Can J Diabetes 45 (2021) 89–95

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Review

Mobile Diabetes Telemedicine Clinics for Aboriginal First Nation People With Reported Diabetes in British Columbia

Keith G. Dawson BA, MD, PhD [a,*]; Andrew Jin MD, MHSc [b]; Matthew Summerskill RN, CDE, BScN, BEd, BA [c]; Dann Swann RN [d]

[a] Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada
[b] School of Population and Public Health, University of British Columbia, Surrey, British Columbia, Canada
[c] Carrier-Sekani Family Services, Prince George, British Columbia, Canada
[d] Seabird Island Indian Band, Agassiz, British Columbia, Canada

Key Messages

- First Nations peoples in Canada often face geographic, social and cultural barriers to accessing diabetes care.
- Diabetes care requires mutual provider-patient understandings, strong relationships and continuity of care.
- Care that includes screening for complications, assessment of disease status and education can be provided by diabetes nurse educators with telemedicine specialist backup.

ARTICLE INFO

Article history:
Received 19 June 2019
Received in revised form
7 May 2020
Accepted 29 May 2020

Keywords:
diabetes mellitus
First Nations
Indigenous
telemedicine

ABSTRACT

Objectives: Our aim in this study was to assess the impact of the Mobile Diabetes Telemedicine Clinic, which serves First Nations communities in British Columbia, on clients' with diabetes condition and management.
Methods: A travelling team visits approximately 120 sites annually. Assessment of persons with diabetes includes interview, physical exam, point-of-care laboratory (glycated hemoglobin, blood glucose, lipid profile, kidney profile) and retinal fundus photographs. Nurses provide education and lifestyle, medication and wellness recommendations. The endocrinologist reviews records and provides further recommendations to primary care providers. To assess the impact at second and later visits, compared with the immediately preceding visit, we measured mean changes in body weight, glycated hemoglobin, urinary albumin:creatinine ratio and estimated glomerular filtration rate, as well as changes in proportions of clients meeting targets for blood pressure, low-density lipoprotein cholesterol, medications, smoking and physical activity.
Results: From 2012 to 2018, a total of 3,045 visits were completed by 1,056 clients with diabetes who attended on at least 2 occasions. Mean time since the preceding visit was 1.6 years. Mean change (after vs before) in glycated hemoglobin was 0.06 (95% confidence limit, −0.03 to 0.14), body weight 0.0 kg (−0.2 to 0.2), albumin:creatinine ratio 1.31 mg/mmol (0.27 to 2.35) and estimated glomerular filtration rate −4.8 mL/min (−6.2 to −3.4). The proportion of clients meeting both blood pressure targets (systolic <130 mmHg and diastolic <80 mmHg) increased from 25% at first visit to 33% at the second and 32% at the third or later visits ($p<0.001$, chi-square test). The proportion of those with low-density lipoprotein cholesterol of <2.0 mmol/L increased from 56% to 62% at the second visit and 69% at the third or later visits ($p<0.001$). The proportion of those taking renin-angiotensin-aldosterone system inhibitors or other antihypertensive agents and statins increased ($p<0.001$), and proportions decreased for smoking ($p<0.001$) and exercising ≥60 min/week ($p=0.002$).
Conclusions: Weight and diabetic control were stabilized. Most management practices showed improvement.

Mots clés :
diabète sucré
Premières Nations
Autochtones
télémédecine

RÉSUMÉ

Objectifs : Le but de notre étude était d'évaluer les répercussions de la Mobile Diabetes Telemedicine Clinic, qui est offerte aux communautés des Premières Nations de la Colombie-Britannique, sur l'état de santé et la prise en charge des clients diabétiques.

* Address for correspondence: Keith G. Dawson BA, MD, PhD, Department of Medicine, University of British Columbia, 4197 Yuculta Crescent, Vancouver, British Columbia V6N 4A9, Canada.
E-mail address: kdaw@mail.ubc.ca

1499-2671/
https://doi.org/10.1016/j.jcjd.2020.05.018

Méthodes : Une équipe itinérante visite des clients dans environ 120 sites par année. L'évaluation des personnes diabétiques repose notamment sur l'entrevue, l'examen physique, les analyses de laboratoire sur le lieu d'intervention (hémoglobine glyquée, glycémie, bilan lipidique, bilan rénal) et les photographies rétiniennes. Des infirmières donnent des recommandations sur l'éducation, le mode de vie, les médicaments et le bien-être. L'endocrinologue passe en revue les dossiers et donne des recommandations supplémentaires aux prestataires en soins primaires. Pour évaluer les répercussions lors de la deuxième visite et des visites subséquentes, nous avons mesuré les changements moyens dans le poids corporel, l'hémoglobine glyquée, le rapport albuminurie/créatininurie et l'estimation du débit de filtration glomérulaire ainsi que les changements dans la proportion des valeurs cibles de la pression artérielle, du cholestérol à lipoprotéines de faible densité, des médicaments, de la consommation de tabac ou de l'activité physique obtenues par les clients par rapport à la visite précédente.
Résultats : De 2012 à 2018, l'équipe itinérante a réalisé un total de 3045 visites auprès de 1056 clients diabétiques qui se sont présentés au moins 2 fois. Le temps moyen par rapport à la visite précédente était de 1,6 an. Les changements moyens (après *vs* avant) étaient de 0,06 (intervalle de confiance à 95 %, de −0,03 à 0,14) pour l'hémoglobine glyquée, de 0,0 kg (de −0,2 à 0,2) pour le poids corporel, de 1,31 mg/mmol (de 0,27 à 2,35) pour le rapport albuminurie/créatininurie et de −4,8 ml/min (de −6,2 à −3,4) pour l'estimation du taux de filtration glomérulaire. La proportion de clients qui atteignaient les valeurs cibles de la pression artérielle (systolique $<$ 130 mm Hg et diastolique $<$ 80 mm Hg) passait de 25 % à la première visite à 33 % à la deuxième visite et à 32 % à la troisième visite ou aux consultations subséquentes ($p < 0{,}001$, test de distribution du x^2). La proportion de clients qui avaient un cholestérol à lipoprotéines de faible densité $<$ 2,0 mmol/L passait de 56 % à 62 % à la deuxième consultation et à 69 % à la troisième consultation ou aux consultations subséquentes ($p < 0{,}001$). La proportion de clients qui prenaient des inhibiteurs du système rénine-angiotensine-aldostérone ou d'autres antihypertenseurs et des statines augmentait ($p < 0{,}001$), et la proportion de clients qui consommaient du tabac ($p < 0{,}001$) ou faisaient de l'exercice $\geq$ 60 min/semaine ($p = 0{,}002$) diminuait.
Conclusions : La maîtrise du poids et du diabète était stabilisée. La plupart des pratiques de prise en charge montraient une amélioration.

Introduction

The incidence of diabetes is rapidly increasing in First Nations (FN) peoples in Canada (1–3). Whether due to poverty, isolation, modernization of lifestyle or psychosocial factors stemming from the ensuing effects of colonization and residential schools (4), there is a recognized need to enhance both accessibility and quality of medical care in FN communities. Part of the legacy of the history of colonization in Canada is that few FN communities have had the overarching support, infrastructure, finances or partnering expertise to mount a system to identify and provide ongoing support to those living with diabetes in their communities.

In the late 1990s, with growing awareness of diabetes-related hardships, the First Nations Chiefs Health Committee explored avenues to help improve FN peoples' access to diabetes services. Consequently, in 2002, the Aboriginal Diabetes Initiative (ADI) supported the creation of a Mobile Diabetes Telemedicine Clinic (MDTC) through the First Nations Chiefs Health Committee and the First Nations Summit Society. The latter's management ended in 2004 and was thereafter organized by the Carrier-Sekani Family Services in Prince George, British Columbia. Initially started as a retinopathy screening service, it was augmented in 2004 to include a full point-of-care diabetes laboratory panel, comprehensive diabetes education and assessments and with best practice recommendations for clients and their primary care providers (PCPs). Subsequently, in 2008, a complete second team from Seabird Island Band in Agassiz was established to cover the southern part of British Columbia. Recommendations by endocrinology and ophthalmology specialists are now provided remotely.

Table 1 summarizes the size and other characteristics of the 2 MDTC target populations ascertained in 2008 (just before inception of the Seabird Island mobile clinic). Since then, the MDTC of Carrier-Sekani Family Services has expanded to well over 60 communities across an expansive region. Clients are distributed over a large number of rural/remote communities, highlighting the logistical challenges involved in providing access to diabetes clinics in FN communities. Current Canadian guidelines for the management of diabetes care (5) state that recent evidence supports the need for those living with diabetes to have access to a specialized team with training in diabetes to provide ongoing self-management education and support. This includes access for FNs, regardless of remoteness or community size.

Although previous outcome reports have been presented elsewhere (6), in this observational study, we report on the outcomes of the MDTC services (excluding eye examination findings and outcomes) between 2012 and 2018, a period in which MDTC staffing had become sufficient to implement full service to the entire target area.

Methods

Study design and population

FN community health workers advised their members that they could be seen by the MDTC at a prescheduled time in their community. The team travelled by road, boat or plane to community

Table 1
Characteristics of MDTC target populations

	Carrier-Sekani	Seabird Island
FN reserve communities served (N)	60*	70
On-reserve resident population, 2005 (total N)	21,879	22,435
On-reserve resident population, 2005, aged 18+ years (N)	14,659	15,278
Prevalence of diabetes in British Columbia on reserve, 2003–2008, aged 18+ years	8.6%	8.6%
Population with diabetes, estimated (N)	1,261	1,314
Population-weighted mean distance † to nearest diabetes education centre (km)	98	47
Population-weighted mean distance † to nearest ophthalmologist (km)	231	116
Population-weighted mean distance † to nearest medical diabetes specialist (km)	507	206

FN, First Nations; *MDTC*, Mobile Diabetes Telemedicine Clinic.
Note: Data taken from Mobile Diabetes Clinic Needs Assessment, 2008, BC Region, First Nations and Inuit Health Program, Health Canada (unpublished).
* Actual number of reserve communities substantially increased since this date.
† Distance from each FN reserve community to nearest point of specified service.

sites. Local health-care teams scheduled appointment times and clients were seen individually.

People known to have diabetes received a comprehensive assessment consisting of: 1) an interview by a nurse, inquiring about diabetes history, medications, secondary complications of diabetes (cardiovascular disease, peripheral vascular disease, renal disease, retinopathy, neuropathy) and related risk factors (family history, high blood pressure [BP], smoking, physical activity, diet, emotions); 2) BP measurement; 3) height and weight (in kilograms) measurement, and calculated body mass index (BMI, in kg/m^2); 4) examination for foot ulcers, sensory testing for neuropathy and foot care education; 5) urinary albumin:creatinine ratio (ACR) to screen for early diabetic nephropathy; 6) capillary (finger prick) serum creatinine measurement (with calculated estimated glomerular filtration rate [eGFR]) to assess renal function; 7) capillary glycated hemoglobin (A1C) and fasting blood glucose (FBG) or random BG measurement; 8) capillary fasting serum lipid profile (total cholesterol [TC], high-density lipoprotein cholesterol [HDL-C], triglycerides [TG], calculated low-density lipoprotein cholesterol [LDL-C] and calculated TC:HDL-C ratio); 9) personal diabetes management education from the nurse and 10) ocular assessment and fundus photography. The assessment was tailored to each client's needs, and clients were able to decline specific procedures if these had been recently performed elsewhere. People who had not previously been diagnosed as having diabetes were screened with FBG or capillary A1C measurement. If the screening result was consistent with diabetes, the client was advised that (s)he probably had diabetes and was offered a comprehensive assessment. These visits targeted holistic education in such topics as mental/spiritual wellness, nutrition/diet, physical activity, therapeutic targets (i.e. A1C, glucose levels, BP, cholesterol), medication therapies and education regarding risks for complications and avoidance strategies; thus, the emphasis of education was largely preventive in focus. Aspects of self-care were emphasized, including the benefits of moderate weight reduction (5% to 10% of initial body weight) (7) in those with obesity. Physical activity of choice was encouraged on a regular basis, commensurate with patients' age and physical limitations. A review of the pathophysiology of diabetes and differences between types of diabetes was accentuated. The use of visuals, engaging tools and storytelling were employed as culturally sensitive methods to facilitate better understanding and build relationships during one-to-one sessions. At the end of each appointment, nurses provided clients with a written summary of their wellness goals and laboratory values. Reports with specific recommendations for PCPs were then made, and the endocrinologist then verified the appropriateness of these and provided his own recommendations via access to the virtual record. Detailed written reports (diabetes and ophthalmology) with a summary of team recommendations were generated and sent by letter post, usually within 1 week, with the client's signed consent, to the physician or community health-care centre that the client had identified as his/her PCP.

Urine ACR and capillary blood hemoglobin A1C were measured using an analyzer (Model DCA2000, Siemens). Creatinine, lipids and glucose were measured in the capillary blood by chemistry analyzer (Piccolo Xpress, Abaxis). These point-of-care devices undergo daily quality control testing in the field, and periodic evaluation and calibration in a reference clinical chemistry laboratory (Canadian External Quality Assurance Laboratory, Vancouver, British Columbia; https://www.ceqal.com). The internal quality control program employs commutable test samples that have reference values assigned by internationally credentialed reference methods. This internal quality control program provides performance data for confirming the accuracy and traceability of the test results to international standards.

An observational study design was used to evaluate the program's effectiveness at improving management of clients' diabetes. The study cohort included all clients with diabetes from Seabird Island Health Services and Carrier-Sekani Family Services who attended the mobile clinic 2 or more times. For purposes of this report, clients of the 2 programs were combined into a single study cohort. The study design was adapted from a model developed for the ADI, First Nations and Inuit Health Program and Health Canada, specifically for purposes of evaluating mobile diabetes clinic programs (8).

Outcome measures

Serial measurements of the following were extracted from the MDTC client records: weight, calculated BMI, systolic and diastolic BP, A1C, urinary ACR, FBG, serum creatinine, estimated eGFR (calculated by the Chronic Kidney Disease–Epidemiology Collaboration equation), TC, HDL-C, TG and fasting LDL-C (calculated by the Friedewald method). We recorded whether (yes/no) the client was using specific categories of medication: insulin, glucagon-like peptide-1 agonists, any oral antihyperglycemic agents (metformin, sulfonylureas, thiazolidinediones, dipeptidylpeptidase-4 inhibitors, sodium/glucose cotransporter 2 inhibitors), renin-angiotensin-aldosterone system (RAAS) inhibitors, other antihypertensive agents, beta-hydroxy beta-methylglutaryl coenzyme A reductase inhibitors (i.e. statins) and other cholesterol-regulating medications. We also recorded (yes/no) self-reported physical activity frequency ($\geq$60 min/week) and self-reported smoking (daily or occasionally).

Statistical analysis

Those who attended the mobile clinic 2 or more times formed the study cohort for the outcome analysis. At second and later clinic visits, the amount of change (after vs before) in client characteristics measured on an interval-ratio scale (weight, BP, A1C, ACR, FBG, eGFR, TC, HDL-C, TG and LDL-C), since the immediately preceding visit, was considered an indicator of improvement or worsening of management of an individual client's diabetes. We tested the null hypothesis that the mean change between successive visits was zero, using a one-sample (paired), two-sided t test. For client categories that were measured in a yes/no or other categorical way, a change in category membership between successive clinic visits was considered to be an indicator of improvement or worsening of management of the individual client's diabetes. We used the chi-square test to test the null hypothesis that there was no association between visit number and category membership.

The clinical research ethics board of the University of British Columbia reviewed and approved the study methods (File No. C02-0101).

Results

Table 2 summarizes clinic activity (both programs combined) between January 1, 2012 and December 31, 2018; a total of 4,547 visits were by persons known to have diabetes. Those screened for diabetes were not included in these data. A total of 2,558 individuals with diabetes attended the clinic, representing 99% of the estimated number of persons with diabetes in the target population (n=2,575; Table 1), Those who attended the mobile clinic 2 or more times (n=1,056), attending a total of 3,045 visits, formed the study cohort for the outcome analysis.

Table 3 compares the characteristics of the study cohort with those who were excluded because they attended only 1 visit. Compared with those excluded, the study cohort members were

Table 2
MDTC activity (January 2012 to December 2018)

	N	%
Visits (clients examined by nurse)	5,484	100%
Visits by clients with diabetes	4,547	83%
First visits in study period	2,558	47%
Second visits in study period	1,056	19%
Third visits in study period	537	10%
Fourth visits in study period	250	5%
Fifth visits in study period	103	2%
Sixth and later visits in study period	43	1%
A1C tests	4,877	89%
Fasting blood glucose tests	2,122	39%
Serum lipid profiles	3,937	72%
Urine ACR tests	1,739	32%
Serum creatinine and eGFR tests	2,777	51%

A1C, glycated hemoglobin; *ACR*, albumin:creatinine ratio; *eGFR*, estimated glomerular filtration rate; *MDTC*, Mobile Diabetes Telemedicine Clinic.

older; had diabetes of longer duration; and were more likely to be using insulin, oral antihyperglycemic agents, RAAS inhibitors, other antihypertensive medications or statins. In addition, they had higher BMI, BP and A1C.

Table 4 compares baseline variables of the study cohort (i.e. at first visit) vs second, third or subsequent visits. Table 4 also shows mean changes between successive visits among the study cohort. Antihyperglycemic therapy increased in intensity: 27% of clients were managed without drugs at first visit, decreasing to 20% at later visits ($p<0.001$); 64% were taking metformin at first visit, increasing to 67.5% at later visits ($p<0.001$); 25% were taking a sulfonylurea at first visit, increasing to 27.5% at later visits ($p=0.076$); and 23% were taking daily insulin at first visit, increasing to 30% at later visits ($p<0.001$). The use of dipeptidylpeptidase-4 inhibitors and sodium/glucose cotransporter 2 inhibitors also increased ($p<0.001$). Mean absolute change in A1C between successive visits was +0.06% (95% confidence interval [CI], −0.03 to +0.14) over a mean interval of 1.6 years. Twenty-five percent of clients had an A1C reduction of >0.60%, and 25% had an A1C increase of >0.70%.

BP showed improvement. Twenty-five percent of clients were normotensive (systolic BP <130 mmHg and diastolic BP <80 mmHg) at first visit, increasing to 32.5% at later visits ($p=0.001$); 49% were taking RAAS inhibitor therapy at first visit, increasing to 62% at later visits ($p<0.001$); 34% were taking other antihypertensive medication at first visit, increasing to 44.5% at later visits ($p<0.001$). Renal function was essentially stable, with a mean change in eGFR between successive visits of −4.79±0.70 mL/min (95% confidence interval, −6.16 to −3.42).

Lipid status also improved. Fifty-six percent of clients had an LDL-C of <2.0 mmol/L at first visit, increasing to 65.5% at later visits ($p<0.001$). At first visit, 40% were treated with a statin, increasing to 51.5% at later visits ($p<0.001$).

Smoking was practised by 24% of clients at first visit, decreasing to 21% subsequently ($p<0.001$). Physical activity ≥60 min/week was practised by 34% of clients at first visit, decreasing to 28% at subsequent visits ($p=0.002$). Between successive visits, clients' mean change in weight was 0.0 kg (95% confidence interval, −0.2 to +0.2 kg).

Discussion

Telemedicine and mobile health programs have helped improve patient outcomes (9). Specific health promotion, screening and education opportunities delivered by mobile diabetes clinics have been recommended in evidence-based clinical practice guidelines as a means by which FN peoples can gain better access to needed health care in Canada (5). The MDTC is unique in combining

Table 3
Status at first clinic visit: Study cohort (returnees) vs excluded (did not return)

	Study cohort, n (%)	Excluded, n (%)	p Value*
Age, years			
<50	204 (20)	515 (34)	<0.001
50–59	281 (27)	344 (23)	
60–69	322 (31)	383 (25)	
70+	230 (22)	279 (18)	
Gender			
Female	571 (57)	847 (57)	0.731
Male	439 (43)	633 (43)	
Duration of diabetes, years			
<3	89 (13)	134 (19)	0.012
3–5.9	127 (18)	133 (19)	
6+	491 (69)	450 (63)	
Body mass index, kg/m^2			
<25	70 (7)	173 (13)	<0.001
25–29.9	220 (23)	343 (26)	
30–39.9	503 (52)	613 (46)	
40+	173 (18)	203 (15)	
Diet only, no medications			
Yes	280 (27)	729 (48)	<0.001
No	757 (73)	792 (52)	
Pills for diabetes			
Any pills	697 (67)	714 (47)	<0.001
Metformin	661 (64)	654 (43)	
Sulfonylurea	256 (25)	252 (17)	
TZD	14 (1)	14 (1)	
DPP-4 inhibitor	41 (4)	57 (4)	
SGLT2 inhibitor	6 (1)	31 (2)	
Insulin			
Yes	234 (23)	269 (18)	0.002
No	803 (77)	1,252 (82)	
RAAS inhibitor			
Yes	511 (49)	504 (36)	<0.001
No	525 (51)	878 (64)	
Other BP medication			
Yes	349 (34)	358 (26)	<0.001
No	687 (66)	1,024 (74)	
HMG-CoA reductase inhibitor (statin)			
Yes	416 (40)	374 (27)	<0.001
No	620 (60)	1,008 (73)	
A1C (%)			
<6.0	195 (20)	564 (39)	<0.001
6.0–7.0	306 (31)	334 (23)	
7.1–7.9	157 (16)	157 (11)	
8.0+	339 (34)	374 (26)	
Key targets (A1C, BP and LDL-C)			
A1C≤7.0%	501 (50)	898 (63)	<0.001
BP (systolic <130 mmHg, diastolic <80 mmHg)	241 (25)	426 (31)	0.002
LDL-C<2.0 (mmol/L)	464 (56)	546 (53)	0.128
All 3 (A1C, BP and LDL-C)	51 (6)	80 (8)	0.271
	Mean ± SD	Mean ± SD	p Value†
Age, years	59.4±12.9	55.4±15.3	<0.001
BMI, kg/m^2	34.0±6.9	32.1±8.8	<0.001
Systolic BP, mmHg	135.4±18.4	131.9±23.5	<0.001
Diastolic BP, mmHg	81.2±11.2	79.7±13.7	0.003
FBG, mmol/L	8.8±3.9	8.5±4.0	0.226
A1C, %	7.8±2.2	7.2±2.2	<0.001
HDL-C, mmol/L	1.2±0.3	1.3±0.4	<0.001
LDL-C, mmol/L	1.9±0.8	2.0±0.8	0.223
TG, mmol/L	2.5±1.2	2.5±1.6	0.895
TC/HDL-C	3.5±0.9	3.4±1.0	0.030
Urine ACR for females, mg/mmol	5.4±11.0	7.7±21.5	0.141
Urine ACR for males, mg/mmol	6.3±10.3	5.3±7.9	0.010
eGFR, mL/min	90.7±31.0	87.3±25.5	0.039

A1C, glycated hemoglobin; *ACR*, albumin:creatinine ratio; *BMI*, body mass index; *BP*, blood pressure; *DPP-4*, dipeptidylpeptidase-4; *eGFR*, estimated glomerular filtration rate; *FBG*, fasting blood glucose; *HDL-C*, high-density lipoprotein cholesterol; *HMG-CoA*, beta-hydroxy beta-methylglutaryl coenzyme A; *LDL-C*, low-density lipoprotein cholesterol; *SD*, standard deviation; *RAAS*, renin-angiotensin-aldosterone system; *SGLT2*, sodium/glucose cotransporter 2; *TC*, total cholesterol; *TG*, triglycerides; *TZD*, thiazolidinediones.

* Chi-square test for distribution of the specified characteristic and returning (or not returning) to the clinic are independent.

† Z test (2-sided) that the true means (among returning clients and among clients who have not yet returned) are the same.

Table 4
Changes in medications, lifestyle parameters and select comorbid conditions of cohort study clients over successive visits

	n / N (%)	p Value*
Diet only, no medications for diabetes		
At first visit	280 / 1,037 (27)	<0.001
At second visit	264 / 1,056 (25)	
At third or later visit	128 / 933 (14)	
Taking any pills for diabetes		
At first visit	697 / 1,037 (67)	<0.001
At second visit	726 / 1,041 (70)	
At third or later visit	747 / 913 (82)	
Taking metformin		
At first visit	661 / 1,037 (64)	<0.001
At second visit	668 / 1,041 (64)	
At third or later visit	652 / 913 (71)	
Taking sulfonylurea		
At first visit	256 / 1,037 (25)	0.076
At second visit	276 / 1,041 (27)	
At third or later visit	259 / 913 (28)	
Taking insulin		
At first visit	234 / 1,037 (23)	<0.001
At second visit	274 / 1,056 (26)	
At third or later visit	317 / 933 (34)	
Taking DPP-4 inhibitor		
At first visit	41 / 1,037 (4)	<0.001
At second visit	97 / 1,041 (9)	
At third or later visit	160 / 913 (18)	
Taking SGLT2 inhibitor		
At first visit	6 / 1,037 (0.6)	<0.001
At second visit	27 / 1,041 (2.6)	
At third or later visit	74 / 913 (8.1)	
A1C≤7.0%		
At first visit	501 / 997 (50)	<0.001
At second visit	509 / 1,023 (50)	
At third or later visit	399 / 922 (43)	
BP (systolic <130 mmHg, diastolic <80 mmHg)		
At first visit	241 / 971 (25)	<0.001
At second visit	328 / 1,008 (33)	
At third or later visit	289 / 913 (32)	
Taking RAAS inhibitor		
At first visit	511 / 1,036 (49)	<0.001
At second visit	559 / 1,005 (56)	
At third or later visit	610 / 901 (68)	
Taking other BP medication		
At first visit	349 / 1,036 (34)	0.001
At second visit	403 / 1,005 (40)	
At third or later visit	438 / 901 (49)	
LDL-C<2.0 mmol/L		
At first visit	464 / 825 (56)	<0.001
At second visit	521 / 842 (62)	
At third or later visit	543 / 789 (69)	
Taking HMG-CoA reductase inhibitor (statin)		
At first visit	416 / 1,036 (40)	<0.001
At second visit	466 / 1,005 (46)	
At third or later visit	516 / 901 (57)	
All 3 key targets (A1C, BP and LDL-C)		
At first visit	51 / 801 (6)	0.034
At second visit	85 / 826 (10)	
At third or later visit	74 / 781 (9)	
Smoking (daily or occasionally)		
At first visit	195 / 810 (24)	<0.001
At second visit	186 / 779 (24)	
At third or later visit	129 / 706 (18)	
Physical activity (60+ min/week)		
At first visit	194 / 570 (34)	0.002
At second visit	179 / 590 (30)	
At third or later visit	145 / 550 (26)	

Change † since immediately preceding visit	Mean±SE	95% CL (p value‡)
Time elapsed, years (n=1,989)	1.61±0.02	1.57–1.66
Weight change, kg (n=1,953)	0.0±0.1	−0.2 to 0.2 (0.75)
A1C, % absolute change (n=1,881)	0.06±0.04	−0.03 to 0.14 (0.206)
Urine ACR change, mg/mmol (n=479)	1.31±0.53	0.27–2.35 (0.013)
eGFR change, mL/min (n=1,035)	−4.79±0.70	−6.16 to −3.42 (<0.001)

(*continued on next column*)

Table 4 (*continued*)

A1C, glycated hemoglobin; *ADR*, albumin:creatinine ratio; *BP*, blood pressure; *CL*, confidence limits; *DPP-4*, dipeptidylpeptidase-4; *eGFR*, estimated glomerular filtration rate; *LDL-C*, low-density lipoprotein cholesterol; *RAAS*, renin-angiotensin-aldosterone system; *SE*, standard error; *SGLT2*, sodium/glucose cotransporter 2.

* Probability that visit number and characteristic are independent (by chi-square test).

† Change showing pre- vs postvisit.

‡ Two-sided paired t test probability of the null hypothesis that the mean change is zero.

mobilized nurses in a specialized field of chronic disease to provide nonconventional health access, point-of-care screening and education alongside an endocrinologist and ophthalmologist. (Although the retinal photographs were completed by the mobile clinic team, the actual interpretation and analyses were performed by independent ophthalmologists and are not reported here but may be reported elsewhere.) The program has helped FN populations attain improved health outcomes and has reached a large number of underserved people. Although both rural and urban health care are plagued by high turnover of health-care personnel, the MDTC has helped mitigate some of these challenges by having established rapport with communities, and in many cases has provided health-care support on a continuing basis.

The study cohort (i.e. those who returned for at least 2 visits) represented those more in need of MDTC services as they had more severe diabetes and associated metabolic conditions than clients who only presented for 1 visit. Indeed, at first visit, almost 66% of patients had had their disease for >6 years. The number of individuals with diabetes attending the mobile clinics during the study period was 99% of the previously estimated number with diabetes in the target population, suggesting that the program was well received in that almost everyone who was eligible likely made use of the program. Furthermore, questionnaires completed after individual visits suggest the MDTC has brought about significant improvements to local education and understandings of diabetes and related health conditions. For instance, there was 99% agreement on questions evaluating whether clients felt respected, learned something new and would use again after a visit with the MDTC. In some areas, these types of programs have led to greater health benefits than seen in adjacent non-FN communities served by the same physicians (10).

The prevention of increase in A1C over time indicates success in working to stabilize glycemic control (and thereby diabetes control) in an environment of a chronic disease often characterized by a worsening of both A1C and health status over time. This is particularly notable given how significant inequities across overarching determinants of health (i.e. income, education, health access, racism, etc.) so negatively influence health outcomes among FN populations. Stabilization occurred even though clients visited the mobile clinic on an average of once every 1.6 years. Although reduction in A1C is a goal for many, preventing increase in A1C is of merit, particularly in light of well-known inequities affecting FN populations. As a marker of risk, the established literature indicates that, for every 1% decrease in A1C (to 7.0%), the risk of developing microvascular complications is reduced by 35%, diabetes-related deaths by 25% and all-cause mortality by 7% (11).

Increased use of RAAS inhibitor and other antihypertensive therapy reduced (improved) BP. Control of BP is critical because cardiovascular disease is the most common cause of death in

people with diabetes. Increased use of statin therapy and improved lipid parameters indicate that patients attained improvements in their medical management, as recommended by the MDTC and evidenced in current clinical practice guidelines (5). Lipid status is also important, as people with diabetes have a cardiovascular age 10 to 15 years older than those without diabetes (12).

Obesity is a pervasive problem in FN people, as it is in the rest of North America (67% of Canadian men and 54% of Canadian women are either overweight or obese) (13). In the MDTC clinics, among all clients at baseline, the prevalence of a BMI$\geq$40 kg/m^2 was 16%, and 65% of patients were obese (BMI$\geq$30 kg/m^2). In the CIRCLE First Nations study (14), the percentage of people with a BMI>40 kg/m^2 was 19.7%, a high prevalence that related to multiple factors. These include racism, poverty and history of residential schools, compounded by a failure of our health-care system to provide nutrition advice that is more compatible with traditional ways of eating (low in carbohydrate and high in fat and protein), along with culturally and socially compatible physical activity recommendations (15). The importance of weight reduction is rarely successfully addressed in both young and elderly patients (16). Continuous vs 1-time programs to support and assist in weight reduction are lacking, and, although many patients are ready to try weight reduction, there are limited supports and numerous compounding barriers preventing long-term success. An appreciation of the major factors influencing weight gain, diabetes prevention and diabetes management, starting with school-age children (14), is needed. There is also a tendency for lifestyle prescriptions to de-emphasize the importance of weight reduction, even though the evidence indicates this is extremely important (16). In older age groups, a loss of 5% to 10% of initial body weight has tremendous implications for health outcomes (7). Physical activity (identified as $\geq$60 min/week) was initially reported by only 34% respondents, decreasing over time to 28%. The literature also suggests that initiatives for group physical activity appear to be limited (17).

Limitations and future considerations

Regarding evaluation of program effectiveness, the main limitation is the observational (nonexperimental) design and the possibility of selection biases. The study cohort consisted of clients who voluntarily attended the clinic 2 or more times. Clients who attended only once were necessarily excluded from the data analysis, as were clients who dropped out after their second or later visits to the clinic. One may speculate that clients who chose to return were more highly motivated, biasing our study toward finding improvement in their condition. However, the study cohort had more severe diabetes and related metabolic conditions at their first visit than those excluded because they only attended once, suggesting that cohort members were motivated by a greater need for help. Thus, it is also plausible that our study was biased toward finding no change, or even worsening. We can only speculate about the net impact of the selection biases. Also, we did not have a control group, so it is possible that improvements observed among the cohort were due to trends in the community or other health-care services.

Several identified areas could potentially improve outcomes. According to Diabetes Canada (5), the American Diabetes Association and the European Association for the Study of Diabetes (18), A1C should be determined every 3 months if goal levels have not been achieved, and therapy should then be escalated if patients are not achieving their individualized target. This should be emphasized and enacted by primary care health-care personnel engaged in diabetes care.

MDTC follow-up visits to communities were frequently requested, but limited resources (e.g. funding, staffing) often prevented this within the shorter time periods (i.e. 3- to 12-month intervals) that would be preferred according to best practice recommendations. Existing relationships between the MDTC and community health staff are strong, and increased communication with community health staff either in-person or via telemedicine or other media could further reduce the risk of adverse outcomes related to diabetes. The limited numbers of screening programs in FN communities, and in school and groups in these communities, could be enhanced as demonstrated by the sucessful approach in this direction by others (10).

In other settings, clinical inertia regarding timely follow up and required medication adjustments represent continuing challenges in the overall treatment of people with type 2 diabetes (17). To help motivate change and minimize challenges, the MDTC has steadily increased its partnerships with PCPs across regions. These partnerships have grown as a result of repeated community visits, increased trust in the MDTC and clients' overall acceptance of services provided by the MDTC.

Previsit informed contact with PCPs, although very desirable, is impractical for a number of reasons. Ongoing communication with PCPs 1 to 2 months after assessments would be desirable for strengthening continuity of care. Although collegiality between PCPs and the MDTC has increased, a larger challenge remains in that many patients are without a PCP or have no dedicated PCP whom they have seen in the last year for continuous follow up. At present, it can be logistically difficult to identify PCPs caring for patients who wish to be seen before an MDTC visit. Physician and nurse turnover in many communities is high, leading to fragmentation in the continuity of care, trust and the inherent patient/health-care provider relationship. Furthermore, wait times for endocrinologists and internists in larger centres can be months. With these factors in mind, the MDTC has more effectively partnered with local community health-care teams (i.e. health directors, community health representatives and community health nurses) to ascertain clinic interest, particularly as relationships between the MDTC and these teams have strengthened over the years. The MDTC approach has also allowed local community health workers maximum flexibility in identifying, prebooking and ascertaining interest among high-risk individuals who are often less likely to prebook an appointment weeks in advance.

Clearly, the frequency of follow-up visits has a relationship to outcome success. We are unable to ascertain whether the recommendations for behaviour change and medication change are enacted by patients and their physicians, but both play an obvious role in shaping outcomes. Diabetes education and complications screening are widely recognized as essential for diabetes wellness. However, access and provision are limited for the vast majority of FN populations. Aside from MDTC efforts, access is commonly provided in the form of "one-offs" involving distant travel, and often given without adequate understanding of underlying cultural, social and fiscal factors. A leading priority in the provision of enhanced care must be the intensification of ongoing follow up (coaching) and education that is timely, culturally sensitive and based on the existing strengths of MDTC client/provider relationships. Increased local education in conjunction with expert diabetes advice and follow up from partnering MDTCs is also needed.

Funding of medications has often been better for FNs in provinces other than British Columbia, as the Non-Insured Health Benefits program currently covers more diabetes medications than the provincial Pharmacare programs. However, the Non-Insured Health Benefits program and BC Pharmacare Plan W demand a trial of medications that increase hypoglycemic risk, weight gain and possible cardiac risk (i.e. sulfonylurea agents) before access to more safe and effective medications are covered. Limiting therapy

options to those that increase risk only serves to dampen peoples' overall interest in accessing health care or in trying other options. This can make care difficult and negatively affect the extent to which optimal therapies are accessed and improved outcomes attained. These therapeutic recommendations have been identified in the 2018 Diabetes Canada guidelines (5).

Finally, it was not possible to document uniform improvement in laboratory values associated with successful long-term outcomes, as long-term complication outcome data are not available (frequency of cardiovascular disease, renal failure, amputations, etc.). The limited documentation of medications taken by patients in earlier years has been improved in recent years by the ability to access Pharmanet (the province-wide network that links all pharmacies in British Columbia to a central data system that members can search for patient prescriptions filled in the province), thus enabling more accurate recognition of medications.

In conclusion, the provision of specialty care by diabetes nursing and technical staff utilizing mobile telemedicine represents an effective method of long-term care delivery to both urban and rural FN communities. The results from this study demonstrate either stabilization or improvement in the majority of outcomes measured. Taken together, the findings suggest improved care and health status in FN people receiving MDTC services. Among the challenges, as in many diabetes programs, is the ability to provide more frequent clinic support to sustain lifestyle, medication and other wellness changes. These challenges could be further supported by building on existing strength areas.

Acknowledgments

The authors are grateful for the editorial assistance of Cynthia N. Lank. Financial support was provided by the Division of Endocrinology, Vancouver General Hospital, and the BC Endocrine Research Foundation. K.G.D. has received permission to publish this article from each of the 2 First Nations organizations that provide the 2 mobile diabetes telemedicine clinics, namely the Seabird Island Indian Band in southern BC and Carrier-Sekani Family Services in northern British Columbia (Prince George). Each of these 2 organizations also has a coauthor identified in this publication. Data regarding clinic visits of all participants are included in electronic format at each of these 2 organizations.

Author Disclosures

K.G.D. is on the speakers' bureau and has received honoraria from Merck, Johnson & Johnson (Janssen) and Boehringer Ingelheim; has received donations from the BC Endocrine Research Foundation for Livewellwithdiabetes.com, Merck, Eli Lilly, Boehringer Ingelheim, Sanofi, Johnson & Johnson (Janssen), Lifescan and AstraZeneca; and has received personal fees from the Seabird Island Indian Band and Carrier-Sekani Family Services. A.J. has received personal fees from the BC Endocrine Research Foundation during the conduct of this study. No other authors have any conflicts of interest to declare.

Author Contributions

K.G.D. was primary author and consulting Endocrinologist. A.J. was co-author and provided the statistical contribution. M.S. was co-author and lead clinic director for Carrier Sekani Family Services and provided extensive revisions with expertise in Mobile clinic care delivery. D.S. was lead clinic director for Seabird Island Band and contributed to authorship and revisions to the manuscript.

References

1. Public Health Agency of Canada. Chapter 6: Diabetes in Canada: Facts and figures from a public health perspective—First Nations, Inuit, and Métis. https://www.canada.ca/en/public-health/services/chronic-diseases/reports-publications/diabetes/diabetes-canada-facts-figures-a-public-health-perspective/chapter-6.html. Accessed November 1, 2019.
2. Turin TC, Saad N, Jun M, et al. Lifetime risk of diabetes among First Nations and non–First Nation People. CMAJ 2016;188:1147–53.
3. Dannenbaum D, Kuzmina E, Lejeune P, Torrie J, Gangbe M. Prevalence of diabetes and diabetes-related complications in First Nations communities in northern Quebec (Eeyou Istchee), Canada. Can J Diabetes 2008;32:46–52.
4. Jacklin KM, Henderson RI, Green ME, Walker LM, Calam B, Crowshoe LJ. Health care experiences of Indigenous people living with type 2 diabetes in Canada. CMAJ 2017;189:E106–12.
5. Diabetes Canada Clinical Practice Guidelines Expert Committee. Diabetes Canada 2018 clinical practice guidelines for the prevention and management of diabetes in Canada. Can J Diabetes 2018;42(Suppl. 1):S1–325.
6. Jin AJ, Martin D, Maberley D, Dawson KG, Seccombe DW, Beattie J. Evaluation of a mobile diabetes care telemedicine clinic serving Aboriginal communities in northern British Columbia, Canada. Int J Circumpolar Health 2004;62(Suppl. 2):124–8.
7. The Diabetes Prevention Program (DPP) Research Group. The Diabetes Prevention Program (DPP). Description of a lifestyle intervention. Diabetes Care 2002;25:2165–71.
8. Jin A. Aboriginal Diabetes Initiative (ADI) funded Mobile Screening and Management Projects—synthesis report. April 2014. Health Canada Contract Number: 4500305656. https://www.researchgate.net/publication/320386708_aboriginal_diabetes_initiative_adi_funded_mobile_screening_and_management_projects_-_synthesis_report. Accessed October 8, 2019. Accessed November 1, 2019.
9. Lee HSW, Chan CKY, Chua SS, Chaiyakunapruk N. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis. Sci Rep 2017;7:12680.
10. Dawson K, Nabih H, deGoeij L, Joseph R. Diabetes and my nation: A model program for diabetes teaching and treatment in aboriginal communities. Can J Diabetes 2009;33:279–80.
11. Stratton IM, Adler AI, Neil HA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): Prospective observational study. BMJ 2000;321:405–12.
12. Booth G, Kapral MK, Fung K, et al. Relation between age and cardiovascular disease in men and women with diabetes compared with non-diabetic people: A populations-based retrospective cohort study. Lancet 2006;368:29–36.
13. Canadian Task Force on Preventive Health Care. Recommendations for prevention of weight gain and use of behavioural and pharmacological interventions to manage overweight and obesity in adults in primary care. CMAJ 2015;187:184–95.
14. Harris SB, Naqshbandi N, Bhattacharyya O, Esler JG, Zinman B, CIRCLE Study Group. Major gaps in diabetes clinical care among Canada's First Nations: Results of the CIRCLE study. Diabetes Res Clin Pract 2011;92:272–9.
15. Greenwood M, de Leeuw S, Lindsay N, Reading C. Beyond the Social: Determinants of Indigenous Peoples' Health. Toronto: Canadian Scholars' Press, 2015.
16. Bjerregaard LG, Jensen BW, Ängquist L, Osler M, Sørensen TIA, Baker JL. Change in overweight from childhood to early adulthood and risk of type 2 diabetes. N Engl J Med 2018;378:1302–12.
17. Pantalone KM, Misra-Hebert AD, Hobbs TM, et al. Clinical inertia in type 2 diabetes management: Evidence from a large, real-world data set. Diabetes Care 2018;41:e113–4.
18. Inzucchi SE, Bergenstal RM, Buse JB, et al. Management of hyperglycemia in type 2 diabetes: a patient-centered approach: Update to a position statement of the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care 2015;38:140–9.