Li et al. BMC Primary Care (2025) 26:45
https://doi.org/10.1186/s12875-025-02743-y

BMC Primary Care

RESEARCH Open Access

The involvement of specialists in primary healthcare teams for managing diabetes: a systematic review and meta-analysis

Jia Li[1,2], Zhihan Xu[3], Huilan Zhou[4], Zhansheng Li[5] and Beibei Yuan[2*]

Abstract

Background Diabetes mellitus requires ongoing management and care coordination. The majority of patients with diabetes were managed in primary healthcare settings. Several quality improvement programs have introduced specialist involvement in primary healthcare teams. However, synthesized evidence is needed to support policy improvements regarding the impact of specialist-primary healthcare coordination on glycemic control in diabetes care.

Objective This systematic review and meta-analysis aimed to assess the effectiveness of specialist involvement in primary healthcare teams on glycemic control of patients with diabetes.

Methods A search of five electronic databases (PubMed, Embase, Web of Science Core Collection, CNKI, and Wanfang Database) was conducted to identify relevant studies published until October 21st, 2023. We assessed the methodological quality of the included studies using the suggested risk of bias criteria for EPOC (Cochrane Effective Practice and Organization of Care). We conducted the certainty assessment using the GRADE guideline. The outcome measured was the HbA1c level. Meta-analyses were performed using random-effects models.

Results A total of 12 studies (7 randomized controlled trials and 5 controlled before-after studies) were included in the meta-analysis. The involvement of specialists in primary healthcare teams was associated with a statistically significant reduction in HbA1c level compared to usual or standard care (mean difference −0.57, 95% CI: -0.86 to -0.27, $I^2 = 88.17\%$).

Conclusion The findings revealed that the interventions might improve the care delivered and patients' health outcomes. However, due to the very low certainty of evidence on the effectiveness on glycemic control, the interventions implemented in the included studies should be employed with caution in future policy-making to achieve improved HbA1c levels. Further research with a more rigorous design is needed to provide evidence of higher certainty and quality.

Registration The systematic review and meta-analysis was registered in the PROSPERO International Prospective Register of Systematic Reviews (registration No. CRD42022384589 available at https://www.crd.york.ac.uk/prospero/#searchadvanced).

*Correspondence:
Beibei Yuan
beibeiyuan@bjmu.edu.cn

Full list of author information is available at the end of the article

Keywords Diabetes mellitus, HbA1c, Specialists, Primary healthcare, Systematic review, Meta-analysis

Introduction

Diabetes mellitus is a widespread chronic disease affecting a significant number of individuals worldwide. Type 2 diabetes mellitus constituted approximately 90% of all diabetic patients [1]. The global prevalence of diabetes in 2021 reached 10.5% among adults aged 20–79 years, indicating that around 536.6 million people suffered from this disease [2]. Diabetes mellitus and its complications accounted for more than 80% of premature deaths caused by non-communicable diseases, making it the seventh leading cause of death. Moreover, it was estimated that nearly 760 billion dollars were spent annually on the management of diabetes patients [3].

Caring for patients with diabetes and other chronic diseases needs long-term and continuous services, including risk factor control, diagnosis, medication prescription, behavioral guidance, emergency treatment, management of complications, rehabilitation, and treatment for co-existing conditions such as mental health disorders. Given that primary healthcare providers located in the community are close to residents and have the advantage of establishing long-term relationships with residents, in most health systems across the world, primary healthcare institutions and general practitioners working there are the major service providers for diabetes patients [4]. However, evidence showed that the provision of comprehensive evidence-based standardized diabetes care in primary healthcare settings has been challenging, and patients' access to specialty care being limited was one essential reason that resulted in unsatisfying management and care for diabetes patients [5]. Furthermore, the growing reliance of diabetes patients on primary healthcare providers has led to an increased workload for them, negatively impacting the quality and efficiency of care delivery, particularly in countries with less developed primary healthcare systems [6–7]. The complexities inherited in the management of diabetes and the limited capability and energy of primary healthcare providers have called for services from interdisciplinary care teams who address the diverse needs of residents through shared care.

Studies on quality improvement programs underlined the construction of interdisciplinary care teams, particularly between primary and specialty healthcare [8, 9], which refined the roles of different healthcare providers and was regarded as an instrumental and effective way of achieving high-quality and patient-centered care in primary healthcare settings [10]. Specialty healthcare was provided by specialists whose expertise is closely related to diabetes management, such as endocrinologists and other diabetes-related healthcare professionals (dietitians, diabetes nurse educators, pharmacists, mental health workers, podiatrists, ophthalmologists, and exercise physiologists) [11]. In certain regions, specialist outreach clinics have been established to enhance specialist care provision and promote better coordination between primary healthcare providers and specialists [12]. Specialists expanded their services to primary healthcare practices through both physical means, such as going to primary healthcare practices to help with their work, as well as digital means, including teleconsultation and online conferences with primary healthcare providers. Collaboration between specialists and primary healthcare providers has been fostered through various intervention models and strategies, such as co-consultations, two-way referrals, task sharing, and regular case conferences [11].

Significant improvements in diabetes care have been observed in the specialist outreach team programs of several countries. For instance, in Australia, the Diabetes Alliance Program, an integrated diabetes care model, was introduced [5], in which the specialist teams with primary healthcare teams worked together through capacity-enhancing case conferences organized in general practice, and at the same time, the general practitioners received support through regular educational sessions and comprehensive feedback from specialists. Similarly, Canada implemented the St. Joseph's Primary Care Diabetes Support Program (SJHC PCDSP) [13], which involved the direct participation of specialists in patients' treatment plans. As an innovative interprofessional team-based model for adults living with diabetes and comorbidities [13], the SJHC PCDSP coordinated and provided standardized evidence-based practice, and supported primary healthcare, resulting in the improvement of patient experience, and reduction of diabetes complications and hospitalizations [5]. Through proactive involvement, the specialists participated in the care of patients with diabetes along with the GPs or other primary healthcare providers and guided the teams in the primary healthcare settings.

Several empirical studies on the collaboration between specialists and primary healthcare providers in diabetes care have been published [13–15]. However, specific conclusions regarding the impact of collaboration on the control of HbA1c levels remained unclear across different trials [16–18]. Lowering HbA1c was clinically associated with decreased morbidity and mortality risks, including cardiovascular events and myocardial infarction, common complications of T2DM [19, 20]. At the same time, in programs to improve the quality of diabetes care, the control of HbA1c level was commonly used as the indicator of effectiveness. Therefore, it was necessary to synthesize evidence that assessed the effectiveness of specialist involvement in primary healthcare teams on HbA1c, the direct health outcome in glycemic control. Relevant meta-analyses analyzed the roles of pharmacists in diabetes management in primary healthcare, given the necessity of drug intervention in diabetes care [17]. One meta-analysis tried to measure the effectiveness of interactive communication in the process of collaboration between specialists and primary healthcare providers [18]. However, the efficacy of interactive communication by itself cannot be established because collaborative interventions are inherently multifaceted. Therefore, this study aims to fill the literature gaps by including studies with a wider range of specialist types and complex collaboration strategies involved. The objective is to synthesize evidence on the impact of specialist involvement in primary healthcare teams on glycemic control among patients with diabetes mellitus.

Methods

Design and registration

This study was a systematic review and meta-analysis, and was reported based on the Guidelines of Systematic Reporting of Examination presented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [21]. The search protocol was registered in the PROSPERO International Prospective Register of Systematic Reviews (registration No. CRD42022384589 available athttps://www.crd.york.ac.uk/prospero/#searchadvanced, accessed on 20 January 2023).

Search strategy

A systematic search was conducted across five electronic databases, namely PubMed, Embase via Elsevier, Web of Science Core Collection, Chinese National Knowledge Infrastructure (CNKI), and Chinese Medicine Premier (Wanfang Database). The search aimed to identify relevant research articles published up until the 21st of October 2023. The search strategy was developed based on four key groups: (1) disease, defined as diabetes mellitus; (2) study participants, including specialists from diabetes-related disciplines (such as endocrinologists, dietitians, pharmacists, podiatrists, and ophthalmologists) and primary healthcare providers (such as family doctors, general practitioners, nurses, or other health professionals in primary healthcare institutions); (3) intervention, focused on collaboration between specialists and primary healthcare providers; and (4) setting, limited to primary healthcare settings. Using this framework, the initial search strategy was built in PubMed by identifying relevant MeSH terms for each group through the PubMed MeSH database and was subsequently tailored for other databases to ensure comprehensive coverage (see Supplementary File 1). The search strategy was built in English and Chinese. We also performed a manual search and screened the reference lists of included articles and related systematic reviews.

Eligibility criteria and outcome measurement

The inclusion criteria followed the PICOS framework: the population (P) of interest was patients with diabetes mellitus; intervention (I) to be included was the expansion of the roles of the specialists from any diabetes-related discipline (such as endocrinologists, dietitians, pharmacists, podiatrists, and ophthalmologists) into primary healthcare settings and they worked collaboratively with primary healthcare providers (family doctors, general practitioners, nurses or other health professionals in primary healthcare institutions). These specialists should actively engage in healthcare delivery through direct collaboration with primary healthcare professionals. For instance, endocrinologists may work with general practitioners (GPs) in case management, taking responsibility for creating management plans and supervising the team's efforts. Ophthalmologists and podiatrists might contribute by performing specialty tests and providing expert support during consultations, particularly for patients experiencing diabetes-related complications; the comparison (C) in the study should be the diabetes patients receiving usual or standard care at primary healthcare institutions; the primary outcome (O) must include the level of HbA1c; the eligible study designs (S) were limited to randomized controlled trials (RCTs) and controlled before-after analysis (CBAs).

We included both English and Chinese literature. We excluded non-experimental studies and studies only including passive specialist involvement (the specialist was not directly involved in the intervention, such as providing regular training to GPs or delivering advanced courses to the GPs [11, 22]). Studies not involving interventions within primary healthcare settings were also excluded.

Selection process and data collection

One reviewer (HLZ) downloaded and imported all articles identified in the five databases into the management tool EndNote (Version 20). After removing duplicates, two authors (HLZ and ZHX) independently screened studies by title and abstract based on the inclusion criteria. Full-text review was performed by two authors (JL and ZHX) independently. Any disagreement between the two authors on the eligibility was resolved through discussions with an additional reviewer (BBY). Multiple reports from the same study were identified by reviewing the method part, including the setting and intervention details. When multiple reports were identified, we linked the reports together for extraction and analysis.

The primary outcomes included in this review were HbA1c levels and other physiological outcomes, including blood pressure (BP), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), and fasting blood glucose (FBG). Secondary outcomes included healthcare utilization, adherence to health behaviors (e.g., diet, physical activity, and medication), health knowledge, quality of life, changes in medication use, and self-management behaviors.

We did not restrict the measurement tools for outcomes, but we only included studies with clearly documented measurement tools, such as validated instruments like EQ-5D-5L and the SF-36 scale for assessing quality of life, as well as structured questionnaires or patient records for measuring healthcare utilization and health behavior adherence. Data from both short-term and long-term follow-ups were all included. We only included the studies using the analysis methods, such as intention-to-treat and per-protocol approaches to ensure a robust evaluation.

The authors, the year of publication, the number of participants involved in the intervention, the characteristics of participants, the designs of studies, the characteristics of interventions, the characteristics of the comparison groups, the duration of the intervention, outcome variables, and other relevant information were extracted for subsequent analysis. One author (JL) extracted data into a Microsoft Excel spreadsheet, which was later verified by another two authors (ZHX and ZSL).

Risk of bias and certainty assessment

We used EPOC (Cochrane Effective Practice and Organization of Care) checklists [23] for RCTs and CBAs to assess the risk of bias for included studies. The checklists comprised 9 items, including random sequence generation, allocation concealment, baseline outcome measurements similar, baseline characteristics similar, incomplete outcome data, knowledge of the allocated interventions adequately prevented during the study, protection against contamination, selective outcome reporting, and other risks of bias. Each item was assessed as having "low risk", "high risk" and "unclear risk" of bias. To assess the certainty of evidence and guide recommendations, we used GRADE guidance [24] to conduct the certainty assessment and to prepare a summary of the findings table. The certainty of evidence for the outcome was evaluated based on the following five GRADE domains, including the risk of bias, inconsistency (measured by statistical heterogeneity and variability across studies), indirectness (evaluated based on the applicability of study populations, interventions, and outcomes to the review question), imprecision (assessed based on sample size and confidence interval width), and publication bias (examined through funnel plots and statistical tests). Based on these criteria, the overall certainty of evidence for the outcome was categorized as high, moderate, low, or very low. Evidence was downgraded when substantial risks of bias, inconsistency, imprecision, indirectness, or publication bias were present. Strong recommendations were made when the benefits of an intervention outweighed the risks, and the certainty of evidence was high or moderate. Meanwhile, conditional recommendations were issued when the quality of evidence was low or very low, or when uncertainty remained regarding the balance of benefits and harms. Risk of bias and certainty assessments were conducted independently by two authors (JL and ZHX) to minimize subjective bias. Discrepancies were resolved through in-depth discussions with an additional author (BBY) when necessary.

Data analysis

The characteristics of the included studies and interventions were displayed in a structured table. The meta-analysis was conducted using Stata 17.0. The primary outcome is the HbA1c level, i.e. the difference in HbA1c level between the pre- and post-intervention, and the effect size in the meta-analysis was the mean difference between the intervention group and the control group. A random-effects model was used to estimate the mean difference at 95% confidence intervals (CI). Statistical heterogeneity was assessed using the Higgins I^2 statistic, where the I^2 value greater than 50% indicated significant heterogeneity.

Two sensitivity analysis was conducted. First, we excluded studies with high risk of bias. Second, we assessed the influence of individual studies by using the leave-one-out method to.

recalculate estimates omitting 1 study at a time. We also explored possible sources for heterogeneity by conducting subgroup analyses based on study and intervention characteristics, such as study design, intervention duration, average age of the study population, and countries. We assessed the potential risk of publication bias using a funnel plot, which visually displayed the effect estimates against their standard errors. Symmetry in the funnel plot indicated a low risk of publication bias, while asymmetry suggested a higher risk. To further evaluate publication bias, the Egger regression test and Begg's test were conducted.

Results

Literature selection

After removing duplication, a total of 1687 articles were initially identified from the database search. After screening the titles and abstracts, 101 potentially relevant studies were included for full-text review. Twelve studies were finally included in this review after screening the full texts. The detailed literature selection process was displayed in Fig. 1.

Characteristics of studies and interventions

In Table 1, the characteristics of the included studies were presented. Of the 12 studies, 8 [25–29, 31, 32, 36] were published after 2010, while 4 [30, 33–35] were published before 2010. Most of the studies (10 out of 12) focused on patients with type 2 diabetes mellitus (T2DM), and one study [28] included patients with the complication of diabetic retinopathy. The sample sizes varied across the studies, ranging from 65 to 2495 participants. Seven studies [25–27, 29, 30, 34, 36] had a sample size larger than 200.

Table 2 provided an overview of the details of the interventions implemented in the included studies. Among the interventions of the included studies, the primary healthcare providers mainly included family physicians, general practitioners, and nurses. The specialists involved in the collaborations varied across the studies and included endocrinologists, ophthalmologists, nurses, dietitians, and pharmacists. In 8 studies [25, 27, 29, 30, 32, 34–36], there was a specialist outreach team composed of healthcare providers with different diabetes-related expertise helping primary healthcare providers in delivering diabetes care. In the other 4 studies [26, 28, 31, 33], only individual specialists participated in the primary healthcare teams.

Of the 12 studies, 10 studies implemented a mixed bundle of collaboration strategies among primary healthcare providers and specialists. Most studies [25, 26, 28, 30, 31, 33–35] incorporated specialists into primary healthcare teams in the form of task-sharing in case management. In five studies [25, 26, 31, 34, 35], the specialists involved in the team were an endocrinologist or a pharmacist responsible for the final decision-making in treatment plans for individuals and the monitoring of the plan

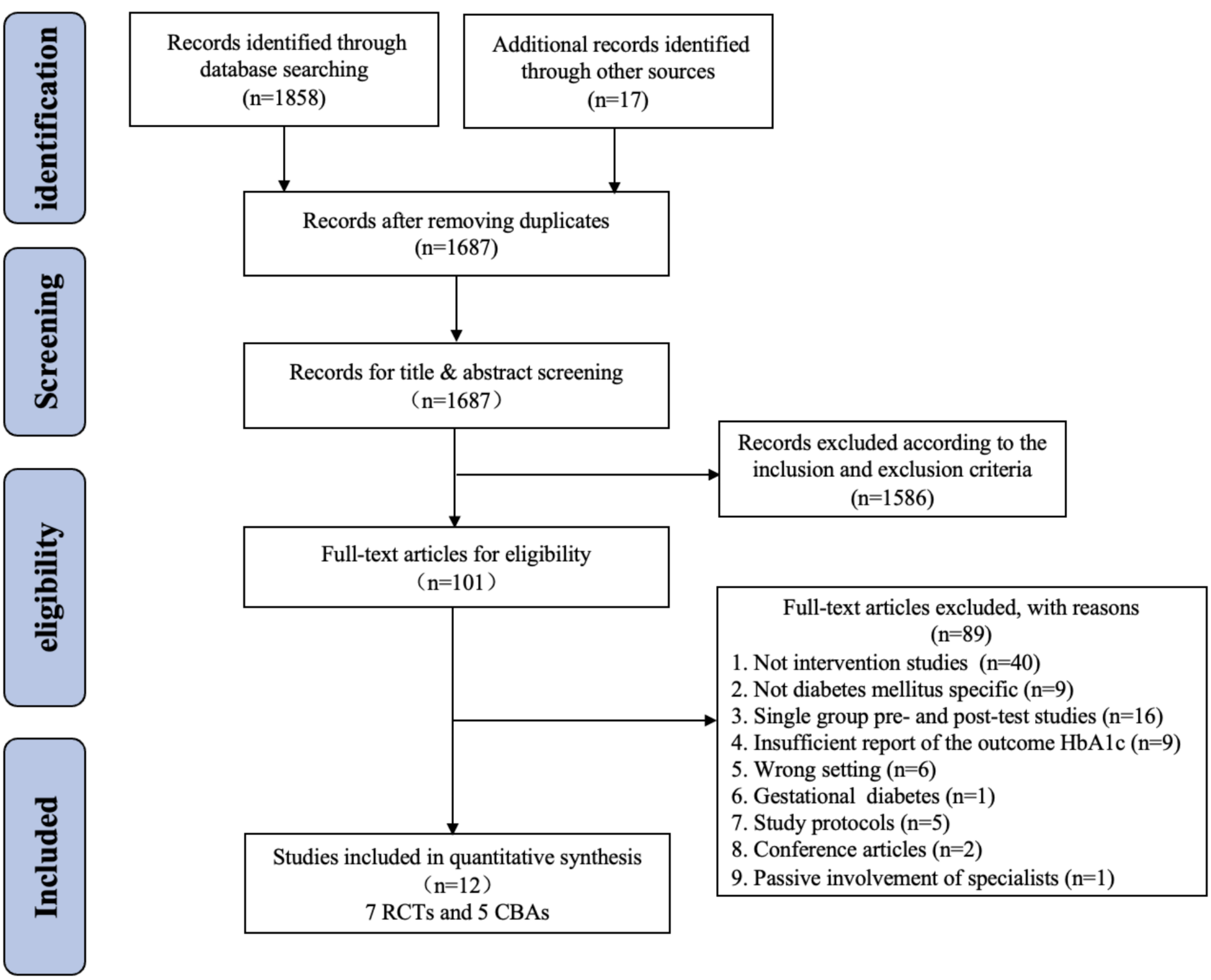

Fig. 1 Literature selection flow diagram

Table 1 Characteristics of included studies

Study ID	Author	Year	Country	Study design	Sample size	Participants
1	Zhang et al. [25]	2019	China	CBA	$N=459$ (I: 289; C: 170)	T2DM patients in communities
2	Sun et al. [26]	2018	China	CBA	$N=233$ (I: 117; C: 116)	T2DM patients in communities
3	Dai et al. [27]	2021	China	CBA	$N=380$ (I: 192; C: 188)	T2DM patients in communities
4	Chen et al. [28]	2020	China	CBA	$N=108$ (I: 53; C: 55)	T2DM patients with early diabetic retinopathy
5	Wilson et al. [29]	2014	The UK	RCT	$N=1280$ (I: 644; C: 636)	Poorly controlled T2DM patients
6	Borgerman et al. [30]	2009	Belgium	RCT	$N=2495$ (I:313; C:2182)	T2DM patients
7	Wagner et al. [31]	2022	The US	RCT	$N=122$ (I: 62; C: 60)	T2DM patients
8	Ni et al. [32]	2019	China	CBA	$N=179$ (I: 88; C: 91)	T2DM patients
9	Choe et al. [33]	2005	The US	RCT	$N=65$ (I: 36; C: 29)	T2DM patients
10	DICE [34]	1994	The UK	RCT	$N=274$ (I: 139; C: 135)	Adult patients with diabetes mellitus
11	Hoskins et al. [35]	1992	Australia	RCT	$N=141$ (I: 69; C: 72)	Patients with diabetes
12	Basudev et al. [36]	2016	The UK	RCT	$N=208$ (I: 93; C: 115)	T2DM patients

Notes: CBA: controlled before-after analysis, RCT: randomized controlled trial, I: intervention group, and C: control group

progress, while the primary healthcare providers took charge of the implementation of the plans and the follow-up of patient health conditions in the case management. The study by Choe et al. [33] incorporated a clinical pharmacist only for assistance in the pharmaceutical plans for individuals with diabetes. In another two studies [28, 30], the specialist was an ophthalmologist providing complementary specialty care for the control of diabetic ophthalmopathy complications.

Regular case-based discussion meetings within the teams were another common strategy employed in the collaborations [26, 30, 35, 36]. Evaluations of glucose control and risk factors [26], individualized management plans for patients [36], and shared approaches to problem-solving in complex patient cases [30] were discussed in these meetings. In the study conducted by Hoskins et al. [35], patients were also involved in the case discussion, and shared care was characterized by more communication between patients, GPs, and specialists. Some additional learning was also arranged for the primary healthcare providers in the case discussions [36].

Two-way referrals of patients between specialists and primary healthcare providers were employed in several studies [25–27, 29, 32]. Specialists managed patients referred from general practices and then referred them back to primary healthcare for follow-up management until satisfying control was achieved. Only one study [27] involved co-consultation, where regular diabetes clinics were set up in communities per week, with specialists working with community doctors to see patients and jointly discuss treatment plans. Three studies [25, 34, 36] also utilized online information systems to assist care delivery. The study by Zhang et al. [25] managed and referred patients with diabetes through an application on mobile phones. The other two studies [34, 36] used computerized systems for remote communication and consultations among primary healthcare providers and specialists.

For outcome measurement, the primary outcome measured in all 12 studies was the change in the level of HbA1c before and after the intervention. Two studies [34, 36] showed null or negative results on the control of HbA1c after intervention. Additionally, several other physiological outcome variables were also measured, including BP (blood pressure) in 6 studies [27, 29, 30, 34–36], LDL (low-density lipoprotein cholesterol) in 4 studies [27, 28, 30, 33], HDL (high-density lipoprotein cholesterol) in 3 studies [27, 28, 30], and FBG (fasting blood glucose) in 4 studies [25–28].

As for secondary outcomes measured, among the four studies [30, 31, 34, 35] reporting healthcare utilization, they all reported that patients in the intervention group had more visits to primary healthcare institutions and received more preventive care with nutrition, ophthalmology, and dentistry. Also, a greater decrease in hospitalization was found in the intervention group in Study

Table 2 Characteristics of interventions

Study ID	Author, year	Primary health-care workers	Specialist(s)	Intervention description	Intervention duration	Comparison group	Health outcome variables
1	Zhang et al., 2019 [25]	GPs	Endocrinologist and nutritionist	Two-way referral, task sharing, case discussion, online system for patient education	6 months	Usual care	HbA1c, FBG
2	Sun et al., 2018 [26]	Family doctors and nurses	Endocrinologist	Two-way referral, case management, task sharing, regular discussions	12 months	Usual care	HbA1c, FBG, 2hPBG,
3	Dai et al., 2021 [27]	GPs	Endocrinologist and specialty diabetes nurses	Regular diabetes clinics in communities per week, two-way referral	Unknown	Usual care	HbA1c, BP, BMI, FBG, TC, LDL, HDL,
4	Chen et al., 2020 [28]	GPs	Ophthalmologist	Patient education, case management	24 months	Usual care	HbA1c, FBG, 2hPBG, TC, TG, LDL, HDL
5	Wilson et al., 2014 [29]	GPs	Intermediate Care Clinics for Diabetes (A specialist team)	Two-way referral	18 months	Usual care	HbA1c, BP, Cholesterol
6	Borgerman et al., 2009 [30]	Primary health-care physicians	The interdisciplinary diabetes care teams: a nurse educator, an internist, a dietician and an ophthalmologist.	Case management, case discussion meetings, enhanced communication among health professionals	18 months	Usual care	HbA1c, BMI, BP, TC, HDL, LDL
7	Wagner et al., 2003 [31]	Nurses and physicians	Pharmacist	Case management, task sharing	12 months	Standardized care	HbA1c
8	Ni et al., 2019 [32]	Primary health-care physicians	Endocrinologists, dietitians, psychologists, cardiologists, nephrologists, and specialist nurses	Two-way referral	12 months	Usual care	HbA1c
9	Choe et al., 2005 [33]	Primary health-care internists	Pharmacist	Pharmacist-assisted case management	12 months	Usual care	HbA1c, LDL
10	DICE, 1994 [34]	GPs	Hospital specialist clinic	Practice guidelines and protocols specification, annual specialist review, computerized system	24 months	Usual care	HbA1c, BP, BMI
11	Hoskins et al., 1993 [35]	GPs	A specialist diabetic clinic	Case discussion, annual clinic review by specialists	12 months	Usual GP care	HbA1c, BP, weight
12	Basudev et al., 2016 [36]	GPs	Specialist diabetes teams	Virtual clinics: case discussion, clinical review, patient consultations	12 months	Usual diabetes care	HbA1c, BP, BMI, weight, cholesterol

Notes: GPs: general practitioners, HbA1c: glycosylated hemoglobin, FBG: fasting blood glucose, 2hPBG: 2-h post-prandial blood glucose, LDL: low-density lipoprotein cholesterol, HDL: high-density lipoprotein cholesterol, BMI: body mass index, BP: blood pressure, TC: total cholesterol, TG: triacylglycerol, and QOL: quality of life

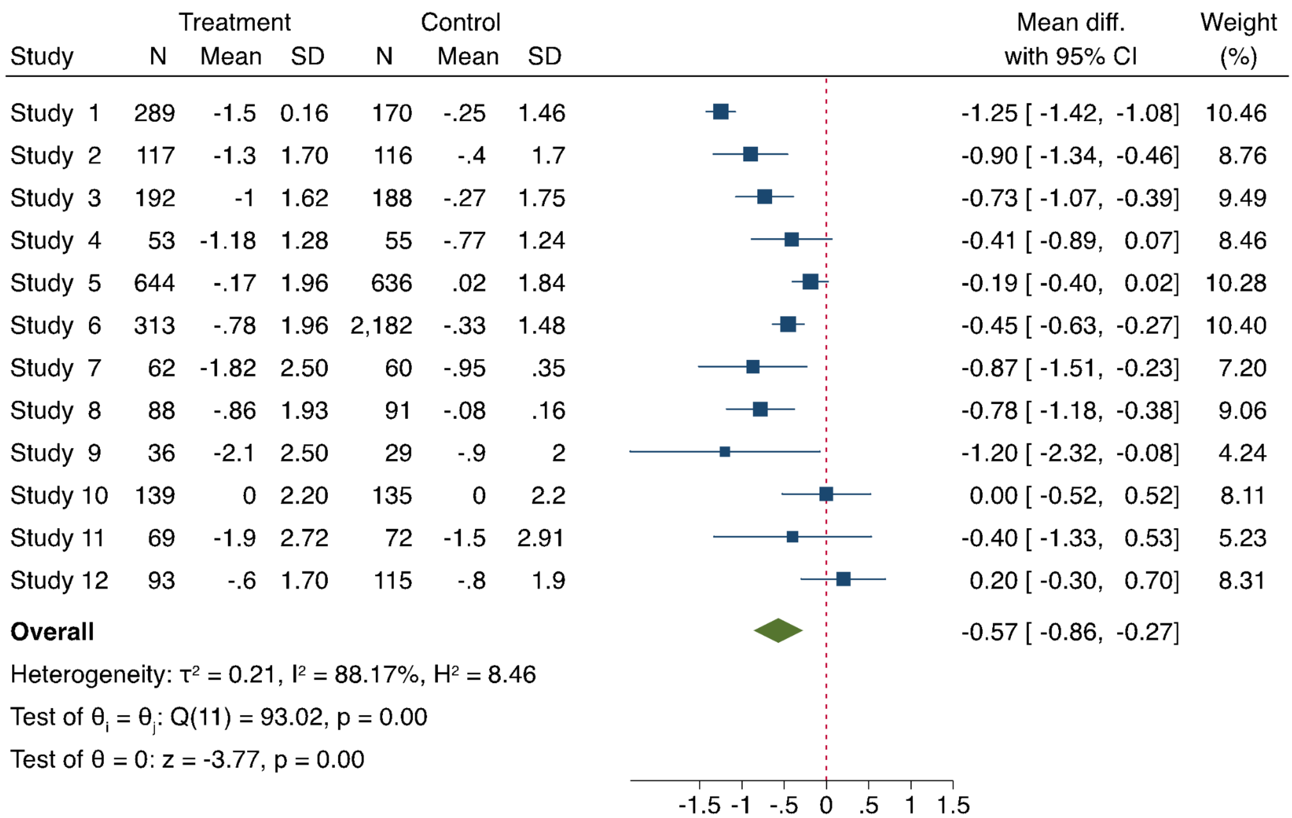

Fig. 2 Forest plots illustrating group data from the meta-analysis of HbA1c

(Notes: (1) N: sample size; Mean diff: mean difference; CI: confidence interval; SD: standard deviation. (2) Heterogeneity: The τ^2 value estimates the absolute between-study variance in effect sizes. The I^2 value quantifies variability across studies. H^2 measures the relative excess variability due to heterogeneity. Statistical significance is tested via Q-tests and Z-tests; (3) Study labels refer to individual trials or sources contributing to the meta-analysis. See Table 2 for detailed study characteristics.)

8 [32]. Studies [33–35] presented that physical measurement and examinations were more frequent in the intervention group. Patients in the intervention group also showed more adherence to health behavior recommendations from GPs, such as having a healthy diet [26, 30, 34] and doing physical activities [30]. Study 2 [26] and 4 [28] reported patients' higher adherence to medication after the intervention. Of the 3 studies [25, 31, 34] measuring patients' health knowledge, two studies [25, 31] found significant improvement in health knowledge among patients in the intervention group than in the control group, while another study [34] showed no significant difference between the two groups. Different scales were used to assess quality of life in 2 studies [31, 32]. One study [31] employed EQ-5D-5 L and Audit of Diabetes-Dependent Quality of Life, and the other [32] used the SF-36 scale. Changes in medication and patients' self-management behaviors were measured and reported in Study 12 [36] and Study 4 [28], respectively.

In terms of the intervention duration, one study [25] had a duration of 6 months, 6 studies [26, 31–33, 35, 36] lasted 12 months, and 4 studies [28–30, 34] lasted 18 months or longer. As for study designs, the included 12 studies consisted of 5 CBAs and 7 RCTs. Usual care or standardized care was employed in the comparison groups of the 12 studies.

The result of meta-analysis on HbA1c

The meta-analysis was conducted on the direct health outcome of glycemic control - the changes in HbA1c level, as shown in the forest plot (Fig. 2). The mean differences and corresponding 95% confidence intervals (CI) in the 12 studies were calculated using means, standard deviations, and sample sizes. Mean differences to the left of the vertical line favor the intervention, indicating a greater HbA1c reduction in the intervention group. Values to the right show no significant effect or worsening HbA1c levels compared to usual care. HbA1c level decreased in most studies after the intervention, except for Study 10 [34] (0.00, 95% CI: -0.52, 0.52) and Study 12 [36] (0.20, 95% CI: -0.30, 0.70). The overall effect estimate of the interventions' effectiveness on the HbA1c was −0.57 (95% CI: -0.86, -0.27), indicating a greater reduction in HbA1c level among diabetes patients in the group with specialists involved in the primary healthcare teams compared with the patients in the usual primary healthcare model group (Z = -3.77, $p < 0.01$). The I^2 statistic was 88.17%, suggesting a high degree of heterogeneity across the 12 studies. Thus, further exploration of the sources of heterogeneity was needed to better understand the variations in the intervention effects across the studies.

Subgroup analysis

To find out the source of heterogeneity, a subgroup analysis was conducted based on the variations of study characteristics, including study designs, the duration of interventions, the average age of participants, and countries (Supplementary File 2 - Table 1).

The overall effect size of CBAs (-0.85, 95% CI: -1.17, -0.53, $I^2 = 77.6\%$) was larger compared to that of RCTs (-0.30, 95% CI: -0.55, -0.06, $I^2 = 58.2\%$). However, the heterogeneity among all CBA studies was still high with an I^2 value of 77.59%, while the I^2 statistics of RCTs was 58.20%. The overall effect size decreased with a longer duration of the intervention. Only one study implemented 6-month intervention, demonstrating the largest effect size of -1.25 (95% CI: -1.42, -1.08), while interventions lasting 12 months and 18 months or more had effect sizes of -0.62 (95% CI: -1.03, -0.21, $I^2 = 65.6\%$) and −0.30 (95% CI: -0.49, -0.11, $I^2 = 40.1\%$), respectively. Different from the effect size of -0.58 (95% CI: -0.97, -0.20, $I^2 = 47.5\%$) in 6 studies with participants aged less than 60, the effect size in another 7 studies with participants aged more than 60 was −0.55 (95% CI: -0.95, -0.16, $I^2 = 93.0\%$). The subgroup analysis also revealed substantial variability in effect sizes across countries. With the greatest heterogeneity, studies conducted in China had the largest effect size (-0.85, 95% CI: -1.17 to -0.53, $I^2 = 77.6\%$), followed by studies in the US (-0.95, 95% CI: -1.50 to -0.40, $I^2 = 0\%$). The effect sizes were smaller for studies conducted in the UK (-0.16, 95% CI: -0.36 to -0.03, $I^2 = 0\%$) and Belgium (-0.45, 95% CI: -0.63 to -0.27, $I^2 = 0\%$). Studies conducted in Australia demonstrated a negligible effect size (0.03, 95% CI: -0.49 to 0.56, $I^2 = 19.6\%$).

Risk of bias and sensitivity analysis

The risk of bias assessment for the included 12 studies was presented in Supplementary File 2 - Fig. 1. Nine studies were at high risk of bias for the assessment of glycemic control, and 3 were at unclear risk. No study was at low risk. The 5 CBAs were all ranked as "high risk" for random sequence generation and allocation concealment because CBAs inherently lack randomization in the allocation of participants. Among the 7 RCTs, the randomization procedure was fully described and ranked as "low risk" for random sequence generation and allocation concealment. "Baseline outcome measurement similar" was recorded and reported in most studies, and only one study [30] had the problem of the primary outcomes being imbalanced at baseline without any adjusted analysis. A major source of bias identified across all studies was the potential contamination between the control group and the intervention group. In 5 studies [2, 3, 10–12], primary healthcare professionals working at the same practice were allocated to intervention or control groups with different care models, in which communications between professionals potentially influenced the usual care model in the control group. For the item "Knowledge of the allocated interventions adequately prevented during the study", all included studies were ranked as "low risk" as the outcome measurement of HbA1c was objective. Data collection and reporting of the outcomes were also rated "low risk" in all 12 studies because they all reported the outcomes of interest described in the method part of our study.

In the sensitivity using the leave-one-out method, we found that exclusion of the study with the largest effect size [1] would result in a HbA1c mean difference of -0.47 (95% CI -0.68 to -0.27, $I^2 = 64.35\%$; Supplementary File 2 - Fig. 2). In the sensitivity analysis of studies not at high risk of bias ($n = 3$ studies), the overall HbA1c mean difference was −0.61 (95% CI: -1.24, 0.02, $I^2 = 69.67\%$; Supplementary File 2- Fig. 3).

The certainty of evidence using the GRADE approach for glycemic control was very low for all studies and was still very low for both RCT and CBA subgroups (Supplementary File 3 - Table 1). The major reasons for downgrading the certainty of evidence were the risks of bias and inconsistency across studies (Supplementary File 3 - Table 1). Specifically, all 5 CBAs were ranked high risk due to the inherent flaws in their study design. In addition, two RCTs with unclear risk of bias had null or negative results, which were different from the positive results for the glycemic outcome in other RCT studies.

Assessment of publication bias

A funnel plot was constructed based on the meta-analysis results and was presented in Supplementary File 2 - Fig. 4. The included 12 studies appeared to be evenly distributed on either side of the vertical line, indicating a low likelihood of publication bias in this study. Both Egger's regression and Begg's tests were conducted to further evaluate the possibility of publication bias. Egger's regression test revealed a bias coefficient of 1.16 with a standard error of 1.73 (95% CI: -2.69, 5.00) and a p-value of 0.52 indicating no significant publication bias. Similarly, Begg's test, with a p-value of 0.73, also suggested a low risk of publication bias.

Discussion

This systematic review and meta-analysis included 7 RCTs and 5 CBAs with a total of 5944 participants to evaluate the effectiveness of specialist involvement in primary healthcare teams on the control of glycemic level. It was found that patients in the intervention groups received more preventive care and had less frequency of hospitalization. Improvements were also observed in their health behaviors and medication adherence. The meta-analysis, incorporating data from 12 studies, indicated that the services delivered through specialist involvement in primary healthcare teams led to lower HbA1c levels compared to the usual care delivered exclusively by family physicians or GPs in primary healthcare institutions, with the mean difference of -0.57 (95% CI: -0.86, -0.27). Despite these positive findings, the certainty of evidence was very low, limiting the generalizability of the interventions in the studies.

Diabetes mellitus is a long-term chronic disease that needs continuous care from initial screening to follow-up monitoring. However, the gap between comprehensive and actual care was obvious given the complexity of diabetes management and the limited number or qualification of health professionals in primary healthcare settings [10, 37]. The inclusion of various specialists, such as pharmacists, diabetes specialists, endocrinologists, nutritionists, ophthalmologists, and dietitians, could enhance the integrated and comprehensive nature of diabetes care in primary healthcare [38, 39]. Different expertise could target different needs in the whole diabetes continuum from prevention to treatment, and then to follow-up management [40, 41]. A previous systematic review extensively explored the involvement of pharmacists in primary healthcare teams and their collaboration [42]. Another meta-analysis conducted by Zarora et al. [12] focused on endocrinologists. Both reviews had the same conclusion that integrated care with proactive specialist involvement can result in modest improvements in HbA1c. Our study, encompassing various specialist types, showed the positive influence of including specialists with diverse diabetes-related expertise in primary healthcare teams, although the certainty of evidence was low.

Interventions in the 12 studies employed complex collaboration strategies within the team, which might be the key mechanism in the improvement of glycemia control. Common collaborative strategies included case management, two-way referrals, task sharing, co-consultation, and regular educational meetings. Some studies also incorporated remote technical support, such as remote consultations and video meetings [34, 36]. Guidelines were also developed to facilitate the collaboration between specialists and primary healthcare providers [32]. Implementing two-way referrals between primary and specialty healthcare created a convenient channel for critically ill patients to receive advanced diabetes care while enabling patients with milder conditions to be managed at the primary healthcare level, thus reducing the burden on specialty care and large hospitals. In the task division within the team, specialists usually undertook the role of technical director and were in charge of handling referrals, developing treatment and management plans, and providing care for patients with complications or difficulties in treatment [43]. Primary healthcare providers, including physicians and nurses, were responsible for follow-up implementation and patient education [44]. The interactive communications between specialists and primary healthcare workers (such as co-consultations, discussion meetings, and educational conferences) provided them with opportunities to discuss cases and stay up-to-date with the latest treatment guidelines and helped improve primary healthcare providers' abilities in diabetes care [12]. Recently, digital technology has gained popularity in diabetes care and it can facilitate the collaboration between specialists and primary healthcare providers when they worked in different places. The use of digital technology in diabetes care included monitoring patients' health conditions, guiding patients to self-management, and remote consultations by specialists who could not be physically present at primary healthcare institutions [45]. In summary, implementing the above collaboration strategies was crucial for effective collaboration between primary healthcare providers and specialists, resulting in effective diabetes care.

There was considerable heterogeneity between the studies which could be due to the interventions being delivered in different healthcare settings, duration of treatment, study designs, and degree of complexity of the diabetes. Subgroup analysis on countries highlighted the potential influence of healthcare system differences. Countries with higher baseline care quality and more equitable healthcare systems, like the UK [46, 47] and Australia [48], may exhibit smaller effect sizes in studies due to less room for improvement. Conversely, countries facing greater healthcare challenges, such as the US [49] and China [50], might show larger effect sizes when new interventions are introduced. Additionally, the subgroup analysis showed that interventions lasting more than 12 months exhibited a less significant effect compared to those lasting only 6 months. This finding aligns with previous studies [51], which suggested that the benefits of longer-term diabetes care interventions might diminish over time, potentially due to reduced patient adherence, intervention fatigue, or other unmeasured confounders.

The subgroup meta-analysis of RCTs demonstrated more consistent results with lower heterogeneity than CBAs. This may be attributed to the well-controlled design of RCTs, which could get a more reliable estimation of effects [52]. However, the effect size of RCTs was significantly less than those of CBAs, suggesting future studies adopt more rigorous designs to prevent the overestimation of effects. The subgroup analysis based on age revealed that interventions in studies with participants under 60 years of age showed an insignificantly larger effect size compared to those with participants aged 60 and older. However, the high heterogeneity in studies with participants aged 60 and older indicated considerable variability, possibly reflecting differences in the severity and comorbidity of diabetes among the age group.

The studies included in the review were mainly conducted in China and high-income countries such as the US, the UK, and Australia, which may restrict the generalizability of the findings to other settings, particularly to other low and middle-income countries. Additionally, the participants selected in the included studies were primarily adults with T2DM and the impact of interventions on their glycemic control. While this provided valuable insights into the effectiveness of specialist participation in managing T2DM, it may not fully capture the experiences of other populations, such as those with type 1 diabetes (T1DM) or gestational diabetes, impacting the generalizability of this review.

This study has several limitations. First, although extensive efforts were made to identify all relevant studies, some unpublished studies or grey literature may have been missed. However, a comparison with the list of studies included in a Cochrane systematic review [53] which included over 500 RCTs focused on quality improvement strategies for diabetes care indicated a minimal likelihood of omitting significant publications. Secondly, the inclusion of CBA studies, which had less methodological rigor, may have influenced the precision and strength of the evidence. While the results were statistically and clinically significant, the pooled effect size in RCTs was notably less than that of CBA studies. Thirdly, collaborative strategies employed in the included studies were inherently multifaceted and involved different combinations of strategies, making it challenging to identify what types of collaboration strategies effectively improved the quality of diabetes care. Furthermore, although subgroup analysis was conducted to identify sources of heterogeneity, varied combinations of complex strategies across different studies might be the main factor contributing to the high level of heterogeneity observed in the results.

In addition, the certainty of the evidence of this meta-analysis result was very low, mainly due to the studies' risks of bias and inconsistency. For included CBAs, they were all ranked "high risk" in the study design, lowering their strength of evidence. Whereas for included RCTs, two of them presented null or negative outcomes in glycemia control, weakening the consistency of the results. The lack of significant outcomes in the 2 RCTs could be linked to a methodological flaw in contamination protection because they randomized patients instead of primary healthcare practices. Thus, the improvements in outcomes observed within the control group might be partly explained by the contamination from the intervention groups, which represented a plausible factor that would narrow the gap between the intervention group and the control group, resulting in a null result.

For policy-making and practice, the results revealed the potential value of implementing interdisciplinary collaboration strategies, such as case management, two-way referrals, and task sharing, to address the complexities of diabetes care. The findings of this meta-analysis suggested that integrating specialists into primary healthcare teams can enhance diabetes management through improved care delivery, patient self-management, and reductions in HbA1c levels. However, the very low certainty of evidence necessitated cautious interpretation and application, and the effect might vary under different healthcare system contexts and baseline quality of care. Future interventions could focus on tailoring approaches to specific populations, such as the elderly who appeared to benefit less from the interventions. Moreover, policies should prioritize supporting long-term patient adherence to treatment plans, as the diminishing effectiveness of longer interventions may be related to intervention fatigue or reduced engagement.

Further research with a more rigorous design was needed to complement evidence with higher quality and certainty on this topic. Moreover, it is important to investigate whether the findings from this review can be generalized to other specialties and clinical disciplines within primary healthcare, including various chronic conditions or acute illnesses, and also to evaluate the effectiveness of collaborative care in diverse populations. Also, conducting comparative effectiveness research to assess the impact of different collaborative care strategies would be valuable if appropriate classification criteria are identified. Additionally, policies or practices could also benefit from more studies to identify important contextual and collaboration features that are essential in improving the effectiveness of the partnership between specialists and primary healthcare providers.

Conclusion

This study aimed to synthesize evidence through meta-analysis regarding the effectiveness of specialist involvement in primary healthcare practices. The findings suggested that such interventions may lead to improvements in care delivery, patient self-management behaviors, and modest reductions in HbA1c levels. However, the evidence supporting these results was of very low certainty, primarily due to the methodological limitations and heterogeneity among the included studies. As a result, these findings should be interpreted with caution and applied selectively. In addition, policymakers and practitioners should carefully evaluate the adaptability of such interventions to local contexts, especially in settings with limited resources or different healthcare delivery systems. Future research with more rigorous methodological designs could explore the effectiveness of specific collaboration strategies and identify factors that are essential in improving the effectiveness of the partnership between specialists and primary healthcare providers.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12875-025-02743-y.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Author contributions

Jia Li and Beibei Yuan developed the study design. Jia Li, Zhihan Xu, Huilan Zhou, and Beibei Yuan conducted the literature search, selection, and data collection. Jia Li and Zhansheng Li conducted the meta-analysis and result interpretation. Jia Li and Beibei Yuan wrote the main manuscript text. All authors reviewed the manuscript, provided revisions, and approved the final manuscript.

Funding

This research was supported by China National Nature Science Fund (72274006).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Health Policy and Management, School of Public Health, Peking University, Beijing, China
[2]Center for Health Development Studies, Peking University, Beijing, China
[3]Chinese Center for Disease Control and Prevention, Beijing, China
[4]School of Public Health, Sun Yat-sen University, Guangzhou, China
[5]Health Commission of Weifang, Weifang, Shandong Province, China

Received: 7 December 2023 / Accepted: 7 February 2025
Published online: 18 February 2025

References

1. Ahmad E, Lim S, Lamptey R, Webb DR, Davies MJ. Type 2 diabetes. Lancet. 2022;400(10365):1803–20. https://doi.org/10.1016/S0140-6736(22)01655-5.
2. Sun H, Saeedi P, Karuranga S et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045 [published correction appears in Diabetes Res Clin Pract. 2023;204:110945]. Diabetes Res Clin Pract. 2022; 183:109119. https://doi.org/10.1016/j.diabres.2021.109119
3. Abdulrhim S, Awaisu A, Ibrahim MIM, Diab MI, Hussain MAM, Al Raey H, et al. Impact of pharmacist-involved collaborative care on diabetes management in a primary healthcare setting using real-world data. Int J Clin Pharm. 2022;44(1):153–62. https://doi.org/10.1007/s11096-021-01327-x.
4. Rabatin J, Williams E, Baier Manwell L, Schwartz MD, Brown RL, Linzer M. Predictors and outcomes of Burnout in Primary Care Physicians. J Prim Care Community Health. 2016;7(1):41–3. https://doi.org/10.1177/2150131915607799.
5. Acharya S, Philcox AN, Parsons M, Suthers B, Luu J, Lynch M, et al. Hunter and New England Diabetes Alliance: innovative and integrated diabetes care delivery in general practice. Aust J Prim Health. 2019;25(3):219–43. https://doi.org/10.1071/PY18179.
6. Petterson SM, Liaw WR, Tran C, Bazemore AW. Estimating the residency expansion required to avoid projected primary care physician shortages by 2035. Ann Fam Med. 2015;13(2):107–14. https://doi.org/10.1370/afm.1760.
7. Abdulhadi N, Al-Shafaee MA, Ostenson CG, Vernby A, Wahlström R. Quality of interaction between primary health-care providers and patients with type 2 diabetes in Muscat, Oman: an observational study. BMC Fam Pract. 2006;7:72. https://doi.org/10.1186/1471-2296-7-72. PMID: 17156424; PMCID: PMC1764013.
8. Weingarten SR, Henning JM, Badamgarav E, Knight K, Hasselblad V, Gano A, et al. Interventions used in disease management programmes for patients with chronic illness-which ones work? Meta-analysis of published reports. BMJ. 2002;325(7370):925. https://doi.org/10.1136/bmj.325.7370.925.
9. American Diabetes Association. Standards of medical care in diabetes–2007. Diabetes Care. 2007;30(Suppl 1):S4–41. https://doi.org/10.2337/dc07-S004.
10. Tricco AC, Ivers NM, Grimshaw JM, Moher D, Turner L, Galipeau J, et al. Effectiveness of quality improvement strategies on the management of diabetes: a systematic review and meta-analysis. Lancet. 2012;379(9833):2252–61. https://doi.org/10.1016/S0140-6736(12)60480-2.
11. Zarora R, Immanuel J, Chivese T, MacMillan F, Simmons D. Effectiveness of Integrated Diabetes Care interventions Involving diabetes specialists working in primary and Community Care settings: a systematic review and Meta-analysis. Int J Integr Care. 2022;22(2):11. https://doi.org/10.5334/ijic.6025. PMID: 35634254; PMCID: PMC9104489.
12. Gruen RL, Weeramanthri TS, Knight SE, Bailie RS. Specialist outreach clinics in primary care and rural hospital settings. Cochrane Database Syst Rev. 2004;2003(1):CD003798. https://doi.org/10.1002/14651858.CD003798.pub2.
13. Reichert SM, Harris S, Harvey B. An innovative model of diabetes care and delivery: the St. Joseph's Primary Care Diabetes Support Program (SJHC PCDSP). Can J Diabetes. 2014/06/10 ed. 2014;38(3):212–5. https://doi.org/10.1016/j.jcjd.2014.03.008
14. Knight AW, Ford D, Audehm R, Colagiuri S, Best J. The Australian Primary Care Collaboratives Program: improving diabetes care. BMJ Qual Saf. 2012;21(11):956–63. https://doi.org/10.1136/bmjqs-2011-000460.
15. Katon WJ, Von Korff M, Lin EHB, Simon G, Ludman E, Russo J, et al. The pathways Study: a randomized trial of collaborative care in patients with diabetes and depression. Arch Gen Psychiatry. 2004;61(10):1042–9. https://doi.org/10.1001/archpsyc.61.10.1042.
16. Smith SM, Allwright S, O'Dowd T. Does sharing care across the primary-specialty interface improve outcomes in chronic disease? A systematic review. Am J Manag Care. 2008;14(4):213–24. PMID: 18402514.
17. Tan ECK, Stewart K, Elliott RA, George J. Pharmacist services provided in general practice clinics: a systematic review and meta-analysis. Res Social Adm Pharm. 2014;10(4):608–22. https://doi.org/10.1016/j.sapharm.2013.08.006.
18. Foy R, Hempel S, Rubenstein L, Suttorp M, Seelig M, Shanman R, et al. Meta-analysis: effect of interactive communication between collaborating primary care physicians and specialists. Ann Intern Med. 2010;152(4):247–58. https://doi.org/10.7326/0003-4819-152-4-201002160-00010.
19. Lenters-Westra E, Schindhelm RK, Bilo HJG, Groenier KH, Slingerland RJ. Differences in interpretation of haemoglobin A1c values among diabetes care professionals. Neth J Med. 2014;72(9):462–6.
20. Mannucci E, Monami M, Lamanna C, Gori F, Marchionni N. Prevention of cardiovascular disease through glycemic control in type 2 diabetes: a meta-analysis of randomized clinical trials. Nutr Metab Cardiovasc Dis. 2009;19(9):604–12.
21. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher

D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71. PMID: 33782057; PMCID: PMC8005924.
22. McDermott RA, Schmidt B, Preece C, Owens V, Taylor S, Li M, et al. Community health workers improve diabetes care in remote Australian indigenous communities: results of a pragmatic cluster randomized controlled trial. BMC Health Serv Res. 2015;15:68. https://doi.org/10.1186/s12913-015-0695-5.
23. Effective Practice and Organisation of Care. Suggested risk of bias criteria for EPOC reviews. Oxford: Effective Practice and Organisation of Care; 2017 [cited 2023 Oct 22]. Available from: https://epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/Resources-for-authors2017/suggested_risk_of_bias_criteria_for_epoc_reviews.pdf
24. Effective Practice and Organisation of Care. EPOC resources for review authors: worksheets for preparing a Summary of Findings tables using GRADE. Oxford: Effective Practice and Organisation of Care; 2020 [cited 2023 Oct 22]. Available from: http://epoc.cochrane.org/resources/epoc-resourcesreview-authors
25. Zhang X, Liu M, Li G, Gu H, Dai J, Liu H, et al. The influence of different management modes on blood glucose control compliance rate in patients with type 2 diabetes. China Med Herald. 2019;16(03):53–6.
26. Sun Q, Mu J. Effect of optimized family doctor team on improving blood glucose management and compliance in community diabetes patients. Chin J Diabetes. 2018;26(11):910–3. https://doi.org/10.3969/j.issn.1006-6187.2018.11.007.
27. Dai H, Chen Y, Liu W, Wu P, Du Z. Cohort study on the intervention effect of general-specialty grading management model on type 2 diabetes patients. Chinse Community Doctors. 2021;37(02):186–8. https://doi.org/10.3969/j.issn.1007-614x.2021.02.092.
28. Chen C, Peng D, Li X, Xu W. Evaluation of the effect on community comprehensive intervention by the general-specialist team on patients with early diabetic retinopathy. Shanghai Med Pharm J. 2020;41(18):47–51.
29. Wilson A, O'Hare JP, Hardy A, Raymond N, Szczepura A, Crossman R, et al. Evaluation of the clinical and cost effectiveness of intermediate care clinics for diabetes (ICCD): a multicentre cluster randomised controlled trial. PLoS ONE. 2014;9(4):e93964. https://doi.org/10.1371/journal.pone.0093964.
30. Borgermans L, Goderis G, Van Den Broeke C, Verbeke G, Carbonez A, Ivanova A et al. Interdisciplinary diabetes care teams operating on the interface between primary and specialty care are associated with improved outcomes of care: findings from the Leuven Diabetes Project. BMC Health Serv Res. 2009/10/09 ed. 2009;9:179. https://doi.org/10.1186/1472-6963-9-179.
31. Wagner ML, McCarthy C, Bateman MT, Simmons D, Prioli KM. Pharmacists improve diabetes outcomes: a randomized controlled trial. J Am Pharm Assoc (2003). 2022/01/15 ed. 2022;62(3):775–782.e3. https://doi.org/10.1016/j.japh.2021.12.015
32. Ni YX, Liu SZ, Li JP, Dong T, Tao L, Yuan L et al. The Effects of Nurse-Led Multidisciplinary Team Management on Glycosylated Hemoglobin, Quality of Life, Hospitalization, and Help-Seeking Behavior of People with Diabetes Mellitus. Journal of Diabetes Research. 2019;2019. https://doi.org/10.1155/2019/9325146
33. Choe HM, Mitrovich S, Dubay D, Hayward RA, Krein SL, Vijan S. Proactive case management of high-risk patients with type 2 diabetes mellitus by a clinical pharmacist: a randomized controlled trial. Am J Manag Care. 2005;11(4):253–60. PMID: 15839185.
34. DICE. Integrated care for diabetes: clinical, psychosocial, and economic evaluation. Diabetes Integr Care Evaluation Team BMJ. 1994;308(6938):1208–12. PMCID: PMC2540045.
35. Hoskins PL, Fowler PM, Constantino M, Forrest J, Yue DK, Turtle JR. Sharing the care of diabetic patients between hospital and general practitioners: does it work? Diabet Med. 1993;10(1):81–6. https://doi.org/10.1111/j.1464-5491.1993.tb02001.x.
36. Basudev N, Crosby-Nwaobi R, Thomas S, Chamley M, Murrells T, Forbes A. A prospective randomized controlled study of a virtual clinic integrating primary and specialist care for patients with type 2 diabetes mellitus. Diabet Med. 2016;33(6):768–76. https://doi.org/10.1111/dme.12985.
37. Rushforth B, McCrorie C, Glidewell L, Midgley E, Foy R. Barriers to effective management of type 2 diabetes in primary care: qualitative systematic review. Br J Gen Pract. 2016;66(643):e114–127. https://doi.org/10.3399/bjgp16X683509.
38. Varroud-Vial M, Mechaly P, Joannidis S, Chapiro O, Pichard S, Lebigot A, et al. Cooperation between general practitioners and diabetologists and clinical audit improve the management of type 2 diabetic patients. Diabetes Metab. 1999;25(1):55–63. PMID: 10335424.
39. Bunn C, Harwood E, Akhter K, et al. Integrating care: the work of diabetes care technicians in an integrated care initiative. BMC Health Serv Res. 2020;20:235. https://doi.org/10.1186/s12913-020-05109-5.
40. World Health Organization. Report on the public consultation to inform development of the Framework on integrated people-centred health services. 2016. https://iris.who.int/handle/10665/ 246252.
41. Atun R, de Jongh T, Secci F, et al. A systematic review of the evidence on integration of targeted health interventions into health systems. Health Policy Plan. 2010;25:1–14. https://doi.org/10.1093/heapol/czp053.
42. Benson H, Lucas C, Benrimoj SI, Williams KA. The development of a role description and competency map for pharmacists in an interprofessional care setting. Int J Clin Pharm. 2019;41(2):391–407. https://doi.org/10.1007/s11096-019-00808-4.
43. Tian Q, Upsher R, Winkley K. Systematic review and meta-analysis of diabetes specialist delivered insulin education for adults with type 2 diabetes in outpatient settings. Patient Educ Couns. 2022;105(4):835–42. https://doi.org/10.1016/j.pec.2021.06.030.
44. Cheng Z, Pan X, Lu F, Zhang C. Application Effect of General practitioner-specialist Model in patients with Diabetic Retinopathy. Chin Gen Pract. 2020;23(S1):24–6.
45. Flood D, Hane J, Dunn M, Brown SJ, Wagenaar BH, Rogers EA, et al. Health system interventions for adults with type 2 diabetes in low- and middle-income countries: a systematic review and meta-analysis. PLoS Med. 2020;17(11):e1003434.
46. Lawton J, Parry O, Peel E, Douglas M. Diabetes service provision: a qualitative study of newly diagnosed type 2 diabetes patients' experiences and views. Diabet Med. 2005;22(9):1246–51. Return to ref 18 in article.
47. Lawton J, Peel E, Parry O, Araoz G, Douglas M. Lay perceptions of type 2 diabetes in Scotland: bringing health services back in. Soc Sci Med. 2005;60(7):1423–35.
48. 2024 Australian Institute of Health and Welfare. Measures of health and health care for Australia and similar countries, July. https://www.aihw.gov.au/reports/international-health-data-comparisons
49. Blumenthal D, Mirror M et al. 2024: A Portrait of the Failing U.S. Health System - Comparing Performance in 10 Nations. Commonwealth Fund, Sept. 2024). https://doi.org/10.26099/ta0g-zp66
50. Yip W, Fu H, Jian W, Liu J, Pan J, Xu D, Yang H, Zhai T. Universal health coverage in China part 1: progress and gaps. Lancet Public Health. 2023;8(12):e1025-e1034. https://doi.org/10.1016/S2468-2667(23)00254-2. PMID: 38000882.
51. Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. Diabetes Care. 2001;24(3):561–87. https://doi.org/10.2337/diacare.24.3.561.
52. Miller CJ, Smith SN, Pugatch M. Experimental and quasi-experimental designs in implementation research. Psychiatry Res. 2020;283:112452. https://doi.org/10.1016/j.psychres.2019.06.027. Epub 2019 Jun 20. PMID: 31255320; PMCID: PMC6923620.
53. Yogasingam S, Konnyu KJ, Lépine J, Sullivan K, Alabousi M, Edwards A, Hillmer M, Karunananthan S, Lavis JN, Linklater S, Moher D, Manns BJ, Mortazhejri S, Nazarali S, Paprica PA, Ramsay T, Ryan PM, Sargious P, Shojania KG, Straus SE, Tonelli M, Tricco A, Vachon B, Yu CH, Zahradnik M, Trikalinos TA, Grimshaw JM, Ivers N. Quality improvement strategies for diabetes care: effects on outcomes for adults living with diabetes. Cochrane Database Syst Rev. 2023;5(5):CD014513. https://doi.org/10.1002/14651858.CD014513. PMID: 37254718; PMCID: PMC10233616.

Publisher's note