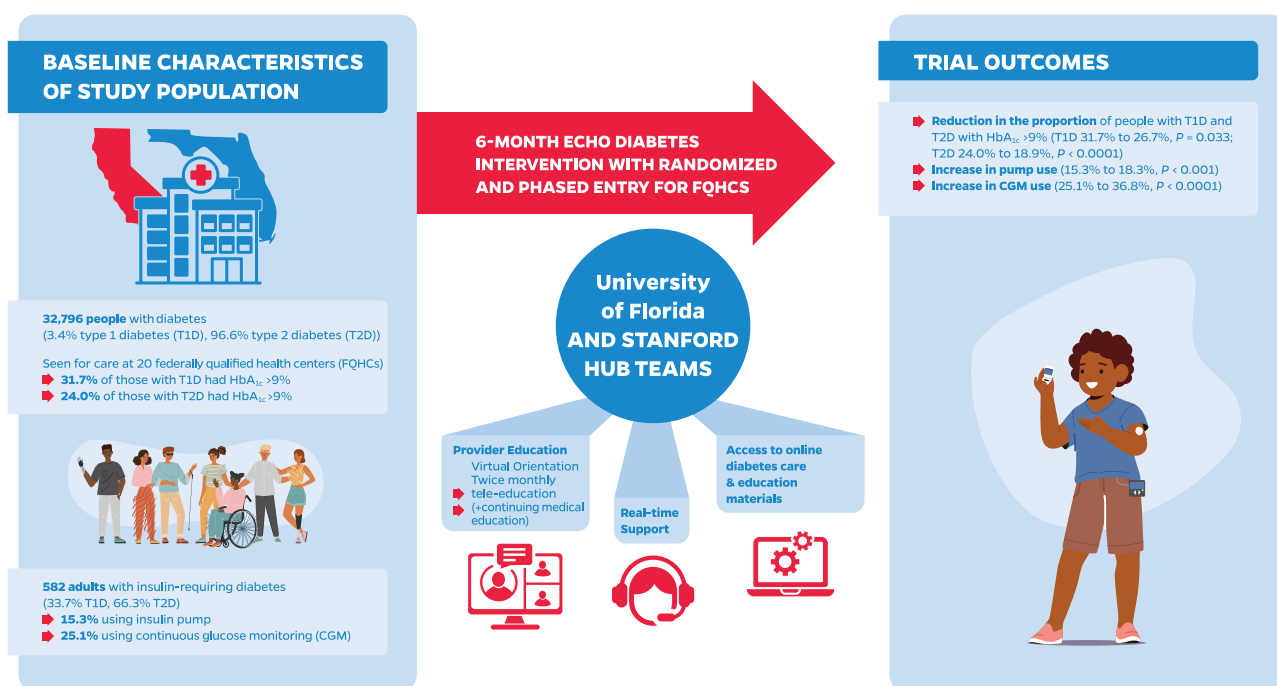


Project ECHO Diabetes Trial Improves Outcomes for Medically Underserved People

Ashby F. Walker, Michael J. Haller, Ananta Addala, Stephanie L. Filipp, Rayhan A. Lal, Matthew J. Gurka, Lauren E. Figg, Melanie Hechavarria, Dessi P. Zaharieva, Keilecia G. Malden, Korey K. Hood, Sarah C. Westen, Jessie J. Wong, William T. Donahoo, Marina Basina, Angelina V. Bernier, and David M. Maahs, for the ECHO Diabetes Study Team

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ARTICLE HIGHLIGHTS

• Why did we undertake this study?

Extension for Community Healthcare Outcomes (ECHO) tele-education models are being implemented around the world with the aim of reducing health disparities. However, most studies on ECHO have only evaluated provider-level outcomes, with no use of randomization.

• What is the specific question we wanted to answer?

Does participation in an ECHO Diabetes intervention result in improved outcomes for people with diabetes who receive care at federally qualified health centers?

• What did we find?

There were significant reductions in the proportion of people with HbA_{1c} >9% and increases in the use of continuous glucose monitors and insulin pumps.

• What are the implications of our findings?

ECHO Diabetes can promote health equity for underserved communities living with diabetes.



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OBJECTIVE

The Project Extension for Community Healthcare Outcomes (ECHO) model is used in 180 countries to address chronic disease care through a provider empowerment, tele-education approach. Few studies have rigorously evaluated the impact of the program on patient outcomes using randomized designs.

RESEARCH DESIGN AND METHODS

Implementation of an ECHO Diabetes program was evaluated using a stepped-wedge design with recruitment of 20 federally qualified health centers (FQHCs) across California and Florida with randomized, phased-in intervention entry. Participating FQHCs (referred to as “spokes”) provided aggregate data, including the Healthcare Effectiveness Data and Information Set (HEDIS) and diabetes technology use. Patients were recruited from spokes, and data collection involved historical and prospective HbA_{1c} measures, HEDIS markers, and pre/post surveys. Linear mixed models were used to generate patient-level monthly HbA_{1c} estimates and evaluate change over time; Poisson regression was used to model clinic-level technology use.

RESULTS

The spoke-level cohort included 32,796 people with type 1 diabetes (T1D; 3.4%) and type 2 diabetes (T2D; 96.6%), of whom 72.7% were publicly insured or uninsured. The patient-level cohort included 582 adults with diabetes (33.0% with T1D, 67.0% with T2D). Their mean age was 51.1 years, 80.7% were publicly insured or uninsured, 43.7% were non-Hispanic White, 31.6% were Hispanic, 7.9% were non-Hispanic Black, and 16.8% were in other race/ethnicity categories. At the spoke level, there were statistically significant reductions before and after the intervention in the proportion of people with HbA_{1c} >9% (range 31.7% to 26.7%; $P = 0.033$). At the patient level, there were statistically significant increases in those using continuous glucose monitoring (range 25.1% to 36.8%; $P < 0.0001$) and pump use (range 15.3% to 18.3%; $P < 0.001$) before and after the intervention.

CONCLUSIONS

The ECHO model demonstrates promise for reducing health disparities in diabetes and contributes to our understanding of program benefits beyond the provider level.

The Project Extension for Community Healthcare Outcomes (ECHO) model was founded at the University of New Mexico in 2003 as a provider tele-education approach aimed at reaching medically underserved communities (1–3). The premise of the model empowers primary care providers (PCPs) to deliver subspecialty care

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through video tele-mentoring, with multidisciplinary subspecialty teams (referred to as “hubs”) training PCPs (referred to as “spokes”) through live, interactional tele-education conferences and by providing real-time support for complex medical decision-making (1–3). The ECHO model is particularly promising for reaching patients at risk for health disparities, because underserved communities are more likely to maintain continuity of care through visits with their PCP than they are through evaluations with subspecialty providers (4). Since its inception in 2003 and original use in hepatitis C management, the Project ECHO model has been used in 180 countries to address a wide range of chronic and infectious diseases (3).

Although there are more than 500 peer-reviewed publications on the Project ECHO model and it is endorsed by the American Medical Association, by India’s government, and throughout many regions in Africa, few, if any, attempts have been made to rigorously evaluate the impact of this program on its founding mission: to reduce health disparities in vulnerable communities (5). The vast majority of Project ECHO evaluations have focused on provider-level outcomes using pre/post surveys of knowledge and confidence in subspecialty care management, or have partially evaluated patient-level outcomes, but without the use of randomization in their research designs (5). Thus, implementation has outpaced rigorous scientific evaluation. Given the rapid growth and scaling of this model globally and the dire need for evidence-based interventions to address health disparities, it is vital to rigorously evaluate the Project ECHO model’s capacity to improve more than provider-level outcomes.

The ECHO Diabetes program was implemented in California and Florida at federally qualified health centers (FQHC) and FQHC “look-alikes” (i.e., health centers that meet the same requirements as set forth by the Health Resources and Services Administration [HRSA] for FQHCs but do not receive federal funding or official designation) (6) that were randomized and had controlled, phased entry into the program. The Project ECHO Diabetes program offered tele-education, real-time support for complex medical decision-making, and access to diabetes support coaches. The ECHO Diabetes

intervention was run from May 2021 through December 2022.

This article presents the results of a stepped-wedge-type trial of the Project ECHO Diabetes program. The aim of the present study was to rigorously evaluate the impact of ECHO Diabetes on health center-level (hereafter called “spoke-level”), provider-level, and patient-level outcomes. In keeping with the larger body of literature on Project ECHO models, we saw significant improvements in our provider-level outcomes related to knowledge and confidence in diabetes care (7). Here, we present the more novel spoke-level and patient-level outcomes from our stepped-wedge trial.

RESEARCH DESIGN AND METHODS

Recruitment of Spokes

The recruitment of spokes for the ECHO Diabetes program was accomplished by focusing on FQHC (and FQHC look-alikes) through use of the Neighborhood Deprivation Index coupled with provider geocoding (8). This novel approach ensured recruitment of spokes that deliver care for communities in medically underserved areas (6). More than 30 million people in the U.S. receive primary care in FQHCs. Federal funding requirements for FQHCs mandate that no one is turned away for care based on insurance status, that need-based sliding scales are used for payment, and that the health care providers must be representative of the communities they serve (i.e., language needs, race, and ethnicity) (6). Look-alike FQHCs were also included. Spokes were compensated with a stipend ranging from \$2,500 to \$10,000 for data acquisition and sharing based on spoke size and data acquisition complexity. Any health care providers from the participating spoke sites were eligible for the ECHO Diabetes intervention.

Recruitment of Patients

Patients were recruited from the participating spokes. The methodology for patient-level recruitment has been previously described (9). All ECHO Diabetes research protocols were overseen by the institutional review board at each academic hub institution; informed consent was obtained before participation. Participating spokes provided patient lists according to the following eligibility requirements for those aged ≥ 18 years: 1) diagnosis of type 1 diabetes (T1D) or 2) diagnosis of

type 2 diabetes (T2D) and needing multiple daily injections (MDIs) of insulin. Lists were randomized and used for recruitment by telephone or in person with study staff who spoke English and Spanish. Through a process of informed consent, participants agreed to participate in survey research, share electronic medical record (EMR) data, and complete at-home HbA_{1c} measurement kits (at baseline and 6 months), with compensation of \$20 for each completed survey.

The Intervention

Health care providers at participating spokes were offered the opportunity to attend real-time, interactive, 1-h, bi-monthly, tele-education sessions; continuing medical education credits were provided. The curriculum was designed using the current standards of diabetes care and delivered by a team of multidisciplinary experts, including adult endocrinologists, pediatric endocrinologists, clinical health psychologists, exercise physiologists, pharmacists, diabetes education, and care specialists, registered dietitians, and medical sociologists. Each tele-ECHO Diabetes session was recorded and available on-demand for health care providers at participating spoke sites, along with access to an online repository of diabetes resources and guidelines. Providers were also able to reach out to the hub team for real-time support with complex medical decision-making, as needed. Finally, spokes also had access to diabetes support coaches for their patients. A full description of the use of diabetes support coaches in the ECHO Diabetes program has been published elsewhere (10) and involved using a combination of a community health worker and peer mentors to address social determinants of health and to create more community capacity within the spokes for people with diabetes. Figure 1 shows a model of the ECHO Diabetes intervention.

Study Design and Randomization

ECHO Diabetes used a variation of a stepped-wedge study design (11), allowing for two phases of program kick-off and patient recruitment at spokes. Spoke sites provided basic metrics of their patient panels, including the number of clinic locations participating in the program and adults with T1D and T2D. Covariate-constrained randomization (12) was

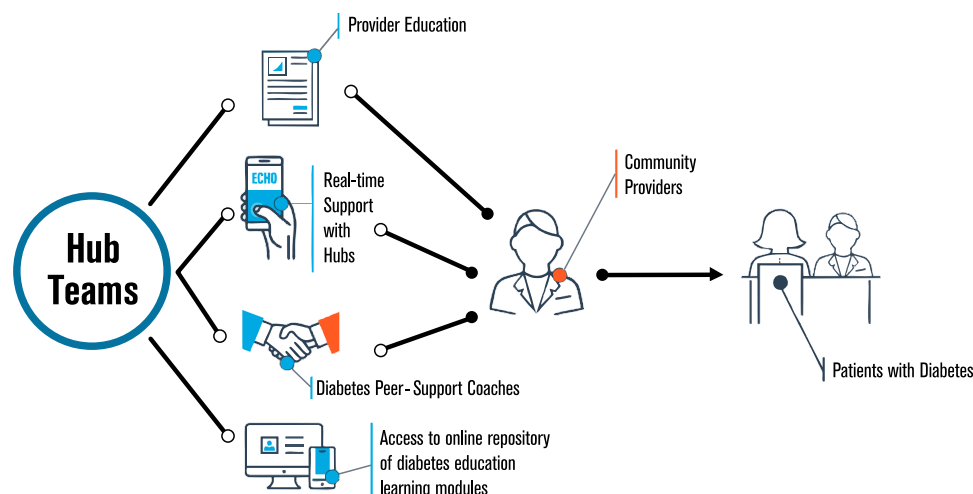


Figure 1—ECHO Diabetes intervention. The ECHO Diabetes intervention included tele-education for providers, real-time support with complex medical decision-making, access to diabetes support coaches, and access to an online repository of diabetes education materials.

used to assign spokes to begin the ECHO Diabetes intervention in May or December of 2021. The randomization design specifications allowed for clinic arm totals to differ by no more than one, and the mean number of patients with diabetes to not differ by greater than 20% between arms (12). Final randomized intervention assignment was distributed to enrolled spokes in spring 2021.

Data Collection

The research aims of ECHO Diabetes were to evaluate the impact of the program across all three levels of data capture: spoke level, provider level (7), and patient level. Spoke-level data capture incorporated the transfer of aggregate-level data by participating centers for calendar years 2020, 2021, and 2022, including Health Effectiveness Data and Information Set (HEDIS) and Uniform Data System diabetes-related measures. Patient-level data capture included historical and prospective HbA_{1c} measures, HEDIS markers obtained from EMRs, and surveys offered at enrollment and conclusion of the ECHO Diabetes intervention that included the Diabetes Distress Scale (13) and self-reported diabetes management questions.

Data Management and Statistical Analysis

Study data for ECHO Diabetes were collected and managed using Research Electronic Data Capture as a secure, web-based platform tool hosted at the University of

Florida (14,15). All data management and analyses were conducted using SAS, version 9.4 (StataCorp, Cary, NC). For all statistical evaluations, $\alpha = 0.05$ defined significance. For spoke-level data, the aggregate data from individual spokes were combined and average rates of HbA_{1c} capture during routine clinic visits were summarized descriptively (mean rate $\pm$ SD) overall and within states. Additionally, average HbA_{1c} values reported by spokes were summarized descriptively (mean rate $\pm$ SD) overall, stratified by state, and broken down by insurance type within those with T1D and T2D, respectively, for the years 2021 and 2022.

Patient scope of the ECHO Diabetes program was summarized descriptively (i.e., frequencies and rates) by averaging clinic-level aggregate patient data overall and broken down by insurance type and by diabetes type (i.e., T1D and T2D) for the entire cohort, as well as stratified by state. Diabetes-related technology use was captured for the subset of participating spokes that documented use of continuous glucose monitoring (CGM) and insulin pump use in the EHR. Generalized linear mixed models with the logit link and a random effect for spoke were used to produce model-estimated rates and 95% CIs, along with statistical testing to evaluate change in rates of CGM and insulin pump use between 2021 and 2022 both overall and within insurance types.

Finally, generalized linear mixed models were used to compute model-estimated rates and associated 95% CIs for HEDIS

metrics using the logit link, including a random effect for spoke. Comparisons were made via these models on demographic characteristics (namely, insurance type and racial/ethnic groups) between states and years.

For patient-level data, to assess the change in participant HbA_{1c} values, generalized linear mixed models were used to compute model-estimated means using the identity link. A random effect for spoke was included to account for clustering within spoke sites. An overall model was fit, in addition to one that included interactions between state and time to assess for significant differences in HbA_{1c} overall and within states, relative to baseline measures. Similarly, on a participating patient level, model-estimated rates and their associated 95% CIs for HEDIS metrics within measurement years were individually computed using generalized linear mixed models with the logit link and a random effect for spoke. The same techniques were used to estimate mean scores of diabetes distress reported on patient surveys. Statistical comparisons were made via these models before and after the ECHO intervention.

RESULTS

Description of Spoke- and Patient-Level Cohorts

Overall, 20 spokes were recruited for participation in ECHO Diabetes ($n = 11$ in California and 9 in Florida). A full list of participating spoke sites and their characteristics is presented in Supplementary

Table 1. Collectively, the 20 spokes provided care to 270,627 adults aged ≥ 18 years (49.4% publicly insured, 23.3% uninsured, and 27.4% commercially insured). Of these patients, the spokes provided aggregate data on a cohort of 32,796 adults with diabetes who were aged ≥ 18 years (T1D, 3.4%; T2D, 96.5%). Table 1 includes baseline data on spoke-level HEDIS rates for HbA_{1c} $>9\%$ by demographic characteristics.

From the participating spoke sites, a cohort of 582 adults aged ≥ 18 years

with T1D and T2D needing multiple daily injections were recruited for participation. Table 2 presents the overall demographic characteristics of the patient-level cohort. The mean age was 51.1 (95% CI 49.5, 52.6) years, 47.8% were female, 33.7% had T1D, 66.3% had T2D, 84.8% listed English as their preferred language, and baseline mean HbA_{1c} was 8.7 (95% CI 8.3, 9.0). In terms of race and ethnicity, 43.7% were non-Hispanic White, 7.9% were non-Hispanic Black, 31.6% were Hispanic, and 16.8%

were categorized as of “other” race/ethnicity. In the patient-level cohort, 57.0% were publicly insured, 23.7% were uninsured, and 19.3% had commercial insurance.

Spoke-Level Findings

Table 1 presents findings from the pre/post stepped-wedge trial for the spoke-level cohort for the HEDIS HbA_{1c} classification categories, as well as CGM and pump use. There was a statistically significant reduction in the overall percentage

Table 1—HbA_{1c} $>9\%$ and technology use for spoke-level cohort before and after ECHO Diabetes intervention ($N = 32,796$; T1D [$n = 1,127$] and T2D [$n = 31,669$])

	Before ECHO diabetes intervention, % (95% CI)	After ECHO diabetes intervention, % (95% CI)	<i>P</i> value*
Spokes contributing insurance breakdowns of HbA_{1c} $>9.0\%$, <i>n</i>			
	17	17	
Rate of adults with T1D and HbA _{1c} $>9.0\%$	31.7 (28.5, 35.3)	26.7 (23.7, 30.1)	0.0330
Commercial	27.8 (21.7, 35.5)	26.9 (20.9, 34.8)	0.8697
Medicaid	38.0 (32.8, 44.0)	34.8 (29.8, 40.7)	0.4254
Medicare	25.0 (16.6, 37.6)	17.8 (10.3, 30.7)	0.3217
Dual-eligible Medicare and Medicaid	20.9 (13.3, 32.7)	18.8 (10.9, 32.5)	0.7747
Uninsured/self-pay/none listed	42.6 (32.5, 55.9)	18.5 (13.0, 26.2)	0.0002
Rate of adults with T2D and HbA _{1c} $>9.0\%$	24.0 (23.5, 24.6)	18.9 (18.4, 19.4)	<0.0001
Commercial	24.0 (22.9, 25.3)	19.4 (18.3, 20.5)	<0.0001
Medicaid	25.8 (24.7, 26.8)	21.4 (20.4, 22.4)	<0.0001
Medicare	14.2 (13.1, 15.4)	12.2 (11.2, 13.3)	0.0105
Dual-eligible Medicare and Medicaid	16.4 (14.8, 18.3)	13.4 (11.8, 15.2)	0.014
Uninsured/self-pay/none listed	30.5 (28.9, 32.0)	20.9 (19.8, 22.0)	<0.0001
Spokes contributing racial/ethnic breakdowns of HbA_{1c} $>9.0\%$, <i>n</i>			
	15	15	
Rate of adults with T1D and HbA _{1c} $>9.0\%$	33.0 (29.7, 36.8)	26.6 (23.5, 30.0)	0.0087
White	29.7 (25.5, 34.5)	23.9 (20.2, 28.3)	0.0609
Black	51.4 (39.4, 67.2)	42.3 (29.5, 60.4)	0.384
Hispanic	36.3 (28.5, 46.3)	32.4 (25.1, 41.8)	0.5277
Other race/ethnicity	31.5 (23.5, 42.2)	30.4 (21.9, 42.4)	0.8821
Rate of adults with T2D and HbA _{1c} $>9.0\%$	24.3 (23.7, 24.9)	19.0 (18.5, 19.5)	<0.0001
White	22.4 (21.5, 23.4)	17.2 (16.4, 18.0)	<0.0001
Black	30.1 (28.1, 32.3)	19.7 (18.4, 21.1)	<0.0001
Hispanic	24.1 (22.9, 25.3)	24.4 (23.3, 25.6)	0.6654
Other race/ethnicity	22.9 (21.7, 24.2)	14.7 (13.7, 15.8)	<0.0001
Spokes contributing CGM data for 2021 and 2022			
	7	7	
Model-estimated rate of adult patients with T1D or T2D using CGM, <i>n</i>	2.1 (0.7, 6.3)	4.4 (1.6, 11.8)	0.2606
Commercial	1.8 (0.4, 8.6)	2.5 (0.8, 7.6)	0.3958
Medicaid	2.2 (0.7, 6.3)	7.3 (2.6, 20.4)	0.2225
Medicare	3.7 (1.5, 9.1)	5.8 (2.5, 13.2)	0.3715
Dual-eligible Medicare and Medicaid	1.1 (0.5, 2.3)	2.5 (1.1, 5.8)	0.3068
Uninsured/self-pay/none listed	1.1 (0.2, 6.3)	1.7 (0.5, 5.7)	0.4974
Spokes contributing insulin pump data for 2021 and 2022, <i>n</i>			
	6	6	
Model-estimated rate of adult patients with T1D or T2D using insulin pumps	0.3 (0.1, 0.6)	0.1 (0.1, 0.3)	0.3813
Commercial	0.2 (0.1, 0.9)	0.2 (0.0, 0.6)	0.6478
Medicaid	0.5 (0.2, 1.2)	0.2 (0.1, 0.5)	0.3576
Medicare	0.1 (0.1, 0.3)	0.1 (0.0, 0.4)	0.2142
Dual-eligible Medicare and Medicaid	0.3 (0.1, 0.5)	0.3 (0.2, 0.5)	0.246
Uninsured/self-pay/none listed	0.1 (0.0, 0.1)	0.01 (0.0, 0.2)	0.9151

**P* values are for change from 2021 to 2022. $P < 0.05$ was considered significant and appears in bold.

Table 2—Patient-level ECHO Diabetes demographics

Characteristic	Overall	California	Florida	P value
<i>n</i> (%)	582 (100.0)	294 (50.5)	288 (49.5)	
Diabetes type				0.0902
Type 1	196 (33.7)	113 (38.4)	83 (29.0)	0.0513
Type 2	386 (66.3)	181 (61.6)	205 (71.0)	
Baseline HbA _{1c} , %*	8.7 [8.3, 9.0]	8.5 [8.1, 9.0]	8.8 [8.3, 9.3]	0.3553
Age, years†	51.1 [49.5, 52.6]	52.4 [50.5, 54.2]	49.6 [47.6, 51.6]	0.0475
Sex				0.0228
Male	261 (46.1)	146 (42.0)	115 (54.9)	
Female	286 (47.8)	122 (49.2)	164 (41.9)	
Unknown	35 (6.1)	26 (8.8)	9 (3.2)	
Race/ethnicity				0.0004
White	235 (43.7)	138 (48.6)	97 (33.4)	
Black	91 (7.9)	9 (2.4)	82 (23.9)	
Hispanic	167 (31.6)	87 (27.5)	80 (32.6)	
Other race(s)/unknown	89 (16.8)	60 (21.5)	29 (10.1)	
Intake insurance				<0.0001
Commercial	109 (19.3)	38 (12.9)	71 (25.4)	
Medicare	120 (20.6)	86 (30.6)	34 (10.9)	
Medicaid	185 (33.1)	102 (34.7)	83 (29.2)	
Dual-eligible	23 (3.3)	18 (5.1)	5 (1.6)	
Medicare and Medicaid				
Other: uninsured/self-pay/unknown	145 (23.7)	50 (16.7)	95 (32.9)	
Language preference				0.2506
English	475 (84.8)	249 (89.0)	226 (78.8)	
Spanish	107 (15.2)	45 (11.0)	62 (21.2)	
How do you usually take insulin?				0.0005
Injection/pen	337 (85.3)	122 (80.7)	215 (87.7)	
Insulin pump	37 (8.3)	29 (17.3)	8 (3.3)	
Pump and injection/pen	9 (2.3)	1 (0.7)	8 (3.3)	
Other	16 (4.1)	2 (1.3)	14 (5.7)	
Do you use an insulin pump?				<0.0001
No	333 (83.2)	113 (73.5)	220 (89.8)	
Yes	66 (16.8)	41 (26.5)	25 (10.2)	
Do you regularly use a CGM?				0.0101
No	296 (74.1)	96 (64.1)	200 (81.7)	
Yes	105 (25.9)	58 (35.9)	47 (18.3)	

Rates presented for categorical data are modeled estimates; for continuous data, modeled mean and 95% CI are reported. Statistical analysis was conducted with generalized linear mixed models, with a random effect accounting for spoke. $P < 0.05$ was considered significant and appears in bold. *Baseline HbA_{1c}: $N = 377$ overall; $n = 180$ California; $n = 197$ Florida. †Age in years calculated with date of birth as of 31 December 2021; $N = 575$ overall, $n = 290$ California, $n = 285$ Florida.

of adults with T1D with HbA_{1c} >9% pre/post intervention: at baseline, 31.7% (95% CI 28.5, 35.3) had HbA_{1c} >9%; after the intervention, that decreased to 26.7% (95% CI 23.7, 30.1; $P = 0.0330$). The same was true for the overall percentage of adults with T2D with HbA_{1c} >9%: at baseline 24.0% (95% CI 23.5, 24.6) had HbA_{1c} >9%; after the intervention, that decreased to 18.9% (95% CI 18.4, 19.4; $P < 0.0001$). When examining the changes according to insurance status, among patients with T1D, the reductions were only statistically significant for those without health insurance

(42.6% preintervention and 18.5% postintervention; $P = 0.002$). The reduction in the percentage of patients with HbA_{1c} >9% was statistically significant for all insurance categories among patients with T2D, with the highest reductions for those who were uninsured (30.5% preintervention and 20.9% postintervention; $P < 0.0001$). In the T1D group, the reductions in HbA_{1c} at the spoke-level were not significant according to race and ethnicity. In the T2D group, the reductions in HbA_{1c} were significant for all racial and ethnic groups ($P < 0.05$), except for those who identified as Hispanic.

Of the 20 participating spokes, only seven were able to provide aggregate pre/post data on CGM and only six on insulin pump use. Of those providing data, at baseline, 2.1% of the T1D and T2D populations were using CGM; after the intervention, this increased to 4.4%. The use of CGM increased for all insurance categories, but the highest increases were seen for Medicaid populations (from 2.2% at baseline to 7.3% postintervention). However, none of the increases at the spoke level was statistically significant. Insulin pump use at baseline was 0.3% (95% CI 0.1, 0.6); after ECHO, the

rate was 0.1% (95% CI 0.1, 0.3), thus slightly decreasing. The changes in pump use at the spoke level were not statistically significant.

Patient-Level Findings

Mean (95% CI) HbA_{1c} for the patient-level cohort was 8.7% (8.5, 8.9) at baseline, 8.6% (8.3, 8.8) at 6 months, and 8.4% (8.1, 8.8) at 12 months (Table 3). The overall reduction in HbA_{1c} before and after the intervention was -0.22 (-0.55 , 0.11). These reductions were not statistically significant, and examining these changes for subgroups based on insurance status or race and ethnicity was not possible due to small numbers of patients ($n = 62$) with complete HbA_{1c} data through 12 months (Table 3). For technology use at the patient level, there were statistically significant increases in both CGM and insulin pump use. The use of CGM increased from 25.1% (15.9, 37.4) to 36.8% (26.6, 48.3; $P < 0.0001$). Insulin pump use increased from 15.3% (9.4, 23.9) to 18.3% (12.6, 26.0; $P < 0.001$) (Table 3). For DDS scores (Supplementary Appendix B, Supplementary Table 2), there was a reduction in total DDS score of -0.08 (-0.17 , 0.02); however, this reduction in overall score was not statistically significant. There was a statistically significant

reduction of -0.22 (-0.36 , -0.08 ; $P = 0.0303$) in the physician-related distress score.

CONCLUSIONS

The findings from this randomized trial confirm the Project ECHO model's capacity to improve provider-level confidence and knowledge in subspecialty care. Perhaps more importantly, these data indicate that Project ECHO, a provider educational empowerment program, can improve spoke-level and patient-level outcomes to reduce health disparities in vulnerable communities. Our evaluation design was highly unique for Project ECHO programs in that it included randomization with a controlled and phased entry into the program for participating health centers, aggregate data-sharing requirements for spoke sites, and patient-level recruitment. By targeting FQHCs, we were able to recruit highly diverse and historically underrepresented cohorts of people with diabetes, and we demonstrated significant improvements within these communities. Notably, participating clinics accomplished our study aims in the midst of the COVID-19 pandemic and dealt with additional unique challenges (i.e., historic wildfires in California and hurricanes in Florida) that stressed FQHC capacity.

The overall proportion of people with HbA_{1c} $>9\%$ decreased significantly from before to after the intervention. At the patient level, CGM and insulin pump use increased significantly from before to after the postintervention. We also saw this improvement within primary care settings, whereas large studies targeting endocrinology settings have not reported the same results nor have these studies contained the diversity of our cohorts (16,17). Given well-documented disparities in CGM and pump use in the U.S. (18–23), as well as disparities in the use of glucagon-like peptide 1 (GLP-1) receptor agonists and sodium–glucose cotransporter 2 (SGLT2) inhibitor medications (24,25), these findings provide a model to improve access to diabetes technologies and medications for communities who experience structural inequities and are at greatest risk for disparate outcomes (26–28). Although provider-level data about the increase in GLP-1s and SGLT2s have been published (7), empowerment at the provider level has important implications for the promotion of health equity within FQHCs. Baseline characteristics of the ECHO Diabetes cohorts have also been published (29) and also demonstrated significantly higher HbA_{1c} levels and lower technology use in Florida prior

Table 3—Patient-level changes before and after ECHO Diabetes intervention

	<i>n</i> ; model estimate (95% CI)		
	6-Month change*	12-Month change*	<i>P</i> value†
HbA_{1c}			
Overall	209; -0.07 (-0.28 , 0.14)	62; -0.22 (-0.55 , 0.11)	0.3543
California	117; -0.22 (-0.45 , 0.01)	33; -0.37 (-0.79 , 0.04)	0.8755
Florida	92; 0.08 (-0.30 , 0.46)	29; -0.12 (-0.68 , 0.43)	
Patient-level mean HbA_{1c} before and after intervention‡	Baseline	6 Months	12 Months
Overall	345; 8.7 (8.5, 8.9)	268; 8.6 (8.3, 8.8)	76; 8.4 [8.1, 8.8]
California	173; 8.5 (8.2, 8.8)	146; 8.3 (8.0, 8.5)	41; 8.1 [7.7, 8.4]
Florida	172; 8.9 (8.6, 9.2)	122; 8.9 (8.5, 9.2)	35; 8.7 [8.2, 9.3]
Change in CGM and insulin pump use before and after ECHO Diabetes intervention	Modeled technology use before survey	Modeled technology use after survey	<i>P</i> value
Insulin pump use ($n = 177$)	15.3 (9.4, 23.9)	18.3 (12.6, 26.0)	<0.0001
Among those who did not use a pump at baseline ($n = 150$)		4.0 (1.7, 9.3)	
CGM use ($n = 175$)	25.1 (15.9, 37.4)	36.8 (26.6, 48.3)	<0.0001
Among those who did not use a CGM at baseline ($n = 130$)		22.3 (15.6, 30.9)	

*Both 6- and 12-month changes are calculated relative to baseline HbA_{1c}; *P* values in bold are for estimates individually significantly different relative to baseline. †Overall *P* value reflects no difference from 6 to 12 months; *P* value reported for site reflects no site $\times$ time interaction.

‡All available data (i.e., not restricted to those with complete measures for before and after style analysis).

to the study intervention when compared with California. Thus, even within medically underserved communities, there are stratified risks based on factors like geographic location, race, and ethnicity, and this intervention showed improved outcomes across both states.

It is also important to note areas where we did not see improvements and to acknowledge several important study limitations. In patients with T1D, changes in HbA_{1c} were not statistically significant according to race and ethnicity at the spoke level, likely due to the smaller cohort size ($n = 1,127$). In the aggregate cohort for T2D, for which there were data on many more patients ($n = 31,669$), there was a statistically significant reduction in the proportion of adults with HbA_{1c} >9% with T2D for every racial and ethnic group except for those categorized as Hispanic. This suggests that, even within populations that are all medically underserved, barriers for Hispanic communities may be especially pronounced. It also suggests that future iterations of ECHO Diabetes interventions should consider offering the tele-ECHO sessions in Spanish, because many of the FQHC providers in Florida, themselves, spoke Spanish as a first language. There was also statistically lower use of technology use by people who preferred to speak Spanish. Differences in HbA_{1c} and technology use were also significantly different for those who were non-Hispanic Black. Overall, risk was stratified even within medically underserved communities, and this underscores the importance of developing targeted intervention in the promotion of health equity in diabetes. Reporting for other groups based on race and ethnicity was limited by the study population demographics.

Despite these limitations, this study makes important contributions to our understanding of the Project ECHO model and its potential to reduce health disparities for medically underserved communities in the U.S. and elsewhere. Given the increase in diabetes globally, especially in low- and middle-income counties where access to basic diabetes care is only available to 10% of the population (28), Project ECHO's remote provider empowerment model offers a viable solution to meeting the complex challenges of this global health crisis (28). The ECHO Diabetes program shows promise for reducing pronounced health outcomes for historically

marginalized communities with diabetes, due to structural inequities (26–28).

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