alhammadi, N. and Qahtani, A. and Hosiky, M. and Shahrani, Faleh and Shehri, Saeed and Ghamdi, Meshari and Shehri, Faisal (2022). Public Awareness Of Diabetes Complications And Its Effect On Treatment Compliance In Asir Region, Saudi Arabia. *Journal of Family Medicine and Primary Care*.

Alshammari, M. (2020). Diabetes Treatment Guidelines And Nurses' Adherence To Them: A Case Of The Uk And Kuwait.

Aronson, R. and Brown, Ruth and Chu, L. and Bajaj, H. and Khandwala, H. and Abitbol, Alexander and Malakieh, Nadia and Goldenberg, R. (2022). Impact Of Flash Glucose Monitoring In People With Type 2 Diabetes Inadequately Controlled With Non‐Insulin Antihyperglycaemic Therapy (Immediate): A Randomized Controlled Trial. *Diabetes, obesity and metabolism*.

Carlson, Anders and Daniel, Timothy and DeSantis, A. and Jabbour, S. and French, Esra and Kruger, D. and Miller, Eden and Ozer, Kerem and Elliott, T. (2022). Flash Glucose Monitoring In Type 2 Diabetes Managed With Basal Insulin In The Usa: A Retrospective Real-World Chart Review Study And Meta-Analysis. *BMJ Open Diabetes Research & Care*.

Chong, Keong and Chang, Jack and Chuang, Lee-Ming (2024). Recent Advances In The Treatment Of Type 2 Diabetes Mellitus Using New Drug Therapies. *Kaohsiung Journal of Medical Sciences*.

Disanto, R. and Subramanian, V. and Gu, Zhen (2015). Recent Advances In Nanotechnology For Diabetes Treatment.. *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*.

Dissanayake, H. and Somasundaram, N. (2023). Polyagonists In Type 2 Diabetes Management. *Current Diabetes Reports*.

Garber, A. and Abrahamson, M. and Barzilay, J. and Blonde, L. and Bloomgarden, Z. and Bush, Michael and Dagogo-Jack, S. and DeFronzo, R. and Einhorn, D. and Fonseca, V. and Garber, J. and Garvey, W. and Grunberger, G. and Handelsman, Y. and Hirsch, I. and Jellinger, P. and McGill, J. and Mechanick, J. and Rosenblit, P. and Umpierrez, G. (2019). Consensus Statement By The American Association Of Clinical Endocrinologists And American College Of Endocrinology On The Comprehensive Type 2 Diabetes Management Algorithm - 2019 Executive Summary.. *Endocrine Practice*.

Garg, Satish and Rodriguez, Erika and Hirsch, I. (2023). New Medications For The Treatment Of Diabetes.. *Diabetes Technology & Therapeutics*.

Garg, S. and Kipnes, M. and Castorino, Kristin and Bailey, T. and Akturk, H. and Welsh, J. and Christiansen, Mark and Balo, Andrew and Brown, Sue and Reid, J. and Beck, Stayce (2022). Accuracy And Safety Of Dexcom G7 Continuous Glucose Monitoring In Adults With Diabetes. *Diabetes Technology & Therapeutics*.

Gillies, C. and Abrams, K. and Lambert, P. and Cooper, N. and Sutton, A. and Hsu, Ron and Khunti, K. (2007). Pharmacological And Lifestyle Interventions To Prevent Or Delay Type 2 Diabetes In People With Impaired Glucose Tolerance: Systematic Review And Meta-Analysis. *British medical journal*.

Henson, J. and Covenant, Alix and Hall, Andrew and Herring, L. and Rowlands, A. and Yates, Thomas and Davies, Melanie (2024). Waking Up To The Importance Of Sleep In Type 2 Diabetes Management: A Narrative Review.. *Diabetes Care*.

Hermanns, N. and Ehrmann, D. and Shapira, Amit and Kulzer, B. and Schmitt, A. and Laffel, L. (2022). Coordination Of Glucose Monitoring, Self-Care Behaviour And Mental Health: Achieving Precision Monitoring In Diabetes. *Diabetologia*.

Huang, Wenzhen and Wei, Weiqin and Wang, Jiecai and Lyu, Yinghua and Li, Li (2021). Effectiveness Of A Nurse-Led Online Educational Programme Based On Basic Insulin Therapy In Patients With Diabetes Mellitus: A Quasi-Experimental Trial.. *Journal of Clinical Nursing*.

Isitt, J. and Roze, S. and Sharland, Helen and Cogswell, G. and Alshannaq, H. and Norman, G. and Lynch, P. (2022). Cost-Effectiveness Of A Real-Time Continuous Glucose Monitoring System Versus Self-Monitoring Of Blood Glucose In People With Type 2 Diabetes On Insulin Therapy In The Uk. *Diabetes Therapy*.

Jain, Chirag and Ansarullah, Ansarullah and Bilekova, Sara and Lickert, H. (2022). Targeting Pancreatic B Cells For Diabetes Treatment. *Nature Metabolism*.

Lagou, V. and Jiang, Longda and Ulrich, A. and Zudina, L. and González, Karla and Balkhiyarova, Zhanna and Faggian, A. and Chen, Shiqian and Todorov, Petar and Sharapov, S. and David, A. and Marullo, L. and Mägi, R. and Rujan, Roxana-Maria and Ahlqvist, E. and Thorleifsson, G. and Gao, He and Evangelou, E. and Benyamin, Beben and Scott, R. and Isaacs, A. and Zhao, Jinghua and Willems, Sara and Johnson, T. and Gieger, C. and Grallert, H. and Meisinger, C. and Müller-Nurasyid, M. and Strawbridge, R. and Goel, A. and Rybin, Denis and Albrecht, E. and Jackson, A. and Stringham, H. and Corrêa, Ivan and Eric, F. and Steinthorsdottir, V. and Uitterlinden, A. and Munroe, P. and Brown, Morris and Julian, Schmidberger and Holmen, O. and Thorand, B. and Hveem, K. and Wilsgaard, T. and Mohlke, K. and Kratzer, W. and Mark, Haenle and Koenig, W. and Boehm, B. and Tan, T. and Tomas, Alejandra and Salem, V. and Barroso, I. and Tuomilehto, J. and Boehnke, M. and Florez, J. and Hamsten, A. and Watkins, H. and Njølstad, I. and Wichmann, H. and Caulfield, M. and Khaw, K. and Duijn, C. and Hofman, A. and Wareham, N. and Langenberg, C. and Whitfield, J. and Martin, N. and Montgomery, Grant and Scapoli, C. and Tzoulaki, I. and Elliott, P. and Thorsteinsdóttir, U. and Stefánsson, K. and Brittain, E. and McCarthy, M. and Froguel, P. and Sexton, P. and Wootten, D. and Groop, L. and Dupuis, J. and Meigs, J. and Deganutti, Giuseppe and Demirkan, A. and Pers, T. and Reynolds, C. and Aulchenko, Y. and Kaakinen, M. and Jones, B. and Prokopenko, I. (2021). Random Glucose Gwas In 493,036 Individuals Provides Insights Into Diabetes Pathophysiology, Complications And Treatment Stratification. *medRxiv*.

Li, Qingsong and Wang, Xiaomeng and Li, Xiaochen and Ya, Li and Guo, Jiangfan and Lili, Wu and Qin, Lingling and Liu, Tonghua (2024). Research Progress In The Treatment Of Diabetes Complications With Yiqi Huoxue Prescriptions Combined With Acupuncture And Moxibustion. *MEDS Chinese Medicine*.

Luo, S. and Zheng, Xueying and Bao, Wei and Nie, Sheng and Ding, Yu and Yue, T. and Zhou, Yilun and Hu, Ying and Li, Hua and Yang, Qiongqiong and Wan, Qijun and Liu, Bicheng and Xu, Hong-yan and Li, Guisen and Xu, Gang and Chen, Chunbo and Liu, Huafeng and Shi, Yongjun and Zha, Yan and Kong, Yaozhong and Su, Guobin and Tang, Ying-qian and Gong, Mengchun and Ji, Linong and Hou, F. and Weng, Jianping (2024). Real-World Effectiveness Of Early Insulin Therapy On The Incidence Of Cardiovascular Events In Newly Diagnosed Type 2 Diabetes. *Signal Transduction and Targeted Therapy*.

Maccari, R. and Ottanà, R. (2015). Targeting Aldose Reductase For The Treatment Of Diabetes Complications And Inflammatory Diseases: New Insights And Future Directions.. *Journal of Medicinal Chemistry*.

Mcintosh, Bonnie and Khatchadourian, Karine and Amed, S. (2017). British Columbian Healthcare Providers' Perspectives On Facilitators And Barriers To Adhering To Pediatric Diabetes Treatment Guidelines.. *Canadian Journal of Diabetes*.

Min, T. and Bain, S. (2020). The Role Of Tirzepatide, Dual Gip And Glp-1 Receptor Agonist, In The Management Of Type 2 Diabetes: The Surpass Clinical Trials. *Diabetes Therapy*.

Moe, Samantha and Kolber, M. and Falk, Jamie (2023). Continuous Glucose Monitoring In Diabetes.

Schinzari, F. and Tesauro, M. and Bertoli, A. and Valentini, A. and Veneziani, A. and Campia, U. and Cardillo, C. (2019). Calcification Biomarkers And Vascular Dysfunction In Obesity And Type 2 Diabetes: Influence Of Oral Hypoglycemic Agents.. *American Journal of Physiology. Endocrinology and Metabolism*.

Soliman, Eman and Essmat, Nariman and Mahmoud, Mona and Mahmoud, Amr (2020). Impact Of Some Oral Hypoglycemic Agents On Type 2 Diabetes-Associated Depression And Reserpine-Induced Depression In Rats: The Role Of Brain Oxidative Stress And Inflammation. *Naunyn-Schmiedeberg's Archives of Pharmacology*.

Sugandh, Fnu and Chandio, Maria and Raveena, Fnu and Kumar, Lakshya and Karishma, Fnu and Khuwaja, Sundal and Memon, Unaib and Bai, Karoona and Kashif, Maham and Varrassi, G. and Khatri, Mahima and Kumar, Satesh (2023). Advances In The Management Of Diabetes Mellitus: A Focus On Personalized Medicine. *Cureus*.

Tan, Kei and Danquah, Michael and Jeevanandam, J. and Barhoum, Ahmed (2023). Development Of Janus Particles As Potential Drug Delivery Systems For Diabetes Treatment And Antimicrobial Applications. *Pharmaceutics*.

Weeda, E. and Burnette, Bethany and Rowe, Sarah and Haas, S. and Zecopoulos, Angeleki and Alnewais, Marwah (2021). Disparity In The Rural-Urban Distribution Of Clinical Trial Sites Used In Studies Cited By Diabetes Treatment Guidelines. *Diabetes, obesity and metabolism*.

Williams, David and Jones, Hannah and Stephens, J. (2022). Personalized Type 2 Diabetes Management: An Update On Recent Advances And Recommendations. *Diabetes, Metabolic Syndrome and Obesity : Targets and Therapy*.

Zhang, Ruining and Xie, Qingxing and Lu, Xi and Fan, Rongping and Tong, Nanwei (2024). Research Advances In The Anti-Inflammatory Effects Of Sglt Inhibitors In Type 2 Diabetes Mellitus. *Diabetology & Metabolic Syndrome*.