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Professional continuous glucose monitoring and endocrinology eConsult for adults with type 2 diabetes in primary care: Results of a clinical pilot program

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ABSTRACT

Background: Limitations in access to specialty diabetes care exist. Endocrinology eConsult that integrates professional continuous glucose monitoring (CGM-enhanced eConsult) may improve healthcare delivery, but has yet to be evaluated. We implemented a pilot program for patients with type 2 diabetes (T2DM) managed by primary care clinical pharmacists using CGM-enhanced eConsult and evaluated the acceptability and clinical outcomes in comparison to routine in-person endocrinology consultation.

Methods: Seventy-four adult patients with established T2DM (age 18–65) were included. Twenty-nine were seen in-person by endocrinology and 45 were seen by pharmacists in primary care. Thirteen patients were referred for CGM-enhanced eConsult. Acceptability was assessed with pre/post clinician acceptability questionnaires and patient assessment of perceived burden. Clinical outcomes included time to first specialty appointment, baseline and 3-month follow-up HbA1c, and antihyperglycemic medication use.

Results: There were no differences in patient acceptability of the CGM-enhanced eConsult as compared to endocrinology referral or pharmacy care. At baseline, all patients referred for eConsult were prescribed insulin. Three-month glycemic outcomes were comparable, with HbA1c reduction 1% + 2% in endocrinology, 1.5% + 1.1% with CGM-enhanced eConsult, and 1.6% + 1.8% in clinical pharmacy ($p = 0.19$). Time to an initial diabetes visit with a pharmacist was significantly shorter than with endocrinology, 20 days (IQR 26) for pharmacy vs. 45 days (IQR 54) for endocrinology, ($p = 0.0001$).

Conclusions: CGM-enhanced eConsult resulted in more timely access to endocrinology expertise, was acceptable to patients, and resulted in similar short-term glycemic outcomes compared to in-person consultation. Effectiveness of CGM-enhanced eConsults should be further explored.

Introduction

Diabetes mellitus is increasingly prevalent and carries significant economic and personal burden [1–3]. The burden of diabetes is often

amplified in safety-net hospital systems, which suffer from limited resources and care for populations with high prevalence of diabetes and comorbid chronic conditions, high rates of missed appointments, and lower rates of medical literacy [4–6]. Interdisciplinary diabetes care

Abbreviations: BMC, Boston Medical Center; BMI, Body mass index; CGM, Continuous glucose monitoring; DPP-4, Dipeptidyl peptidase-4; eConsult, Electronic consultation; ED, Emergency department; EMR, Electronic medical record; GLP-1 RA, glucagon-like peptide-1 receptor agonist; HbA1c, Hemoglobin A1c; IQR, Interquartile range.

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teams that incorporate primary care clinicians, clinical pharmacists, certified diabetes care and education specialists, and endocrinologists have proven to be acceptable to patients and effective in improving diabetes-related health outcomes [7–9]. In particular, integration of clinical pharmacists into diabetes care has demonstrated decreases in drug expenditures, hospital readmissions, emergency department (ED) visits, and improved health outcomes, including improved glycemic control and adherence to diabetes standards of care [10–14]. However, engagement with the interdisciplinary specialty diabetes care team may be challenging to patients cared for in safety-net clinics due to competing social and medical demands.

Professional continuous glucose monitoring (CGM) has been previously evaluated in a small pilot study in a safety-net population as an adjunctive tool that resulted in improved short-term glycemic outcomes [15]. However, it is not known whether CGM may also help to mitigate healthcare delivery challenges for safety-net patients. Professional CGM enables collection of glucose data in a blinded fashion and has been demonstrated in some studies to be effective in modestly reducing hemoglobin A1c (HbA1c) and decreasing growth in healthcare costs [16,17]. Care delivery mechanisms that integrate professional CGM and interdisciplinary care teams may yield improvements in healthcare access and patient outcomes. However, optimal methods for integrating diabetes clinical disciplines and incorporating CGM diagnostic capabilities within a safety-net healthcare system are unclear. Although prior studies have demonstrated that asynchronous electronic consultations (eConsults) are acceptable to both patients and clinicians, may ameliorate poor access to subspecialty care, and may reduce in-person consultation [18–20] evidence supporting the integration of eConsults and CGM is limited.

In an attempt to improve access to endocrinology for patients with diabetes within our institution, we implemented a clinical pilot program consisting of a revised diabetes care management pathway integrating primary care clinicians, clinical pharmacists, professional CGM, and endocrinologists using an eConsult model. The provider and patient acceptability as well as clinical outcomes of the clinical pilot program were evaluated in comparison to traditional in-person endocrinology referral.

Methods

Setting

Boston Medical Center (BMC) is an academic safety-net hospital in Boston, Massachusetts. Nearly 60% of BMC patients are from underserved populations, including racial/ethnic minorities and public insurance beneficiaries. Prior to this intervention, traditional, in-person referral for endocrinology consultation was available to primary care clinicians for specialty diabetes care. However, within our institution, in-person referral has historically been complicated by long wait times and high missed appointment rates of nearly 50% for new diabetes referrals. Additionally, clinical pharmacists have been routinely integrated into our primary care practices and provide another option for longitudinal diabetes care through a scope of practice referral agreement, working alongside and in collaboration with primary care clinicians in the same clinical location.

Clinical pilot program

In November 2018, we initiated a six-month clinical pilot program within the Department of General Internal Medicine introducing the use of professional CGM and endocrinology eConsultation as a new referral option for clinical pharmacists who provide longitudinal diabetes care within primary care clinics at our institution. While professional CGM was available within our institution for in-person endocrinology referrals at a treating endocrinologist's discretion, professional CGM had not previously been integrated into care provided by clinical

pharmacists. Two clinical pharmacists, certified as diabetes care and education specialists, requested eConsults for selected patients they believed may benefit from professional CGM and endocrinology eConsult (CGM-enhanced eConsult). This decision was at their clinical discretion, consistent with the nature of the clinical pilot program, and was requested for patients with a discrepancy between self-monitored blood glucose values and HbA1c, concern for or reported hypoglycemia, patients on multiple antihyperglycemic agents including insulin with HbA1c not at goal, and patients not routinely self-monitoring glucose values at home to allow for therapeutic changes.

Patients were asked to wear a professional CGM (FreeStyle Libre Pro, Abbott), which was placed by the clinical pharmacists either at their first visit or the subsequent follow up appointment. The FreeStyle Libre Pro is a factory-calibrated glucose sensor which stores interstitial fluid glucose measurements every 15 min for up to 14 days. This system does not provide real-time visual data for patients to view; rather, all data are recorded in a patient-blinded fashion and are subsequently available for retrospective review. Patients were advised to continue their normal daily routines and medication administration but were asked to complete a diet and medication log while wearing the sensor to provide additional contextual data to support retrospective interpretation of the glucose data. The sensor was worn for seven to 14 days.

At a return visit, all sensor glucose data were downloaded by the clinical pharmacists to the LibreView web-based software which was available for their review with the patient. The data was subsequently interpreted by one endocrinologist (DS) within the endocrinology clinic with expertise in the interpretation of CGM data. In conjunction with the CGM data, the endocrinologist used the patient recorded diet and medication log and clinical data from the pharmacist's and primary care clinician's documentation in the shared electronic medical record (EMR) to generate an individualized eConsult report. The eConsult report included diagnostic interpretations and recommendations and was completed within two weeks of CGM data download. The endocrinologist was not directed by a protocol, but rather, provided the eConsult report based on available clinical data and clinical expertise.

Study design and participants

In this prospective cohort study, designed to evaluate acceptability and clinical outcomes of the CGM-enhanced eConsult clinical pilot program, we collected clinical data from the EMR for English-speaking, adult patients (ages 18–65) with a diagnosis of type 2 diabetes for at least 6 months. As surveys were only available in English, non-English speaking patients were excluded. Eligible patients referred for diabetes care from the Department of General Internal Medicine within our institution between November 2018 and May 2019 were included. While clinical pharmacists are well integrated into our hospital based General Internal Medicine primary care clinic, they are not yet integrated into all community health centers affiliated with our institution. Therefore, patients from community health centers were excluded from the pilot program. A sample size was not determined prior to initiation as this was an exploratory analysis of the feasibility, acceptability, and preliminary clinical outcomes of the clinical pilot program using CGM-enhanced eConsults and in preparation for a future randomized controlled study of the effectiveness of such an intervention. This study was reviewed and determined exempt by the Boston University Medical Campus Institutional Review Board.

Data collection

Clinical outcomes

We collected clinical data at baseline (initial pharmacy or endocrinology visit) and at three-month follow up from the patient's medical record. HbA1c, antihyperglycemic medications, and diabetes-related complications and comorbidities were collected from the EMR. Through chart review, we also collected data on processes related to

diabetes care, including time to initial visits from referral date, the number of appointments scheduled and attended, as well as acute care service utilization (ED visits and hospitalizations) with diabetes and its associated complications as a primary diagnosis. Appointments related to diabetes complications or management of diabetes were defined as visits with endocrinology, registered dietitians, or their primary care clinicians where diabetes was documented as discussed, as well as visits for evaluation and care of neuropathy, retinopathy, or nephropathy. The clinical outcomes of interest were short-term glycemic control as measured by HbA1c, anti-hyperglycemic medication use, and clinical process metrics, including time to appointment and number of follow-up appointments.

Acceptability

Patient burden and clinician acceptability of the three referral processes were the primary measures of acceptability. Within two weeks of the patient's appointment, either with endocrinology or a clinical pharmacist, patients were contacted by a trained research team member via telephone and/or email to complete an assessment of perceived burden questionnaire. Questionnaires were completed online or over the phone, with the assistance of trained research team members to allow for inclusion of limited and non-readers. The patient-facing perceived burden questionnaire was modified from the Perceived Research Burden Assessment and used as a proxy of acceptability [21]. The questionnaire inquired about perceptions of direct risks and appraisals of indirect burden, such as inconvenience based on required time and travel. Each participant was contacted a maximum of three times until the questionnaire was successfully completed. Participants could decline to answer the questionnaire as the survey was voluntary.

To better understand the care delivery process, we also assessed clinician acceptability of current referral processes, as well as interest in eConsults. Twenty-five clinicians in endocrinology, two pharmacists in general internal medicine and 177 clinicians (inclusive of 96 internal medicine resident trainees) in internal medicine clinics with integrated clinical pharmacists were invited to complete the questionnaire. Clinicians were contacted by email with two subsequent reminders to voluntarily complete the online acceptability questionnaire at baseline and six months after implementation of the pilot program.

Baseline primary care clinician acceptability questionnaires included eight questions based on a five-point Likert scale evaluating ease of referral system use, perception of complexity, usefulness of consultations provided, and comfort with implementing recommendations for both endocrinology and clinical pharmacist referrals. Follow up acceptability questionnaires included nine Likert scale questions assessing similar aspects of acceptability related to use of the CGM-enhanced eConsult. Separate acceptability questionnaires were created for endocrinologists and clinical pharmacists that included six scale-based questions about the appropriateness and completeness of referrals and attitudes regarding the use of eConsults. All clinician questionnaires included a free response section for additional comments. Questionnaires were completed online by clinician participants utilizing REDCap, a secure HIPAA-compliant web-based application. No financial compensation was provided to patient or physician participants.

Data analysis

Quantitative data were analyzed using SAS® OnDemand for Academics (SAS Institute, Cary, NC). All results are expressed as the mean and standard deviation for normally distributed continuous variables or median and interquartile range (IQR) for non-parametric data and as relative percentages for categorical variables. Group comparisons of continuous variables were performed using analysis of variance and t-tests for normally distributed data or the Wilcoxon-rank sum test for non-parametric data. Fisher's exact test was used for categorical variables. In addition, Kaplan-Meier curves representing time to specialty diabetes care appointments were compared using log-rank statistics. All

tests for significance and resulting *P*-values are two-sided, with a 0.05 level of significance.

Results

Participant characteristics

During the six-month pilot period, 696 new diabetes referrals from internal medicine to either endocrinology (*n* = 497) or clinical pharmacists (*n* = 199) were scheduled. Of these new referrals, 42% of patients (*n* = 293) did not arrive to their scheduled appointments. The missed appointment rate was 31.7% for referrals to clinical pharmacists vs. 46.3% for referrals to endocrinology (*p* < 0.0001). After exclusion of non-eligible patients, clinical data and process metrics were collected for 74 individuals: 29 seen within endocrinology and 45 seen by clinical pharmacists, Fig. 1. Placement of a professional CGM and eConsult was requested by clinical pharmacists for 13 patients.

Among adult, English-speaking patients with established type 2 diabetes, there were no significant differences in baseline demographics and HbA1c between those referred to endocrinology or clinical pharmacists for diabetes care. Baseline characteristics of patients among endocrinology and clinical pharmacist referrals are shown in Table 1.

Clinical outcomes

At baseline, a higher proportion of patients referred to clinical pharmacists were prescribed metformin (77.8% vs. 69%, *p* = 0.43), DPP-4 inhibitors (15.6% vs. 3.5%, *p* = 0.14), and had atherosclerotic cardiovascular disease (35.6% vs. 17.2%, *p* = 0.12) compared to those referred to endocrinology. All 13 patients selected by clinical pharmacists to have a CGM-enhanced eConsult were prescribed basal insulin and approximately half (53%) were prescribed basal-bolus insulin therapy.

Changes in medications and glycemic outcomes between referral pathways are shown in Table 2. At three-month follow up, glycemic control as measured by HbA1c was not significantly different between the groups. Patients seen by endocrinology had a reduction in HbA1c of 1% + 2% (11 + 22 mmol/mol), as compared to 1.5% + 1.1% (16.5 + 12.1 mmol/mol) in those who had a CGM-enhanced eConsult, and 1.6% + 1.8% (17.6 + 19.8 mmol/mol) in those seen by clinical pharmacists without completion of an eConsult (*p* = 0.19). The frequency of patients prescribed basal and bolus insulin increased in patients treated by endocrinologists as compared to those treated by clinical pharmacists. In addition, the CGM-enhanced eConsult was associated with twice the number of patients prescribed GLP-1 receptor agonists (GLP-1 RA) and reduced insulin use, in comparison to slightly increased use of both basal and bolus insulin in the other two groups. Of patients who received an eConsult, 23% (*n* = 3) had clinically significant hypoglycemia, defined as greater than 4% of sensor glucose readings < 70 mg/dL [22]. CGM metrics and summary of recommendations for each patient receiving an eConsult are shown in supplementary table 1. Recommendations were either completely or partially followed in 10/13 (77%) eConsults. Of the three patients for whom recommendations were not followed, two did not return for care with the clinical pharmacists within the following 3 months and one had loss of insurance coverage which precluded a change in medications.

The time to a scheduled initial diabetes visit with a clinical pharmacist (20 [IQR 26] business days) was significantly shorter than with endocrinology (45 [IQR 54] business days), *p* = 0.0001, as shown in Fig. 2. All eConsults were completed within two weeks of sensor download. On average, patients referred for diabetes care had four appointments for diabetes or diabetes-related complications during the three-month observational period and attended 3 of them, regardless of referral pathway (4.7 + 2.3 visits scheduled for patients referred to endocrinology as compared to 4.3 + 2.3 visits scheduled for patients referred to clinical pharmacists, *p* = 0.84; 3 + 2.1 visits attended for

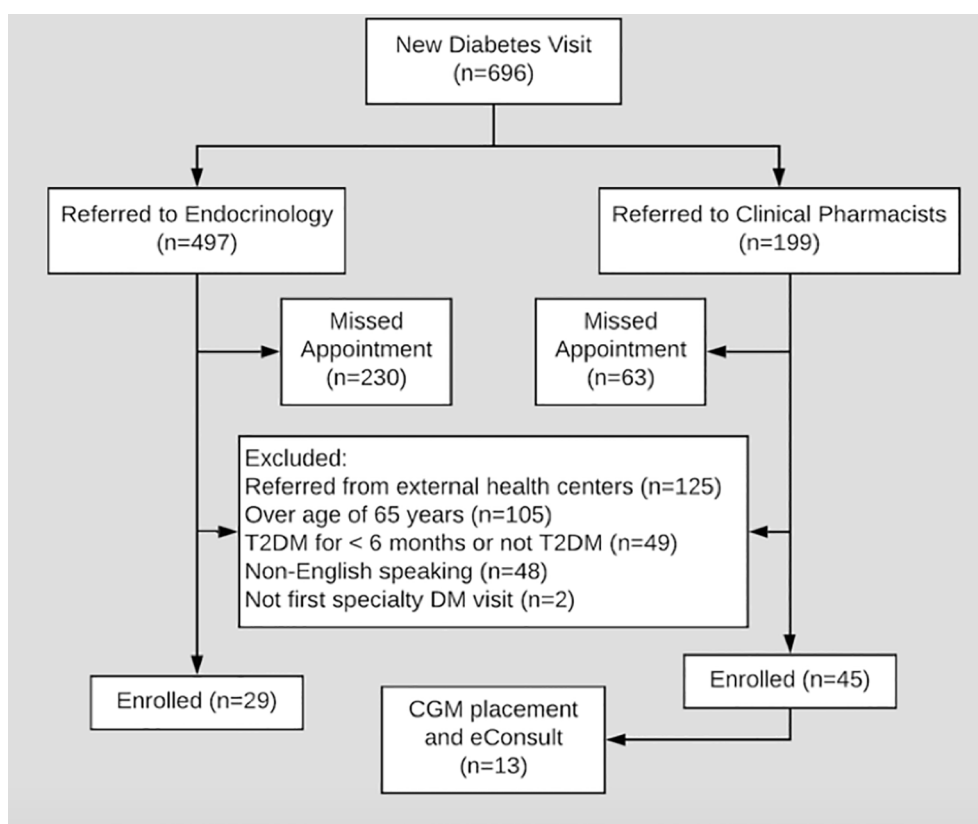


Fig. 1. Study cohort.

Table 1

Baseline characteristics of patients among Endocrine and clinical pharmacist referrals.

	All	Endocrine	Pharmacist
n	74	29	45
Age (years)	53.9 + 9.2	52.5 + 11.6	54.7 + 7.2
Sex, male	40 (54.1)	14 (48.3)	26 (57.8)
Initial HbA1c (%)	10.3 + 2.2	10.5 + 2.5	10.2 + 2.0
Initial HbA1c (mmol/mol)	89 + 24.2	91 + 27.5	88 + 22
Race/Ethnicity			
Black	55 (74.3)	21 (72.4)	34 (75.6)
White	10 (13.5)	4 (13.8)	6 (13.3)
Hispanic	10 (12.2)	4 (13.8)	6 (13.3)
Obese (BMI > 30)	39 (52.7)	16 (55.2)	23 (51.1)
Basal Insulin	43 (58.1)	17 (58.6)	26 (57.8)
Bolus Insulin	20 (27)	9 (31)	11 (24.4)
Metformin	55 (74.3)	20 (69)	35 (77.8)
SU	20 (27)	5 (17.2)	15 (33.3)
GLP-1 RA	11 (14.9)	4 (13.8)	7 (15.6)
SGLT-2 inhibitor	1 (1.4)	0 (0)	1 (2.2)
DPP4 inhibitor	8 (10.8)	1 (3.5)	7 (15.6)
Thiazolidinediones	3 (4.1)	2 (6.9)	1 (2.2)
Renal Complication	29 (39.2)	12 (41.4)	17 (37.8)
Retinopathy	25 (33.8)	10 (34.5)	15 (33.3)
Neuropathy	29 (39.2)	13 (44.8)	16 (35.6)
ASCVD	21 (28.4)	5 (17.2)	16 (35.6)

Data are mean + SD or n (%).

Obese defined as body mass index > 30 kg/m². SU = sulfonylurea. GLP-1 RA = glucagon-like peptide-1 receptor agonist. SGLT-2 = sodium-glucose co-transporter-2. DPP-4 = dipeptidyl peptidase-4. ASCVD = Atherosclerotic Cardiovascular Disease. Renal complication defined as presence of proteinuria.

patients referred to endocrinology, 2.9 + 1.7 visits attended for patients referred to clinical pharmacy, $p = 0.32$).

Acceptability

Baseline acceptability questionnaires were completed by 38 primary care clinicians (21% response rate), two clinical pharmacists in general internal medicine, and 15 endocrine clinicians (14 endocrinologists and one nurse practitioner, 63% response rate). Responses demonstrated that although 71.1% of primary care clinicians found the standard of care in-person endocrinology consult to be useful, 23.7% found the referral process unnecessarily complex. Moreover, 42.1% of primary care clinicians believed the length of time between endocrinology referral and scheduling was unacceptable, compared to 34.4% with referral to clinical pharmacy. While endocrine clinicians felt that the majority of new diabetes referrals were medically necessary (76%), they reported only 55% of new patient referrals were complete with relevant history and workup.

Following six months of the pilot program, follow up acceptability questionnaires were completed by 18 primary care clinicians, two clinical pharmacists within internal medicine, and 12 endocrine clinicians (11 endocrinologists and one nurse practitioner). None of the primary care clinicians who completed the follow up questionnaire had patients who received an eConsult through their care with the clinical pharmacists. There were no significant changes in specialty clinicians' perceptions of referral completeness or medical necessity. Of 15 free-text responses by primary care clinicians and endocrine clinicians, lack of familiarity with the new CGM-enhanced eConsult referral pathway was frequently noted, although clinical pharmacists reported that both they and patients had a positive experience with the use of professional CGM and the eConsult.

The assessment of patient burden was completed by 16 patients referred to endocrinology (55% response rate), 23 patients referred to

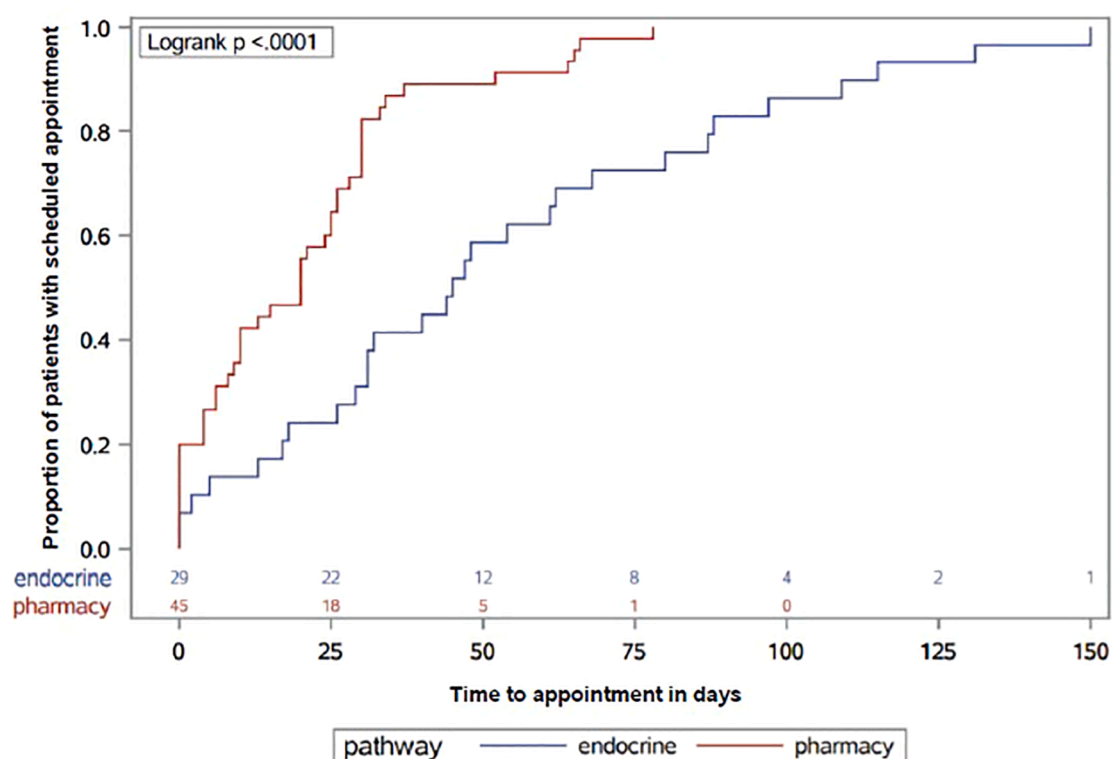
Table 2

Outcomes of care by pathway of patients at baseline and at 3-month follow up.

	Baseline				3-month follow up			
	Endocrine (n = 29)	eConsult (n = 13)	PharmD (n = 32)	P	Endocrine (n = 29)	eConsult (n = 13)	PharmD (n = 32)	P
HbA1c %	10.5 + 2.5	10.5 + 1.6	10.1 + 2.2	0.79	9.5 + 2	9 + 1.1	8.5 + 1.8	0.19
HbA1c (mmol/mol)	91 + 27.5	91 + 17.6	87 + 24.2	0.79	80 + 22	75 + 12.1	69 + 19.8	0.19
Basal Insulin	17 (58.6)	13 (100)	13 (40.6)	0.0004	19 (65.5)	12 (92.3)	14 (43.8)	0.008
Bolus Insulin	9 (31)	7 (53.9)	4 (12.5)	0.015	10 (34.5)	4 (30.8)	5 (15.6)	0.24
Metformin	20 (69)	10 (76.9)	25 (78.1)	0.78	21 (72.4)	9 (69.2)	24 (75)	0.94
SU	5 (17.2)	3 (23.1)	12 (37.5)	0.20	6 (20.7)	2 (15.4)	11 (34.4)	0.34
GLP-1 RA	4 (13.8)	3 (23.1)	4 (12.5)	0.63	5 (17.2)	6 (46.2)	8 (25)	0.15
SGLT-2i	0 (0)	1 (7.7)	0 (0)	0.18	1 (3.5)	1 (7.7)	1 (3.1)	0.58
DPP-4i	1 (3.5)	0 (0)	7 (21.9)	0.04	3 (10.3)	0 (0)	8 (25)	0.08
TZD	2 (6.9)	0 (0)	1 (3.1)	0.78	2 (6.9)	0 (0)	2 (6.3)	1.00

Data are mean + SD or n (%). Fisher exact *p* values are reported for categorical data.

SU = sulfonylurea. GLP-1 RA = glucagon-like peptide-1 receptor agonist. SGLT-2i = sodium-glucose co-transporter-2 inhibitor. DPP-4i = dipeptidyl peptidase-4 inhibitor.

**Fig. 2.** Time to first scheduled diabetes visit between clinical pathways Kaplan-Meier curve illustrating the proportion of patients with a scheduled appointment between clinical pathways.

clinical pharmacists (72% response rate), and six patients who were seen by clinical pharmacists with completion of a CGM-enhanced eConsult (46% response rate). Overall, there were no significant differences in patient-reported burden for patients seen by endocrinology or for whom a CGM-enhanced eConsult was completed. However, patients seen by clinical pharmacists without the completion of an eConsult felt that their visits occurred too frequently as compared to those seen by endocrinologists (*p* = 0.04), and patients seen by endocrinology felt their diabetes management visits lasted too long (duration of visit) in comparison to those seen by clinical pharmacists (*p* = 0.07).

Discussion

In this evaluation of a new CGM-enhanced eConsult referral mechanism for adult patients with type 2 diabetes, patients referred to

endocrinology as compared to clinical pharmacists had similar baseline demographics and glycemic control. Patients seen in each of the referral pathways, including those receiving a CGM-enhanced eConsult, had similar short-term glycemic outcomes. Despite the exploratory nature of this clinical pilot program and small absolute numbers, interesting changes in diabetes therapies were observed between patients seen by endocrinologists and those seen by clinical pharmacists, with or without the addition of a CGM-enhanced eConsult. We observed a doubling of GLP-1 RA use in patients seen by clinical pharmacists, notably there was an overall reduction in insulin use (including 43% fewer patients using bolus insulin) after CGM-enhanced eConsult. This contrasted with slightly increased insulin use in the other two groups, without significant changes in short-term glycemic control and suggests that CGM may have provided value in allowing for de-escalation of therapies carrying risk for hypoglycemia. These exploratory findings need to be further

evaluated in a larger cohort.

Both primary care clinicians and specialty diabetes care providers identified difficulties with referral processes, including access and resource issues, timeliness, and incomplete workup despite a shared EMR. Similar to prior studies evaluating medical subspecialty referrals, [23,24] a high percentage of diabetes specialty clinicians within our institution, both endocrinology clinicians and clinical pharmacists, felt referral requests contained incomplete information. These findings are consistent with prior research and may reflect lack of standardization in referral practices, insufficient familiarity with, or absence of, an institutional referral policy, and limitations in current communication strategies [24–26].

At our institution, the lag between referral placement and actual appointment could have contributed to the high missed appointment rate in endocrinology, as has been demonstrated in prior studies of subspecialty referrals [27]. Notably, time to scheduling of a diabetes care appointment was significantly different between referral mechanisms, taking nearly two and a half times as long to schedule an in-person visit with endocrinology as compared to with clinical pharmacy. Given limitations in access to endocrine specialty care [28], coupled with local endocrine clinician survey responses indicating that nearly one quarter of referrals for specialty diabetes care were not medically necessary, there is question as to the appropriateness of referrals for what may be a population of lower complexity patients who may be successfully managed by clinical pharmacists. Our findings support the use of integrated qualified clinical pharmacists for longitudinal diabetes management, therefore enabling better coordinated care by providing timely access within the same clinic as a patients' primary care clinician.

All of the patients selected for CGM-enhanced eConsult were prescribed basal insulin and half were using basal-bolus insulin therapy, which may suggest that these patients were felt to be of greater complexity compared to those for whom eConsult was not requested. Our findings of similar short-term glycemic control for CGM-enhanced eConsults and in-person endocrinology visits, as well as the acceptability of the eConsult process by both clinical pharmacists and patients, supports further exploration of the effectiveness of this alternative diabetes care delivery model to support clinicians in primary care with management of complex patients with type 2 diabetes.

Finally, we identified similar patient acceptability of the eConsult model to traditional, in-person referral to endocrinology or care from clinical pharmacists alone. Patients seen by clinical pharmacists without an eConsult felt appointments occurred too frequently, while patients seen by endocrinologists felt visits lasted too long. Reasons for this difference are unclear as patients had similar numbers of follow up appointments; future research is needed to explore this finding.

Our study has several strengths. We evaluated both patient and clinician acceptability of referral pathways. This enabled us to obtain a dual perspective on the various referral pathways, in addition to measurable clinical outcomes. It also showed the need for referral system changes from both primary care clinician and specialist perspectives, justifying the use of alternative referral methods in the future. Evaluation of clinical outcomes of each referral mechanism and process metrics enabled us to evaluate the overall impact of referral pathways, while also understanding at which points changes in the referral pathways would be most helpful.

Our study results should be interpreted in light of multiple limitations. The sample size was small and overall enrollment rate was low at 10.6%, predominantly due to a high rate of missed appointments to clinical visits and one quarter of referrals to endocrinology for diabetes care from community health centers. Additionally, as we restricted our cohort to exclude adults over the age of 65 years and non-English speakers, accounting for a large portion of ineligible patients, the characteristics of the patients studied may not be reflective of the overall patient population within our institution and it is difficult to generalize our findings to the broader population of patients with type 2 diabetes

served by our institution. As a single center study at a large safety-net hospital, findings may not be generalizable to the broader population. The number of patients for whom a CGM-enhanced eConsult was requested was small and our study was not a randomized controlled study; thus, conclusions regarding acceptability and effectiveness are limited. In addition, most clinicians noted that they were unaware of the availability of this process on follow up questionnaires and due to a low response rate to follow-up questionnaires, primary care clinician acceptability of the eConsult was not available. While professional CGM was used to make initial changes to therapies, repeat professional CGM was not completed, as such changes in CGM metrics are not available for comparison. Lastly, as this was an observational study of short duration, it is difficult to draw longer term conclusions with regards to most of our outcomes.

Conclusion

In this clinical pilot, for more complex patients on insulin therapy, implementation of CGM-enhanced eConsults between primary care pharmacy and endocrinology allowed for timely access to endocrinologist expertise and resulted in similar short-term glycemic outcomes to in-person endocrinology visits with similar measures of patient acceptability. Given these exploratory findings, the effectiveness of CGM-enhanced eConsults should be explored in future studies.

Conflicts of interest and funding support

The authors of this manuscript report no conflicts of interest.

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CRediT authorship contribution statement

Kathryn L. Fantasia: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing - original draft. **Mary-Catherine Stockman:** Conceptualization, Methodology, Data curation, Writing - original draft. **Zhihui Ju:** Formal analysis, Writing - review & editing. **Paola Ortega:** Investigation, Data curation. **Erika L. Crable:** Conceptualization, Methodology, Writing - review & editing. **Mari-Lynn Drainoni:** Conceptualization, Methodology, Writing - review & editing. **Allan J. Walkey:** Conceptualization, Methodology, Writing - review & editing. **Megan Bergstrom:** Investigation, Writing - review & editing. **Statelyn O'Brien:** Investigation, Writing - review & editing. **Devin Steenkamp:** Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcte.2021.100254>.

References

- [1] Bommer C, Sagalova V, Heesemann E, Manne-Goehler J, Atun R, Bärnighausen T, et al. Global economic burden of diabetes in adults: projections from 2015 to 2030. *Diabetes Care* 2018;41:963–70. <https://doi.org/10.2337/dc17-1962>.
- [2] Cannon A, Handelsman Y, Heile M, Shannon M. Burden of Illness in Type 2 diabetes mellitus. *J Manag Care Spec Pharm* 2018;24:S5–13. <https://doi.org/10.18553/jmcp.2018.24.9-a.s5>.
- [3] Rubin RR, Peyrot M. Quality of life and diabetes. *Diabetes Metab Res Rev* 1999;15:205–18.
- [4] Belyeu B, Chwastiak L, Russo J, Kiefer M, Mertens K, Chew L, et al. Barriers to engagement in collaborative care treatment of uncontrolled diabetes in a safety-net

- clinic. *Diabetes Educ* 2017;43:621–30. <https://doi.org/10.1177/0145721717739813>.
- [5] Gaskin DJ, Hadley J. Population characteristics of markets of safety-net and non-safety-net hospitals. *J Urban Heal* 1999;76:351–70. <https://doi.org/10.1007/BF02345673>.
 - [6] Rabi DM, Edwards AL, Southern DA, Svenson LW, Sargious PM, Norton P, et al. Association of socio-economic status with diabetes prevalence and utilization of diabetes care services. *BMC Health Serv Res* 2006;6. <https://doi.org/10.1186/1472-6963-6-124>.
 - [7] National Diabetes Education Program. Working together to manage diabetes: a guide for pharmacy, podiatry, optometry and dentistry. Bethesda, MD: 2014.
 - [8] Berkowitz SA, Eisenstat SA, Barnard LS, Wexler DJ. Multidisciplinary coordinated care for Type 2 diabetes: a qualitative analysis of patient perspectives. *Prim Care Diabetes* 2018;12:218–23. <https://doi.org/10.1016/j.pcd.2018.01.005>.
 - [9] Conley MP, Chim C, Magee CE, Sullivan DJ. A review of advances in collaborative pharmacy practice to improve adherence to standards of care in diabetes management. *Curr Diab Rep* 2014;14. <https://doi.org/10.1007/s11892-013-0470-0>.
 - [10] Fazel MT, Bagalagel A, Lee JK, Martin JR, Slack MK. Impact of diabetes care by pharmacists as part of health care team in ambulatory settings: a systematic review and meta-analysis. *Ann Pharmacother* 2017;51:890–907. <https://doi.org/10.1177/1060028017711454>.
 - [11] Joseph T, Hale GM, Eltaki SM, Prados Y, Jones R, Seamon MJ, et al. Integration strategies of pharmacists in primary care-based accountable care organizations: a report from the accountable care organization research network, services, and education. *J Manag Care Spec Pharm* 2017;23:541–8. <https://doi.org/10.18553/jmcp.2017.23.5.541>.
 - [12] Brummel A, Lustig A, Westrich K, Evans MA, Plank GS, Penso J, et al. Best practices: improving patient outcomes and costs in an ACO through comprehensive medication therapy management. *J Manag Care Spec Pharm* 2014;20:1152–8.
 - [13] Hae MC, 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;11:253–60.
 - [14] Ragucci KR, Fermo JD, Wessell AM, Chumney EC. Effectiveness of pharmacist-administered diabetes mellitus education and management services. *Pharmacotherapy* 2005;25:1809–16. <https://doi.org/10.1592/phco.2005.25.12.1809>.
 - [15] Hashmi S, Mon S. Benefits of use of professional CGM in low socioeconomic population. *Diabetes* 2018;67:903-P.
 - [16] Park C, Le QA. The effectiveness of continuous glucose monitoring in patients with Type 2 diabetes: a systematic review of literature and meta-analysis. *Diabetes Technol Ther* 2018;20:613–21. <https://doi.org/10.1089/dia.2018.0177>.
 - [17] Sierra JA, Shah M, Gill MS, Flores Z, Chawla H, Kaufman FR, et al. Clinical and economic benefits of professional CGM among people with type 2 diabetes in the United States: analysis of claims and lab data. *J Med Econ* 2018;21:225–30.
 - [18] Vimalananda VG, Gupte G, Seraj SM, Orlander J, Berlowitz D, Fincke BG, et al. Electronic consultations (e-consults) to improve access to specialty care: A systematic review and narrative synthesis. *J Telemed Telecare* 2015;21:323–30. <https://doi.org/10.1177/1357633X15582108>.
 - [19] Nabelsi V, Lévesque-Chouinard A, Liddy C, Pilon MD. Improving the referral process, timeliness, effectiveness, and equity of access to specialist medical services through electronic consultation: Pilot study. *J Med Internet Res* 2019;21:1–14. <https://doi.org/10.2196/13354>.
 - [20] Ackerman SL, Dowdell K, Clebak KT, Quinn M, Shipman SA. Patients assess an econsult model's acceptability at 5 us academic medical centers. *Ann Fam Med* 2020;18:35–41. <https://doi.org/10.1370/afm.2487>.
 - [21] Lingler JH, Schmidt KL, Gentry AL, Hu Lu, Terhorst LA. A new measure of research participant burden: brief report. *J Empir Res Hum Res Ethics* 2014;9:46–9. <https://doi.org/10.1177/1556264614545037>.
 - [22] Battelino T, Danne T, Bergenstal RM, Amiel SA, Beck R, Biester T, et al. Clinical targets for continuous glucose monitoring data interpretation: recommendations from the international consensus on time in range. *Diabetes Care* 2019;42:1593–603. <https://doi.org/10.2337/dci19-0028>.
 - [23] O'Malley AS, Reschovsky JD. Referral and consultation communication between primary care and specialist physicians finding common ground. *Arch Intern Med* 2011;171:56–65. <https://doi.org/10.1001/archinternmed.2010.480>.
 - [24] Gandhi TK, Sittig DF, Franklin M, Sussman AJ, Fairchild DG, Bates DW. Communication breakdown in the outpatient referral process. *J Gen Intern Med* 2000;15:626–31. <https://doi.org/10.1046/j.1525-1497.2000.91119.x>.
 - [25] Hysong SJ, Esquivel A, Sittig DF, Paul LA, Espadas D, Singh S, et al. Towards successful coordination of electronic health record based-referrals: a qualitative analysis. *Implement Sci* 2011;6. <https://doi.org/10.1186/1748-5908-6-84>.
 - [26] Mehrotra A, Forrest CB, Lin CY. Dropping the baton: specialty referrals in the United States. *Milbank Q* 2011;89:39–68. <https://doi.org/10.1111/j.1468-0009.2011.00619.x>.
 - [27] Shrestha MP, Hu C, Taleban S. Appointment wait time, primary care provider status, and patient demographics are associated with nonattendance at outpatient gastroenterology clinic. *J Clin Gastroenterol* 2017;51:433–8. <https://doi.org/10.1097/MCG.0000000000000706>.
 - [28] Vigersky RA, Fish L, Hogan P, Stewart A, Kutler S, Ladenson PW, et al. The clinical endocrinology workforce: current status and future projections of supply and demand. *J Clin Endocrinol Metab* 2016;99:3112–21. <https://doi.org/10.1210/jc.2014-2257>.