

Determinants, Barriers and Outcomes of Treatment and Behavioural Adherence in Patients with Type II Diabetes on Insulin Therapy: A Narrative Review

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Abstract

Insulin is still important for many adults with type 2 diabetes (T2D), but in the real world, people often miss, miscalculate, or stop taking their doses, which can lead to high blood sugar levels and more healthcare visits. The current narrative review integrated determinants, alterable obstacles, and clinical and health-economic outcomes related to insulin adherence and persistence in adults with T2D undergoing insulin therapy. Seven databases were examined; 26 peer-reviewed empirical studies were incorporated and synthesized through SANRA-informed narrative techniques, reflexive thematic analysis, and theory-guided integration utilizing the Health Belief Model and Theory of Planned Behavior. There were six interrelated mechanisms: cognitive-motivational appraisal and psychological insulin resistance; capability and self-regulation (skills, self-efficacy, SMBG); routine disruption and regimen complexity driving omission, mistiming, and miscalculation; provider relationship and structured follow-up as social influence and accountability; system-level affordability and treatment design shaping persistence; and consistent links between adherence/persistence and better HbA_{1c}/CGM outcomes with lower utilization and costs, while digital tools often improve glycemia through titration support and less clinical inertia. Different ways of measuring adherence, such as self-report, claims, and connected-device dosing, show that adherence is often based on the quality of the dose, not just the number of doses. Determinant-matched interventions that include counseling, technical training, making things easier, and protecting access are needed.

Keywords: Insulin adherence, persistence, type 2 diabetes, psychological insulin resistance, self-efficacy, regimen complexity, dose omission, dose mistiming, telemonitoring, health-economic outcomes

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Introduction

As the function of β -cells decreases, type 2 diabetes (T2D) frequently culminates in the need for insulin therapy. This implies that individuals who are undergoing insulin therapy are required to adhere to the prescribed treatment plan in order to prevent high blood sugar levels and other health complications. As of 2025, the International Diabetes Federation (IDF) estimates that there are 589 million adults around the world who are affected by diabetes, which accounts for 11.1% of the total population. This figure is expected to increase to 853 million by the year 2050. The International Diabetes Federation (IDF) Diabetes Atlas, in its tenth edition, projected that 537 million adults would be diagnosed with diabetes in the year 2021. This figure demonstrates the rapid spread of diabetes across the globe (Magliano & Boyko, 2021). The financial burden is also significant: in 2022, the United States spent \$412.9 billion on diabetes care, which accounted for approximately one-fourth of all spending on health care (Parker et al., 2024). Diabetes care was the cause of this significant financial burden. In light of the fact that the prevalence of diabetes is increasing along with the costs associated with it, it is of utmost significance for medical professionals and public health officials to optimize insulin-related self-management.

As stated by the American Diabetes Association Professional Practice Committee in 2025, insulin is the most effective treatment for lowering blood sugar levels in people who have type 2 diabetes (T2D). Insulin continues to be the primary treatment when other treatments are unsuccessful. Those who took oral medications for their diabetes lost the ability to control their blood sugar levels over time, which meant that they needed to take more insulin (Turner et al., 1999). This was discovered by the UK Prospective Diabetes Study. The justification for prolonged insulin administration is quantitative rather than theoretical: in UKPDS 35, each 1% decrease in HbA_{1c} correlated with a 37% reduction in microvascular complications and a 14% decrease in myocardial infarction, thereby identifying glycemic exposure as a mechanistic link between insulin dynamics and long-term results (Stratton et al., 2000). This finding suggests that prolonged insulin administration may be beneficial for patients with metabolic syndrome. However, the clinical effectiveness of insulin is contingent upon consistent dosing, titration, and long-term adherence to the injection schedule.

In the real world, insulin is not as effective as it could be because people forget to take it, take it at the wrong time, or stop taking it altogether. The percentage of adults with type 2 diabetes who adhere to their insulin regimens typically falls somewhere between 62% and 64% (Cramer, 2004). The rate of nonpersistence increased from 24.3% at six months to 36.5% at eighteen months, according to Gimeno et al., 2024. The pooled adherence for basal insulin was 55.6%. A systematic review of missed and mistimed insulin doses (37 publications; 58,617 participants) revealed that missed doses occurred in 25 studies and mistiming occurred in 10 studies, highlighting timing as a distinct adherence phenotype (Robinson et al., 2021). Missed doses were found in 25 of the studies evaluated. Within the first six months of treatment, 25.8% of patients in a multicenter cohort stopped receiving basal insulin therapy. The primary reasons for this were resistance (46.8%), the burden of injection frequency (23.5%), or financial considerations (15.1%) (Zhang et al., 2020). The significance of these patterns lies in the fact that missing doses can lead to an increase in HbA_{1c} and variability, and compensatory dosing can lead to an increase in the risk of hypoglycemia and a decrease in self-efficacy, both of which can make it more difficult to maintain titration and care over time.

There are a lot of different things that can influence adherence. Psychological insulin resistance continues to be a prevalent condition (Polonsky et al., 2005), and it is possible to quantify it with the help of insulin appraisal tools such as the Insulin Treatment Appraisal

Scale (Lee, 2018). Peyrot et al. (2005) found that between fifty percent and fifty-five percent of general practitioners and nurses in DAWN delayed the administration of insulin until it was deemed "absolutely necessary." This finding reflects clinical inertia, as stated by Phillips et al. (2001). According to Schillinger et al.'s 2002 study, a lack of adequate health literacy was found to be associated with suboptimal glycemic control (HbA_{1c} \geq 9.5%; odds ratio = 2.03) and retinopathy (OR = 2.33). Nonadherence is linked to depression, according to Gonzalez et al. (2008). In the GRADE study, a one-unit increase in diabetes distress predicted a 0.76-point decrease in adherence at the subsequent six-month visit, according to Hoogendoorn et al. (2024). In the United States, 25.5% of insulin users reported underuse due to cost, which was linked to a higher chance of having a HbA_{1c} level of 9% or higher (OR=2.96) (Herkert et al., 2019). This led to studies of insulin access (Cefalu et al., 2018). Affordability is a structural issue related to diabetes. It is necessary to conduct a revised synthesis that focuses on insulin-treated type 2 diabetes (Davies et al., 2013) in order to identify leverage points for multilevel interventions. This is because there is a great deal of variability among the determinants and outcomes.

Aim

To synthesize evidence on determinants, barriers, and outcomes of adherence in adults with T2D receiving insulin.

Objectives

1. Identify patient-, provider-, and system-level determinants of insulin adherence and persistence.
2. Characterize modifiable barriers driving missed/mistimed doses and discontinuation.
3. Summarize clinical and health-economic outcomes associated with adherence patterns.

Methodology

Research Design

A narrative review design was employed to consolidate evidence regarding the determinants, barriers, and outcomes of insulin adherence and persistence in adults with type 2 diabetes undergoing insulin treatment. SANRA principles for narrative reviews guided methodological transparency and reporting quality. This included structured documentation of how evidence was selected and handled (Baethge et al., 2019). The researcher used narrative synthesis conventions to combine different types of quantitative and intervention results (Popay et al., 2006). The researcher used reflexive thematic analysis to put the findings together, and did it in phases that followed established guidelines (Braun & Clarke, 2006, 2021).

Eligibility Criteria and Included Evidence Base

The analytic corpus consisted of 26 peer-reviewed empirical studies, constituting the finalized eligible set for synthesis. Eligibility criteria were utilized to ascertain relevance to the specified aims and objectives: (a) adult populations with T2D receiving insulin treatment (basal, basal-bolus, premixed, or fixed-ratio combinations including basal insulin), (b) assessment of insulin adherence, persistence, or dosing regularity (including missed, skipped, or mistimed doses), and/or (c) documentation of determinants/barriers at the patient, provider, or system levels and/or subsequent clinical or health-economic outcomes associated with adherence patterns. Studies encompassing various diabetes types were retained solely if they involved insulin-treated adults and supplied data relevant to T2D insulin utilization behaviors or care processes (e.g., regimen administration burden, dosing supports), thereby facilitating barrier and system-level inferences in accordance with the review objectives.

Information Sources and Search Strategy

Seven databases were used for electronic searching: MEDLINE through PubMed, Embase, CINAHL, PsycINFO, Scopus, Web of Science Core Collection, and Cochrane CENTRAL. The first search found 612 records from PubMed, 781 from Embase, 204 from CINAHL, 96 from PsycINFO, 645 from Scopus, 512 from Web of Science, and 88 from CENTRAL. This made a total of 2,938 records in the database. Supplementary searching included checking citations going back and forward, which added 34 more records, bringing the total to 2,972 before deduplication. There were 2,160 unique records left for screening after 812 duplicates were taken out. Search concepts used controlled vocabulary and keywords to find type 2 diabetes, insulin therapy (basal, basal bolus, premixed, fixed ratio combinations), adherence and persistence (missed doses, mistimed doses, PDC, discontinuation), determinants and barriers, and outcomes (glycemic indices, healthcare utilization, costs). PRISMA is mainly a framework for systematic reviews, but reporting a record flow makes it easier to check and is in line with modern expectations for transparency (Page et al., 2021).

Screening and Study Selection

Title and abstract screening was done on 2,160 records. 2,070 of them were clearly not relevant, so 90 full texts were checked to see if they met the criteria. We left out 64 full texts for a number of reasons, such as not being T2D populations, not having insulin treated samples, not having adherence or persistence measurements, being pediatric or gestational samples, not being empirical formats, or not having outcomes that were linked to taking insulin. The final set of studies included 26 studies, which served as the basis for synthesis. Eligibility was based on adult T2D populations who were taking insulin and reporting at least one of the following: adherence or persistence metrics, determinants or barriers at the patient, provider, or system levels, or clinical and health economic outcomes linked to adherence patterns. Studies encompassing various diabetes types were preserved solely when adult insulin utilization behaviors and obstacles were directly relevant to T2D care settings.

Data Extraction and Evidence Handling

Data were organized into a structured matrix that included the study design, setting and country, recruitment source, sample size and population characteristics, insulin regimen context, adherence or persistence operationalization, determinants and barriers categorized as patient level, provider level, or system level, and outcomes such as HbA_{1c}, fasting glucose, CGM metrics, healthcare utilization, and costs. Reported effect estimates and significance values were used to keep the quantitative results, and then they were combined in a narrative form to make it easier to compare studies, as suggested by Popay et al. (2006).

Methodological Quality and Risk-of-Bias Appraisal

Because the evidence base included cross-sectional observational studies, pragmatic/claims-based comparative studies, and randomized trials, appraisal was design-sensitive. The Mixed Methods Appraisal Tool (MMAT) was used to rate the overall methodological quality of different types of studies. It works for quantitative descriptive, randomized, non-randomized, and mixed-methods designs (Hong et al., 2018). For randomized trials, domain-based risk-of-bias assessment was based on RoB 2 principles, such as the randomization process, deviations from planned interventions, missing outcome data, outcome measurement, and selective reporting (Sterne et al., 2019). For non-randomized intervention-effect estimates (including observational comparative effectiveness analyses), bias domains were consistent with ROBINS-I (confounding, selection, intervention classification, deviations, missing data, outcome measurement, and reporting) (Sterne et al., 2016). Appraisal outputs were utilized analytically (rather than as exclusion criteria) to adjust interpretive confidence and to contextualize

themes when results were predominantly based on self-reporting, brief follow-up periods, or residual confounding characteristic of claims analyses.

Thematic Synthesis Using Reflexive Thematic Analysis

A thematic synthesis was performed utilizing Braun and Clarke's reflexive thematic analysis (RTA), implemented as a six-phase iterative process: familiarization with extracted findings, systematic coding, candidate theme development, theme review against the dataset, theme definition/naming, and narrative composition (Braun & Clarke, 2006). Using a mix of inductive and deductive coding, we found common barriers and determinants and outcomes linked to adherence across studies. Inductive coding found these things, while deductive coding linked the results to theoretically meaningful ideas that are important for medication-taking behavior. Theme quality assurance adhered to RTA quality principles, encompassing coherence (distinct conceptual boundaries), internal consistency, and analytical depth surpassing mere topic summaries (Braun & Clarke, 2021). To keep track of things, each theme was tied to specific study-level evidence and the review goals. This made it clear how many studies backed up each thematic claim.

Theory-Guided Integration and Proposed Model Development

To link determinants and barriers to adherence behaviors and subsequent outcomes, synthesis employed theory-guided interpretation. The Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) were chosen beforehand as simple explanatory frameworks because they directly model perceived benefits/risks, self-efficacy/control, social influence, and intention formation—constructs that were used over and over again in the studies that were included. During synthesis, coded determinants and barriers were linked to constructs like fear of harm, perceived benefits, perceived behavioral control/self-efficacy, subjective norms, and clinician relationship factors. These links were then used to find connections to adherence behaviors (missed or late doses, discontinuation, and persistence) and outcomes (glycemic indices, utilization, and costs). This made it possible to create a proposed conceptual model that shows how multilevel determinants could lead to adherence patterns and then to clinical and health-economic outcomes. This is in line with narrative synthesis guidance that stresses looking at the relationships between study findings (Popay et al., 2006).

Ethics

This review utilized published and de-identified data from primary studies and did not involve the collection of new data from human participants. Consequently, ethics approval was unnecessary for the review itself. During study characterization, the researcher recorded any ethical approvals and consent procedures that were reported in the primary studies.

Findings

Characteristics of the included studies (n = 26)

The evidence included cross-sectional surveys, longitudinal observational studies, randomized and quasi-experimental interventions, technology-enabled trials, and extensive administrative claims analyses from Asia, the Middle East, Europe, and North America. Some studies were done in clinics and relied on self-reported adherence, while others used claims-based proxies (PDC/persistence gaps) or injections recorded by devices. Yong et al. (2022) did an analytical cross-sectional survey of 360 adults with T2D who were going to an outpatient diabetes clinic at Hospital Queen Elizabeth II in Sabah, Malaysia. They used the Medication Compliance Questionnaire and Health Belief Model constructs. This was one of the few patient-level cross-sectional surveys done in Asia and the Middle East. Alomran et al. (2020) conducted a multistage-sampled cross-sectional survey involving 366 adults with T2D at primary healthcare centers in Al-Ahsa, Saudi Arabia, emphasizing psychological insulin

resistance and the doctor–patient relationship. Using the Insulin Adherence Questionnaire for Diabetes Mellitus and multivariable logistic regression, Nasruddin and Bachok (2021) did a cross-sectional study in five government primary care clinics in Klang district, Malaysia. They looked at 249 adults with T2D who had been on insulin for at least two months. Alsaidan et al. (2023) did a descriptive cross-sectional survey in Al-Jouf, Saudi Arabia, at seven primary and secondary healthcare sites (three hospitals, one diabetes center, and three private clinics). They enrolled 415 insulin users on basal-bolus regimens (mixed diabetes types; about 49.6% reported T2D) and used descriptive statistics to look at missed doses and barriers. Xie et al. (2024) did an observational study in China with 120 adults with T2D who were treated with IDegAsp from February 2019 to March 2022. They looked at fear (D-FISQ) and a compliance questionnaire, and used logistic regression to compare the compliant ($n = 89$) and noncompliant ($n = 31$) groups. Fu et al. (2024) looked at 222 adults with type II diabetes who were being treated with insulin at a regional teaching hospital in central Taiwan. They used a cross-sectional consecutive sample and measured psychological insulin resistance (barriers to insulin treatment questionnaire) and self-management (Partners in Health scale). Muhammad et al. (2025) did a cross-sectional study in a tertiary diabetes clinic in Iraq over six months ($n = 111$ adults with T2D on insulin ≥ 6 months). They defined adherence as $\geq 80\%$ of prescribed injections in the last 30 days and used multivariable logistic regression. In 2025, De Moraes Oliveira et al. did a long-term predictive study at a specialty outpatient clinic in São Paulo state, Brazil. They collected baseline data from 119 adults with T2D on insulin and then checked their adherence and A1c levels again after three months (follow-up $n = 70$), using the Theory of Planned Behavior.

Provider and mixed-perspective surveys included Bellido et al. (2024), which was a cross-sectional online survey of 160 Spanish doctors (80 primary care; 80 specialists) that asked them about their thoughts on suboptimal dosing and possible solutions. Newson et al. (2025) was a multinational cross-sectional online survey of 1150 adults in the US, UK, and Germany who used analog insulin pens (850 with T2D and 300 with T1D) that measured missed and mistimed basal/bolus doses over 30 days and perceived barriers/solutions. The rigor and setting of intervention studies were different. Zainudin et al. (2024) compared USM-IAM counseling to standard counseling in a single-center parallel RCT at Hospital Universiti Sains Malaysia. The study included 180 adults aged 18 to 65 with T2D, HbA1c levels between 8 and 15%, and who had been on insulin for at least a year. There were follow-ups at 3 and 6 months and IAQDM adherence scoring. He et al. (2024) did a single-center open-label randomized clinical trial in Nanjing, China, with 180 participants (152 analyzed) using MMAS-8, knowledge, beliefs (BMQ), and self-efficacy (C-DMSES). They made weekly calls for 3 months. Selvadurai et al. (2021) did a multicenter randomized controlled trial in 15 Malaysian government primary health clinics (randomized $n = 160$; completed $n = 139$) to compare monthly re-education of pharmacists on injection techniques with standard counseling over four months, with six-month outcomes (MCQ, ITAS, HbA1c). Sungkapinyo et al. (2025) employed a quasi-experimental two-group pretest–posttest design in a tertiary hospital diabetes clinic in southern Thailand ($n = 60$; 30/group), implementing a 4-week LINE-based support program based on the IMB model.

Hangaard et al. (2025) did a Danish multicenter open-label RCT ($n = 331$; 3 months) that compared telemonitoring (CGM + connected pen + activity tracker with clinician calls) to standard care. Nørlev et al. (2025) did a post-hoc analysis of the telemonitoring arm using connected-pen injection data ($n = 165$) to measure basal adherence and dose deviations. In Atlanta, US clinics, Galindo et al. (2023) ran a pilot randomized crossover trial ($n = 80$; two 12-



week phases) testing a smart insulin pen cap with reminders against a masked control. In 36 German diabetes clinics, Hermanns et al. (2023) ran a 12-week multicenter open-label RCT with 251 people randomized. They compared the My Dose Coach app to written titration charts. Tamez-Pérez et al. (2022) wrote about a 16-week pilot study in northern Mexico (n = 158) using My Dose Coach for basal titration in a single group. Snel et al. (2024) tried out a 16-week SMS-supported titration service with only one arm (n = 30 enrolled; 29 activated). Nayak et al. (2023) assessed voice-based conversational AI for basal insulin management in a limited randomized controlled trial across four primary care clinics (n = 32; duration of 8 weeks). Bajaj et al. (2025) looked at how well people followed app-guided titration in a Phase 3a multinational RCT subgroup in ONWARDS 5 (icodec + dosing app; n ≈ 541 with app data; 52 weeks). Wright et al. (2022) used Optum Clinformatics (PSM cohorts n = 3,077/group; 12 months) to compare switching to Gla-300 versus first-generation basal insulin; Edelman et al. (2022) used Optum Clinformatics (PSM n = 1,357/group; 12 months) to compare iGlarLixi versus free-dose BI + GLP-1 RA; Umpierrez et al. (2025) used Medicare claims in ethnic minority older adults (matched cohorts ~1,160/group; 2019–2021) to compare iGlarLixi versus basal-bolus or premixed; and Aroda et al. (2024) used IQVIA PharMetrics Plus (n = 64,953; 1–2 years follow-up) to estimate persistence/adherence to newly initiated basal insulin and associated utilization/costs.

Table 1: *Summary of Included Studies*

Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Yong, Goh, & Loh (2022)	Journal of Public Health	Determine insulin adherence rate and reasons for non-adherence; examine Health Belief Model (HBM) constructs in relation to insulin adherence; identify predictors of non-adherence among adults with T2DM.	Analytical cross-sectional survey of T2DM outpatients at Hospital Queen Elizabeth II, Sabah (n=360). Insulin adherence measured with the validated Medication Compliance Questionnaire (MCQ).	Overall adherence prevalence was 60.3%. Forgetfulness was the most common adherence reason (66.9%). All HBM constructs correlated significantly with adherence; HBM constructs explained 40.9% of variance in adherence. Strongest predictors were perceived benefits followed by self-efficacy.	Cross-sectional design limits causal inference; adherence was self-reported and thus subject to recall and social desirability bias (limitations implied; not detailed further in the provided abstract).
Alomran, Almubarak,	Journal of Family and Community	Determine psychological insulin	Cross-sectional survey in Al-	Approximately one-third of participants had	Cross-sectional design; survey self-report



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Alrashed y, & Khan (2020)	Medicine	resistance (PIR) and assess effect doctor-patient relationship on PIR among adults with type 2 diabetes attending primary healthcare centers.	Ahsa primary and healthcare centers, Saudi Arabia. Multistage sampling. Of 396 distributed questionnaires, 366 were returned (92% response). Chi-square testing used for associations (alpha=0.05).	PIR. Willingness to use insulin was associated with age (P=0.013) and diabetes duration (P=0.0001). Strongest negative attitudes were hearing about a bad experience with insulin (59.34%, P<0.05) and fear of dependence (54.20%, P<0.05). Better-rated doctor-patient relationship was associated with greater willingness to take insulin (e.g., 64.9% vs 24.5% and 70.3% vs 22.9%, P=0.0001).	vulnerable to recall and response biases; generalizability limited to PHC attendees in one region (limitations partly implied in the provided abstract).
Nasruddin & Bachok (2021)	Malaysian Journal of Medical Sciences	Determine the proportion of adherence to insulin therapy and associated factors in adults with T2DM treated in primary health care centers.	Cross-sectional study in Klang district, Malaysia (five government primary care clinics). Convenience sampling; n=249 adults with T2DM on insulin >=2 months. Adherence assessed with validated Insulin	Adherence proportion was 8.4% (95% CI 6.0-13.0). In multivariable analysis, adherence was associated with self-monitoring of blood glucose (AOR 5.39; 95% CI 1.20-24.13; P=0.028), exercise (AOR 3.38; 95% CI 1.14-10.03; P=0.029), and number of daily insulin injections	Cross-sectional design; self-reported adherence (recall/social desirability bias); convenience sampling; single-district setting limits generalizability; substantial missing fasting blood sugar data (~38.15%) may reduce precision.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
			Adherence Questionnaire for Diabetes Mellitus (IAQDM; 34 items; Cronbach's alpha=0.88). Adherence defined as total score >=80%. Multivariable logistic regression performed; model diagnostics reported (Hosmer-Lemeshow P=0.989; ROC area=76.15%).	(AOR 1.63; 95% CI 1.09-2.44; P=0.017). Glycaemic indices were not significantly associated with adherence, despite most having elevated HbA1c.	
Wright Jr et al. (2022)	Journal of Managed Care & Specialty Pharmacy	Compare persistence, adherence, HbA1c change, healthcare resource utilization (HRU), and costs among adults with T2D switching from first-generation basal insulin to insulin glargine 300 U/mL (Gla-300) versus switching to	Retrospective, claims-based analysis using Optum Clinformatics data. Adults with T2D switching between April 1, 2015 and August 31, 2019; 12-month follow-up. Propensity score matching produced 3,077 participants	Gla-300 was associated with higher persistence at 12 months (45.5% vs 42.1%; adjusted P=0.0001) and higher adherence (42.8% vs 38.2%; adjusted P=0.0006) versus first-generation basal insulin. HbA1c reduction was larger (-0.65% vs -0.45%; adjusted P=0.0040), more achieved HbA1c <8%	Claims data cannot verify actual medication use or dosing; residual confounding possible despite matching; reasons for switching/discontinuation not available; generalizability limited to insured claims populations (limitations inherent; not fully detailed in provided



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		an alternative first-generation basal insulin.	per group; models adjusted for hospitalization imbalance.	(47.2% vs 40.9%; P<0.0001). Hospitalizations and ED visits were lower for Gla-300; pharmacy costs were higher, but total healthcare costs were similar (\$41,255 vs \$45,316 per person-year).	abstract).
Edelman et al. (2022)	Journal of Managed Care & Specialty Pharmacy	Compare persistence, glycaemic change, healthcare resource utilization (HRU), and costs among adults with T2D switching to fixed-ratio iGlarLixi versus newly initiated free-dose basal insulin plus GLP-1 receptor agonist combinations.	Retrospective observational analysis using US Optum Clinformatics (January 2017-November 2019). Adults with baseline HbA1c >=8%. Cohorts propensity score matched 1:1 (n=1,357 per group). Outcomes assessed over 12 months; subgroup analysis baseline HbA1c >=9%.	iGlarLixi showed higher persistence (44.8% vs 36.3%; HR 1.22, 95% CI 1.11-1.35; P<0.001) and higher adherence (41.3% vs 18.7%; OR 3.06, 95% CI 2.57-3.65; P<0.001). HbA1c reductions were similar (-1.2% vs -1.3%; P=0.1913), with limited follow-up HbA1c availability. Outpatient pharmacy visit rates and pharmacy costs were lower with iGlarLixi; hospitalization and ED rates were comparable.	Observational claims design with potential residual confounding; claims/lab data may be incomplete or misclassified; cannot verify dosing/ingestion; reasons for discontinuation unavailable; follow-up HbA1c data limited (36% overall; 24% in HbA1c >=9%); data ended in 2019.
Alsaidan et al. (2023)	Journal of Clinical Medicine	Describe adherence patterns and factors linked with missed	Cross-sectional survey (July 1-October 30, 2022) in seven	40.7% reported forgetting insulin doses weekly; among those, 38.5% missed 1-2	Self-reported adherence may be over- or underestimated; convenience



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		insulin doses among people using basal-bolus insulin regimens in primary and secondary healthcare settings (Al-Jouf, Saudi Arabia).	primary centers, three general hospitals, one diabetes center, three private clinics. Convenience sample; n=415 patients (>14 years) self-administering basal-bolus insulin. Pre-validated Arabic questionnaire (Cronbach's alpha=0.833). Descriptive statistics only.	doses. Common reasons: away from home (36.1%), inability to adhere to diet (24.3%), embarrassment injecting in public (23.7%). Barriers: hypoglycemia (31%), weight gain (26%), needle phobia (22%). Difficulties: preparing injections (18.3%), bedtime dosing (18.3%), cold storage (18.1%). Suggested improvements: reducing injections (30.8%) and more convenient timing (29.6%).	sampling and single-region setting limit generalizability; descriptive analysis only; adherence assessed with a single item about weekly forgetting.
Bellido et al. (2024)	Patient Preference and Adherence	Assess physicians' perceptions of the extent of suboptimal insulin dosing, barriers to optimal dosing, and potential solutions in people with diabetes treated with	Cross-sectional online survey of Spanish physicians (n=160; 80 primary care, 80 specialists) using a 53-item questionnaire; recruitment September 2021-January 2022. Analyses	Physicians estimated that suboptimal dosing was common but usually affected a minority of patients: (>65%) reported that 0-30% of insulin-treated patients missed/skipped, mistimed, or miscalculated	Findings are that physician perceptions rather than measured patient behavior; voluntary participation may limit representativeness; Spanish patient data were absent; survey self-report susceptible to recall bias; no qualitative



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		insulin Spain.	in descriptive only.	doses in the prior 30 days, and >75% estimated 0-30% missed/skipped bolus and basal doses. Perceived contributors included forgetting (missed basal 67.5%; missed bolus 73.8%), being out of routine (basal 46.9%; bolus 55.0%), being too busy/distracted (basal 44.4%; bolus 42.5%), and believing it is acceptable to miss doses sometimes (basal 38.8%; bolus 53.8%). For miscalculation, key factors were uncertainty about dose amount (basal 49.4%; bolus 61.3%) and regimen complexity (basal 38.1%; bolus 48.8%). Proposed very helpful solutions included more time for meaningful dosing conversations (50.0%), automatic glucose	interviews conducted.

Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Xie, Chen, & He (2024)	Medicine	Investigate fear and compliance with insulin degludec/insulin aspart (IDegAsp) injections in T2DM and identify factors influencing compliance.	Observational study of n=120 T2DM patients treated with IDegAsp (Feb 2019-March 2022). Fear assessed with Diabetes Fear of Injecting and Self-testing Questionnaire (D-FISQ). Compliance assessed with a self-designed 11-42 score instrument; compliant defined as ≥ 30 (n=89) vs noncompliant (n=31).	Participants demonstrated high fear of injecting and self-testing: mean D-FISQ 39.19 ± 4.59 , FSI 17.55 ± 2.65 and FST 21.64 ± 3.59 . Compliance domain scores (higher=better) were medication 10.48 ± 1.52 , diet 12.18 ± 2.27 , blood glucose monitoring 0.84 ± 0.12 , and lifestyle change 9.13 ± 2.21 . Univariate comparisons showed no differences between compliance and noncompliance	recording (50.0%), app reminders (43.8%), automatic recording of insulin timing/dose (43.1%), having insulin and glucose data in one place (41.9%), and real-time dosing calculation guidance (37.5%). Compliance measured by self-report; observational design limits causal inference; modest sample size limits generalizability; Chinese D-FISQ not formally established; ethics approval not reported in the provided text.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
			Analyses included chi-square and multivariate logistic regression.	groups by gender, age, lifestyle, education, occupation, treatment method, income, or payment method (all $P > 0.05$), but significant differences by disease duration, complications, cognition, self-efficacy, number of comorbidities, and living status (all $P < 0.05$). Multivariate analysis identified disease duration ≥ 5 years (OR 8.140, 95% CI 1.822-36.369, $P = 0.006$), presence of complications (OR 19.310, 95% CI 5.420-68.796, $P < 0.001$), average/poor cognition (OR 0.118, 95% CI 0.047-0.296, $P < 0.001$), average/poor self-efficacy (OR 0.034, 95% CI 0.010-0.116, $P < 0.001$), ≥ 3 comorbidities (OR 2.645, 95% CI 1.146-6.109, $P = 0.023$), and	



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Zainudin et al. (2024)	BMC Endocrine Disorders	Evaluate whether USM-Insulin Adherence Module (USM-IAM) counseling improves insulin adherence and glycaemic outcomes (FBS, HbA1c) compared with standard counseling among adults with uncontrolled T2DM on insulin.	Single-center randomized parallel controlled trial in a tertiary endocrine clinic. Adults 18-65 years, HbA1c 8-15%, on insulin >=1 year. n=180 randomized (90 per group); 6-month follow-up; intention-to-treat with missForest on imputation; repeated-measures ANOVA. Adherence measured by validated Malay IAQDM.	Both intervention (USM-IAM) and standard counseling groups improved adherence and HbA1c over time. Adherence increased significantly from baseline in counseling (+7.64 points at 3 months, 95% CI 4.40-10.89; P<0.001; +10.79 at 6 months, 95% CI 6.97-14.64; P<0.001) and in USM-IAM (+8.30 at 3 months, 95% CI 5.14-11.47; P<0.001; +10.21 at 6 months, 95% CI 7.03-13.40; P<0.001), with no significant between-group effect (P=0.159). FBS improved significantly only in USM-IAM (-1.374 mmol/L at 3 months, 95% CI -2.50 to -0.25;	Single-center setting; adherence self-reported; missing data required imputation; modest incremental benefit over standard counseling for HbA1c.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
				<p>P=0.011; -1.713 at 6 months, 95% CI -2.95 to -0.473; P=0.003), while standard counseling changes were not statistically significant (6-month P=0.056). HbA1c decreased significantly in both groups: standard counseling -0.617% at 6 months (95% CI -1.03 to -0.20; P=0.001) and USM-IAM -1.03% (95% CI -1.41 to -0.65; P<0.01), with no significant between-group difference (P=0.253). Across both groups, the proportion achieving IAQDM $\geq 80\%$ rose from 8.9% at baseline to 34.7% at 3 months and 34.2% at 6 months.</p>	
Fu et al. (2024)	International Journal of Nursing Practice	Assess psychological insulin resistance (PIR) levels and identify factors	Cross-sectional design; consecutive sampling in a regional teaching	Mean PIR score was 3.14 (max 8). Positive self-management was associated with self-injection, fewer	Limitations were not reported in the provided abstract; design is cross-sectional and relies on self-report measures,



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		associated with self-management among insulin-treated adults with type II diabetes.	hospital outpatient setting (central Taiwan). n=222. PIR measured with barriers to insulin treatment questionnaire; self-management measured with Partners in Health scale.	expectations regarding positive outcomes, no diabetes-related complications, less fear of injection and self-testing, no hypoglycaemia in the previous year, and younger age. Self-injection and absence of complications were the most common factors across self-management domains.	limiting causal inference and increasing risk of measurement bias.
He et al. (2024)	Journal of Clinical Pharmacy and Therapeutics	Identify factors influencing insulin adherence using the KAP model and evaluate whether pharmacist-led interventions targeting these factors improve adherence and glycaemic control in outpatients with T2DM.	Single-center open-label randomized clinical trial (2022-2023) at a tertiary hospital in Nanjing, China. 180 enrolled; 152 analyzed after exclusions (intervention n=75, control n=77). Determinant assessment used MMAS-8, knowledge questionnaire (alpha=0.823), C-DMSSES, and BMQ.	At baseline, mean MMAS-8 adherence score was 4.79±1.92 and 50.66% had poor adherence. Patients with good adherence had lower HbA1c (7.28±1.33% vs 9.77±2.41%, P<0.001), higher knowledge scores (11.70±1.04 vs 7.03±1.53, P<0.001), stronger medication beliefs (9.29±2.19 vs -1.69±3.60, P<0.001), and higher diabetes management self-efficacy.	Single-center design; modest sample and short follow-up; self-reported adherence; longer-term sustainability and generalizability uncertain.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations	
				<p>Intervention: (P<0.001). 3 months of Multivariable weekly analysis telephone identified follow-up plus diabetes duration education; (OR 1.031, control: P=0.008), standard care. medical insurance coverage (OR 1.590, P=0.040), knowledge (OR 1.051, P=0.005), self-efficacy (OR 1.005, P=0.002), and medication beliefs (OR 1.506, P<0.001) as positive predictors of adherence, while HbA1c was negatively associated (OR 0.954, P=0.006). Following the 3- month pharmacist-led intervention, the intervention group showed higher adherence (6.65±0.98 vs 5.56±1.46, P<0.001), lower HbA1c (7.73±2.66% vs 9.00±2.35%, P<0.001), higher self-efficacy (147.09±20.44 vs 128.10±19.43, P<0.001), higher knowledge</p>		



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Nørlev et al. (2025)	Diabetes Research and Clinical Practice	Use connected insulin-pen injection data to characterize basal insulin adherence behavior and associated participant characteristics in telemonitoring among insulin-treated adults with T2D.	Post hoc analysis of the DiaMonT trial telemonitoring intervention arm (12 weeks). n=165 adults used Dexcom G6 CGM, NovoPen6 connected pens, and Fitbit activity trackers. Adherence defined as percent days with pen-recorded basal dose matching HCP-recommended dose; non-adherence <=80%. Regression and group comparisons performed.	Weekly averaged overall adherence ranged from 70.6% (week 1) to 79.3% (week 5) and exceeded 74% in weeks 2-12. Using an >80% threshold, 54% (90/165) were adherent. Deviations from recommended dose occurred in 98.8% of participants; only 1.2% administered all doses exactly as recommended. Across all days, 76.0% (95% CI 75.3-76.7) of doses were correct, 8.2% reduced, 12.4% increased, and 3.3% missed; 62.7% missed at least one dose, but only 7.2% missed >10% of doses. Mean dose deviation was	Intervention-arm only; imputed missing injections as missed (0 units), which may misclassify; reasons for deviations not captured; bolus adherence not assessed because recommended bolus doses were unavailable.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Umpierrez et al. (2025)	Diabetes, Obesity and Metabolism	Compare treatment persistence, adherence, and healthcare resource utilization among older	Retrospective cohort study using Medicare Fee-for-Service and Part D claims (index July 1, 2019-December 30,	3.9%±23.7, and 14.5% made daily basal adjustments without HCP instruction. Non-adherent participants had higher BMI (median 33.8 vs 31.3 kg/m ² ; P=0.04), higher HbA _{1c} (8.1 vs 7.5%; P=0.01), higher total daily insulin dose (60 vs 40.5 IU; P=0.002), and less weekly exercise (P=0.005). In multivariable models, higher daily insulin dose reduced odds of adherence (OR 0.99, 95% CI 0.98-0.99), higher HbA _{1c} reduced odds (OR 0.97, 95% CI 0.94-0.99), and higher physical activity increased odds (OR 2.55, 95% CI 1.23-5.28). Persistence was higher with iGlarLixi (26.9%) than basal-bolus (7.6%) or premixed (18.9%) (adjusted P<0.0001). Mean persistent days	Claims-based exposure cannot confirm medication use; potential unmeasured confounding and coding errors; hypoglycaemia

Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		adult ethnic minorities with T2D after intensifying basal insulin to iGlarLixi versus basal-bolus or premixed insulin.	2021). Adults ≥ 65 years African American, Asian, and Hispanic groups. Basal-bolus and premixed cohorts propensity score matched 1:1 to iGlarLixi (~1,160 per comparison). Persistence defined by a 45-day permissible gap (sensitivity 60-day). Adherence defined as PDC $\geq 80\%$.	were (iGlarLixi) 247.3 vs 156.0 (basal-bolus) and 214.5 (premixed). Adherence (PDC $\geq 80\%$) was numerically higher with iGlarLixi (28.0%) vs basal-bolus (8.0%) and premixed (19.0%), adjusted ORs 2.08 and 1.30. Hypoglycaemia and HCRU rates were generally lower with iGlarLixi, with some subgroup exceptions and low event counts.	identified via ICD-10 without severity stratification; some subgroup models limited by low event counts; clinical measures such as HbA1c were not available.
de Moraes Oliveira et al. (2025)	Health Psychology and Behavioral Medicine	Identify Theory and Planned Behavior (TPB) psychosocial predictors of insulin adherence and glycaemic control among adults with type 2 diabetes using insulin.	Prospective of observational study with baseline and 3-month follow-up in a Brazilian specialty outpatient clinic (Nov 2019-Mar 2020). Baseline n=119 (110 completed To); follow-up n=70. TPB	Attitude predicted Intention (beta=0.36; P=0.0173). Intention predicted adherence: each 1-point increase in Intention corresponded to a 12.5% mean increase in dose proportion and a 25% higher probability of taking insulin	High attrition reduced power and may introduce bias; single-site recruitment; adherence measured by self-report; Perceived Behavioral Control reliability modest (alpha=0.57); short follow-up and omission of indirect belief-based TPB



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Muhamad et al. (2025)	Current Medical Research and Opinion	Identify demographic, clinical, lifestyle, and treatment-related predictors of insulin adherence among adults with T2D on insulin therapy.	Cross-sectional study in an Iraqi tertiary diabetes clinic (2024). Adults with T2D on insulin ≥ 6 months; n=111. In-person structured validated questionnaire. Adherence defined as taking $\geq 80\%$ of prescribed	every day or measured at practically every day. Perceived Behavioral Control moderated effects of Attitude and Subjective Norm on Intention (interaction betas negative). Intention did not predict HbA1c at follow-up after item and GEMA dose proportion; HbA1c measured by HPLC at both timepoints. Regression and moderation analyses performed.	Among 111 participants, 44.1% were adherent ($\geq 80\%$ of prescribed injections) and 55.9% were non-adherent. In univariate analyses, adherence was higher among those following a diabetic diet (OR 5.13, $P < 0.001$), exercising regularly (OR



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations	
				<p>injections over 2.96, $P=0.033$), prior 30 days. self-injecting Univariate insulin (OR 2.231, $P=0.040$), and multivariate performing logistic SMBG (OR 2.596, $P=0.020$). Lower regression with adherence was backward associated with elimination; current smoking model (OR 0.104, $P=0.003$), family diagnostics history of reported. diabetes (OR 0.031, $P<0.001$), diabetes complications (OR 0.178, $P<0.001$), hospital admission in the past year (OR 0.132, $P<0.001$), other chronic diseases (OR 0.004, $P<0.001$), injection fear (OR 0.406, $P=0.041$), and herbal medicine use (OR 0.406, $P=0.041$). Ten insulin-belief items did not differ between adherent and non-adherent groups (all $P>0.05$). In the final multivariate model, SMBG was a positive predictor (OR 3.679; 95% CI 1.069-12.661; $P=0.039$), while</p>		



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Newson et al. (2025)	Patient Preference and Adherence	Document suboptimal insulin dosing (missed/skipped and mistimed basal/bolus doses) and identify barriers and desired solutions among adults with diabetes using analog insulin pens.	Multinational cross-sectional online survey (US, UK, Germany) conducted November 2021-February 2022. Adults with self-reported clinician-diagnosed diabetes using analog pens; n=1,150 (T2D n=850; T1D	Among adults using analog pens (T2D n=850; T1D n=300), suboptimal dosing in the prior 30 days was common. Overall, 48.2% reported missing/skipping ≥ 1 basal dose (mean 3.6 ± 3.6 ; median 2; IQR 1-5; range 1-30) and 45.7% reported mistiming ≥ 1 basal dose (mean smoking (OR 0.098; $P=0.022$) and family history of diabetes (OR 0.039; 95% CI 0.012-0.125; $P<0.001$) were negative predictors; female gender showed a borderline association (OR 0.226; 95% CI 0.060-0.847; $P=0.072$). Model performance: Omnibus $P<0.001$; Hosmer-Lemeshow $P>0.05$; 84.7% correctly classified; Cox & Snell $R^2=0.468$; Nagelkerke $R^2=0.627$.	Cross-sectional and self-reported behaviors risk and social desirability bias; online panel sampling may exclude people without internet; results pooled across countries; pandemic context may have influenced routines.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations	
				<p>n=300). Users of connected pens/caps/sleeves excluded. Descriptive statistics only.</p> <p>3.9±4.0; median 3; IQR 1-5; range 1-44). Among bolus users, 59.6% missed/skipped bolus doses (mean 4.6±7.4; median 2; IQR 1-5; range 1-90) and 53.6% mistimed bolus doses (mean 5.1±8.13; median 3; IQR 2-5; range 1-120). Key reasons for missed/skipped basal doses were forgetting (34.1%), being too busy/distracted (24.9%), and finding it too complicated/burdensome (24.0%); similar patterns were reported for bolus (busy/distracted 26.2%, forgetting 25.2%, burdensome 17.8%). Although most reported being confident in dosing (somewhat 46.0%; extremely 42.0%), 40.9% did not record insulin doses/timing and 40.2% felt overwhelmed.</p>		



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
				Only 41.3% discussed suboptimal dosing with a healthcare professional in the prior 30 days (T1D 54.3% vs T2D 36.7%). Top very helpful solutions emphasized automation, including auto-recording glucose (41.3%), combining insulin and glucose data (38.9%), and auto-recording insulin dose/timing (35.6%).	
Aroda et al. (2024)	BMJ Open Diabetes Research & Care	Assess real-world persistence and adherence to newly initiated basal insulin in adults with T2D; quantify associations with healthcare resource utilization and direct medical costs; identify predictors of persistence	Retrospective cohort using IQVIA PharMetrics Plus US adults initiating basal insulin 2016-2018; final n=64,953 with continuous enrollment pre/post. Persistence defined by drug/device-specific refill-gap	Over 1 year, 56.8% were persistent and 41.9% adherent. Persistent/adherent patients had fewer hospitalizations and ED visits and fewer hospitalization days (year 1 and year 2; many comparisons P<0.05 to P<0.0001). In year 2, total medical costs were lower for adherent vs	Claims cannot confirm medication ingestion; potential residual confounding/healthy-user bias; limited socioeconomic/clinical detail; generalizability limited to insured continuously enrolled populations; HbA1c subset analyses were small.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		and adherence.	thresholds; adherence by PDC over 360 days (adherent if PDC >=80%). Confounding adjusted via IPTW; predictors via multivariable logistic regression.	non-adherent (\$14,303 vs \$15,661; P=0.005). Prior use of both oral and injectable antidiabetic medication predicted persistence (OR 1.50; 95% CI 1.44-1.57) and adherence (OR 1.48; 95% CI 1.42-1.55).	
Hangaard et al. (2025)	European Journal of Internal Medicine	Evaluate effectiveness and safety of telemonitoring versus standard of care for improving glycemic control in insulin-treated adults with T2D.	Danish multicenter open-label randomized controlled trial (DiaMonT), 3 months. n=331 randomized (telemonitoring n=166; control n=165). Telemonitoring used CGM (Dexcom G6), connected pen (NovoPen 6), activity tracker, apps; clinicians monitored data and contacted participants. Primary outcome: change in	Telemonitoring improved glycemic control: estimated treatment difference for time-in-range was +13.6% (95% CI 7.2 to 20.0), P=0.004. HbA1c decreased by 7.6 mmol/mol (~0.69%), P=0.001; time above range decreased (-13.1%, P=0.004); no difference in time below range. Two intervention-related insulin mix-up/overdose serious adverse events required hospital care; no severe hypoglycemia occurred.	Open-label design; cannot isolate which telemonitoring component drove effect; technology eligibility may limit generalizability; baseline measurement conditions may bias effect estimates; longer-term outcomes and cost-effectiveness not assessed.

Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Galindo et al. (2023)	Journal of Diabetes Science and Technology	Evaluate whether a smart pen cap with alarms/reminders improves adherence, reduces omission/mistiming, and improves glycemic control and satisfaction in adults with uncontrolled T2D on basal insulin.	CGM time-in-range (3.9-10.0 mmol/L) at 3 months; ANCOVA used. Pilot randomized cross-over trial in two clinics (Atlanta). n=80 randomized after run-in. Two 12-week phases: active feedback (alarms/reminders) vs masked control (no feedback). Outcomes included adherence, insulin omission/mistiming, HbA1c, mean daily glucose, and treatment satisfaction (DTSQc). Cross-over analyses used Grizzle and Prescott methods.	Active phase improved daily glucose (147.0±34 vs 157.6±42 mg/dL; P<0.01) and HbA1c reduction favored active vs control (-0.98% vs -0.72%; P=0.006). No significant differences in overall adherence, insulin omission, or mistiming were observed. Satisfaction was high in both phases (DTSQc 15.5±3.7 vs 14.9±3.6).	Small pilot sample; close follow-up and free supplies may overestimate benefits; run-in excluded those unable to use technology; open-label and trial context limit generalizability.
Sungkapi nyo, Yodchai, &	Digital Health	Assess effectiveness of a LINE application-	Quasi-experimental two-group pretest-	Experimental group improved knowledge (3.53±1.52 to	Non-random individual allocation and no blinding;



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
Chinnawong (2025)		based insulin injection support program on knowledge, insulin adherence behaviors, and capillary blood glucose in adults with uncontrolled T2D.	posttest study in a tertiary-hospital diabetes clinic (southern Thailand) over 4 weeks (April-July 2024). n=60 experimental, 30 control). Experimental received LINE rich-menu support plus weekly group meetings; control received standard nursing care. Outcomes: knowledge (0-7), observed behavior checklist (0-20), and fasting capillary glucose. Analyses used t-tests and chi-square/Fisher tests.	4.90±1.47; P<0.001) insulin adherence behaviors (14.37±2.33 vs 17.53±1.70; P<0.001) exceeded control post-test (knowledge 4.90 vs 3.73; behaviors 17.53 vs 14.97; both P<0.001). No significant differences in fasting capillary glucose within or between groups.	potential selection/contamination by clinic-day grouping; short follow-up and reliance on single fasting glucose measure; unmeasured confounders (diet, stress) not controlled.
Bajaj et al. (2025)	Diabetes, Obesity and Metabolism	Post hoc analysis of ONWARDS 5 to describe adherence to app-based dose guidance	Post hoc analysis of the insulin icodec with dosing-app arm. App adherence	Only 5.0% of administered doses differed from app guidance. 56.7% had at least one clinician override	Post hoc analysis; open-label trial may not generalize to routine care; digital access inequities



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		for once-weekly insulin icodec and examine associations with outcomes.	defined by requesting and following dose guidance with automatic titration possible; subgroups by fraction of weeks adherent. Modeling assessed associations between adherence and pre-breakfast SMBG and weekly hypoglycemia described.	(most increases). Higher app adherence (medium/high vs low) was associated with lower modeled pre-breakfast SMBG and higher modeled weekly insulin dose (both $P < 0.0001$). HbA1c decreased across all adherence subgroups; clinically significant hypoglycemia rates were low with no severe hypoglycemia observed.	possible; adherence definition counts clinician overrides as non-adherence, potentially underestimating appropriate titration.
Herman ns et al. (2023)	The Lancet Regional Health - Europe	Test whether a smartphone application for basal insulin titration improves glycaemic control compared with written titration charts among adults with T2D and suboptimal control.	Multicenter open-label parallel randomized controlled trial in Germany (36 diabetes practices), 12 weeks. n=251 randomized (app n=128; control n=123). Intervention titrated basal insulin using My Dose Coach app; control used written chart.	App group achieved greater HbA1c reduction; adjusted between-group difference -0.31% in favor of app (95% CI -0.69 to -0.01 ; $P=0.0388$). Basal insulin dose increased more with app (difference $+5.5$ IU; $P=0.0011$). Safety was comparable; no severe hypoglycemia or ketoacidosis reported.	Short duration; open-label; fasting SMBG focus limits broader glycemic assessment; center-level effects and smartphone compatibility/digital literacy may affect uptake and generalizability.



Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
			Primary outcome: baseline-adjusted HbA1c change at week 12 (intention-to-treat).		
Tamez-Pérez et al. (2022)	Journal of Diabetes Science and Technology	Evaluate a digital-tool-supported basal insulin titration algorithm (My Dose Coach) for achieving fasting glucose targets and improving HbA1c and well-being in adults with T2D in Mexico.	a Prospective single-group open-label pilot study (16 weeks) in a Northern Mexico hospital outpatient setting. n=158 enrolled (141 completed). App suggested dose adjustments based on fasting self-measured plasma glucose; paired t-tests and McNemar tests used; missing data handled with imputation/L OCF.	58.9% achieved SMPG target (90-130 mg/dL), and 55.7% achieved fasting blood glucose goals. Mean SMPG reduction 30.9 mg/dL (P<0.001) and reduction 63.4 mg/dL (P<0.001). HbA1c reduced by approximately 1.78%-1.97% depending on approach. Well-being improved; no severe hypoglycemia events reported.	No randomized control group; short follow-up; single setting; app largely evaluated with insulin glargine; causal inference and generalizability limited.
Snel et al. (2024)	Diabetes Therapy	Evaluate an SMS-supported basal insulin titration service for adults with T2D new to	Single-arm 16-week study; planned n=111 but enrolled n=30 (29 activated). Participants received daily	Among 29 participants who started service, 72% achieved successful titration at week 16 with median	Very small sample size due to recruitment challenges; single-arm design without comparator;

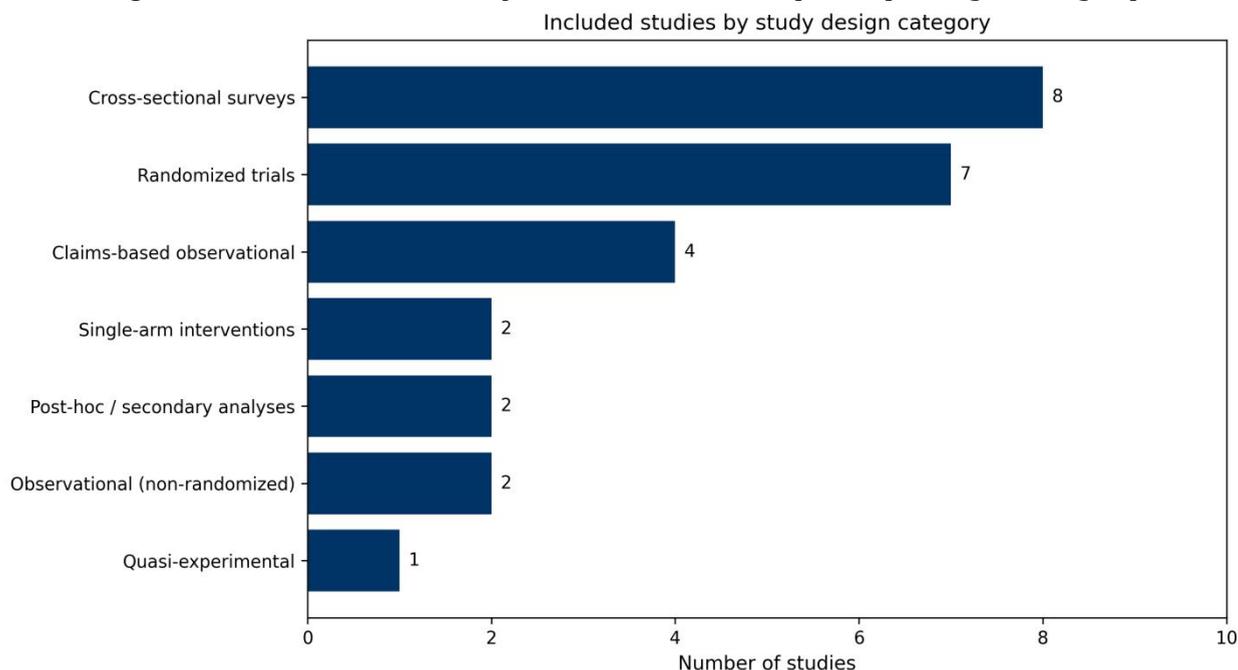


Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		insulin, focusing on achieving stable fasting blood glucose within target range by week 16.	SMS prompts for fasting blood glucose measurement and evening insulin injections, with dose adjustments until target stabilization.	time 49 days. HbA _{1c} decreased by 1.58%, and fasting blood glucose decreased by 64 mg/dL over 16 weeks. No adverse events or device-related issues were reported.	pandemic-era recruitment may bias sample; limited generalizability.
Nayak et al. (2023)	JAMA Network Open	Examine whether a voice-based conversational AI application can support home-based basal insulin titration to achieve faster glycemic control, improve insulin adherence, and reduce diabetes-related emotional distress compared with standard care.	Randomized clinical trial in four primary care clinics at an academic medical center (March 2021-December 2022). n=32 adults requiring initiation or adjustment of once-daily basal insulin; 8-week follow-up; intention-to-treat analysis.	AI group achieved optimal dosing quickly (median 15 days vs >56 days; P=0.006) and had higher adherence (82.9%±20.6 vs 50.2%±43.0; difference 32.7%; P=0.01). More achieved glycemic control (81.3% vs 25.0%; P=0.005) and fasting glucose improved (difference -68.9 mg/dL; P=0.001). Diabetes-related emotional distress improved in AI group (P=0.03).	Small sample size and short follow-up; single health system setting; broader implementation, scalability, and equity considerations not assessed in provided abstract.
Selvadurai et al. (2021)	Saudi Pharmaceutical Journal	Evaluate impact of pharmacist monthly insulin injection technique re-education on	Randomized open-label multicenter trial in 15 Malaysian government clinics (6-month follow-	HbA _{1c} decreased in both groups, with greater reduction in intervention (-1.19%±0.10; P<0.001) versus control	Per-protocol analysis; open-label assessment may bias outcomes; short duration for lipohypertrophy resolution;

Authors (Year)	Journal	Aims	Methodology	Findings	Limitations
		injection technique, adherence, perception toward insulin therapy, lipohypertrophy, and glycaemic control in adults with T2D.	up). n=160 randomized; n=139 completed (control n=69; intervention n=70). Control received standard counseling; intervention received monthly counseling and injection-technique re-education for 4 months. Measures included injection-technique checklist, Medication Compliance Questionnaire, Insulin Treatment Appraisal Scale, and HbA _{1c} .	(-0.79%±0.24; P=0.001). Between-group, improved injection technique (+2.02 score; P<0.001), adherence (+1.48 score; P<0.001), and perception (ITAS -1.99; P=0.037) and achieved an additional HbA _{1c} reduction of 0.63% (P=0.008).	lifestyle confounding not fully controlled; limits on generalizability.

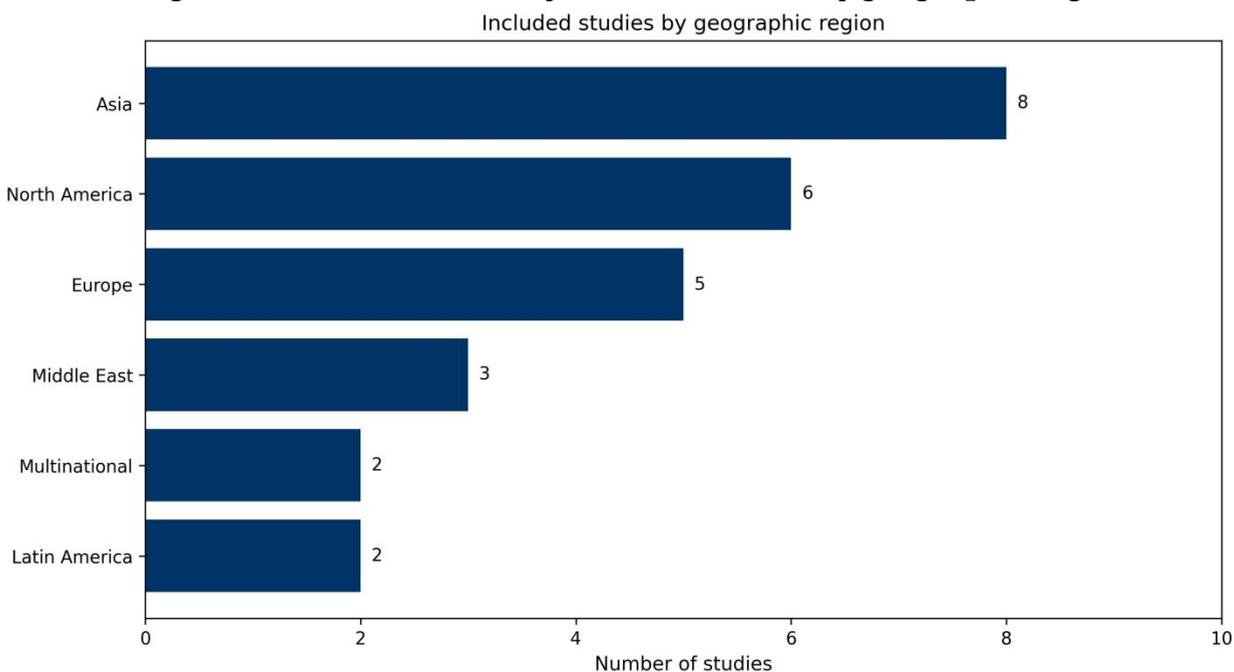
Figures: Characteristics of Included Studies (N = 26)

Figure 1: Distribution of included studies by study design category



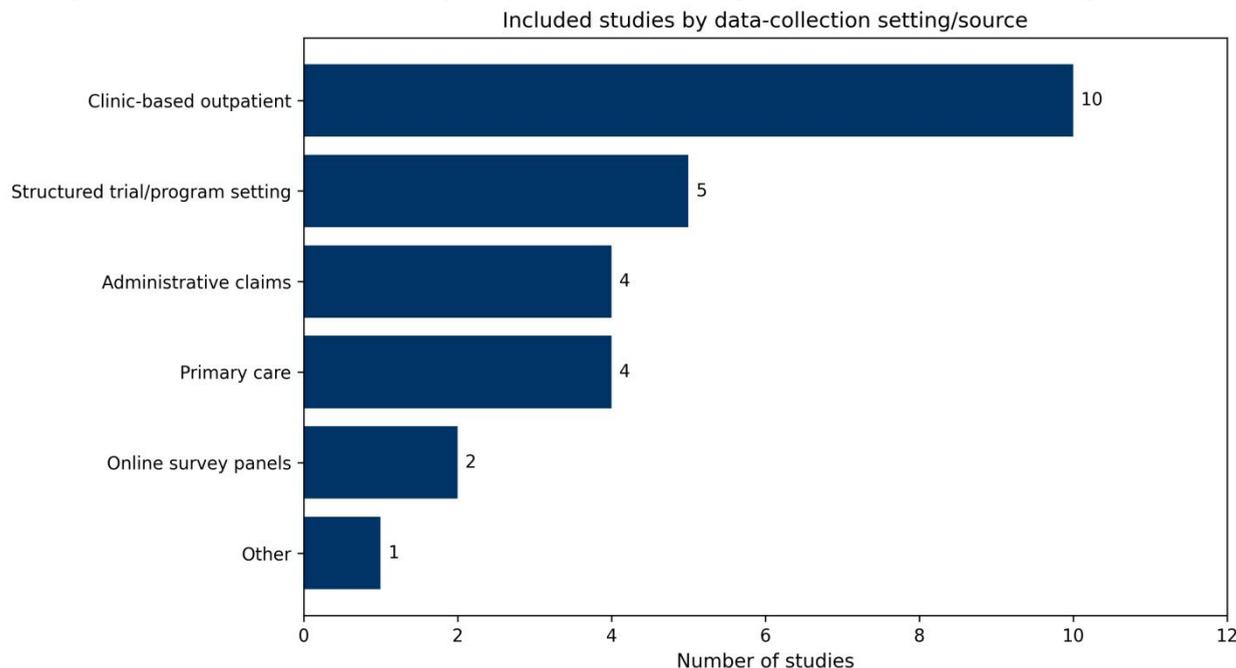
Note. Design categories were harmonized across heterogeneous methodologies (surveys, randomized trials, claims-based analyses, and secondary analyses).

Figure 2: Distribution of included studies by geographic region.



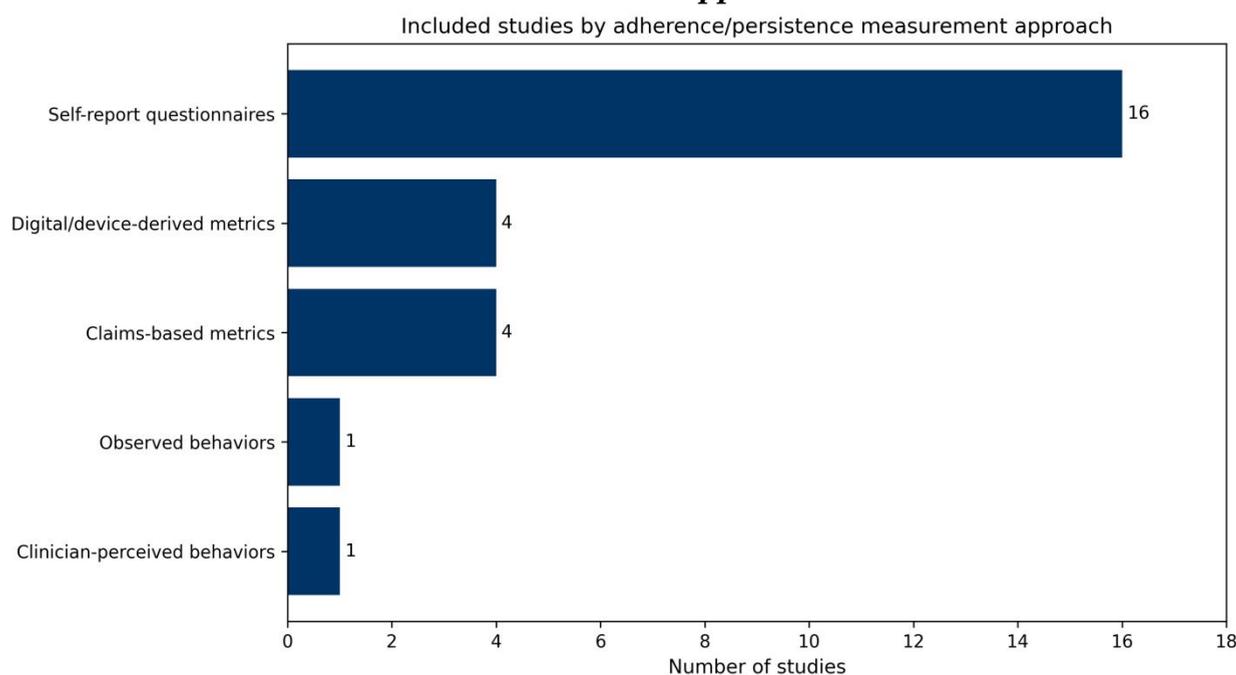
Note. Region reflects the primary study setting or data source location; multinational studies were coded as a separate category.

Figure 3: Distribution of included studies by data-collection setting or source.



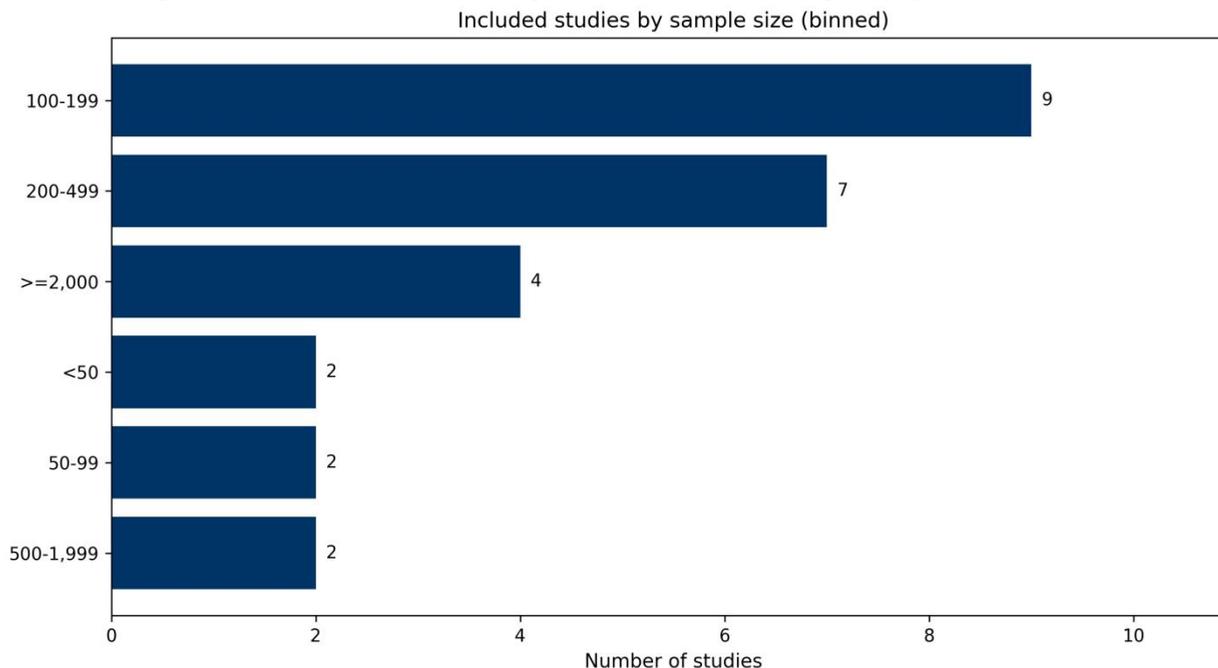
Note. Settings were grouped by dominant data origin (clinic-based outpatient, primary care, administrative claims, online panels, and structured trial/program contexts).

Figure 4: Distribution of included studies by adherence or persistence measurement approach.



Note. Measurement approach was classified by primary adherence or persistence ascertainment method (self-report, digital/device-derived metrics, observed behaviors, clinician-perceived behaviors, or claims-based metrics).

Figure 5: Distribution of included studies by sample size (binned).



Note. Sample-size bins were used to visualize evidence concentration across small, medium, and large studies, including large administrative-claims cohorts.

Thematic Analysis

The thematic synthesis utilized Braun and Clarke’s reflexive method, structured deductively to meet the review objectives (patient/provider/system determinants; modifiable barriers to missed/mistimed doses and discontinuation; clinical and economic outcomes) while facilitating inductive theme development from the reported findings. In practice, the analysis proceeded through: (1) repeated reading of study summaries to achieve familiarization; (2) initial coding of determinants, barriers, and outcomes (e.g., “forgetting,” “dose uncertainty,” “self-efficacy,” “provider relationship,” “insurance,” “persistence–HRU link”); (3) clustering codes into candidate themes spanning multilevel determinants and behavioral mechanisms; (4) reviewing themes against the full set of findings to ensure coverage and non-redundancy; (5) defining and naming themes as explanatory constructs rather than topic lists; and (6) producing an integrated narrative that connects themes to theory and culminates in a parsimonious theoretical model of insulin adherence in adults with T2D. Adherence definitions varied significantly across studies, including self-report scales, missed-dose frequency, PDC thresholds, device-recorded injections, or persistence gaps. This variation necessitated an interpretive synthesis that focuses on convergent mechanisms instead of pooled prevalence estimates.

Theme 1. Cognitive–motivational appraisal of insulin (benefits, barriers, fear, and “psychological insulin resistance”) shapes adherence intentions and day-to-day execution

It is corroborated by 9 out of 26 studies (Yong et al., 2022; Alomran et al., 2020; Xie et al., 2024; Fu et al., 2024; de Moraes Oliveira et al., 2025; He et al., 2024; Muhammad et al., 2025; Selvadurai et al., 2021; Newson et al., 2025). A consistent pattern in the evidence indicates that adherence is not merely a technical act of insulin injection; it is a cognitively and emotionally charged behavior influenced by perceived benefits, anticipated harms, and identity- or stigma-related significances. This cognitive-motivational layer is present in both theoretical studies and practical clinical datasets, serving as an essential link between patient beliefs and

observable adherence patterns.

The HBM-based study from Malaysia found that 60.3% of people were following their insulin regimen. All of the HBM constructs were strongly linked to adherence, and together they explained 40.9% of the variance. The strongest predictors were perceived benefits and self-efficacy (Yong et al., 2022). This finding makes "motivational valuation" a measurable factor: when insulin is seen as helpful and easy to handle, people are more likely to stick with it, even though forgetting is still a common reason for not doing so (66.9% of people said they forgot as a reason for not doing so) (Yong et al., 2022). The same motivational structure can be seen in the Brazilian TPB application, where intention predicted adherence behavior: for every 1-point increase in intention, the mean dose proportion went up by 12.5% and the chance of taking insulin "every day or almost every day" went up by 25%. Attitude predicted intention, and perceived behavioral control changed how much attitude affected intention. This means that when control is high, attitudes matter less because behavior becomes more routine and less thought out (de Moraes Oliveira et al., 2025). These studies together show that the cognitive-motivational substrate is not just descriptive, but also predictive and helpful in understanding how things work.

Psychological insulin resistance (PIR), which is having fearful, avoidant, or resistant attitudes toward insulin, came up as a separate problem in many situations. About a third of people in Saudi primary care had PIR, and negative attitudes were strongly linked to vicarious "bad experience" stories (59.34%) and fears of dependence (54.20%), both of which were significant (Alomran et al., 2020). Notably, PIR was not characterized as a static trait: participants who assessed the doctor-patient relationship as "mostly appropriate" or "very appropriate" exhibited a significantly greater willingness to take insulin (e.g., 64.9% vs 24.5% and 70.3% vs 22.9%, with $P = 0.0001$), suggesting that motivational barriers are relationally modifiable (Alomran et al., 2020). In Taiwan, the average score for PIR was 3.14 out of 8. Better self-management was linked to less fear of injection/self-testing, being younger, not having had hypoglycemia in the past year, and having fewer expectations of positive insulin outcomes. Self-injection and not having complications were common signs of better self-management (Fu et al., 2024). The results from Taiwan build on the Saudi findings by showing that PIR-like barriers are connected to larger areas of self-management, not just the willingness to start insulin. Fear of injections is a tangible emotional factor that emerged with quantifiable correlations. In a Chinese cohort treated with insulin degludec/aspart (IDegAsp), patients reported significant fear (D-FISQ mean 39.19 ± 4.59), and multivariable analysis identified cognitive level and self-efficacy as primary predictors of compliance: average/poor cognition (OR 0.118) and average/poor self-efficacy (OR 0.034) were strongly correlated with decreased compliance, whereas complications (OR 19.310) and longer disease duration ≥ 5 years (OR 8.140) were associated with variations in compliance, in addition to comorbidity burden and living alone (Xie et al., 2024). These effect sizes show that fear and cognition are not minor factors; they are major factors, especially in regimens that require two injections a day and ongoing titration. In Iraq, fear of injection was negatively correlated with adherence in univariate analysis (OR 0.406); however, the final multivariable model highlighted smoking, family history, and SMBG. This indicates that fear may function through interrelated behavioral or contextual pathways and may necessitate targeted measurement to identify independent effects in smaller samples (Muhammad et al., 2025).

Structured education can also change people's beliefs and attitudes. In the Malaysian pharmacist re-education trial, monthly injection-technique re-education enhanced perceptions of insulin therapy (ITAS decreased), adherence (MCQ increased), and HbA_{1c}

levels, with the intervention yielding superior outcomes compared to standard counseling (e.g., adherence change significantly better, $p < 0.001$; ITAS between-group difference $p = 0.037$; HbA_{1c} additional reduction $p = 0.008$) (Selvadurai et al., 2021). The pharmacist intervention based on the Knowledge–Attitude/Belief–Practice (KAP) model revealed that medication beliefs and diabetes management self-efficacy were predictors of adherence. Additionally, targeted pharmacist-led follow-up enhanced adherence (MMAS-8: 6.65 ± 0.98 vs 5.56 ± 1.46), HbA_{1c} ($7.73 \pm 2.66\%$ vs $9.00 \pm 2.35\%$), knowledge, self-efficacy, and beliefs (all $P < 0.05$) (He et al., 2024). These intervention results enhance the interpretive assertion: cognitive–motivational barriers are actionable rather than mere correlates.

Lastly, patients' reports of "burden" and perceived complexity show a lack of motivation and may make it harder for even confident patients to stick to their treatment plan. A survey of pen users from many countries found that many of them missed or took their doses at the wrong time. One of the main reasons they gave was that it was "too complicated/burdensome" (Newson et al., 2025). This backs up the idea that motivational appraisal includes more than just fear and perceived need; it also includes cognitive load and perceived effort. Theme 1 supports Objective 1 (patient-level determinants) and Objective 2 (modifiable barriers). It also gives the theoretical basis for a model in which appraisals (HBM/TPB attitudes and perceived benefits/barriers) affect intention and readiness, which then work with capability and context to determine actual adherence.

Theme 2. Capability and self-regulation (knowledge, skills, self-efficacy, SMBG, and behavioral routines) are proximal drivers of adherence and can be strengthened through targeted interventions

Ten of 26 studies (Yong et al., 2022; Nasruddin & Bachok, 2021; Zainudin, 2024; He, 2024; Selvadurai, 2021; Sungkapinyo, 2025; Xie, 2024; Fu, 2024; Muhammad, 2025; Nørlev, 2025) support this theme. Patient compliance with insulin is another key theme. Patients must know what to do, how to do it, and how to do it again when things change. Education, skill-building, monitoring support, and structured follow-up can change many factors in this capability layer. An indicator of capability and belief, self-efficacy consistently predicts. Self-efficacy and perceived benefits were major predictors of adherence in the HBM study (Yong et al., 2022). In the IDegAsp fear/compliance study, self-efficacy correlated with compliance (average/poor OR 0.034), indicating that confidence in injections and monitoring is necessary for sustained adherence in more complex regimens (Xie et al., 2024). Self-injection improved self-management in Taiwan, suggesting a link between capability and autonomy (Fu et al., 2024). In Iraq, self-injection (OR 2.231) and SMBG (OR 2.596) increased the odds of adherence, proving that capability is a practice, not an attitude (Muhammad et al., 2025).

Despite an 8.4% adherence rate, the Malaysia primary-care adherence study found adherence-related behavioral modifications. SMBG (AOR 5.39), exercise (AOR 3.38), and daily injections (AOR 1.63 for each extra injection) all affected adherence (Nasruddin & Bachok, 2021). SMBG feedback supports dose timing and self-efficacy, and patients who stick to their treatment may monitor more. However, the study shows that adherence is part of a larger group of health-management behaviors that include insulin use, health tracking, and routines. Specific capability interventions had quantifiable benefits. In the randomized USM–Insulin Adherence Module (USM-IAM) counseling trial, both the intervention and standard counseling groups improved adherence scores and HbA_{1c} over time. The percentage of people who adhered at least 80% from 8.9% to 34% at 3 and 6 months increased significantly. The intervention group had significant fasting blood sugar reductions, while the control group did not (Zainudin et al., 2024). However, primary outcomes were not statistically significant. Even

with standard care, repeated counseling and teaching how to change doses can improve capability and routines. Incremental module content may require larger samples, longer follow-up, or objective adherence metrics to establish differences between groups.

Pharmacy interventions caused capability-related changes. Compared to standard care, pharmacist-led weekly calls and education on knowledge and beliefs improved adherence and glycemic control in China (He et al., 2024). Monthly injection technique re-education in Malaysia improved technique, reduced lipohypertrophy in the intervention arm, increased adherence, changed insulin thoughts, and lowered HbA_{1c} more than in the control arm (Selvadurai et al., 2021). These studies demonstrate that "capability" goes beyond generic diabetes education to include injection techniques, missed dose strategies, storage, timing, and titration. When they include reminders, instruction, and feedback, digital support programs can build capability. A LINE app-based support program improved insulin adherence and knowledge, but fasting capillary glucose levels did not change over a 4-week period (Sungkapinyo et al., 2025). However, the lack of glycemic change does not indicate a lack of effect, but rather the discrepancy between short-term follow-up and HbA_{1c} and the complex factors affecting fasting glucose levels.

Finally, device injection data demonstrate capability in real dosing situations. Using connected insulin pens, telemonitoring post-hoc analysis found 70.6% to 79.3% weekly adherence, but only 1.2% adhered to all recommended doses and 98.8% had dose deviations (Nørlev et al., 2025). The alignment of patient behavior with safe, effective dosing decisions in the face of real-life uncertainty is what adherence is, not binary compliance. Even in structured telemonitoring, patients often make changes (sometimes for the right reasons, sometimes not). Nørlev et al. (2025) found that non-adherent participants had higher HbA_{1c} levels, insulin doses, and lower physical activity, suggesting that capability deficits may contribute to clinical complexity and treatment fatigue. The theme 2 addresses Objective 1 (patient-level determinants like self-efficacy, SMBG, skills) and Objective 2 (modifiable barriers) and reframes "adherence" as a self-regulated behavior with measurable capability levers.

Theme 3. Routine disruption and regimen complexity drive missed, mistimed, and incorrect dosing; these are modifiable through simplification, cues, and decision support

Six of the 26 studies support it (Yong et al., 2022; Alsaïdan et al., 2023; Newson et al., 2025; Bellido et al., 2024; Nørlev et al., 2025; Muhammad et al., 2025). In various settings and study designs, the predominant proximal cause of nonadherence is not ideological resistance but rather everyday disruptions, such as being busy, deviating from routine, being away from home, feeling embarrassed in public, or experiencing uncertainty regarding dose calculations. This theme talks about the "execution gap" between what people want to do and what they actually do. This is the exact space where cues to action (HBM), perceived control (TPB), and system supports can help people take their doses on time and not miss them.

Forgetfulness was the main reason for not taking insulin in Malaysia (66.9%), even among people who said they generally had positive feelings about insulin (Yong et al., 2022). In Al-Jouf, Saudi Arabia, 40.7% of people said they forgot to take their insulin every week. Of those who forgot, 38.5% missed 1–2 doses a week, but 33.7% missed 3–4 doses or more. Some of the reasons were being away from home (36.1%), not being able to stick to their diet (24.3%), and being embarrassed to inject in public (23.7%). Common problems included hypoglycemia (31%), gaining weight (26%), and being afraid of needles (22%). Preparing injections, taking them at bedtime, and storing them in the cold were also common problems. Participants also expressed the rationale for simplification: decreasing the frequency of injections (30.8%) and selecting more convenient timing (29.6%) were regarded as facilitators of adherence (Alsaïdan

et al., 2023). Even though this sample had both T1D and T2D, the barriers are very similar to what adults with T2D have gone through in other studies, especially how routine disruptions and the burden of injections affect each other.

Big surveys from many countries show that disruption and complexity are very important. In an online survey of insulin pen users, almost half (48.2%) said they had missed or skipped basal doses in the last 30 days, and almost half (45.7%) said they had mistimed basal doses. Common reasons for this were forgetting, being too busy or distracted, or finding the regimen too complicated or burdensome. A significant number did not document dose/timing, and merely 41% engaged in discussions regarding suboptimal dosing with a healthcare professional, indicating that execution failures frequently remain undetected by clinicians unless specifically inquired about (Newson et al., 2025). The Spanish physician-perspective survey found that the same things caused missed, mistimed, and miscalculated doses: forgetting, being out of routine, being too busy or distracted, and not knowing how much insulin to take. They also found that regimen complexity was a factor in miscalculation (Bellido et al., 2024). Both the patient and the doctor agree on what causes nonadherence, which makes us more sure that routine disruption is a main barrier and not just something that happens in certain situations.

The connected pen study also shows that suboptimal use includes not only missed doses but also changes in dosing (either more or less), which could be a sign of uncertainty or compensatory behavior. 76.0% of doses were "correct" on all days, but 8.2% were lower, 12.4% were higher, and 3.3% were missed. 14.5% made daily basal adjustments without HCP instruction, and 62.7% missed at least one dose during follow-up (Nørlev et al., 2025). This pattern supports the idea that complexity leads to both omission and dosing variability. This is an important detail for interventions, because reminders alone may not fix mistakes or changes in dose that aren't necessary.

Lastly, the Iraq study introduces culturally specific execution barriers that have clinical significance: the use of herbal medications was linked to reduced adherence (OR 0.406), indicating conflicting treatment regimens and beliefs that can interfere with insulin administration, even when negative insulin beliefs were not markedly different among adherence groups (Muhammad et al., 2025). This means that "routine disruption" could include things like alternative medicine practices, social routines, and competing self-care scripts. Theme 3 most directly supports Objective 2 by describing the changeable obstacles that lead to missed or late doses and the risk of stopping treatment. It also encourages interventions that focus on making treatment plans simpler, setting up reminder systems, combining insulin and glucose data collection, and giving real-time dosing advice. These are all things that come up a lot in studies of technology and health systems.

Theme 4. Provider relationship and structured follow-up operate as social influence and accountability mechanisms that reduce resistance and improve adherence behaviors

Five out of 26 studies (Alomran et al., 2020; Bellido et al., 2024; He et al., 2024; Selvadurai et al., 2021; Hangaard et al., 2025) support it. Insulin adherence is relational; it is influenced by the quality and frequency of patient-provider interactions, the extent to which clinicians foster psychologically safe environments for discussing missed doses, and the availability of structured follow-up. This theme encompasses provider-level determinants and corresponds with TPB subjective norms, in addition to HBM cues to action and self-efficacy support. The Saudi PIR study illustrates this correlation with distinctly pronounced contrasts: the propensity to utilize insulin was significantly greater among participants who evaluated the doctor-patient relationship more favorably (Alomran et al., 2020). The mechanism is

credible and clinically recognized: supportive relationships may diminish stigma, rectify misconceptions (e.g., “insulin induces dependence”), and normalize anxieties, consequently reducing psychological resistance and promoting adherence.

Doctors say that time and communication are two of the most important parts of a solution. In Spain, physicians considered “having the time for more meaningful conversations about insulin dosing routines” to be very beneficial (50%), and they similarly appreciated real-time dosing calculation assistance, app reminders, and integrated data systems that facilitate more informed discussions (Bellido et al., 2024). This finding is not just a wish; it shows that problems on the provider side (like time and fragmented data) are system-level factors that show up as problems with patient support on the provider side. Interventional studies demonstrate that structured and repeated provider contact enhances adherence and glycemic outcomes. Pharmacist-led interventions, including weekly calls and education, enhanced adherence, beliefs, self-efficacy, and HbA_{1c} levels compared to standard care (He et al., 2024). Monthly re-education of pharmacists on injection techniques led to better adherence and perceptions, which in turn led to lower HbA_{1c} levels and better technique metrics (Selvadurai et al., 2021). These two trials are very important because they show what “supportive follow-up” means in practice: structured check-ins that happen more than once and deal with skills, beliefs, and practical barriers instead of just counseling once.

Telemonitoring is a digitally mediated but still relational intervention in which clinicians look at incoming data and contact participants over and over again. In the Danish multicenter RCT, telemonitoring improved CGM time-in-range and HbA_{1c} compared to standard care (treatment difference in TIR favoring telemonitoring; HbA_{1c} improved by about -7.6 mmol/mol), with clinician contact time of about an hour per participant during the trial (Hangaard et al., 2025). The main goal was glycemic control, not adherence per se. However, the structure of telemonitoring (frequent reviews, feedback loops, and dose adjustment support) is similar to adherence-support mechanisms in that it makes people more accountable, less uncertain, and allows for quick corrections when mistakes happen. The trial also highlights a caution for implementation: two incidents of insulin mix-up/overdose related to the intervention occurred, emphasizing that enhanced monitoring must be accompanied by human factors safeguards (Hangaard et al., 2025). Theme 4 pertains to Objective 1 (provider-level determinants) and bolsters Objective 2 by demonstrating that nonadherence frequently remains concealed and can be mitigated when clinicians establish regular forums to discuss dosing regimens, anxieties, and mistakes without prejudice.

Theme 5. System-level structures and treatment design (affordability, regimen burden, and simplification through therapy choice) shape persistence and adherence trajectories

Six of the 26 studies support it (He et al., 2024; Aroda et al., 2024; Wright et al., 2022; Edelman et al., 2022; Umpierrez et al., 2025; Alsaidan et al., 2023). Even if people are highly motivated and capable, how well they can stick to a regimen over months and years depends on the structures and designs of the system as a whole. This theme brings together issues of economic access, insurance coverage, and the structural problems that come with regimen complexity, such as how often injections are needed and how devices are set up. In the KAP-based pharmacist trial, insurance and affordability were clear factors. Insurance status had the biggest effect ($\beta = 0.463$) on insulin adherence, and it stayed a significant factor along with knowledge, self-efficacy, beliefs, and diabetes duration (He et al., 2024). This underscores a systemic truth: financial protection facilitates continuous medication access, mitigates rationing behaviors, and fosters adherence-promoting practices (such as SMBG supplies and follow-up). In extensive US claims analyses, adherence and persistence metrics inherently

include access, as they rely on fill patterns; although not flawless indicators of ingestion, they monitor a crucial system-mediated prerequisite: timely insulin acquisition (Aroda et al., 2024; Wright et al., 2022; Edelman et al., 2022; Umpierrez et al., 2025).

Treatment design, especially how simple the regimen is, turned out to be a factor in persistence. A Medicare study of older ethnic minorities found that iGlarLixi had a much higher persistence rate than basal-bolus or premixed regimens (26.9% vs. 7.6% vs. 18.9% using a 45-day gap). iGlarLixi also had a higher adherence rate (PDC \geq 80%) than basal-bolus (8.0%) and premixed (19.0%) (Umpierrez et al., 2025). Basal-bolus regimens require multiple daily injections and frequent dosing decisions. These differences are in line with the burden/complexity mechanism discussed in Theme 3. They also show that simplifying regimens is a structural change, not just an educational one. In Optum claims data comparing a fixed-ratio combination (iGlarLixi) with free-dose basal insulin plus GLP-1 RA, iGlarLixi was linked to higher persistence (44.8% vs. 36.3%; HR 1.22) and much higher adherence (41.3% vs. 18.7%; OR 3.06). It also cut down on visits to the pharmacy and outpatient clinics and cut down on pharmacy claims costs, even though the reductions in HbA_{1c} were similar when follow-up A_{1c} was available (Edelman et al., 2022). The implication is that simplified delivery (single device, fixed-ratio) can enhance persistence/adherence and decrease utilization, even when glycemic variations are diminished by absent lab data or therapeutic equivalence.

The formulation of basal insulin and strategies for switching also have an effect on persistence and adherence. In a claims-based comparison, switching to second-generation glargine 300 U/mL (Gla-300) was linked to slightly higher persistence and adherence than switching to other first-generation basal insulins (persistence 45.5% vs 42.1%; adherence 42.8% vs 38.2%). It also led to a greater drop in HbA_{1c} (-0.65% vs -0.45%) and fewer hospitalizations and emergency room visits. The total cost of healthcare was the same, even though pharmacy costs were higher (Wright et al., 2022). This pattern shows that system-level "value" is affected by clinical stability and less acute care, which may be linked to better persistence and a lower risk of hypoglycemia.

The Saudi basal-bolus descriptive analysis highlights the systemic burdens present in daily life: requirements for cold storage, difficulties in bedtime dosing, and the stigma surrounding public injection are not merely psychological—they are infrastructural and social limitations. Participants clearly stated that minimizing the frequency and timing of injections would enhance adherence (Alsaidan et al., 2023). This corresponds with empirical findings indicating that simpler regimens correlate with enhanced persistence in claims studies (Umpierrez et al., 2025; Edelman et al., 2022).

Lastly, large cohort evidence links persistence and adherence to past treatment history. For example, people who had taken both oral and injectable antidiabetic medications before were more likely to stay on their medications (OR 1.50) and follow their treatment plan (OR 1.48) than people who had only taken oral medications before. This suggests that system exposure and treatment intensification pathways affect readiness and continuity (Aroda et al., 2024). This could be because of better education, more intensive care, or a phenotype of higher engagement made possible by healthcare systems. Theme 5 talks about Objective 1 (system-level determinants) and sets up Objective 3 by showing how regimen design and access lead to adherence/persistence, and how adherence/persistence lead to outcomes and costs.

Theme 6. Adherence and persistence are consistently associated with better glycemic outcomes and lower healthcare utilization; technology can improve outcomes by reducing inertia and supporting dose decisions, though adherence effects vary by modality and measurement

It is backed up by 11 of 26 studies (Wright et al., 2022; Edelman et al., 2022; Umpierrez et al., 2025; Aroda et al., 2024; Hangaard et al., 2025; Galindo et al., 2023; Hermanns et al., 2023; Tamez-Pérez et al., 2022; Snel et al., 2024; Nayak et al., 2023; Bajaj et al., 2025). The last theme brings together clinical and economic outcomes and looks at how likely it is that better adherence/persistence is a mediator of those outcomes. In claims studies, higher adherence and persistence are associated with reduced hospitalizations and lower costs. In digital and telehealth trials, better glycemia is common, but the reason for this is not always clear. It may be due to better titration (which reduces clinical inertia) rather than just more frequent adherence. This difference is important for understanding what "adherence interventions" mean in insulin therapy.

In a substantial U.S. claims cohort of basal insulin initiators ($n = 64,953$), 56.8% exhibited persistence, while 41.9% demonstrated adherence ($PDC \geq 80\%$). Adherence and persistence were linked to fewer hospitalizations and ER visits, shorter hospital stays, and lower total all-cause direct medical costs in the second year after starting treatment for adherent patients (\$14,303 vs. \$15,661). After adjustment, HbA_{1c} levels went down in the group with lab data, which made adherence more likely (Aroda et al., 2024). The scale and analytic weighting (IPTW) bolster the inference that adherence and persistence patterns have significant cost and utilization ramifications, even in cases where pharmacy expenses may rise with persistence.

In the same way, claims-based comparative effectiveness studies show that persistence and adherence lead to better clinical outcomes and less use. People who switched to Gla-300 were more likely to stick with their treatment and had a bigger drop in HbA_{1c} levels. They also had fewer hospitalizations and emergency room visits, and their total costs stayed the same even though their pharmacy costs went up. This suggests that the costs were offset by less acute care (Wright et al., 2022). Compared to free-dose combinations, fixed-ratio combination therapy (iGlarLixi) made people more likely to stick with their treatment and cut down on visits to the pharmacy and outpatient clinics (Edelman et al., 2022). In older adult ethnic minority Medicare beneficiaries, iGlarLixi demonstrated significantly greater persistence compared to basal-bolus therapy, alongside numerically lower hypoglycemia event rates and generally reduced hospitalization and emergency department visit rates (Umpierrez et al., 2025). These studies collectively substantiate Objective 3: adherence and persistence are not merely process metrics; they forecast significant downstream utilization patterns.

Interventions that use technology show a more complex picture: glycemic improvement happens often, but adherence metrics don't always change. This suggests that other factors, like better dose titration and less inertia, could be at work. In a randomized crossover trial utilizing a smart insulin pen cap equipped with alarms and reminders, the active phase resulted in a superior mean daily blood glucose level and a more pronounced reduction in HbA_{1c} (-0.98% vs -0.72%) compared to the masked phase; however, no significant differences were noted in adherence, omission, or mistiming metrics. Patients were still very happy with both phases (Galindo et al., 2023). This means that real-time feedback might help with dosing decisions or engagement without changing the specific adherence metrics used, or that adherence was already high because of the trial context (free supplies, run-in competence screening), making differences harder to see.

Digital tools that are more focused on titration show consistent glycemic benefits, probably by lowering clinical inertia and making it easier to safely raise the dose. In Germany, a smartphone titration app (My Dose Coach) resulted in a more significant reduction in HbA_{1c} compared to written titration charts (adjusted between-group difference -0.31%). Participants

using the app also titrated to higher insulin doses (+5.5 IU difference), with similar safety outcomes (Hermanns et al., 2023). In Mexico, a single-group pilot using the same platform saw significant improvements in reaching their goals (58.9% reached the SMPG goal and 55.7% reached the FBG goal). They also saw a reduction in HbA_{1c} of about 1.8–2.0%, better wellbeing scores, and no severe hypoglycemia (Tamez-Pérez et al., 2022). An SMS-guided titration service, albeit limited in size (n≈29 active participants), reported a 72% success rate in titration, alongside enhancements in HbA_{1c} (–1.58%) and FBG (–64 mg/dl) (Snel et al., 2024). These studies show that structured titration support, whether it's through an app or SMS, can help people with diabetes have better blood sugar levels by making it easier to keep up with regular measurement-adjustment cycles that many routine care systems have trouble with.

When they offer frequent, independent decision support, more advanced digital systems can help people stick to their plans and get better results. In a randomized clinical trial of a voice-based conversational AI for basal insulin management, the AI group achieved optimal dosing significantly faster (median 15 days vs >56 days), exhibited superior insulin adherence (82.9% vs 50.2%), and demonstrated higher rates of achieving glycemic control (81.3% vs 25.0%), alongside improved fasting blood glucose changes and diminished diabetes-related emotional distress (Nayak et al., 2023). This study is small (n=32), but it is important because it shows that decision-support systems can help with both adherence execution (reminders, accountability) and dosing optimization (titration), which can lead to measurable clinical and emotional benefits in the short term.

An app that helps with weekly insulin titration also shows a link between dose guidance adherence and outcomes. In the ONWARDS 5 post hoc analysis, only 5% of doses deviated from app guidance. Increased adherence to app-based dose guidance correlated with significantly lower estimated pre-breakfast SMBG levels and higher weekly insulin doses, while hypoglycemia rates remained low and no severe events were reported (Bajaj et al., 2025). Even though HbA_{1c} got better for all adherence subgroups, the difference in SMBG and dosing suggests a mechanism: following decision support increases the chances of proper titration and better glycemic control, even when the average change in HbA_{1c} is generally good for all participants.

The Danish telemonitoring RCT offers robust evidence that integrated remote monitoring enhances glycemic control (time-in-range and HbA_{1c}) relative to standard care (Hangaard et al., 2025). The trial does not specifically identify adherence as the mediator; however, its elements—integrated pens, CGM visibility, clinician calls, and dose adjustments—likely operate through both adherence (routine reinforcement) and titration (mitigating inertia and rectifying deviations). This is in line with the main point of Theme 6: outcomes get better when systems make insulin self-management less uncertain and less stressful, whether that's by making the regimen simpler, following up with the provider, or using decision-support technologies. Theme 6 directly addresses Objective 3 and also makes it clear that "adherence" interventions in insulin therapy often work through more than one way, such as how often and when to inject, how accurate the dose is, and how well the titration works.

Integrated interpretation mapped to the review objectives

Across themes, determinants of insulin adherence and persistence in adults with T2D cluster into: patient-level cognitive-motivational factors (perceived benefits, fear, PIR, intention), capability factors (knowledge, technique, self-efficacy, SMBG), provider-level relational and communication supports (therapeutic alliance, time for dosing conversations, structured follow-up), and system-level structures (insurance/access, regimen design and

complexity, technology infrastructure). Forgetfulness, disruption of routine, embarrassment in public, travel, storage/timing issues, fear of hypoglycemia, weight gain, needles, and uncertainty about the dose are all things that can cause people to miss or take their doses at the wrong time. Higher adherence and persistence usually lead to better clinical and health-economic outcomes, such as better HbA_{1c} or CGM metrics, fewer hospitalizations or visits to the emergency room, and lower medical costs. Pharmacy costs may be higher at times, but they are often offset.

One important difference between studies is that the choice of how to measure adherence affects what looks "effective." Injection data from devices show that almost everyone has dose deviations, even when overall adherence is moderate to high (Nørlev et al., 2025). This means that interventions should focus on the quality and safety of dose decisions, not just the number of injections. In the same way, titration-support tools may help lower blood sugar even when traditional adherence metrics stay the same (Galindo et al., 2023; Hermanns et al., 2023). This supports the idea that reducing clinical inertia is a separate mechanism.

Theoretical Framework and Proposed Model

To achieve the objective of formulating a theory-based explanatory model, the most robust synthesis is a dual-theory integration of the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). This is because these frameworks are directly examined in the included evidence and collectively address both motivational appraisal and intention-to-action pathways. HBM gives structure to perceived benefits, perceived barriers (like fear and stigma), perceived severity/susceptibility, cues to action, and self-efficacy (Yong et al., 2022). TPB gives structure to attitudes, subjective norms, perceived behavioral control, and intention, which is the most direct predictor of behavior (de Moraes Oliveira et al., 2025). The evidence demonstrates that provider relationships and structured follow-up serve as subjective norms and action cues (Alomran et al., 2020; Bellido et al., 2024; He et al., 2024). Additionally, system-level simplification and decision-support technologies act as externalized perceived control and cues, thereby diminishing the intention-behavior gap (Nayak et al., 2023; Bajaj et al., 2025; Hermanns et al., 2023).

Suggested comprehensive framework (narrative delineation). In adults with T2D undergoing insulin therapy, adherence and persistence stem from the interplay of three interconnected domains. First, cognitive-motivational appraisal integrates HBM perceived benefits and barriers with TPB attitudes: when benefits (glycemic control, complication prevention) surpass barriers (fear of hypoglycemia, weight gain, needles, stigma, dependence myths), patients cultivate enhanced positive attitudes and diminished psychological resistance (Yong et al., 2022; Alomran et al., 2020; Fu et al., 2024; Xie et al., 2024). Second, social influence and perceived control combine TPB subjective norms and perceived behavioral control with HBM cues to action and self-efficacy. For example, supportive relationships with clinicians, meaningful conversations about dosing, follow-up from pharmacists and nurses, and telemonitoring contacts all strengthen norms ("this matters; it's doable") and provide repeated cues. Education and skill-building also increase perceived control and self-efficacy (Alomran et al., 2020; Bellido et al., 2024; He et al., 2024; Selvadurai et al., 2021; Hangaard et al., 2025). Third, doing something in real life turns intention into behavior. In this case, routine disruptions and complex regimens create an intention-behavior gap that shows up as missed, mistimed, or miscalculated doses. This gap is minimized when systems reduce friction through regimen simplification (fixed-ratio combinations, basal strategies) and when technology provides reminders, integrated data capture, and real-time decision support for

titration and dose calculation (Newson et al., 2025; Umpierrez et al., 2025; Edelman et al., 2022; Wright et al., 2022; Nayak et al., 2023; Bajaj et al., 2025; Hermanns et al., 2023). Behavior over time leads to clinical outcomes (HbA_{1c}, CGM time-in-range, fasting glucose) and economic outcomes (hospitalization/ED use, costs). These outcomes then feed back into appraisal: better control may make people feel like they are getting more benefits and have more self-efficacy, while hypoglycemia events or weight gain may make people feel like they have more barriers and make them less likely to stick to their plan (Wright et al., 2022; Aroda et al., 2024; Hangaard et al., 2025). This combined model fits with the strongest quantitative evidence: HBM constructs explain 40.9% of adherence variance, with perceived benefits and self-efficacy being the most important (Yong et al., 2022), and TPB intention predicting dose proportion and adherence likelihood, with attitude predicting intention (de Moraes Oliveira et al., 2025). It also takes into account practical factors like insurance (system-level feasibility), regimen design (structural burden), and digital decision support (externalized cues/control), which is exactly what the review goals are.

Discussion

The variation in insulin adherence operationalization across studies (self-report scales, missed-dose frequency, PDC thresholds, device-recorded injections, persistence gaps) has interpretive consequences as well as methodological ones. Reporting medication adherence requires clear definitions of (a) the adherence phase (initiation, implementation, persistence), (b) the observation window for the metric, and (c) the relationship between the measured behavior and the intended regimen (De Geest et al., 2018). This synthesis is more credible because it focuses on convergent mechanisms rather than pooled prevalence, but prevalence literature should still be used for context. A recent systematic review and meta-analysis found that 55% of people maintain their insulin therapy, with similar low pooled T2D estimates and a lot of variation between studies based on country income and measurement methods (Boonpattharathiti et al., 2024). Due to genuine behavioral failure and rigorous adherence definitions that reflect implementation quality rather than refill continuity, some primary-care samples have extremely low adherence.

The studies reviewed show that appraisal is a proximal determinant of intentions and a distal determinant of execution. However, “psychological insulin resistance” may be oversimplified as an attitudinal barrier independent of affect, identity, and social exposure. The social transmission and cultural pattern of insulin “meaning” (progression, failure, dependency) often leads to anticipatory avoidance even after technical competence (Liu et al., 2023). Stigma-specific evidence shows that concealment motives and anticipated judgment can turn positive beliefs into public-setting dose omission and mistiming—an execution failure that would be misclassified as “forgetfulness” without context (Sedaei et al., 2025). These findings help interpret the multi-country survey signals: regimen “burden” often refers to cognitive load and social risk management, suggesting that education-only interventions may fail.

In the dataset, fear of hypoglycemia is an obstacle, but external evidence suggests nonlinearity: fear may increase adherence (hypervigilance, over-monitoring) and unsafe dose manipulation. The fear of hypoglycemia is linked to maladaptive avoidance behaviors that worsen glycemic outcomes in a large observational study (Wang et al., 2021). Fear may be a cognitive schema rather than an emotional “stop signal” because it is linked to illness perceptions and decreased adherence, with some effects mediated by perceived control (Fariba et al., 2024). Many cross-sectional studies have found unexpected positive correlations between fear and adherence, aligning with vigilant adherence that coexists with other negative

quality of life effects (Yildirim et al., 2024). According to the device-data theme from the included studies, dose deviations are nearly universal even when "adherence" seems moderate, suggesting that affective states may affect insulin administration more than insulin itself.

Diabetes-related distress further depletes self-regulatory capacity under sustained demand, worsening the intention–behavior relationship. Meta-analytic evidence shows a high aggregated prevalence of diabetes distress, with substantial heterogeneity across instruments, suggesting that distress is powerful enough to determine implementation quality at the population level (Feleke & Ashager, 2025). Depressive symptoms and diabetes distress predict decreased glucose-lowering regimen adherence over time, regardless of treatment arm, enhancing causal plausibility beyond cross-sectional confounding (Hoogendoorn et al., 2024 in longitudinal trials). Supplementary evidence shows that psychological distress is an independent predictor of diabetes medication adherence, indicating that adherence interventions that ignore mental health will consistently miss a significant variance component (Akshatha & Nayak, 2024).

The trials show that education and structured follow-up can improve adherence and HbA_{1c} levels, but previous reviews emphasize that "capability" must be defined in terms of injection biomechanics and tissue effects, not knowledge assessments. Lipohypertrophy can reduce absorption predictability, increase glycemic variability, and help patients believe insulin is ineffective, affecting appraisal and dosage adjustments. Improper technique, lipohypertrophy, and glycemic instability were strongly correlated in a comprehensive review (Tian et al., 2023). The systematic review found that structured injection education can reduce lipohypertrophy and improve glycemic outcomes, supporting a mechanistic pathway from skill acquisition to clinical advantage beyond "motivation" (Ichikawa et al., 2022). Correct technique and site rotation improve glycemic control and reduce injection complications, proving that technique is a quantifiable exposure and not a secondary competence (Abujbara et al., 2022). This synthesis proposes redefining "adherence" as implementation fidelity in the context of uncertainty, with technique and titration skills as the main factors likely to produce sustainable improvements.

Self-efficacy was consistently found as a predictor in the reviewed studies, but external modelling suggests that it may mediate knowledge and adherence behaviour (Liu et al., 2023). This has major implications for interventions that prioritise information dissemination over mastery experiences. This mediation framework supports the evidence that multiple pharmacist interactions are more effective than single-session counseling because repetition creates corrective feedback loops that improve perceived control and procedural automaticity.

This paper's physician-perspective evidence shows that time constraints and fragmented data are issues. Adherence-innovation reviews agree that system-design failures that require too much coordination from patients (dose calculation, documentation, supply management) cause adherence failures (Kardas, 2024). According to the current synthesis's focus on mechanism-metric alignment, systematic reviews of telehealth and mobile apps show small to moderate improvements in medication adherence, depending on the intervention component (feedback, tailoring, escalation pathways) and the adherence measure. Pharmacist workflows allow repeated barrier identification and regimen troubleshooting, which may explain why pharmacist-led interventions improve adherence more consistently than pure education (Zhang et al., 2024). Behavior-change-technique mapping in T2D adherence interventions shows that multi-component designs using problem-solving, prompts/cues, self-monitoring, and social support are more effective than information-only approaches, correction to overly "general" education programs (Teo et al., 2024). A recent synthesis on T2D

adherence found that interventions that target behavioral determinants and integrate support into standard care improve adherence (Highton et al., 2025).

The studies' affordability indicators and insulin rationing evidence are consistent at the system level. Cost-related insulin rationing is common among U.S. adults under 65, especially in underinsured and marginalized groups (Fang & Selvin, 2023). The current synthesis's "routine disruption" theme points to macroeconomic structures rather than individual forgetfulness, as global survey evidence shows that out-of-pocket expenses ration insulin and testing supplies, resulting in downstream mental health effects and limited life choices (Souris et al., 2024). Recent analyses suggest that insulin rationing may not correlate with hospitalization or emergency department utilization in certain strata due to concurrent healthcare rationing, which may obscure these relationships. Therefore, these findings advise against using utilization alone to validate adherence interventions in financially constrained populations (Borden et al., 2025). The "insulin crisis" and underuse of cost-reducing alternatives like biosimilar insulin continue to be discussed (Cucinotta et al., 2024).

The current synthesis distinguishes adherence effects from titration and clinical inertia. Delay intensification and suboptimal titration are systemic failures caused by risk aversion, limited follow-up capacity, and insufficient decision support, which lead to patient dose uncertainty and compensatory self-adjustment (Almigbal et al., 2023). By reducing daily decision-making and error risk, simplification strategies may improve persistence and glycemic control. Even though some cohorts lack high-quality adherence measurement, fixed-ratio basal insulin/GLP-1RA combinations improve adherence and satisfaction compared to more complex injectable regimens (Elamin & Barnish, 2024). The claims-based findings were supported by real-world overviews showing that fixed-ratio combinations make treatment adherence easier and reduce hypoglycemia (Frias, 2025). The importance of seeing adherence gains as design effects rather than motivational shifts is also stressed. Once-weekly basal insulin (e.g., icodec) aims to reduce injection frequency, but adherence research requires phase-specific metrics to identify "weekly omission" and delayed dosing patterns that differ from daily basal regimens (Morales et al., 2024).

Integrating glucose and dosage data to aid safe decision-making and reduce documentation burdens is becoming more important as technology guidance recognises connected devices as essential adherence infrastructure assets (American Diabetes Association Professional Practice Committee, 2026). The larger body of connected-pen research also shows that a device's value depends on how well it fits into the workflow and gets feedback. If a device's data does not allow clinician response, it could turn monitoring into surveillance without changing behavior, or worse, it could increase errors if users trust automation too much (Heinemann et al., 2026).

Synthesis Implications

The adherence interventions most likely to succeed across the included studies are those that: (a) concurrently reduce perceived barriers and fear while increasing perceived benefits and confidence; (b) enhance capability through technique training, knowledge acquisition, and SMBG-supported feedback loops; (c) foster supportive contact and normalize discussions regarding missed doses; and (d) structurally alleviate burden through regimen simplification and decision-support tools that align with patients' daily routines. The outcome literature shows that these improvements could be useful for more than just lowering blood sugar levels. They could also lower hospital stays and total medical costs, even if pharmacy costs go up with regular medication use (Aroda et al., 2024; Wright et al., 2022).

Recommendations

Intervention design must be aligned with determinant factors and specific phases, distinguishing between initiation resistance, implementation errors, and non-persistence. Structured, repeated counseling should be used to break down cognitive and motivational barriers like fear, stigma, and myths about dependence. This should include normalizing missed or mistimed dosing disclosure and reframing insulin as a way to improve performance rather than a sign of failure. Capability should be regarded as a technical exposure; regular audits of injection techniques (including site rotation, storage, needle usage, and lipohypertrophy screening) and practical training on dose-related issues (such as missed-dose protocols and travel/public injection planning) should be integrated into follow-up procedures. Simplifying the regimen (for example, by reducing the number of injections and using fixed-ratio options when they make sense) and using cueing systems (like reminders and integrated dose-glucose logging) should help reduce execution failures. Scheduled touchpoints (led by pharmacists or nurses) and conversations based on data should be part of provider workflows to cut down on dose uncertainty and clinical inertia. At the system level, the most important things to do are to make sure that insulin and SMBG/CGM supplies are always available and that digital decision support is integrated with safety measures.

Limitations

Evidence heterogeneity restricts comparability among studies due to the significant variation in adherence constructs (self-report, PDC/persistence, device logs), which conflates initiation, implementation, and persistence. Numerous studies were cross-sectional, limiting causal inference and facilitating confounding by health engagement, disease severity, and access. Claims-based outcomes might wrongly classify real use and mix the effects of insurance into adherence metrics. Device-recorded dosing can pick up on changes, but without context, it can incorrectly label clinically appropriate changes as "nonadherence." A number of intervention studies exhibited brief follow-up periods, small sample sizes, and restricted objective adherence assessments, hindering the identification of lasting effects and mediating pathways.

Future Directions

Research ought to standardize definitions of adherence phases and triangulate measures (claims + device dosing + patient-reported reasons) to differentiate between omission, mistiming, miscalculation, and discontinuation. Future studies should evaluate the suggested HBM-TPB integrated model utilizing explicit mediators (self-efficacy, perceived control, stigma, distress) and moderators (regimen complexity, socioeconomic constraint). Trials ought to juxtapose determinant-matched intervention bundles against education-only controls, incorporating extended follow-up and safety outcomes (hypoglycemia, insulin mix-ups). Implementation science ought to assess scalable team-based models (pharmacist/nurse + digital titration) and measure cost savings resulting from diminished acute utilization within practical limitations.

Conclusion

The best way to explain why adults with type 2 diabetes stick to their insulin is as a multilevel, self-regulated behavior that is influenced by cognitive-motivational appraisal, capability and routines, provider relationship and follow-up, and system-level access and regimen design. Execution gaps—missed, mistimed, and miscalculated doses—are the most common proximal failures. These are made worse by routine disruption and complexity. There is a strong link between better adherence and persistence and better glycemic outcomes and lower healthcare use. However, technology effects often work through titration support and less inertia, not just

through more frequent doses. So, effective strategies must include targeting beliefs and feelings, skill-based support, simpler plans, and systems that make things easier.

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