Nonconventional diabetes-related care strategies for patients with chronic kidney disease: A scoping review of the literature

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Abstract

Background: Patients with diabetes and chronic kidney disease (CKD) are at high risk of diabetes-related complications. Diabetes care can support these individuals, but outpatient clinic appointments can be difficult to attend, given their already high burden of multimorbidity.

Methods: We systematically searched the medical and grey literature for studies that evaluated the effect of non-conventional diabetes care strategies on diabetes-related outcomes in adults with stages 2–5 CKD or using dialysis (end of search December 30, 2017). We included both randomized-controlled trials and observational studies. Study selection and data extraction were completed by two independent reviewers. Diabetes-related outcomes included glycemic, blood pressure, and lipid control, along with microvascular complications, macrovascular complications, and death.

Results: After screening 2177 relevant citations, we identified 34 studies which met inclusion. The majority were observational studies. Studies were frequently small, single-centered, and excluded patients with more advanced CKD. Non-conventional diabetes care strategies included community-based care, unique self-management and education programs, nurse-led care clinics, dialysis-based diabetes programs, telemedicine, and interdisciplinary care clinics. Programs were most often developed by study investigators. Although there were limitations to several of the included studies, programs were described to have modest effects on physiologic outcomes, and in some cases, diabetes-related complications and death.

Conclusions: Nonconventional diabetes-related care might be helpful to patients with CKD. Prior to developing and implementing programs, however, it will be important to study them more rigorously, understand their acceptability to patients, and evaluate their costs and feasibility in a real-world setting.

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Introduction

The prevalence of multimorbidity is increasing among patients with diabetes. It is estimated that most adults with diabetes now live with at least one comorbid chronic disease, and as many as 40% have three or more other medical conditions.[1–3]

Patients who live with diabetes and chronic kidney disease (CKD) are an especially vulnerable population. Compared with those without kidney disease, they struggle with dysglycemia and are at increased risk of microvascular disease, macrovascular disease, and even death.[4–6] Glycemic management, diabetes education, dietary counseling, and screening for diabetes-related complications can be helpful to these individuals.[7,8]

Traditionally, diabetes-related care is provided to patients at separate outpatient clinic appointments with physicians and allied health professionals (i.e. certified diabetes educators, dieticians) every 3–6 months. For patients with CKD and diabetes who live with many other medical comorbidities, these additional clinic appointments can be difficult to attend and can add to an already high burden of health care. At busy outpatient clinic appointments, healthcare providers can also struggle to fully address their complex needs.[1]

Nonconventional diabetes care strategies (i.e. diabetes care that is *not* delivered at traditional outpatient clinic appointments with physicians, diabetes educators, or dieticians), might better support these vulnerable individuals. To our knowledge, there has been no previous effort to systematically identify and describe the effect of these strategies on diabetes-related outcomes in patients with CKD. A thorough review of the literature is important, as we look toward new alternatives to manage complex patients in a patient-centered manner.

Scoping reviews of the literature can help investigators to examine the extent, range, and nature of available evidence.[9] We conducted a scoping review of studies which evaluated the effect of nonconventional diabetes care strategies on diabetes-related outcomes in adults aged ≥ 18 years with diabetes and CKD. Our primary aims were to: (1) understand the breadth of nonconventional diabetes-related care strategies and (2) ascertain how these programs were developed and implemented. Our secondary aim was to determine the effect of these programs on diabetes-related outcomes (i.e. metabolic control (glycemic control, blood pressure, and lipid control), microvascular complications, macrovascular complications, and death).

Methods

Design

We conducted our review using the methods suggested by Arksey, Levac, and Tricco (PRISMA-ScR).[10,11] Our processes were guided by an internal, unpublished protocol.

Patients

We included studies of adults aged ≥ 18 years with CKD and diabetes (type 1 or 2). We defined CKD as stages 2–5 disease (i.e. an estimated glomerular filtration rate (eGFR) < 90 ml/min/1.73 m^2), the presence of micro or macroalbuminuria, receipt of dialysis, or an investigator diagnosis of CKD.

Diabetes care strategies

We defined nonconventional diabetes care strategies as those where diabetes-related care was provided outside of a traditional outpatient clinic appointment with a physician, diabetes educator, or dietician. Diabetes-related care was defined as the management of glycemia, blood pressure, and lipids; screening for related complications (i.e. microvascular or macrovascular disease); self-management support and education.

Control

Included studies could either have or not have a control group.

Outcomes

Diabetes-related outcomes included physiological outcomes (glycemic, lipid, blood pressure control), microvascular outcomes (retinopathy or blindness, decline in kidney function or progression to renal replacement therapy, neuropathy, gastroparesis, erectile dysfunction, autonomic dysfunction), macrovascular outcomes (myocardial infarction, heart failure, stroke, amputation, ulcers), and death.

Study design

We included both randomized-controlled trials (RCTs) and non-randomized studies (e.g. cohort, case-control, pre- and post-intervention studies).

Identification of studies

We first consulted an experienced health sciences librarian (BD) to develop a comprehensive search strategy. This strategy included a combination of key words and Medical Subject Heading (MeSH) terms that were consistent with our research aims and study population (Table 1 of the Online Supplementary Material). We validated our final search strategy through the retrieval of a key set of previously identified relevant articles.

We next searched electronic databases including MEDLINE, EMBASE, CINAHL, Cochrane Library, Scopus, BIOSIS, and Web of Science for relevant citations published until October 6, 2017 (no start date). We then reviewed the reference lists of all included studies and used the Related Articles feature in PubMed to identify

Table 1. Characteristics of included studies.

Author	Country	Design	Inclusion	# with DM and CKD	Program	Duration of program	Control
Community-based care							
Tobe et al.[12]	Canada	RCT	18+, First Nations, DM2, HTN. Subgroup with DM2 and CKD.	34 (17 intervention)[a]	Reserve clinic visit with home care nurse at 6 weeks, then every 3 months. Stopped BP meds and started Irbesartan (dose titrated as per protocol with specialist support).	1 year	Home care nurse visits, but if BP uncontrolled, follow-up appointment set with primary care physician. Letter with treatment recommendations sent.
Senior et al.[13]	Canada	P. cohort	17+, DM, HTN, or albuminuria. Subgroup with DM and CKD.	216[a]	Local clinic visits with allied health professional. Education, BP, cholesterol, and glycemic support. Meds adjusted under protocol with specialist support.	Mean 8.8 months	None
Tan et al.[14]	New Zealand	P. cohort	40–75, Maori and Pacific natives, DM2, HTN, creatinine 130–300 μmol/l, and >0.5 g proteinuria, previously studied as part of DEFEND study.	65 (33 intervention)	Community clinic visit with health-care assistant every month. BP management, transport to hospital for other appointments.	11–21 months	Usual care
Jiamjariyapon et al.[15]	Thailand	Cluster RCT	18–70, stages 3 and 4 CKD, DM, or HTN. Subgroup with CKD and DM.	237 (129 intervention)[a]	Home visits with multidisciplinary care team (health-care officer, village volunteer, family) at 1 month then every 3 months. Education, medication adjustment, and self-management support.	2 years	Usual care with group-based educational program at district hospital
Tan et al.[16]	New Zealand	P. cohort	18–65, Pasifika natives, DM2, ACR >40 on 2/3 samples, eGFR >40 ml/min/1.73 m², life expectancy 2 years.	43	Community clinic or home visit with nurse every 2–6 weeks. BP medication adjustment by protocol with support of specialist. Adherence support, education, and comprehensive regular medical review by diabetologist or GP for patients with complex medical history.	2 years	None
Walker et al.[17]	New Zealand	P. cohort	18+, DM2 (A1c > 8%), BP > 140/80, ACR > 30 mg/mmol on three occasions separated by 1 week.	52	CKD nurse practitioner offered care in family practice clinics every 2 weeks × 12 weeks. Tailored education and care plans, self-management, and education materials. Support for transport to appointments.	1 year	NR
Thomas et al.[18]	United Kingdom	Pre and post	Mild to moderate CKD. Subgroup with DM and CKD.	NR (13 GP practices)[a]	CKD care bundle implemented in GP practices, supported by renal nurse. Treat to target BP, self-management, and education (DVD, written information, group sessions).	NR	Usual care
Self-management/education							
Sevick et al.[19]	United States	RCT	Self-referred, community dwelling adults, DM2, 18+ years. Subgroup with DM and CKD.	32 (16 intervention)[a]	Group counselling weekly to monthly, glucose meter use training, provision of pedometer, and PalmOne Tungsten/E2 (personal device assistant) to support dietary self-monitoring.	6 months	Glucose meter training, provision of pedometer, group seminars, lay diabetes magazine, and monthly contact with study team.
Pagels et al.[20]	Sweden	Pre and post	CKD with eGFR > 30 ml/min/1.73 m².	58	Group sessions every semester for three consecutive days. Self-management education, exercise, problem-solving skills, medication adjustment, and goal setting.	Mean 4 months	None
Thomas and Bryar[21]	United Kingdom	P. cohort	18+, DM at risk of kidney disease, ACR > 2.5 mg/mmol men or >3.5 in women.	176 (116 intervention)	Self-management package inclusive of written materials, DVD, and self-monitoring diary.	NR	Usual care
Kazawa et al.[22]	Japan	P. cohort	20–74, DM2, eGFR 15–59 ml/min/1.73 m², attending hospital clinics in Japan.	62 (31 in intervention)	Nurse educator face-to-face interview every 2 weeks in home or research center followed by monthly phone calls. Education on diet, drug therapy, and exercise/rest balance, medication adherence, self-management.	1 year	Usual care

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Table 1. (continued)

Author	Country	Design	Inclusion	# with DM and CKD	Program	Duration of program	Control
Trocha et al.[23]	Germany	P. cohort	DM1 with HTN, retinopathy, >500 mg proteinuria, creatinine <265 µmol/l.	91 (45 intervention)	BP self-management sessions with allied health professionals every week to 4 months. Education, self-monitoring, and self-adjustment of BP medications.	Up to 10 years (mean 124 months)	Usual care
Williams et al.[44]	Australia	RCT	18+, DM (type 1 or 2), eGFR < 60 ml/min/1.73 m² or ACR > 2 in men and >3.5 in women, HTN, comprehend English, mentally competent.	75 (39 intervention)	Renal nurse visits every 2 weeks for medication self-management. Motivational interviewing, medication review, DVD, and self-monitoring BP.	3 months	Usual care
Nurse-led clinic							
Van Zuillen et al.[24]	Amsterdam	RCT	Creatinine clearance 20–70 ml/min. Subgroup with DM and CKD.	48 (25 intervention)[a]	Addition of nurse practitioner to nephrologist care in outpatient clinic. Promoted healthy lifestyle, self-management support, treat to target BP, and medication adherence.	NR	Usual care
Woodward et al.[25]	United States	P. cohort	DM2, HTN on >1 BP medication, SBP > 140 mmHg, DBP > 85 mmHg. Subgroup with CKD and DM.	41[a]	Clinic appointment with nurse. Education, written materials, treat to target BP, lifestyle advice, and risk factor management. Letter back to the GP to make treatment changes if needed.	2 years	None
Interdisciplinary care clinic							
Garcia-Garcia et al.[26]	Mexico	Pre and post	Patients referred to CKD clinic. CKD stages 3 and 4, at least one follow-up visit.	225[a]	Multidisciplinary (nurse, dietician, social worker, physician) CKD clinic visit every 1–3 months. Addressed glycemic control, BP, CKD, CVD risk reduction, anemia, mineral metabolism, medication adherence, and social and economic support. Recommendations about diet and exercise.	NR	None
Leung et al.[27]	Hong Kong	P. cohort	30–80, Chinese, DM2, albuminuria, creatinine 150–400, no evidence of rapid progression of renal disease.	160 (80 intervention)	Structured diabetes specialist/pharmacist clinic visit. Saw diabetes doc every 3–4 months with pharmacist visits half-way between clinic visits. Treat to target BP, A1c, and LDL, self-management support, medication adherence, regular lab monitoring.	2 years	Usual care
Hitomi et al.[28]	Japan	P. cohort	CKD on hemodialysis.	32 (17 intervention)	Multidisciplinary visit with physician, dietitian, pharmacist, and nurses. Education, self-management support, medication adjustment, and foot care.	NR	Dietician only
Bayliss et al.[29]	United States	P. cohort	Adult, referred for nephrology care by GP, eGFR 30–59, and comorbid diabetes and/or hypertension. Subgroup with DM and CKD.	878 (114 intervention)[a]	Multidisciplinary (docs, pharmacists, diabetes educator, dietician, social worker, and nurse) CKD clinic visits every 1–6 months with remote support if needed. Education, self-management support, medication adjustment, depression screening, and dietary assessment. Weekly team meetings to review all patients.	Mean 1.95 years	Shared care between GP and nephrologist
Rayner et al.[30]	United Kingdom	Pre and post	<65, DM, eGFR < 50 ml/min/1.73 m² with decline over time, not receiving RRT or attending pre-dialysis specialty clinic.	1002	Weekly database review to identify patients with deteriorating eGFR. Specialist diabetes-kidney clinic visits offered every 2–4 months until home BP was controlled or eGFR decline slowed. Education, BP management, diet and self-management support, and smoking cessation.	NR	Usual care

(continued)

Table 1. (continued)

Author	Country	Design	Inclusion	# with DM and CKD	Program	Duration of program	Control
Fogelfeld et al.[31]	United States	RCT	18–70, DM2, CKD stages 3 and 4, albuminuria, and micro or macrovascular complications, normal cognitive function, fasting or random glucose < 400mg/dl.	120 (60 intervention)	Multidisciplinary clinic visit (endocrinologist, nephrologist, diabetes educator, nurse practitioner) every 1 month for 6 months followed by every 2 months for 18 months. Additional follow-up visits if needed. Treat to target BP, A1c, and lipids.	2 years	Usual care
Luciano Ede et al.[32]	Brazil	P. cohort	CKD referred to clinic, followed for 3 months. Subgroup with CKD and DM.	368[a]	Multidisciplinary clinic visit (docs, social worker, nutritionist, nurse, and psychologist) every month. Dietary support, risk factor management, BP control, medication adjustment, glycemic control, smoking cessation, and motivation to adopt lifestyle change.	1 year	None
Glover et al.[33]	United Kingdom	Pre and post	DM and eGFR < 60 ml/min/1.73 m², or rate of decline > 5 ml/min/1.73 m² per year.	182	Diabetic nephropathy clinic with kidney and diabetes specialist nurse, nephrologist, and dieticians. Risk factor management as guided by clinical practice guidelines.	NR	Usual care
Lipscombe et al.[34]	Canada	Cohort	DM, part of PD program.	132	Chiropodist available during weekly PD clinics. Foot assessment and education. If wound care required, referred to another chiropody clinic (care provided on site later in study).	3 years	None
Low et al.[45]	Singapore	Case-control	DM, CKD stages 3 and 4, referred to diabetes-kidney clinic.	837 (418 intervention)	Diabetes-kidney clinic. Patients had combined assessments with nephrologists, endocrinologists, and allied health. Provided glycemic, BP, and lipid control.	Median 3 years	Usual care
Telemedicine Ishani et al.[35]	United States	RCT	18+, eGFR < 60ml/min/1.73 m², with clinic visit. Subgroup with CKD and DM.	447 (191 intervention)[a]	Remote interdisciplinary CKD care via telehealth device every 30 days. In-home training, health literacy, and lifestyle counseling. Management of BP, volume status, proteinuria, DM, mood, lipids, self-management support, and education. In-person clinic visits as needed.	1 year	Usual care with educational class
Joubert et al.[36]	France	Pre and post	18–80, DM, chronic HD.	15	Self-monitoring of blood sugar three to six times per day followed by blinded CGM × 5 days every 2 weeks. Data sent to a single diabetes expert and recommendations sent back to nephrologist.	12 weeks	Usual care
Kepenekian et al.[37]	France	P. cohort	18–83, DM2 on insulin, HD for >3 months, A1c > 6.5%.	28	CGM with insulin titration by remote physician based upon algorithm.	3 months	None
Dialysis-based diabetes care program Prentice et al.[38]	Canada	P. cohort	19+, DM, HD.	57	Baseline foot assessment with HD nurse with risk stratification and education. Follow-up monthly for those at high risk and annually for low risk. Education and foot care kit provided to those at high risk.	15 months	None
McMurray and McDougall[39]	United States	P. cohort	DM, part of HD program.	83 (45 intervention)	Foot assessment with diabetes care manager with risk stratification. Foot checks quarterly (more frequently if existing foot problem), education, motivational support, and referral system.	2 years	Usual care the first year then foot program the subsequent year.

(continued)

Table 1. (continued)

Author	Country	Design	Inclusion	# with DM and CKD	Program	Duration of program	Control
Neil et al.[41]	United States	P. cohort	18+, DM, ESRD on HD.	32 (13 intervention)	Foot assessment with HD nurse along with individual education, provision of shoes and inserts.	6 months	Usual care on alternate dialysis days
McMurray et al.[40]	United States	RCT	DM on PD or HD.	83 (45 intervention)	DM care manager provided self-management education, motivational coaching, nutrition counselling, BP, lipid and glycemic monitoring, foot checks, screening reminders. Informed physician of need for medication changes. Multidisciplinary diabetes advisory committee provided program oversight quarterly.	1 year	Usual care on alternate dialysis days
Cappy et al.[42]	United States	P. cohort	HD. Subgroup with DM and CKD.	8[a]	Progressive, self-paced exercise (cycling before or during HD or walking on a treadmill before HD). Option of stretching or lightweights during HD.	1 year	None
Marn Pernat et al.[43]	United States	Pre and post	18+, DM, initiated HD with at least 13 dialysis sessions.	35,513 pre (25,779 post)	Monthly intradialytic foot evaluations. Education, foot assessment, organized wound care, and referral to podiatrist/orthopedic clinic if needed.	NR	None

DM: diabetes mellitus; CKD: chronic kidney disease; RCT: randomized controlled trial; HTN: hypertension; BP: blood pressure; P. cohort: prospective cohort; ACR: albumin to creatinine ratio; A1c: hemoglobin A1c; eGFR: estimated glomerular filtration rate; GP: general practitioner; NR: not reported; SBP: systolic blood pressure; DBP: diastolic blood pressure; CVD: cardiovascular disease; LDL: low-density lipoprotein; RRT: renal replacement therapy; PD: peritoneal dialysis; CGM: continuous glucose monitoring; HD: hemodialysis; ESRD: end-stage renal disease.
[a]Only a subgroup of the study population had CKD and DM.

additional citations. Further, using similar search terms (e.g. nontraditional, diabetes), we searched Google for relevant citations up to December 30, 2017. We completed each search strategy in Google within a single browsing session.

Two reviewers (K.K.C and V.K) independently screened the titles and abstracts of all identified citations against selection criteria and categorized them as include, exclude, or uncertain. We decided a priori to include studies where only a subgroup of patients had both CKD and diabetes, if at least one diabetes-related outcome was reported for the subgroup. If multiple studies reported outcomes for a similar group of patients (e.g. if studies published both short- and long-term outcomes in separate papers for one patient group), we included the longer term study. We excluded studies not written in English, case reports, case series, clinical practice guidelines, reviews, and commentaries. We pilot tested the first 10 citations for consistency and clarity of our selection criteria.

We then retrieved full text articles for those studies that we deemed to include, as well as those we were uncertain about including. All full text articles were reviewed against our selection criteria. Reviewers communicated regularly through the study selection process. If there were discrepancies about whether to include a study, we resolved them by consensus. If no resolution could be attained, a third party resolved the discrepancies (S.M.R). A flow diagram of study inclusion and exclusion is detailed in Figure 1 of the Online Supplementary Material.

Charting and summarizing the data

Reviewers used standard forms to abstract the characteristics of all included studies (design, country, publication year), along with their population, intervention, outcomes, and relevant results. Given the heterogeneity of included studies, we presented our results descriptively.

Reviewers completed their charting independently. We pilot tested the first 10 articles to ensure that our data abstraction was consistent and made necessary changes prior to abstracting the remaining articles.

Results

Of the 2177 unique citations identified in our literature search, 34 studies met inclusion.[12–45] The characteristics of included studies are noted in Table 1, and study outcomes and results are reported in Table 2.

There were 7 RCTs,[12,19,24,31,35,40,44] one cluster RCT,[15] 19 observational cohort/case-control studies,[13,14,16,17,21–23,25–29,32,34,37–39,41,42,45] and 7 pre- and post-intervention studies included.[18,20,26,30,33,36,43] Studies were conducted in Australia,[44] Brazil,[32] Canada,[12,13,34,38] France,[36,37] Germany,[23] Hong Kong,[27] Japan,[22,28] Mexico,[26] the Netherlands,[24] New Zealand,[14,16,17] Singapore,[45] Sweden,[20] Thailand,[15] the United Kingdom,[18,21,30,33] and

the United States.[19,25,29,31,35,39–43] Most studies included fewer than 100 participants with stages 2–4 CKD and diabetes. The majority excluded patients with stage 5 disease or using dialysis. Some reported high losses to follow-up.[26,42]

We categorized nonconventional care programs using the Cochrane Effective Practice and Organization of Care (EPOC) taxonomy.[46] This taxonomy classifies health system interventions into groups based upon conceptual or practical similarities.[46] We grouped programs into community-based care (i.e. outreach service), unique diabetes self-management support and education, nurse-led care clinics (i.e. role expansion), interdisciplinary care clinics (i.e. team care), dialysis-based diabetes care programs (i.e. site of service delivery), and telemedicine strategies. If programs had overlapping features (e.g. community-based care program was led by a nurse), we used their location of delivery to categorize them. Most of the programs were developed by research investigators. Only four studies included patients in their program development, implementation, or evaluation.[18,21,22,44]

Community-based care

Community-based diabetes care programs brought diabetes support to patients' homes, community clinics, or primary care practices. Most interventions were developed for Indigenous populations.[12,14,16] Most studies were small and observational in design.[12–18]

These programs were multifaceted and included protocol guided blood pressure management, glycemic support and education, and self-management support. Nurses most often administered the program with the support of a medical specialist if needed. Care was offered in person, up to once monthly.

Over the short term, community-based care programs were described to have a modest, positive effect on blood pressure, cholesterol, and glycemic control. A reduction in proteinuria was also described. Where evaluated, programs did not appear to have an effect on cardiovascular outcomes or death.[14]

Self-management support/education

Nonconventional diabetes self-management support and education programs aimed to help participants adopt healthier lifestyles and self-manage their disease and treatments. However, rather than delivering self-management support traditionally (i.e. at an outpatient education appointment), studies evaluated the effect of printed materials and videos, group counseling, and devices (e.g. Palm Pilots) on patient outcomes. Self-management support programs were administered by allied health professionals, and contact was offered to participants up to once weekly. Most of the programs aimed to improve glycemic control or

Table 2. Study outcomes and results.

	Glycemia	Cholesterol	BP	Renal	Retinopathy	Ulcers/ amputation	CVD	Death	Results
Community-based care									
Tobe et al.[12]			x	x					Not all outcomes reported in CKD/DM group. Some with CKD/DM and existing overt nephropathy had regression to microalbuminuria, but regression to normoalbuminuria did not occur.
Senior et al.[13]	x	x	x	x					No change in eGFR and creatinine. Significant reduction in A1c, BP, LDL, and cholesterol in stages 2 and 3 CKD. Significant reduction in SBP for stage 2 CKD.
Tan et al.[14]	x	x	x	x		x	x	x	Significant improvement in SBP at 1 year, but no difference over long term. No change in eGFR and albuminuria in 1 year. No change in A1c, cholesterol, CV outcomes, and death.
Jiamjariyapon et al.[15]	x			x			x	x	Not all outcomes reported in CKD/DM subgroup. In CKD/DM, significantly lower A1c in intervention group (7.3 vs. 7.9%).
Tan et al.[16]	x		x	x		x	x	x	Proportion who reached BP 125/85 doubled over follow-up. Higher proportion had urinary ACR < 30 mg/mmol (19 vs. 33%). Significant reduction in A1c (81 mmol/mol to 71), SBP (137 to 126 mmHg), DBP (84 to 74 mmHg), eGFR (68 to 57 ml/min/1.73 m²), and ACR (126 to 51 mg/mmol).
Thomas et al.[18]			x						After intervention, slightly higher proportion met BP targets (48 pre- vs. 49.2 post-intervention).
Self-management/education									
Sevick et al.[19]	x	x	x						Not all outcomes reported in CKD/DM group. No difference in A1c or glucose between intervention and control.
Pagels et al.[20]	x		x	x					Significant improvement in A1c (7.1 to 6.6%), % of patients with target SBP < 130 mmHg (25 to 45%), and % of patients with target DBP < 80 mmHg (49 to 59%). No change in eGFR and albuminuria.
Thomas and Bryar[21]	x		x						No statistically significant difference in BP and A1c between groups.
Kazawa et al.[22]	x	x	x	x					At 24 months, kidney function maintained in intervention but deteriorated in control. No patient started dialysis in intervention (2 in control). A1c significantly declined at 6 months and remained stable thereafter in controls; slight decline in A1c was observed in intervention. No difference in BP and HDL between groups.
Trocha et al.[23]	x		x	x	x			x	At the end of follow-up, SBP significantly lower in intervention than controls (−4/−6 vs. 5/0.3 mmHg). BP reduced in intervention group and increased in control group. Annual rate of eGFR decline lower in intervention vs. control; 7 (16%) intervention vs. 22 (48%) control died, 11 (24%) intervention vs. 18 (39%) control started HD, 3 (7%) intervention versus 9 (20%) control amputation, and 5 (11%) intervention versus 10 (22%) control new blindness.
Williams et al.[44]			x						At 9 months, reduction in BP in intervention and control group with no significant difference between groups.
Nurse-led clinic									
Van Zuillen	x		x	x			x	x	Not all outcomes reported in CKD/DM. No significant difference in A1c between groups.
Walker et al.[17]	x	x	x	x					ACR declined over 12 months (−6.75 mg/mmol/month). Significant reduction in creatinine clearance (−0.3 ml/min/1.73 m²), BP (150/92 vs. 132/76 mmHg), cholesterol (5.25 vs. 4.6 mmol/l), and A1c (8.75 vs. 7.55%) over study duration.
Woodward et al.[25]	x		x	x			x		Not all outcomes reported in CKD/DM. Significant improvement in SBP (178 to 150 mmHg), DBP (88 to 76 mmHg), and A1c (8.7 to 8.1%). Lower percentage of patients with microalbuminuria (47 vs. 28%).

(continued)

Table 2. (continued)

	Glycemia	Cholesterol	BP	Renal	Retinopathy	Ulcers/ amputation	CVD	Death	Results
Interdisciplinary care clinic									
Garcia-Garcia et al.[26]	x	x	x	x					Significant reduction in fasting glucose (149 to 130 mg/dl), A1c (8.5 to 7.8%) after intervention. Percentage of patients reaching target glucose (<130 mg/dl) improved from 54% to 68%. eGFR declined over time (31 to 28 ml/min/1.73 m^2).
Leung et al.[27]	x	x		x				x	Intervention had lower SBP (140 vs. 148 mmHg), DBP (68 vs. 72 mmHg), creatinine (4 vs. 5 μmol/l), LDL (2 vs. 3 mmol/l), rate of creatinine change (3382 μmol/l/year), rate of ESRD 13.5 vs. 24per 100 PYs, and rate of death 4.3 vs. 14.8 per 100 PYs compared to usual care.
Hitomi et al.[28]			x				x		No difference in BP or albuminuria before HD. CV events in intervention 29% vs. controls 53%. No deaths in intervention and 20% in control.
Bayliss et al.[29]	x	x	x	x					Not all outcomes reported in CKD/DM. No difference in A1c between groups.
Rayner et al.[30]				x					Significantly lower rate of eGFR decline (−5.2 vs. 1.1 ml/min/1.73 m^2) after intervention, fewer started RRT.
Fogelfeld et al.[31]	x	x	x	x					Greater % of patients in intervention arm had improved ACR (63 vs. 43% controls) and attained target A1c < 7% (50 vs. 31.6%). No statistically significant difference in hypoglycemia, lipid control, and BP. Lower proportion developed ESRD in intervention (13 vs. 28%).
Luciano Ede et al.[32]	x			x			x		Not all outcomes reported in the DM/CKD group. Lower fasting glucose (218 to 137 mg/dl), proteinuria (1.6 to 1.0 mg/mmol), SBP (143 to 125 mmHg), DBP (87 to 79 mmHg), and eGFR (55 to 53 ml/min/1.73 m^2) after intervention.
Glover et al.[33]	x	x	X	x				x	Higher proportion met target SBP (53 vs. 67%), A1c (20 vs. 51%), and total cholesterol (52 to 80% mg/mmol) after intervention; 7% died and 5% reached ESRD
Lipscombe et al.[34]						x			Chiropodist care protective against death, amputation in regression analysis. Percentage of patients with amputations decreased each year of program (9 to 2.9 amputations during last year).
Low et al.[45]	x	x	X	x					45.8 vs. 54.2% progressed to CKD stage 5 in case (i.e. diabetes–kidney clinic) compared with control group (45% lower hazard). Linear mixed models noted reduction in A1c, DBP, and ACR in cases. No difference in SBP and LDL between groups.
Telemedicine									
Ishani et al.[35]	x	x	X	x				x	Not all outcomes reported in CKD/DM. No difference in outcomes between intervention and control.
Joubert et al.[36]	x								A1c declined significantly after intervention (6.85 to 6.46%) and mean CGM glucose (8.3 to 7.7 mmol/l).
Kepenekian et al.[37]	x								Lower A1c (8.4 to 7.6%) after intervention as well as mean CGM glucose (9.9 to 8.9 mmol/l). No severe hypoglycemic events.
Dialysis-based diabetes care program									
Prentice et al.[38]						x			Significant reduction in number of wounds, improvement in grade of wounds. No significant improvement in staging of wound. Five new amputations after intervention.
McMurray and McDougall[39]						x			No amputations in intervention group versus 5 lower extremity versus 2 finger amputations in controls. Fewer hospitalizations for DM, PVD, infections, and amputations in intervention group. When usual care switched to intervention, decrease in diabetes-related hospitalizations and amputations from the preceding year.

(continued)

Table 2. (continued)

	Glycemia	Cholesterol	BP	Renal	Retinopathy	Ulcers/ amputation	CVD	Death	Results
Neil et al.[41]						x			No new foot ulcers. One developed a new toe ulcer (unclear if patient is in intervention or control group).
McMurray et al.[40]	x					x		x	A1c declined from 6.9% to 6.3% in intervention (no change in controls), no severe hypoglycemic events, no progression of neuropathic disease in intervention (progression in control), no amputations (5 lower extremity and 2 finger amputation in control), fewer diabetes/vascular related hospitalizations (10 vs. 1 in control), and foot risk assessment scores remained unchanged (2.0 to 2.2) in intervention (worsened in controls; 2.7 vs. 3.3). Majority had screening eye exam. No change in mortality.
Cappy et al.[42]	x								Mean glucose nonsignificantly declined (12.9 to 11.7 mmol/l). Mean A1c levels did not change significantly but three patients experienced improvement.
Marn Pernat et al.[43]						x			Amputation rate pre-intervention 1.30 per 100 PY, post-intervention 1.07 per 100 PY (rate reduction of 17%, $p = 0.0034$).

BP: blood pressure; CVD: cardiovascular disease; CKD: chronic kidney disease; DM: diabetes mellitus; eGFR: estimated glomerular filtration rate; A1c: hemoglobin A1c; BP: blood pressure; LDL: low-density lipoprotein; HDL: high-density lipoprotein; SBP: systolic blood pressure; ACR: albumin to creatinine ratio; DBP: diastolic blood pressure; HD: hemodialysis; ESRD: end-stage renal disease; PY: person-years; RRT: renal replacement therapy; CGM: continuous glucose monitoring; PVD: peripheral vascular disease.

blood pressure. Studies were small and most often observational in design.[19–23,44]

Over the short term, programs were described to have small positive effects on glycemic control, blood pressure control, and kidney function. In one study where participants learned to self-manage and self-titrate their own blood pressure medications, there may have been beneficial effects on renal outcomes (i.e. the need for renal replacement therapy), amputation, blindness, and death.[23]

Nurse-led care clinics

Two small studies evaluated the effect of nurse-led care clinics on diabetes-related outcomes. At outpatient appointments, nurses adjusted participants' cardioprotective (i.e. blood pressure and lipid-lowering agents) and glycemic medications, conducted diabetes-related screening (e.g. foot screening), and provided education, adherence, and self-management support. Clinic visits were offered up to twice per month.

Over the short term, nurse-led care was described to have beneficial effects on glycemia, blood pressure, lipid control, and kidney function. Their effect on other microvascular outcomes, macrovascular outcomes, or death was not described.[24,25]

Interdisciplinary care clinics

Interdisciplinary care clinics were the most frequent care strategy studied. These clinics brought health-care professionals together to provide diabetes-related care at a single outpatient visit. The majority of studies were observational, but included more participants than studies of other programs.[26–34,45]

At their appointments, participants had their cardioprotective and glycemic medications adjusted, were screened for diabetes-related complications, and were offered self-management support. Appointments were offered up to once per month, and in some cases, remotely between clinic visits (i.e. telephone support). In some studies, routine interdisciplinary team meetings were also held to discuss participant cases.

Interdisciplinary care may have had beneficial effects on glycemic, lipid, blood pressure control, and kidney function. Where studied, cardiovascular outcomes, end-stage kidney disease, amputations, and mortality may have been lower in participants who were part of interdisciplinary care clinics.

Telemedicine

Telemedicine strategies used telecommunications to deliver diabetes-related health services to patients (i.e. technology, telephone-based support).[35–37]

In two small studies, patients wore continuous glucose monitoring (CGM) devices, and blood sugars were sent remotely to care providers for glycemic medication adjustment. Another randomized controlled study offered remote, interprofessional care to patients via a telemedicine device.

Short-term improvements in glycemic control (i.e. 3 months) was reported in CGM studies. Remote interprofessional care did not appear to reduce the risk of microvascular outcomes, macrovascular outcomes, or death in patients with CKD and diabetes.

Dialysis-based diabetes care

Dialysis-based diabetes care strategies offered care to patients during hemodialysis sessions. Studies of these programs were small, observational, and often did not involve a control group.[38–43]

The majority were foot care programs where patients received education and had their feet examined while dialyzing. One study offered multifactorial diabetes care to patients in the dialysis unit (i.e. glycemic control, self-management support, foot care).[40] Support was offered up to weekly, by hemodialysis nurses and in-unit diabetes case managers.

Programs may have had beneficial effects on glycemic control, ulcers, amputations, and death.

Discussion

Twenty-five to 50% of patients with diabetes live with CKD.[8] Where the prevalence of multimorbidity will only continue to increase,[1] it is important to evaluate new strategies to provide these complex individuals with patient-centered health care.

We conducted a comprehensive scoping review of the medical and grey literature to systematically identify and describe nonconventional diabetes-related care strategies and their effects on diabetes-related outcomes in adults with diabetes and CKD. We found that unique self-management and education programs, telemedicine, dialysis-based diabetes care, nurse-led care clinics, interdisciplinary care clinics, and community-based care programs have been evaluated in some patients with diabetes and stages 2–4 CKD. Care programs were most often developed by study investigators and were in some cases time and resource-intensive (e.g. offered care up to once weekly, used telemedicine technology).

Programs were described to have beneficial effects on glycemic, lipid, blood pressure control, and kidney function. However, studies were limited in their design (observational, lack of control), involved a small number of participants (typically < 100), and were short in duration. Where RCTs of programs were conducted, community-based diabetes care, self-management education programs, and interdisciplinary care clinics had reported benefits.

Based upon our review, we might suggest that prior to developing, implementing, or continuing these programs

(i.e. in centers that may already have access to nonconventional strategies), it might be beneficial to study these strategies as part of large RCTs. Given the complexity of some programs, it would also be important to understand their feasibility on a larger scale because of their resource and time requirements.[47] Finally, given low participant numbers and often high dropout rates in some studies, consideration should be given to involving patients in program design. This might ensure that interventions address patient values and their cultural and psychosocial needs. This may better promote patient adherence to interventions.[47]

Strengths and limitations

We conducted a comprehensive review and abstracted study data using standardized processes and structured tools. We screened and abstracted citations in duplicate. We summarized the characteristics of studies and interventions, and we noted any beneficial effects on diabetes-related outcomes.

There are limitations to discuss. Our review was a scoping review rather than a systematic review. As such, we included all levels of evidence (i.e. did not restrict to RCTs). Although we commented upon some of the limitations of included studies, we did not formally evaluate their quality.[11,48] We also excluded non-English studies and we were lenient in our definition of CKD. CKD is typically defined by an eGFR < 60 ml/min/1.73 m^2 or microalbuminuria lasting >3 months. Some studies did not report these definitions per se, and as such, some patients may have been misclassified with this condition.

Although we used broad search terms, due to the nature of our research question, we may not have identified all nonconventional strategies. We used the EPOC taxonomy to classify care programs but recognize that some programs had overlapping features (i.e. nurse-led clinics also offered self-management strategies). We did summarize study characteristics and outcomes, but were unable to draw conclusions about the most effective care strategies for adult patients with diabetes and CKD.

Conclusions

Small, frequently observational studies, have described that nontraditional diabetes care strategies might potentially be effective for patients with diabetes and CKD. We suggest that before developing and studying new ways of caring for patients with multimorbidity, patients should be included in program development, they should be studied in a randomized-controlled fashion, and the feasibility and health economic benefit of these programs should be explored in a real-life setting.

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Supplemental material

Supplemental material for this article is available online.

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