

Remote Endocrinology Support for Primary Care Clinicians Managing Type 2 Diabetes: A Systematic Review of Randomized Controlled Trials

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Abstract

Remote endocrinology support may strengthen diabetes management in primary care, but the clinical effectiveness of clinician-directed models remains uncertain. This systematic review evaluated randomized trials of structured remote endocrinology support for primary care clinicians managing adults with type 2 diabetes. PubMed/MEDLINE, Europe PMC, and ClinicalTrials.gov were searched through September 29, 2026, supplemented by citation searching. Eligible interventions included electronic consultations, video-based case conferencing, and specialist-led telementoring. Findings were synthesized narratively because of clinical and methodological heterogeneity. Five cluster-randomized trials, including one modified stepped-wedge trial, met eligibility criteria. The clearest favorable findings concerned prescribing: in one trial, guideline-concordant glucagon-like peptide 1 receptor agonist and/or sodium-glucose cotransporter 2 inhibitor use was higher in eligible patients with ischemic heart disease (65.2% vs. 47.6%; difference, 17.6 percentage points; 95% CI, 4.6 to 30.7), whereas glycated hemoglobin target attainment was similar (83.2% vs. 80.9%; $p = 0.28$). Another trial reported greater prescribing increases in a post-randomization matched-cohort analysis (19.3 vs. 6.9 percentage points). Across trials, comparative glycemic and cardiometabolic outcomes showed no consistent improvement. Favorable glycemic findings from telementoring relied on pre-post comparisons rather than randomized treatment-effect estimates. Specialist recommendation uptake was incomplete. Among four results assessed with Risk of Bias 2, three raised some concerns, and one was at high risk of bias; safety reporting was limited. Remote endocrinology support may improve selected prescribing practices, but its effects on clinical outcomes remain uncertain. Larger, rigorous randomized trials evaluating clinical outcomes, implementation, and safety are needed.

Categories: Family/General Practice, Endocrinology/Diabetes/Metabolism

Keywords: clinical endocrinology, electronic consultation, primary medical care, systematic review, type 2 diabetes mellitus

Introduction And Background

Type 2 diabetes (T2D) is managed predominantly in primary care, where clinicians coordinate long-term glycemic, cardiovascular, renal, and weight-related care. Treatment decisions increasingly require attention to cardiovascular and kidney protection alongside glucose control. This broader approach requires individualized treatment choices that account for comorbidities, patient preferences, potential adverse effects, and barriers to accessing therapy. These considerations are particularly relevant when translating treatment recommendations into a practical care plan for an individual patient. The 2022 American Diabetes Association and European Association for the Study of Diabetes consensus recommends glucagon-like peptide-1 (GLP-1) receptor agonists or sodium-glucose cotransporter 2 inhibitors (SGLT2is) for selected patients with cardiorenal risk, independently of background metformin therapy [1]. Yet a systematic review of therapeutic inertia found that, in most included studies, the median interval between above-target glycated hemoglobin (HbA1c) and treatment intensification exceeded one year [2].

Endocrinology input may be particularly useful for persistent hyperglycemia, complex treatment regimens, or uncertainty about medication selection, without replacing longitudinal primary care. Access can nevertheless be constrained. A US workforce analysis published in 2014 estimated a shortfall of approximately 1,500 adult endocrinologist full-time equivalents at that time [3]. Gaps between recommendations and prescribing are also evident: among 537,980 Veterans Affairs patients with T2D and established atherosclerotic cardiovascular disease in 2020, 11.2% received an SGLT2i, and 8.0% received a GLP-1 receptor agonist (GLP-1RA) [4].

Remote endocrinology support offers several ways to connect specialist expertise with primary care

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decisions. Asynchronous electronic consultations provide patient-specific recommendations after record review. Video consultations and case conferences allow real-time discussion between clinicians, sometimes involving patients, while specialist-led telementoring, such as Project ECHO, combines case-based learning with continuing clinical support. Some address individual decisions; others build clinician capacity. A systematic review of 36 electronic consultation studies across specialties reported improved access and avoided referrals, although none of the included studies reported clinical outcomes [5]. Changes in prescribing or referral patterns should therefore not be equated with patient benefit.

The wider diabetes telemedicine literature does not directly answer whether support directed toward primary care clinicians improves care. A meta-analysis of 111 randomized trials of telemedicine interventions reported modest reductions in HbA1c, but it covered heterogeneous telemedicine strategies without isolating clinician-directed endocrinology support [6]. Moreover, remote endocrinology models vary in intensity, delivery, and accompanying interventions; their effects on prescribing and clinical outcomes cannot be assumed to be equivalent. Appraisal must also separate randomized effect estimates from descriptive or non-randomized analyses.

This systematic review aimed to evaluate randomized controlled trials of structured remote endocrinology support directed primarily toward primary care clinicians managing adults with T2D and to narratively synthesize their effects on glycemic and cardiometabolic outcomes; medication optimization and guideline-concordant prescribing; and healthcare utilization, implementation, and safety.

Review

Methods

Study Design and Reporting Standards

This systematic review evaluated randomized controlled trials of remote endocrinology support for adults with T2D managed in primary care. Individually randomized, cluster-randomized, and stepped-wedge randomized designs were eligible. The review was conducted and reported in accordance with the PRISMA 2020 statement [7].

Literature Search Strategy

PubMed/MEDLINE, Europe PMC, and ClinicalTrials.gov were searched through September 29, 2026. PubMed was searched from database inception, while Europe PMC was used to identify recent publications from 2024 onward and preprints not yet indexed in MEDLINE. ClinicalTrials.gov was searched for completed, ongoing, and unpublished trials.

Searches combined concepts related to T2D, remote specialist input, primary care, and randomized study designs. Terms included electronic consultation, teleconsultation, telementoring, Project ECHO, video conferencing, case conferencing, specialist support, shared care, and related terminology. Controlled vocabulary and free-text terms were adapted to each source. No language restrictions were applied.

Forward and backward citation searching of included studies and related-article searching in PubMed were also performed. Reports identified during preliminary scoping were evaluated using the same eligibility criteria. All searches were completed on September 29, 2026 (Table 1).

Source	Search approach	Coverage
PubMed/MEDLINE	(T2D OR T2DM OR diabet*) AND (eConsult* OR teleconsult* OR telementor* OR telemedicine OR "Project ECHO" OR "video conferenc*" OR "case conferenc*" OR "specialist support" OR "shared care") AND ("primary care" OR "general pract*" OR "family pract*" OR PCP* OR FQHC* OR "village doctor*") AND (random* OR trial OR cluster* OR "stepped wedge")	Database inception to September 29, 2026
Europe PMC	Diabetes terms combined with electronic consultation, teleconsultation, telementoring, video conferencing, specialist support, shared care, and randomized-trial terms	Published records from 2024 to September 29, 2026; preprints without date restriction
ClinicalTrials.gov	Diabetes combined with eConsultation, telementoring, Project ECHO, teleconsultation, virtual specialist support, shared care, and remote endocrinology terms	All records through September 29, 2026
Additional searching	Forward and backward citation searching, PubMed-related article searching, and records identified during preliminary scoping	Completed September 29, 2026

TABLE 1: Search strategies.

Eligibility Criteria

Eligibility was defined using the Population, Intervention, Comparator, Outcomes, and Study design framework.

Trials were eligible if they included adults with T2D receiving care in a primary care setting and evaluated structured remote input from an endocrinologist or a multidisciplinary specialist team that included an endocrinologist. Eligible models included asynchronous electronic consultation or specialist recommendations, video-based case conferencing or teleconsultation, and specialist-led telementoring. Ongoing responsibility for diabetes management had to remain primarily within primary care.

Patient-facing components were permitted within multicomponent interventions when clinician-directed specialist support remained a core component, and the specialist team did not assume primary responsibility for diabetes management. Interventions centered predominantly on direct specialist-to-patient telemanagement, specialist replacement of primary care, or in-person specialist input were excluded. Interventions without identifiable endocrinologist involvement were also excluded.

Usual primary care was the eligible comparator, including routine access to specialist advice available within the local healthcare system. Mixed-diabetes populations were eligible if at least 80% of the relevant analytical population had T2D or if T2D-specific results were reported separately.

Eligible outcomes included glycemic and cardiometabolic outcomes, medication optimization and guideline-concordant prescribing, healthcare utilization and costs, implementation outcomes, exposure to specialist support, and safety outcomes. Trials were required to report at least one extractable outcome relevant to these domains (Table 2).

PICOS element	Inclusion criteria	Exclusion criteria
Population	Adults with T2D managed in primary care; mixed populations eligible if ≥80% had T2D or T2D-specific results were reported separately	T1D-only populations; mixed populations with <80% T2D and no separate T2D results; non-primary-care settings
Intervention	Remote endocrinologist or endocrinologist-containing specialist support directed primarily toward primary care clinicians through e-consultation, specialist recommendations, video consultation, case conferencing, or telementoring	Predominantly direct specialist-to-patient management; in-person specialist input; specialist replacement of primary care; no identifiable endocrinologist involvement
Comparator	Usual primary care, including routine specialist access available within the local system	No concurrent comparator; exclusively in-person specialist-led care
Outcomes	Glycemic or cardiometabolic outcomes, prescribing, healthcare utilization or costs, implementation, intervention exposure, or safety	No extractable relevant outcome
Study design	Randomized controlled trials, including individually randomized, cluster-randomized, and stepped-wedge designs, with full results available	Non-randomized studies; protocols without results; ongoing trials; completed trials without available results; conference abstracts without sufficient data

TABLE 2: Study eligibility criteria according to the PICOS framework.

PICOS, Population, Intervention, Comparator, Outcomes, and Study design; T1D, type 1 diabetes; T2D, type 2 diabetes

Study Selection

Following duplicate removal, titles and abstracts were screened against the predefined eligibility criteria. Potentially eligible reports underwent full-text assessment, and reasons for exclusion were recorded. Multiple reports arising from the same trial were linked to avoid duplicate inclusion. Trial registrations were categorized as ongoing, completed without available results, or otherwise ineligible. Study selection was documented using a PRISMA 2020 flow diagram [7].

Data Extraction

Data were extracted using a standardized form. Extracted study characteristics included country, study design, randomization unit, numbers of randomized and analyzed clusters or clinicians, participant sample size, proportion with T2D, participant characteristics, comparator care, and follow-up duration.

Intervention characteristics included delivery modality, frequency, and recipients of specialist input, degree of patient involvement, and relevant co-interventions. Outcome definitions, analytical methods, healthcare utilization, implementation measures, costs, and reported adverse events were also extracted.

Comparative estimates, endpoint values, changes from baseline, ORs, CIs, and p-values were recorded as reported and were not treated as interchangeable measures. Continuous HbA1c outcomes were distinguished from categorical glycemic targets. T2D-specific estimates were preferentially extracted from mixed-diabetes populations when available. Missing numerical values were not imputed.

The analytical basis of each estimate was documented, distinguishing randomized comparisons from matched-cohort and pre-post analyses. When numerical values differed between narrative text and tables, the tabulated result was prioritized, and the discrepancy was documented.

Classification of Interventions

Interventions were classified according to how endocrinology support was delivered to primary care: asynchronous electronic consultation or specialist recommendations, video-based consultation or case conferencing, and specialist-led telementoring. Models were further characterized by the degree of patient-specific guidance, frequency of specialist contact, clinician education, and accompanying co-interventions.

Risk of Bias Assessment

Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool for cluster-randomized trials [8],

targeting the effect of assignment to intervention.

For the main traffic-light figure, one review-relevant result was selected from each trial, prioritizing the principal clinical or treatment outcome where applicable. The assessment covered bias arising from the randomization process; bias arising from the timing of identification or recruitment of participants within clusters; bias due to deviations from intended interventions; bias due to missing outcome data; bias in measurement of the outcome; and bias in selection of the reported result.

Domain-level and overall judgments were classified as low risk, some concerns, or high risk according to RoB 2 decision algorithms. The appropriateness of each analysis for estimating the effect of assignment was also considered. Results that did not provide an identifiable randomized treatment-effect estimate, including descriptive pre-post comparisons across calendar periods, were not assigned a RoB 2 judgment for the randomized effect. Judgments were summarized in a traffic-light plot.

Data Synthesis

Meta-analysis was not performed because of substantial clinical and methodological heterogeneity across the included trials. Interventions differed in their mechanisms and intensity of specialist support, while outcomes included continuous HbA1c change, categorical glycemic targets, practice-level prescribing proportions, healthcare utilization, costs, and implementation measures. Analytical approaches also differed, including randomized comparisons, matched-cohort analyses, and pre-post comparisons.

Findings were therefore synthesized narratively within three prespecified domains: glycemic and cardiometabolic outcomes; medication optimization and guideline-concordant prescribing; and healthcare utilization, implementation, and safety.

Comparative between-group estimates and CIs were prioritized when available. Randomized comparisons were explicitly distinguished from matched-cohort and pre-post estimates, which were reported descriptively and were not interpreted as randomized treatment effects. The direction, magnitude, and precision of effects were described using the original reported metrics. Statistical significance alone was not used to determine effectiveness, and nonsignificant findings were not interpreted as evidence of equivalence.

Formal statistical heterogeneity, meta-regression, and funnel-plot analyses were not undertaken because quantitative pooling was not performed and the number of included trials was small.

Results

Study Selection

The search identified 133 records. After removing 16 duplicates, 117 records underwent title and abstract screening, resulting in the exclusion of 95 records. Of the 22 reports sought for retrieval, one could not be obtained. The remaining 21 reports underwent full-text eligibility assessment, and 16 were excluded because they did not meet the predefined eligibility criteria. Five randomized controlled trials were included in the systematic review and narrative synthesis. The study selection process is presented in Figure [1](#).

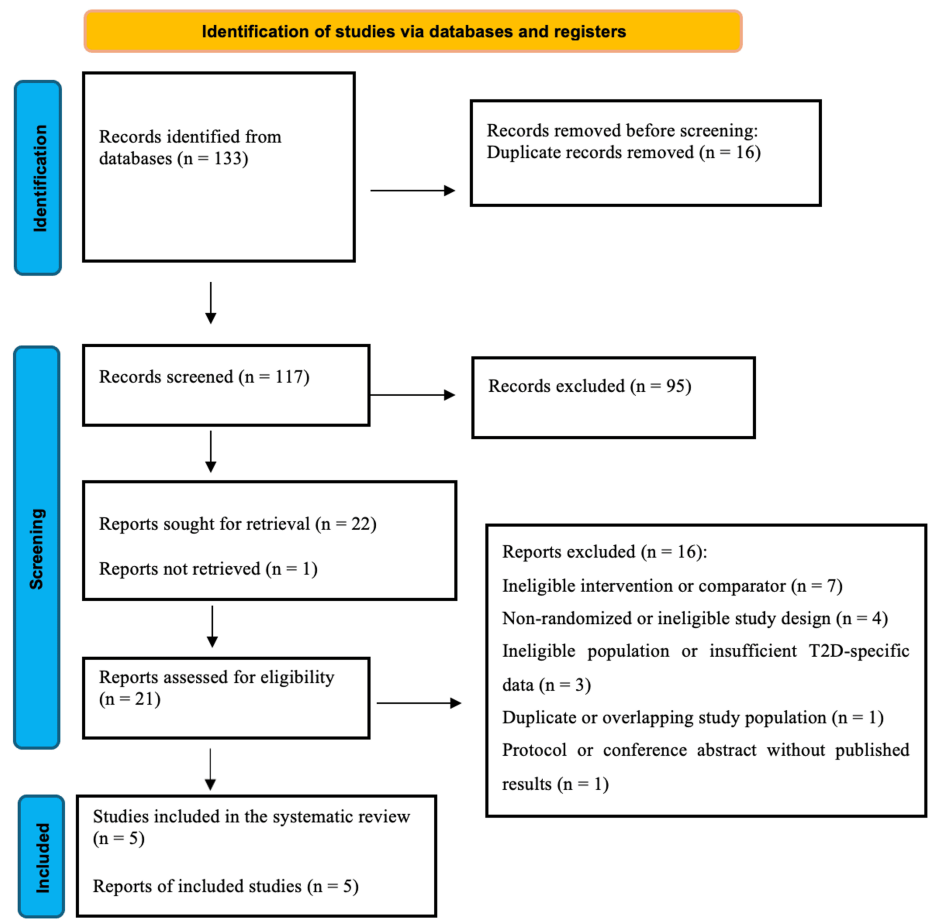


FIGURE 1: PRISMA 2020 flow diagram of the study selection process.

The diagram summarizes study identification, screening, eligibility assessment, and inclusion in the systematic review, adapted from the PRISMA 2020 statement [7].

Study Characteristics

Five randomized trials published between 2008 and 2026 were conducted in China [9], Denmark [10], and the United States [11-13]. All employed cluster randomization, with allocation occurring at the level of village clinics [9], general practices [10], health centers [11], or primary care physicians (PCPs) [12,13]. Four trials used parallel-group designs [9,10,12,13], whereas Walker et al. [11] employed a modified stepped-wedge design with two randomized intervention initiation periods.

Sample sizes and analytical populations varied substantially. Zhang et al. [9] analyzed 215 patients, while Prætorius et al. [10] assessed aggregated outcomes from general practices. Walker et al. [11] reported separate health-center and patient-level cohorts comprising 32,796 and 582 adults, respectively. Oseran et al. [12] randomized 161 physicians but conducted patient-level analyses using a matched cohort following post-randomization exclusions. Smith et al. [13] randomized 97 physicians and enrolled 639 patients, of whom 635 were included in the reported analysis.

Three trials exclusively involved patients with T2D [9,10,12]. In contrast, T2D accounted for 96.6% of Walker's health-center cohort and 66.3% of its patient-level cohort [11], compared with 93.2% of Smith's analytical population [13]. T2D-specific glycemc findings were available for Walker's health-center cohort but not its patient-level cohort or Smith's study. Follow-up ranged from three months to a mean of 21 months. Comparators generally involved usual primary care, although the availability of specialist advice and other background diabetes services varied. Detailed study characteristics are presented in Table 3.

Study	Country	Study design	Population and sample size	Intervention	Comparator	Follow-up	Outcomes assessed
				Village doctor-led	Usual village doctor		

Zhang et al. (2026) [9]	China (rural Jiangsu)	Parallel-group cluster-randomized pilot trial; six village clinics randomized equally between groups.	Adults aged ≥65 years with T2D. 226 enrolled; 215 analyzed (107 intervention, 108 control). Mean age: 72.6 years; 53.0% female.	integrated care incorporating glucose monitoring, additional clinician training, noncash incentives, and video consultations with endocrinologists for persistent hyperglycemia.	care under the National Basic Public Health Service program, including glucose monitoring, counseling, and routine follow-up without access to the intervention telemedicine system.	Three months	HbA1c change (primary), fasting and postprandial glucose, and adherence to blood glucose monitoring.
Prætorius et al. (2025) [10]	Denmark (Aarhus)	Parallel-group cluster-randomized trial; 27 general practices randomized (14 intervention, 13 control). Outcome data collected from 14 intervention and 11 control practices.	Adults with T2D registered at participating practices. Mean of 121 patients with T2D per practice at baseline; outcomes assessed using aggregated practice-level data.	Four 45-minute videoconferences over 12 months between general practitioners and endocrinologists, combining guideline-based education with case discussions. An introductory webinar addressed the diabetes information platform.	Usual primary care with existing written or telephone access to endocrinology advice.	12-month intervention; outcomes assessed at months 12-15.	Guideline-concordant GLP-1RA/SGLT2i, ACE inhibitor/ARB, and statin prescribing (co-primary outcomes); HbA1c, blood pressure, and LDL cholesterol target attainment.
Walker et al. (2025) [11]	United States (California and Florida)	Modified stepped-wedge cluster-randomized trial; 20 federally qualified health centers and comparable centers randomized to intervention initiation in May or December 2021.	Health-center cohort: 32,796 adults with diabetes, including 31,669 with T2D (96.6%). Separate patient-level cohort: 582 adults, including 386 with T2D (66.3%); the latter recruited patients with T1D or T2D requiring multiple daily insulin injections. Mean patient-level age: 51.1 years.	Project ECHO Diabetes, comprising multidisciplinary specialist-led telementoring, case-based clinical support, educational resources, and access to diabetes support coaches.	Usual care during periods preceding intervention implementation.	Health-center assessments across 2021-2022; patient-level follow-up through 12 months.	HbA1c outcomes, glycemic target attainment, continuous glucose monitoring, insulin pump use, and diabetes distress. T2D-specific glycemic outcomes available at the health-center level.
Oseran et al. (2022) [12]	United States (Boston)	cluster-randomized trial; 161 PCPs randomized (81 intervention, 80 control), followed by a matched-cohort analysis.	Adults with T2D, aged <81 years, with HbA1c 8.5-10.5%. 130 intervention patients matched to 130 controls; 98 matched pairs had six-month HbA1c data. Mean age: 62.6 vs. 61.3 years.	Unsolicited, HbA1c-triggered endocrinology electronic consultations providing individualized recommendations following medical record review.	Usual primary care with access to existing endocrinology consultation services.	Six months (primary assessment); additional assessments at 12 and 18 months.	HbA1c change (primary), glucose-lowering medication prescribing, implementation of specialist recommendations, and in-person endocrinology visits.
Smith et al. (2008) [13]	United States (Rochester, Minnesota)	Parallel-group cluster-randomized trial; 97 PCPs randomized (50 intervention, 47 control).	639 patients enrolled (360 intervention, 279 control); 635 analyzed (358 intervention, 277 control) under 94 physicians. T2D: 592 patients (93.2%). Median age: 62 vs. 60 years.	Repeated endocrinologist review of electronic clinical records, with individualized cardiovascular risk management recommendations and evidence-based messages delivered electronically to primary care teams.	Established chronic care model with an on-site diabetes educator and periodic generic electronic messages concerning cardiovascular risk reduction.	Mean 21 months (range, three to 36 months); healthcare costs assessed over one year.	Diabetes care processes, HbA1c, blood pressure, lipid control, estimated cardiovascular risk, medication use, healthcare utilization, and costs. T2D-specific outcomes not separately reported.

TABLE 3: Characteristics of included randomized controlled trials.

ACE, angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; HbA1c, glycated hemoglobin; GLP-1RA, glucagon-like peptide-1 receptor agonist; LDL, low-density lipoprotein; PCP, primary care physician; SGLT2i, sodium-glucose cotransporter 2 inhibitor; T1D, type 1 diabetes; T2D, type 2 diabetes

Remote Endocrinology Support Models

The five trials evaluated three approaches to remote endocrinology support: synchronous video consultation, specialist-led telementoring, and asynchronous electronic consultation. Zhang et al. [9] and Prætorius et al. [10] used video-based interactions, Walker et al. [11] evaluated telementoring, and Oseran et al. [12] and Smith et al. [13] delivered electronic specialist recommendations. The interventions differed in the timing and intensity of specialist involvement, the extent of patient-specific guidance, and the components of care that accompanied them.

The two video-based models had different clinical aims. Prætorius et al. [10] provided four structured 45-minute conferences over 12 months between general practitioners and endocrinologists. Each session combined guideline-based education with discussion of patient cases chosen by the general practitioners, who documented the clinical decisions. Zhang et al. [9] used three-way consultations between village doctors, endocrinologists, and patients whose glycemic control remained inadequate after initial management by the village doctor. This intervention also included additional clinician training and small noncash rewards for patients whose blood glucose was within the target range.

Asynchronous support gave individualized recommendations without any direct contact between specialist and patient. Oseran et al. [12] used HbA1c-triggered electronic consultations based on endocrinologist review of the medical record, and PCPs decided whether to act on the recommendations. Smith et al. [13] used repeated specialist reviews linked to clinical encounters to send patient-specific advice on cardiovascular risk management, together with evidence-based messages. Both groups in this trial received care within an established chronic care model that included an on-site diabetes educator.

Walker et al. [11] used interactive telementoring sessions led by specialists, with on-demand clinical support, recorded educational material, and access to diabetes support coaches for patients. Unlike the other models, which centered on individual patients, this approach focused on clinician education and capacity building.

In three trials, the comparison was additional structured specialist support against usual care that already included some access to endocrinology advice [10,12,13]. The contribution of individual components could not be separated in the multicomponent interventions [9,11].

Clinical and Treatment Outcomes

Comparative glycemic results were largely inconclusive, and outcome definitions and follow-up periods varied considerably. In Zhang et al. [9], mean HbA1c fell by 0.42% in the intervention group and by 0.23% with usual care after three months. The adjusted between-group difference in change was -0.16 percentage points (95% CI, -0.47 to 0.14; $p = 0.135$). Fasting glucose fell more quickly in the intervention group during weekly monitoring (group-by-week interaction $\beta = -0.05$; 95% CI, -0.09 to -0.01; $p = 0.023$), but postprandial glucose did not differ significantly between groups.

Oseran et al. [12] reported six-month HbA1c reductions of 0.89% in the intervention group and 0.69% in matched controls ($p = 0.28$). There were no significant differences at 12 or 18 months. These estimates came from a matched-cohort analysis carried out after post-randomization exclusions, not from a comparison of all patients assigned through clinician randomization. In Smith et al. [13], median HbA1c at follow-up was 6.7% in both groups, with an adjusted difference of 0.00 on the log-transformed scale (95% CI, -0.03 to 0.03; $p = 0.95$). The proportion reaching HbA1c <7% was also similar (53% vs. 56%; OR 0.91; 95% CI, 0.65 to 1.28).

Prætorius et al. [10] measured attainment of glycemic targets rather than change in mean HbA1c. The proportion reaching HbA1c <7.5% was 83.2% in the intervention group and 80.9% in controls (difference, 2.3 percentage points; 95% CI, -2.0 to 6.6; $p = 0.28$). Blood pressure and low-density lipoprotein (LDL) cholesterol targets did not differ significantly between groups. Smith et al. [13] likewise found no significant differences in blood pressure or estimated 10-year coronary risk. However, the proportion reaching LDL cholesterol <130 mg/dL was lower in the intervention group (76% vs. 82%; OR, 0.71; 95% CI, 0.50 to 0.99).

In Walker et al. [11], the proportion of adults with T2D and HbA1c >9% fell from 24.0% before implementation to 18.9% afterward ($p < 0.0001$). This figure came from aggregate health-center data and is a pre-post comparison, not a treatment effect estimated from the randomized rollout. The patient-level

HbA1c analyses included both type 1 and T2D and did not report separate estimates for T2D.

Taken together, the comparative analyses did not show a consistent improvement in HbA1c or cardiometabolic outcomes. However, the width of the CIs, the differences in outcome measurement, and the analytical limitations mean that these nonsignificant findings cannot be read as evidence of equivalence or as evidence that clinically relevant effects are absent.

The clearest medication-related differences concerned prescribing of GLP-1RAs and SGLT2is. In Prætorius et al. [10], 65.2% of patients with T2D and ischemic heart disease in intervention practices received a GLP-1RA and/or SGLT2i, compared with 47.6% in control practices (difference, 17.6 percentage points; 95% CI, 4.6 to 30.7; $p = 0.01$). Prescribing of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers for albuminuria was similar between groups (94.7% vs. 95.8%), as was statin prescribing among eligible patients (90.1% in both groups).

Oseran et al. [12] reported a larger increase in GLP-1RA and/or SGLT2i prescribing in the intervention group than in matched controls (19.3 vs. 6.9 percentage points; $p = 0.003$), driven mainly by SGLT2i prescribing (12% vs. 2%; $p = 0.005$). Baseline SGLT2i prescribing was lower in the intervention group (1.5% vs. 9.2%), and this imbalance should be considered when interpreting the later change. An increase in the number of glucose-lowering medications was also more common in the intervention group (26.2% vs. 13.1%; $p < 0.001$). Changes in metformin prescribing (+3.1% vs. -3.1%) and sulfonylurea prescribing (+1.5% vs. -6.9%) also favored the intervention (both $p = 0.03$).

In Smith et al. [13], aspirin use was higher with specialist decision support (66% vs. 52%; OR, 1.99; 95% CI, 1.31 to 3.02). Use of metformin, insulin, statins, and renin-angiotensin system inhibitors did not differ significantly. The remaining trials did not report comparable estimates for glucose-lowering prescribing [9,11].

In the trials that assessed both domains, improvements in some prescribing measures were not matched by statistically significant differences in glycemic outcomes [10,12,13]. These results describe prescribing decisions only. They do not show whether medications were dispensed, whether patients took them, or whether they led to clinical benefit.

Healthcare Utilization and Implementation Outcomes

Two trials assessed healthcare utilization. Oseran et al. [12] reported fewer subsequent in-person endocrinology visits in the intervention group than in matched controls (13 vs. 29; $p = 0.012$), while the number of solicited electronic consultations was the same in both groups (four each). Smith et al. [13] found no significant differences in office visits ($p = 0.28$), formal endocrinology referrals ($p = 0.35$), or contacts with the diabetes educator ($p = 0.45$).

Smith et al. [13] also reported lower adjusted total healthcare costs in the intervention group over one year (difference, -\$2,311; 95% CI, -\$4,667 to -\$266; $p = 0.02$) and lower outpatient costs (difference, -\$288; 95% CI, -\$550 to -\$25; $p = 0.04$). These figures reflect overall healthcare spending rather than diabetes-specific costs. The investigators attributed much of the difference to hospitalizations for elective musculoskeletal and orthopedic care in the control group and acknowledged that it may have arisen by chance. The cost analysis did not include the cost of developing the electronic decision-support system.

Exposure to specialist recommendations was incomplete. In Oseran et al. [12], 145 of 275 initially eligible intervention patients (53%) were excluded after eligibility reassessment or specialist review, and the median interval from generation of the eligibility list to electronic consultation was 94 days. Across 130 consultations, endocrinologists made 211 management recommendations, of which 80 (38%) were implemented within six months. Adjustments to existing medications were implemented more often than new medications (53% vs. 28%).

In Smith et al. [13], 951 of 1,361 specialist reviews (70%) identified gaps in care and generated recommendations. PCPs rated the recommendations as useful in 59% of evaluated instances and reported using them in patient management in 49%. In Zhang et al. [9], 34 of 107 intervention patients (31.8%) received no endocrinology teleconsultation, 51 received one, and 22 received two. Adherence to blood glucose monitoring was higher with integrated care than with usual care (87.60% vs. 76.47%; adjusted difference, 12.29 percentage points; 95% CI, 6.42 to 18.17; $p < 0.001$). The separate effects of teleconsultation and patient incentives could not be determined.

Walker et al. [11] did not report session attendance, so individual exposure to telementoring could not be quantified. In the patient-level cohort, which included both types of diabetes, continuous glucose monitoring use rose from 25.1% to 36.8% and insulin pump use from 15.3% to 18.3%. Both are pre-post changes, not randomized comparisons specific to T2D. At the health-center level, technology use data were available from only seven centers for continuous glucose monitoring and six for insulin pumps.

Prætorius et al. [10] reported no serious adverse events during the trial. Adverse events, including hypoglycemia, were not reported in the remaining four trials [9,11-13], and absence of reporting should not be taken as absence of harm (Table 4).

Study	Glycemic and cardiometabolic outcomes	Medication-related outcomes	Healthcare utilization and implementation
Zhang et al. (2026) [9]	HbA1c change: -0.42% vs. -0.23%; adjusted difference -0.16 percentage points (95% CI, -0.47 to 0.14). Fasting glucose group-by-week interaction: β = -0.05 (95% CI, -0.09 to -0.01).	No comparative prescribing outcomes reported.	Monitoring adherence: 87.60% vs. 76.47%; adjusted difference 12.29 percentage points (95% CI, 6.42 to 18.17). 34 of 107 intervention patients received no teleconsultation.
Prætorius et al. (2025) [10]	HbA1c <7.5%: 83.2% vs. 80.9%; difference 2.3 percentage points (95% CI, -2.0 to 6.6). No significant differences in blood pressure or LDL target attainment.	GLP-1RA/SGLT2i prescribing among eligible patients: 65.2% vs. 47.6%; difference 17.6 percentage points (95% CI, 4.6 to 30.7). No significant differences in ACE inhibitor/ARB or statin prescribing.	Four scheduled video conferences over 12 months. No serious adverse events reported.
Walker et al. (2025) [11]	T2D HbA1c >9%: 24.0% before vs. 18.9% after implementation; pre-post comparison, not a randomized treatment effect.	No comparable T2D-specific prescribing outcomes reported.	Patient-level CGM use: 25.1% to 36.8%; insulin pump use: 15.3% to 18.3%. Mixed-diabetes cohort; pre-post changes.
Oseran et al. (2022) [12]	Six-month HbA1c change: -0.89% vs. -0.69% in matched pairs (p = 0.28). No significant differences at 12 or 18 months.	GLP-1RA/SGLT2i prescribing change: +19.3 vs. +6.9 percentage points (p = 0.003). Increase in number of glucose-lowering agents: 26.2% vs. 13.1% (p < 0.001).	In-person endocrinology visits: 13 vs. 29 (p = 0.012). 80 of 211 recommendations (38%) implemented.
Smith et al. (2008) [13]	Median HbA1c at follow-up: 6.7% in both groups; adjusted difference 0.00 on the log scale (95% CI, -0.03 to 0.03). LDL <130 mg/dL: OR 0.71 (95% CI, 0.50 to 0.99).	Aspirin use: 66% vs. 52%; OR 1.99 (95% CI, 1.31 to 3.02). No significant differences in other major medication classes.	Adjusted annual total healthcare cost difference: -\$2,311 (95% CI, -\$4,667 to -\$266). PCPs reported using 49% of evaluated specialist messages.

TABLE 4: Clinical, treatment, and healthcare delivery outcomes.

ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CGM, continuous glucose monitoring; GLP-1RA, glucagon-like peptide 1 receptor agonist; HbA1c, glycated hemoglobin; LDL, low-density lipoprotein; SGLT2i, sodium-glucose cotransporter 2 inhibitor; T2D, type 2 diabetes

Risk of Bias Assessment

Risk of bias was assessed for one prespecified result per trial using the RoB 2 tool for cluster-randomized trials [8]. Of the four assessed results, three had some concerns [9,10,13], and one was at high risk of bias [12]. Outcome measurement was at low risk in all four. Most concerns arose at the participant level. Allocation concealment was not described in two trials [9,12], and in Smith et al., patients were recruited after their physicians had been allocated [13]. In Prætorius et al., the analyzed patients were identified from practice records after randomization, and two control practices withdrew before outcome collection [10]. In Oseran et al., 53% of eligible intervention-arm patients were excluded after randomization, and the remainder were compared with matched controls, so the analysis did not preserve the randomized comparison [12]. The analysis plan was unavailable or changed after randomization in three trials [9,12,13]. Walker et al. was not assessed because its estimates compared calendar periods before and after implementation rather than randomized groups [11]. Domain-level judgments are shown in Figure 2.

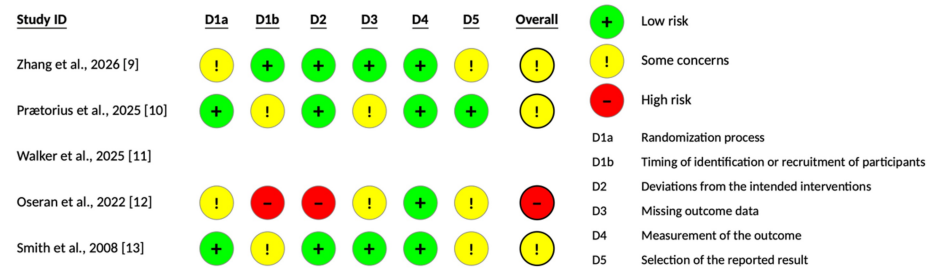


FIGURE 2: Risk of bias assessment of the prespecified comparative result of each included trial using the Cochrane RoB 2 tool for cluster-randomized trials.

Risk of bias was assessed using the Cochrane RoB 2 tool for cluster-randomized trials[8]. Assessed outcomes were HbA1c change at three months [9], GLP-1RA/SGLT2i prescribing in patients with ischemic heart disease [10], HbA1c change at six months [12], and HbA1c at the end of follow-up[13]. Green (+) indicates low risk, yellow (!) indicates some concerns, and red (-) indicates high risk. Walker et al. [11] was not assessed because the selected outcome was reported as a pre-post comparison rather than an identifiable randomized treatment-effect estimate.

GLP-1RA, glucagon-like peptide-1 receptor agonist; HbA1c, glycated hemoglobin; RoB 2, Risk of Bias 2; SGLT2i, sodium-glucose cotransporter 2 inhibitor

Discussion

Across five cluster-randomized trials, remote endocrinology support changed prescribing decisions more consistently than glycemic or cardiometabolic outcomes. The clearest signal was greater GLP-1RA and SGLT2i use in eligible patients [10], supported less securely by a matched-cohort analysis [12]. Comparative HbA1c, blood pressure, and lipid outcomes showed no consistent improvement [9,10,12,13], but imprecision in several trials, limited follow-up, and departures from randomized comparisons prevent firm conclusions.

This divergence is clinically coherent. Prætorius et al. measured prescribing in patients with ischemic heart disease [10], for whom these agents are indicated for cardiorenal protection, largely independent of glucose lowering [1]. In a network meta-analysis, both classes reduced all-cause and cardiovascular mortality, nonfatal myocardial infarction, and kidney failure, with absolute benefit rising with baseline risk [14]. Better prescribing may therefore matter without HbA1c change, although no included trial measured these events. Prescribing does not necessarily indicate medication exposure: 31.4% of new diabetes prescriptions in one large cohort went unfilled [15], while none of the included trials directly assessed medication adherence.

The models engaged primary care differently, and cross-trial contrasts cannot rank them. Unsolicited record-based advice targeted individual decisions [12,13], case conferencing centered on cases chosen by general practitioners [10], and Zhang et al. embedded video consultation in a multicomponent package [9]. Contrast and headroom were often limited: three comparators already offered specialist advice [10,12,13], HbA1c target attainment exceeded 80% in both arms of Prætorius et al. [10], and both arms of Smith et al. reached a median HbA1c of 6.7% [13]. In a quality improvement meta-analysis, interventions targeting professionals alone appeared beneficial only when baseline HbA1c control was poor [16]. Telementoring had mostly been evaluated through non-randomized studies and self-reported provider outcomes [17]; Walker et al. [11] used a randomized rollout but reported a pre-post glycemic estimate.

Exposure was incomplete: in Oseran et al., 53% of eligible intervention patients were excluded before consultation, the median wait was 94 days, and 38% of recommendations were implemented [12]; physicians reported using 49% of evaluated messages in Smith et al. [13]; and 31.8% of Zhang et al.'s intervention patients had no teleconsultation [9]. Attrition from available to delivered, accepted, and prescribed advice may reflect timeliness, workflow integration, and clinician engagement, although barriers likely differed by model. A broader meta-analysis of clinical decision support interventions found a pooled 5.8 percentage-point improvement in recommended care processes, compared with a median 0.3 percentage-point improvement in clinical target attainment [18]. Fewer in-person endocrinology visits [12] may signal substitution rather than efficiency, and lower costs in Smith et al. [13], influenced by elective orthopedic admissions among controls and excluding development costs, cannot establish cost-effectiveness. Remote support should complement, not replace, referral when specialist-led care is needed. Similar uncertainty is evident in the broader e-consultation literature: Vimalananda et al. found that evidence for important outcomes remained modest, with most studies using observational designs within a single healthcare system [19]. Although that review covered multiple specialties, it reinforces the need to distinguish encouraging service-level findings from demonstrated clinical effectiveness in diabetes care.

Strengths include a focused clinician-directed question, restriction to randomized designs, classification of delivery models, and explicit distinction between randomized and non-randomized estimates. Confidence is limited: cluster randomization did not prevent post-allocation identification or exclusion of participants; three of four results assessed with RoB 2 raised some concerns, one was at high risk of bias [12], and Walker et al. [11] was not assessed. Interventions were often multicomponent, some populations included type 1 diabetes, follow-up varied, adverse events were rarely reported, and only three countries were represented. At the review level, only five trials were eligible, heterogeneity precluded pooling, and Embase and CENTRAL were not searched.

Future cluster trials should be powered for patient-level outcomes, identify eligible participants before randomization where feasible, preserve randomized allocation in their analyses, and extend follow-up to capture cardiorenal events. They should report recommendation uptake, medication dispensing and adherence, hypoglycemia, intervention fidelity, clinician engagement, and implementation costs. Proctor et al.'s implementation outcomes framework distinguishes adoption, acceptability, feasibility, fidelity, and sustainability from service and clinical outcomes [20]. Applying these distinctions to remote endocrinology support could help clarify whether limited clinical improvement reflects incomplete delivery or uptake, rather than insufficient effectiveness of the support itself. Meanwhile, remote endocrinology support is best viewed as a way to improve selected prescribing decisions, not an established route to better glycemic or clinical outcomes.

Conclusions

Evidence from five randomized trials suggests that structured remote endocrinology support for primary care clinicians may improve selected prescribing outcomes, particularly guideline-concordant use of GLP-1RAs and SGLT2is. However, consistent improvements in glycemic and cardiometabolic outcomes were not demonstrated, and the implications for longer-term clinical benefit remain uncertain. The small number of heterogeneous trials, incomplete implementation of specialist recommendations, and methodological limitations, including risk of bias concerns, restrict confidence in these findings. Further adequately powered randomized trials with appropriate analytical methods, longer follow-up, and standardized assessment of clinical outcomes, implementation, safety, and costs are needed to establish the effectiveness and clinical value of these models.

Additional Information

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All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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