Published in final edited form as:

J Diabetes Complications. 2018 October ; 32(10): 934–939. doi:10.1016/j.jdiacomp.2018.06.005.

The 30-Year Cost-Effectiveness of Alternative Strategies to Achieve Excellent Glycemic Control in Type 1 Diabetes: An Economic Simulation Informed by the Results of the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC)

William H. Herman, MD, MPH¹, Barbara H. Braffett, PhD², Shihchen Kuo, RPh, PhD³, Joyce M. Lee, MD, MPH⁴, Michael Brandle, MD⁵, Alan M. Jacobson, MD⁶, Lisa A. Prosser, PhD⁷, John M. Lachin, ScD², and The Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Research Group

¹Departments of Internal Medicine and Epidemiology, University of Michigan, Ann Arbor, MI ²The Biostatistics Center, George Washington University, Washington, DC ³Department of Internal Medicine, University of Michigan, Ann Arbor, MI ⁴Pediatric Endocrinology, Child Health Evaluation and Research Unit, University of Michigan, Ann Arbor, MI ⁵Division of Endocrinology and Diabetes, Kantonsspital St. Gallen, Sankt Gallen, SG, Switzerland ⁶Winthrop-University Hospital, Mineola, NY ⁷Department of Pediatrics, University of Michigan, Ann Arbor, MI

Abstract

Objective: To simulate the cost-effectiveness of historical and modern treatment scenarios that achieve excellent vs. poor glycemic control in type 1 diabetes (T1DM).

Research Design and Methods: We describe and compare the costs of intensive and conventional therapies for T1DM as performed during DCCT, and modern intensive and basic therapy scenarios using insulin analogs, pens, pumps, and continuous glucose monitoring (CGM) to achieve excellent or poor glycemic control. We then assess the differences in treatment costs and the costs of outcomes over 30 years and report incremental cost-effectiveness ratios.

Results: Over 30 years, DCCT intensive therapy cost \$127,500 to \$181,600 more per participant than DCCT conventional therapy, and modern intensive therapy cost \$87,700 to \$409,000 more per individual than modern basic therapy. Excellent glycemic control averted as much as \$90,900 in costs from complications and added ~1.62 quality-adjusted life-years (QALYs) per participant over 30 years. When costs and QALYs were discounted at 3% annually, DCCT intensive therapy and modern intensive therapies that use multiple daily injections (MDI) or pumps are cost-saving or cost-effective (<\$100,000/QALY-gained). If applied to all patients with T1DM, modern intensive therapy using pumps and CGM is not cost-effective (>\$250,000/QALY-gained) but

Correspondence: William H. Herman, MD, MPH, University of Michigan, 1000 Wall Street, Room 6108 / SPC 5714, Ann Arbor, MI 48105-1912, Phone: (734) 936-8279, Fax: (734) 647-2307, wherman@umich.edu.

Trial Registration: clinicaltrials.gov NCT00360815 and NCT00360893.

would be more cost-effective if associated with less hypoglycemia, better glycemic control, fewer complications, or improved health-related quality-of-life.

Conclusions: Use of the least expensive intensive therapy needed to safely achieve treatment goals for patients with T1DM represents a good value for money.

Keywords

Type 1 diabetes; multiple daily injections; insulin pump therapy; continuous glucose monitoring; cost-effectiveness

In this paper, a companion to a paper in which we assessed the complication, quality-of-life, and cost implications of 30-years of excellent (HbA1c ~7% (53 mmol/mol)) vs. poor (HbA1c ~9% (75 mmol/mol)) glycemic control,¹ we perform scenario analyses to estimate the long-term cost-effectiveness of DCCT and modern-day intensive therapies for type 1 diabetes mellitus (T1DM) that achieve excellent glycemic control. In these analyses, we update our earlier estimates of the resource utilization and costs of DCCT intensive and conventional therapies² and compare DCCT multiple daily injections (MDI) and DCCT continuous subcutaneous insulin infusion (pump) therapy to DCCT conventional therapy. We then construct three modern intensive therapy scenarios that include team care, quarterly outpatient visits, and frequent self-monitoring of blood glucose (SMBG), use of insulin analogs, and multiple daily injections (MDI) or pumps with or without continuous glucose monitoring (CGM). We compare these modern treatment scenarios to modern “basic” therapy which includes the use of insulin analogs, but involves briefer outpatient visits, less supervision, and less frequent SMBG. We assume that both DCCT intensive and modern intensive therapies achieve and maintain excellent glycemic control with HbA1c levels similar to those achieved by the intensive therapy group during DCCT (~7% or 53 mmol/mol) and that DCCT conventional therapy and modern basic therapy achieve freedom from symptoms, avoid extremes of glycemia, and achieve HbA1c levels similar to those achieved by the conventional therapy group during DCCT (~9% or 75 mmol/mol).

RESEARCH DESIGN AND METHODS

DCCT intensive therapy was provided by a multidisciplinary team and involved weekly telephone calls, monthly outpatient visits, periodic counseling by dietitians and mental health professionals, 3 or more daily injections of animal or human insulins or pump therapy using human insulin, and 4 times daily self-monitoring of blood glucose (SMBG).² DCCT conventional therapy involved quarterly outpatient visits, 1 or 2 daily injections of animal or human insulins, and once or twice daily urine glucose testing or SMBG.²

In this report, we have updated our previous estimates of the resources used for intensive therapy during the DCCT using multiple daily injections (MDI) and pump therapy and the resources used for conventional therapy during the DCCT.² We assumed that the human insulins (Humulin or Novolin human regular and NPH insulins) and the supplies most commonly used in clinical practice in the U.S. today were used for the entire 30 years of follow-up. We applied the average wholesale price or sale price to each resource and weighted its use according to its current market share to calculate its cost. We excluded the

resources used for the research components of the DCCT including the costs of hospitalization at the initiation of DCCT intensive therapy and the costs of changing from one type of intensive therapy to the other.

We also constructed three modern treatment scenarios to represent intensive therapy in common use today (modern MDI therapy, modern pump therapy, and modern pump therapy with CGM) and one additional scenario to represent basic therapy in use today (modern basic therapy). Our estimates of the resources used for modern intensive therapies were based on current patterns of clinical practice and the recommendations of the American Diabetes Association published in the Standards of Medical Care in Diabetes including the use of insulin analogs for all patients with T1DM.³ Our estimate of the resources used for modern basic therapy was based on expert opinion and included use of insulin analogs but less intensive outpatient follow-up and less frequent SMBG (once daily). Because of the transition from animal and human insulins to analog insulins and the dramatic increase in the costs of insulins over the past 30 years,⁴ we estimated the costs of modern intensive and basic therapies over the entire 30-year time horizon assuming that the use of each analog insulin, supply, and device was reflected by its current market share. We applied the unit cost as assessed by the average wholesale price or sale price to each item and weighted its use according to its market share to estimate the cost of each therapy.

Appendix Tables 1A and 1B shows the resources used for healthcare providers, SMBG, insulin delivery, tests, and procedures by diabetes treatment scenario. Appendix Table 2 shows the time and unit costs associated with healthcare provider visits, tests, and procedures. Appendix Tables 3A and 3B shows the annual costs of healthcare provider visits, tests, and procedures by diabetes treatment scenario. Appendix Tables 4A and 4B show the annual costs of medications, equipment, and supplies by diabetes treatment scenario. Appendix Tables 5A and 5B show the annual per person treatment costs for each of the diabetes treatment scenarios.

Costs

We adopted a healthcare sector perspective and considered only direct medical costs. We used multiple sources to estimate costs and adjusted costs with the general consumer price index so that all costs are expressed in 2014 U.S. dollars.

Analyses

We summed the annual costs of therapy for each of the diabetes treatment scenarios over 30 years. We also summed the annual costs of complications, comorbidities, and death and the annual QALYs accrued by the groups achieving excellent and poor glycemic control over 30 years.¹ We calculated the cumulative per person direct medical costs and QALYs by adding the total costs of the diabetes treatments and complications, comorbidities, and death, and by adding the total QALYs associated with the clinical outcomes associated with excellent and poor glycemic control over 30 years. We then calculated incremental cost-effectiveness ratios (ICERs) as the difference in average cumulative per participant costs of the treatments, complications, comorbidities, and death divided by the difference in the average cumulative per participant QALYs among those who maintained excellent vs. poor glycemic control.

ICERs were expressed as cost per QALY-gained. To calculate discounted ICERs, we applied a 3% annual discount rate to both costs and QALYs. Our analyses were framed as “what-if” or scenario analyses. Excel and SAS 9.1 were used for data management and analysis. All DCCT/EDIC sites received Institutional Review Board approval for DCCT/EDIC and all subjects provided written informed consent.

RESULTS

Table 1 shows the annual and 30-year per participant undiscounted and discounted costs of treatment for each of the DCCT treatment scenarios. The undiscounted annual cost of DCCT conventional therapy was \$4,749, DCCT MDI therapy was \$7,319, and DCCT pump therapy was \$10,982 per participant per year. The undiscounted cumulative 30-year treatment cost of DCCT conventional therapy was \$124,466, DCCT MDI therapy was \$204,001, and DCCT pump therapy was \$306,112. The discounted 30-year costs of DCCT conventional therapy was \$90,175, DCCT MDI therapy was \$145,075, and DCCT pump therapy was \$217,691.

Table 2 shows the annual and 30-year per participant undiscounted and discounted costs of each of the modern treatment scenarios. The undiscounted annual per participant cost of modern basic therapy was \$8,133, modern MDI therapy was \$10,792, modern pump therapy was \$12,935, and modern pump therapy with CGM was \$22,318. The 30-year, cumulative, per participant, undiscounted treatment costs were \$213,159 for modern basic therapy, \$300,816 for modern MDI therapy, \$360,543 for modern pump therapy, and \$622,121 for modern pump therapy with CGM. The discounted 30-year costs of modern basic therapy was \$154,432, modern MDI therapy was \$213,925, modern pump therapy was \$256,400, and modern pump therapy with CGM was \$442,420.

We have previously reported the event costs and ongoing costs of complications, comorbidities, and death, the number of individuals with excellent or poor glycemic control who experienced the events over 30 years, and the 30-year cumulative per participant undiscounted costs of complications, comorbidities, and death.¹ The undiscounted costs of complications, comorbidities, and death over 30 years were \$118,257 for individuals with poor glycemic control and \$27,369 for those with excellent glycemic control, a difference of ~\$90,900 over 30 years. We have also previously reported that over 30 years, participants achieving excellent glycemic control accrued 18.58 undiscounted QALYs and those achieving poor glycemic control accrued on average 16.96 undiscounted QALYs, a difference of 1.62 QALYs over 30 years.¹

Table 3 summarizes the discounted incremental cost-effectiveness ratios (ICERs) by DCCT diabetes treatment scenario over 30 years. DCCT MDI therapy was cost-saving and DCCT pump therapy was cost-effective (\$82,018/QALY) compared to DCCT conventional therapy.

Table 4 summarizes the discounted ICERs by modern diabetes treatment scenario over 30 years. Modern intensive MDI therapy was extremely cost-effective (\$3,835/QALY) and modern pump therapy was cost-effective (\$52,654/QALY) compared to modern basic therapy. Modern pump therapy with CGM (\$266,457/QALY) was not cost-effective compared to modern basic therapy (cost per QALY gained >\$100,000).

DISCUSSION

The cost of DCCT intensive therapy for T1DM that achieved excellent glycemic control was greater than the cost of DCCT conventional therapy that achieved poor glycemic control, and within intensive therapy, the cost of DCCT pump therapy was greater than the cost of DCCT MDI therapy. Nevertheless, compared to DCCT conventional therapy that achieved poor glycemic control, DCCT MDI therapy was cost-saving (increased QALYs and reduced costs) and DCCT pump therapy cost <\$100,000 per QALY-gained. In the U.S., a cost of \$100,000 per QALY-gained has been proposed as an appropriate threshold to define good value for money spent.^{5,6}

After the publication of the DCCT results, the DCCT Research Group developed a Monte Carlo simulation model to describe and compare the lifetime benefits and costs of intensive versus conventional therapy as practiced in the DCCT.⁷ From a healthcare sector perspective and over a lifetime, DCCT intensive therapy was projected to be a good value for the money spent, costing ~\$20,000 per QALY gained in 1994 U.S. dollars (or ~\$32,000 in 2014 U.S. dollars). In that analysis, we used a weighted average of the costs of DCCT MDI and DCCT pump therapy and included the costs of changing from one form of intensive therapy to the other. In the current analysis, we modeled the treatment costs of MDI and pump therapy separately and found that over 30 years, MDI therapy was cost-saving and pump therapy was cost-effective costing ~\$82,000 per QALY-gained.

There are a number of differences in the approaches we used in this study compared to our previous study of DCCT therapies.⁷ In the current study: (1) we adopted a 30-year time horizon to reflect the availability of empiric data rather than simulating a lifetime time horizon; (2) we considered the costs and quality-of-life impact of acute metabolic complications, cardiovascular disease, and death; (3) we used empiric but lower health utility scores for both uncomplicated diabetes and diabetes-related complications and comorbidities; and (4) we used costs as assessed in 2014 U.S. dollars rather than 1994 U.S. dollars. Despite these differences, both studies revealed that DCCT intensive therapy represents a good value for the money spent.

Because the approaches to the management of T1DM have changed dramatically over the more than 20 years since the publication of the results of the DCCT, the costs of both modern basic and intensive therapies have increased. When both the costs of treatment and the costs of complications, comorbidities, and deaths are considered, and costs and QALYs are discounted at 3% per year, modern MDI therapy that achieves excellent glycemic control is highly cost-effective (\$3,835/QALY) and modern pump therapy that achieves excellent glycemic control is cost-effective (\$52,654/QALY) compared to modern basic therapy that achieves poor glycemic control. Only modern pump therapy using CGM is not cost-effective (>\$266,000/QALY).

The high cost of CGM and the lack of long-term, randomized, controlled clinical trials demonstrating the benefits of CGM for longer than 2 years have limited its translation into routine clinical practice.^{8–16} Payers in many countries do not routinely cover CGM. In the U.S., payers often restrict CGM coverage to subsets of T1DM patients with hypoglycemia

unawareness or histories of severe hypoglycemia. If and when there are less expensive alternatives to the currently available pumps and CGM devices (such as the sensor-based flash glucose monitoring systems^{17,18}), modern pump therapy with CGM will be more cost-effective than we have estimated. Despite not being cost-effective as a first-line treatment strategy for the entire population with T1DM, an evidence-based, tiered, four-stage treatment algorithm for T1DM has suggested that modern pump therapy with CGM is appropriate as a third-line strategy for the treatment of patients with T1DM complicated by hypoglycemia.¹⁶

There are a number of limitations to our study. First, we have assumed that if intensive therapy participants were provided with the same resources and received the same expert multidisciplinary care during EDIC that they received during DCCT, or if they received all of the resources currently recommended by the American Diabetes Association for the treatment of type 1 diabetes, they could maintain the same level of excellent glycemic control that they achieved during the 6.5 years of DCCT. Because of the lack of randomized controlled trials comparing the long-term impact of intensive therapy with MDI, pumps, and pumps using CGM on glycemic control in adults with T1DM, we have also assumed that each of the intensive therapy scenarios achieve and maintain excellent glycemic control over 30 years. This assumption is supported by the results of a systematic review of randomized controlled trials that demonstrated no clinically meaningful differences in severe hypoglycemia or glycemic control in adults with T1DM treated with MDI vs. pump or with MDI vs. pump with CGM.⁸ Of note, essentially all of the trials were of much shorter duration than 3-years. It is likely that some patients receiving intensive therapy will not achieve and maintain excellent glycemic control and that some patients receiving basic therapy will. Nevertheless, the DCCT demonstrated that with the resources used over the 6.5 year trial, the randomly allocated treatment groups were able to achieve and maintain a 2% difference in mean updated HbA1c. If intensive therapy with pump or pump with CGM achieves better glycemic control or less hypoglycemia than intensive therapy with MDI over the long-term, intensive therapy with pump or pump with CGM will be more cost-effective than we estimated. We have also assumed that there are no differences in health utility scores among patients treated with MDI, pumps, and pumps with CGM. If compared to modern MDI therapy, modern pump or pump therapy with CGM are associated with improved health-related quality-of-life, modern intensive therapy with pumps or pumps with CGM will be more cost-effective than we estimated.

Second, we have made the simplifying assumption that a single type of intensive therapy (MDI, pump, or pump with CGM) will be used by all patients with T1DM. If instead, intensive therapy is tailored to the needs of individual patients with T1DM, if more expensive therapies are reserved for patients who fail to achieve treatment goals with less expensive therapies, and if more expensive therapies are used only by patients who continue to achieve treatment goals, intensive therapy as a whole will be more cost-effective.

Third, as previously noted, our estimates of the quality-of-life impact and the costs of complications, comorbidities, and death may be low. If the quality-of-life impact and costs of complications, comorbidities, and death are greater than we estimated, intensive therapy will be more cost-effective than we estimated.

Fourth, we did not perform analyses from a societal perspective or consider costs from the informal healthcare sector (e.g., patient- and caregiver-time costs) or from the non-healthcare sector (e.g., productivity losses arising from disease-related absence from work, long-term disability, and premature death). To the extent that intensive therapy takes more time than conventional therapy, we have underestimated the costs of intensive therapy. To the extent that the complications of diabetes that cause disability and premature mortality occur more frequently with basic therapy than intensive therapy, we have underestimated the costs of basic therapy.

Fifth, 30-years of follow-up may not be long enough to see the full benefits of excellent glycemic control, especially given that the cumulative risk of expensive complications including ESRD accelerate after 20 years of T1DM.¹⁹ Longer follow-up may make intensive therapy appear even more cost-effective.

And finally, perhaps most importantly, this economic analysis did not take into account patient preferences. Patient preferences must be considered in the choice of therapy for type 1 diabetes, which affects every aspect of daily living.

In summary, this 30-year simulation informed by the results of DCCT/EDIC suggests that when intensive therapy achieves and maintains excellent glycemic control, the greater costs of intensive therapy with MDI and pumps are substantially offset by the reduced costs of complications, comorbidities, and death and improvements in health-related quality-of-life. Our results support the use of intensive therapy for T1DM so long as a treatment goal of HbA1c ~7% (55 mmol/mol) is achieved safely. They also highlight the economic benefit of delivering intensive therapy at as low a cost as possible. Our analyses suggest that the widespread adoption of more expensive insulins, supplies, and devices as a general treatment strategy will reduce the cost-effectiveness of intensive therapy unless they achieve better clinical outcomes. Intensive therapy using pumps with CGM is not currently cost-effective as a general treatment strategy because of its substantially greater cost and uncertain long-term clinical superiority. Pump therapy with CGM may still be an appropriate therapy for selected patients who have poor glycemic control and/or problematic hypoglycemia and who achieve improved long-term outcomes with such therapy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

A complete list of participants in the DCCT/EDIC Research Group is presented in the Supplementary Material published with this article.

Industry contributors have had no role in the DCCT/EDIC study but have provided free or discounted supplies or equipment to support participants' adherence to the study: Abbott Diabetes Care (Alameda, CA), Animas (Westchester, PA), Bayer Diabetes Care (North America Headquarters, Tarrytown, NY), Becton Dickinson (Franklin Lakes, NJ), Eli Lilly (Indianapolis, IN), Extend Nutrition (St. Louis, MO), Insulet Corporation (Bedford, MA), Lifescan (Milpitas, CA), Medtronic Diabetes (Minneapolis, MN), Nipro Home Diagnostics (Ft. Lauderdale, FL), Nova Diabetes Care (Billerica, MA), Omron (Shelton, CT), Perrigo Diabetes Care (Allergan, MI), Roche Diabetes Care (Indianapolis, IN), and Sanofi-Aventis (Bridgewater, NJ).

Funding/Support: The DCCT/EDIC has been supported by cooperative agreement grants (1982–1993, 2012–2017), and contracts (1982–2012) with the Division of Diabetes Endocrinology and Metabolic Diseases of the National Institute of Diabetes and Digestive and Kidney Disease (current grant numbers U01 DK094176 and U01 DK094157), and through support by the National Eye Institute, the National Institute of Neurologic Disorders and Stroke, the General Clinical Research Centers Program (1993–2007), and Clinical Translational Science Center Program (2006–present), Bethesda, Maryland, USA.

Additional statement for collaborators: Additional support for this DCCT/EDIC collaborative study was provided by Grant Number P30DK092926 Michigan Center for Diabetes Translational Research Methods and Measurement Core.

Appendix

Appendix Table 1A.

Annual frequency of healthcare provider visits, monitoring, insulin delivery, tests, and procedures by DCCT treatment scenario

Category	HCPCS code	Time per visit or unit (minute)	Number of annual injections/visits/tests/procedures		
			Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Healthcare providers					
Endocrinologist for office/outpatient visit	99211	5	0	0	0
	99212	10	0	8	8
	99213	15	2	0	0
	99214	25	1	2	2
	99215	40	1	2	2
Diabetes educator for DSME/T visit	G0108	30	2	2	2
Dietitian for MNT visit	97803	15	1	2	2
Ophthalmologist for consultation visit	92014		1	1	1
Clinical psychologist for behavioral consultation visit	96151	15	1	1	1
	96152	15	1	1	1
Monitoring					
SMBG			365 (1/day)	1,460 (4/day)	1,460 (4/day)
Insulin delivery					
Insulin injection			730 (2/day)	1,460 (4/day)	Pump
Tests					
A1C	83036		4	12	12
Lipid panel	80061		1	1	1
Urinalysis	81000		1	1	1
Urine albumin	82042		1	1	1
Urine creatinine	82570		1	1	1

Category	HCPCS code	Time per visit or unit (minute)	Number of annual injections/visits/tests/procedures		
			Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Serum creatinine	82565		1	1	1
Procedures					
Venipuncture	36415		4	12	12

Abbreviations: DSME/T, diabetes self-management education/training; MNT, medical nutrition therapy; SMBG, self-monitoring of blood glucose; HCPCS, healthcare common procedure coding system; MDI, multiple daily injections; Pump, insulin pump therapy; R, human regular insulin; N, human NPH insulin.

Appendix Table 1B.

Annual frequency of healthcare provider visits, monitoring, insulin delivery, tests, and procedures by modern treatment scenario

Category	HCPCS code	Time per visit or unit (minute)	Number of annual injections/visits/tests/procedures			
			Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Healthcare providers						
Endocrinologist for office/outpatient visit	99211	5	0	0	0	0
	99212	10	0	0	0	0
	99213	15	0	0	0	0
	99214	25	3	2	1	0
	99215	40	1	2	3	4
Diabetes educator for DSME/T visit	G0108	30	2	2	2	2
Dietitian for MNT visit	97803	15	1	2	2	2
Ophthalmologist for consultation visit	92014		1	1	1	1
Clinical psychologist for behavioral consultation visit	96151	15	1	1	1	1
	96152	15	1	1	1	1
Monitoring						
SMBG			365 (1/day)	1,460 (4/day)	1,460 (4/day)	1,460 (4/day) and CGM
Insulin delivery						
Insulin injection			1,460 (4/day)	1,460 (4/day)	Pump	Pump
Tests						
A1C	83036		4	4	4	4
Lipid panel	80061		1	1	1	1

Category	HCPCS code	Time per visit or unit (minute)	Number of annual injections/visits/tests/procedures			
			Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Urinalysis	81000		1	1	1	1
Urine albumin	82042		1	1	1	1
Urine creatinine	82570		1	1	1	1
Serum creatinine	82565		1	1	1	1
Procedures						
Venipuncture	36415		4	4	4	4

Abbreviations: DSME/T, diabetes self-management education/training; MNT, medical nutrition therapy; SMBG, self-monitoring of blood glucose; HCPCS, healthcare common procedure coding system; MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring; L, lispro; G, glargine.

Appendix Table 2.

Unit costs for healthcare provider visits, tests, and procedures

Category		Cost in 2014 US dollars					
		HCPCS Code	Description	Time per visit or unit	Non-facility price	Facility price	Cost ^{2,3}
Healthcare providers	Visit type						
Diabetologist/ Endocrinologist	Physician visits	99211	Office/outpatient visit for established pts	5 minutes	\$20.06	\$9.31	\$14.69
		99212	Office/outpatient visit for established pts	10 minutes	\$43.70	\$25.43	\$34.57
		99213	Office/outpatient visit for established pts	15 minutes	\$73.08	\$51.58	\$62.33
		99214	Office/outpatient visit for established pts	25 minutes	\$107.83	\$79.17	\$93.50
		99215	Office/outpatient visit for established pts	40 minutes	\$144.37	\$111.41	\$127.89
Diabetes educator (Nurse and Pharmacist)	Diabetes educator visits for DSME/T	G0108	<i>Individual</i> outpatient DSMT for initial and follow-up visits	30 minutes	\$53.38	\$53.38	\$53.38
Dietitian	Dietitian visits for MNT	97803	<i>Individual</i> MNT for follow-up visit	15 minutes	\$30.81	\$28.66	\$29.74
Ophthalmologist	Physician visits (Consultations)	92014	<i>Comprehensive</i> ophthalmological service for established patients		\$126.10	\$82.75	\$104.43
Clinical psychologist	Behavioral visits (Consultations)	96151	Health and behavior <i>assessment</i> ,	15 minutes	\$20.78	\$20.42	\$20.60

Category		Cost in 2014 US dollars					
		HCPCS Code	Description	Time per visit or unit	Non-facility price ¹	Facility price ¹	Cost ^{2,3}
		96152	face-to-face with the patient: re-assessment Health and behavior <i>intervention</i> , face-to-face; individual	15 minutes	\$19.70	\$19.34	\$19.52
Tests							
A1C		83036					\$21.76
Lipid panel		80061					\$29.60
Urinalysis		81000					\$7.17
Urine albumin		82042					\$10.15
Urine creatinine		82570					\$11.60
Serum creatinine		82565					\$11.60
Procedures							
Venipuncture		36415					\$5.00

Abbreviations: DSME/T, diabetes self-management education/training; MNT, medical nutrition therapy; HCPCS, Healthcare Common Procedure Coding System.

¹The non-facility price and facility price for healthcare providers were based on 2014 Medicare physician fee schedule. Available at: <http://www.cms.gov/apps/physician-fee-schedule/search/search-criteria.aspx>

²The unit costs of tests and procedures were based on the average national pricing amount from 2014 Medicare clinical laboratory fee schedule. Available at: <http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ClinicalLabFeeSched/index.html>

³The unit costs of healthcare provider visits were the average of the non-facility price and facility price.

Appendix Table 3A.

Annual costs of healthcare provider visits, tests, and procedures by DCCT treatment scenario

Category	Item ¹	Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Healthcare providers				
Endocrinologist for office/outpatient visit	Unit cost	\$34.57; \$62.33; \$93.50; \$127.89		
	Frequency	4	12	12
	Total	\$346.05	\$719.34	\$719.34
Diabetes educator for DSME/T visit	Unit cost	\$53.38		
	Frequency	2		
	Total	\$106.76	\$106.76	\$106.76
Dietitian for MNT visit	Unit cost	\$29.74		
	Frequency	1	2	2
	Total	\$29.74	\$59.48	\$59.48

Category	Item ¹	Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Ophthalmologist for consultation visit	Unit cost	\$104.43		
	Frequency	1		
	Total	\$104.43	\$104.43	\$104.43
Clinical psychologist for behavioral consultation visit	Unit cost	\$20.60; \$19.52		
	Frequency	2		
	Total	\$40.12	\$40.12	\$40.12
Subtotal		\$627.10	\$1,030.13	\$1,030.13
Tests				
A1C	Unit cost	\$21.76		
	Frequency	4	12	12
	Total	\$87.04	\$261.12	\$261.12
Lipid panel	Unit cost	\$29.60		
	Frequency	1		
	Total	\$29.60	\$29.60	\$29.60
Urinalysis	Unit cost	\$7.17		
	Frequency	1		
	Total	\$7.17	\$7.17	\$7.17
Urine albumin	Unit cost	\$10.15		
	Frequency	1		
	Total	\$10.15	\$10.15	\$10.15
Urine creatinine	Unit cost	\$11.60		
	Frequency	1		
	Total	\$11.60	\$11.60	\$11.60
Serum creatinine	Unit cost	\$11.60		
	Frequency	1		
	Total	\$11.60	\$11.60	\$11.60
Subtotal		\$157.16	\$331.24	\$331.24
Procedures				
Routine venipuncture	Unit cost	\$5.00		
	Frequency	4	12	12
	Total	\$20.00	\$60.00	\$60.00
Subtotal		\$20.00	\$60.00	\$60.00
Grand total		\$804.26	\$1,421.37	\$1,421.37

Abbreviations: DSME/T, diabetes self-management education/training; MNT, medical nutrition therapy; MDI, multiple daily injections; Pump, insulin pump therapy; R, human regular insulin; N, human NPH insulin.

¹. The unit costs were based on the Medicare reimbursement fee schedules. Available at: <http://www.cms.gov/Medicare/Medicare.html>

Appendix Table 3B.

Annual costs of healthcare provider visits, tests, and procedures by modern treatment scenario

Category	Item ¹	Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Healthcare providers					
Endocrinologist for office/outpatient visit	Unit cost	\$34.57; \$62.33; \$93.50; \$127.89			
	Frequency	4	4	4	4
	Total	\$408.39	\$442.78	\$477.17	\$511.56
Diabetes educator for DSME/T visit	Unit cost	\$53.38			
	Frequency	2			
	Total	\$106.76	\$106.76	\$106.76	\$106.76
Dietitian for MNT visit	Unit cost	\$29.74			
	Frequency	1	2	2	2
	Total	\$29.74	\$59.48	\$59.48	\$59.48
Ophthalmologist for consultation visit	Unit cost	\$104.43			
	Frequency	1			
	Total	\$104.43	\$104.43	\$104.43	\$104.43
Clinical psychologist for behavioral consultation visit	Unit cost	\$20.60; \$19.52			
	Frequency	2			
	Total	\$40.12	\$40.12	\$40.12	\$40.12
Subtotal		\$689.44	\$753.57	\$787.96	\$822.35
Tests					
A1C	Unit cost	\$21.76			
	Frequency	4			
	Total	\$87.04	\$87.04	\$87.04	\$87.04
Lipid panel	Unit cost	\$29.60			
	Frequency	1			
	Total	\$29.60	\$29.60	\$29.60	\$29.60
Urinalysis	Unit cost	\$7.17			
	Frequency	1			
	Total	\$7.17	\$7.17	\$7.17	\$7.17
Urine albumin	Unit cost	\$10.15			
	Frequency	1			
	Total	\$10.15	\$10.15	\$10.15	\$10.15
Urine creatinine	Unit cost	\$11.60			
	Frequency	1			
	Total	\$11.60	\$11.60	\$11.60	\$11.60
Serum creatinine	Unit cost	\$11.60			

Category	Item ¹	Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
	Frequency	1			
	Total	\$11.60	\$11.60	\$11.60	\$11.60
Subtotal		\$157.16	\$157.16	\$157.16	\$157.16
Procedures					
Routine venipuncture	Unit cost	\$5.00			
	Frequency	4			
	Total	\$20.00	\$20.00	\$20.00	\$20.00
Subtotal		\$20.00	\$20.00	\$20.00	\$20.00
Grand total		\$866.60	\$930.73	\$965.12	\$999.51

Abbreviations: DSME/T, diabetes self-management education/training; MNT, medical nutrition therapy; MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring; L, lispro; G, glargine.

¹The unit costs were based on the Medicare reimbursement fee schedules. Available at: <http://www.cms.gov/Medicare/Medicare.html>

Appendix Table 4A.

Annual costs of DCCT medications and equipment/supplies by DCCT treatment scenario

Category	Item ¹	Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Medications				
Insulin ²	Unit cost	Vial; R/N: \$0.13/\$0.13	Vial; R/N: \$0.13/\$0.13	Vial; R: \$0.13
	Unit	21,900 (60 u/day)		
	Total	\$2,847.00	\$2,847.00	\$2,847.00
Glucagon kit	Unit cost	\$209.62		
	Amount	1		
	Total	\$209.62	\$209.62	\$209.62
Subtotal		\$3,056.62	\$3,056.62	\$3,056.62
Equipment/supplies				
Glucose meter ³	Unit cost	\$34.95; \$45.00		
	Warranty	2–5 years		
	Total	\$11.38	\$11.38	\$9.00
Glucose test strip ⁴	Unit cost	\$1.44; \$1.15		
	Frequency	365 (1/day)	1,460 (4/day)	1,460 (4/day)
	Total	\$525.60	\$2,102.40	\$1,679.00
Lancet ⁴	Unit cost	\$0.11; \$0.10		
	Frequency	365 (1/day)	1,460 (4/day)	1,460 (4/day)
	Total	\$40.15	\$160.60	\$146.00
Insulin syringe ⁵	Unit cost	\$0.30		
	Frequency	730 (2/day)	1,460 (4/day)	0

Category	Item ¹	Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
	Total	\$219.00	\$438.00	\$0.00
Insulin pen needle ⁶	Unit cost	\$0.39		
	Frequency	0	0	0
	Total	\$0.00	\$0.00	\$0.00
Alcohol prep pad	Unit cost	\$0.05		
	Frequency	730 (2/day)	1,460 (4/day)	365 (1/day)
	Total	\$36.50	\$73.00	\$18.25
Glucose tablet	Unit cost	\$0.16		
	Amount	300		
	Total	\$48.00	\$48.00	\$48.00
Urine test strip for ketone and glucose (Keto-Diastix)	Unit cost	\$0.24		
	Amount	30		
	Total	\$7.20	\$7.20	\$7.20
Insulin pump ⁷	Unit cost	\$0.00	\$0.00	\$7,660.00
	Warranty	4 years		
	Total	\$0.00	\$0.00	\$1,915.00
Pump infusion set ⁷	Unit cost	\$0.00	\$0.00	\$13.59
	Duration	2–3 days		
	Total	\$0.00	\$0.00	\$1,983.95
Pump cartridge/syringe ⁷	Unit cost	\$0.00	\$0.00	\$4.635
	Duration	2–3 days		
	Total	\$0.00	\$0.00	\$676.64
Pump battery	Unit cost	\$0.00	\$0.00	\$1.615
	Duration	Typical use: 2–3 weeks for an alkaline battery; 5–7 weeks for a lithium battery		
	Total	\$0.00	\$0.00	\$20.79
Subtotal		\$887.83	\$2,840.58	\$6,503.83
Grand total		\$3,944.45	\$5,897.20	\$9,560.45

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; R, human regular insulin; N, human NPH insulin.

¹. The unit costs (except the pump battery) were based on the RED BOOK Online-Micromedex Solutions; Micromedex 2.0, (electronic version). Truven Health Analytics, Greenwood Village, Colorado, USA. Available at: <http://www.micromedexsolutions.com.proxy.lib.umich.edu/>. The unit costs of the pump battery were based on the sale price at <http://www.walmart.com>

². The unit costs of insulin were expressed as the per-unit cost, and the costs of vials and disposable pens were considered to estimate the unit costs of insulin.

³. The unit costs of glucose meters were estimated based on the feature whether they can communicate with insulin pumps. For the glucose meters communicating with insulin pumps, their costs were based on the glucose meters manufactured by Lifescan and Bayer. For the glucose meters not communicating with insulin pumps, their costs were based on the glucose meters manufactured by Roche, Lifescan, Bayer, and Abbott.

⁴. The unit costs of glucose test strips and lancets were based on the strips and lancets specific to each individual glucose meter that we have included in the analysis.

⁵. The unit cost of insulin syringes was based on the 0.5-mL insulin syringes manufactured by Becton, Dickinson and Company.

⁶. The unit cost of insulin pen needles was based on the pen needles manufactured by Becton, Dickinson and Company, Novo Nordisk, and Owen Mumford.

⁷. The unit costs of insulin pumps, pump infusion sets, and pump cartridges/syringes were based on the products manufactured by Medtronic and Animas.

Appendix Table 4B.

Annual costs of modern medications and equipment/supplies by modern treatment scenario

Category	Item ¹	Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Medications					
Insulin ²	Unit cost	Vial; L/G: \$0.24/\$0.30	Pen; L/G: \$0.31/\$0.30	Vial; L: \$0.24	Vial; L: \$0.24
	Unit	21,900 (60 u/day)			
	Total	\$5,913.00	\$6,679.50	\$5,256.00	\$5,256.00
Glucagon kit	Unit cost	\$209.62			
	Amount	1			
	Total	\$209.62	\$209.62	\$209.62	\$209.62
Subtotal		\$6,122.62	\$6,889.12	\$5,465.62	\$5,465.62
Equipment/supplies					
Glucose meter ³	Unit cost	\$34.95; \$45.00			
	Warranty	2–5 years			
	Total	\$11.38	\$11.38	\$9.00	\$9.00
Glucose test strip ⁴	Unit cost	\$1.44; \$1.15			
	Frequency	365 (1/day)	1,460 (4/day)	1,460 (4/day)	1,460 (4/day)
	Total	\$525.60	\$2,102.40	\$1,679.00	\$1,679.00
Lancet ⁴	Unit cost	\$0.11; \$0.10			
	Frequency	365 (1/day)	1,460 (4/day)	1,460 (4/day)	1,460 (4/day)
	Total	\$40.15	\$160.60	\$146.00	\$146.00
Insulin syringe ⁵	Unit cost	\$0.30			
	Frequency	1,460 (4/day)	0	0	0
	Total	\$438.00	\$0.00	\$0.00	\$0.00
Insulin pen needle ⁶	Unit cost	\$0.39			
	Frequency	0	1,460 (4/day)	0	0
	Total	\$0.00	\$569.40	\$0.00	\$0.00
Alcohol prep pad	Unit cost	\$0.05			
	Frequency	1,460 (4/day)	1,460 (4/day)	365 (1/day)	365 (1/day)
	Total	\$73.00	\$73.00	\$18.25	\$18.25
Glucose tablet	Unit cost	\$0.16			
	Amount	300			
	Total	\$48.00	\$48.00	\$48.00	\$48.00
Urine test strip for ketone and glucose (Keto-Diastix)	Unit cost	\$0.24			
	Amount	30			
	Total	\$7.20	\$7.20	\$7.20	\$7.20

Category	Item ¹	Modern Basic (L,L,L,G)	Modern Intensive MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Insulin pump ⁷	Unit cost	\$0.00	\$0.00	\$7,660.00	\$7,660.00
	Warranty	4 years			
	Total	\$0.00	\$0.00	\$1,915.00	\$1,915.00
Pump infusion set ⁷	Unit cost	\$0.00	\$0.00	\$13.59	\$13.59
	Duration	2–3 days			
	Total	\$0.00	\$0.00	\$1,983.95	\$1,983.95
Pump cartridge/syringe ⁷	Unit cost	\$0.00	\$0.00	\$4.635	\$4.635
	Duration	2–3 days			
	Total	\$0.00	\$0.00	\$676.64	\$676.64
Pump battery	Unit cost	\$0.00	\$0.00	\$1.615	\$1.615
	Duration	Typical use: 2–3 weeks for an alkaline battery; 5–7 weeks for a lithium battery			
	Total	\$0.00	\$0.00	\$20.79	\$20.79
CGM–receiver ⁸	Unit cost	\$0.00	\$0.00	\$0.00	\$436.88
	Warranty	1–4 years			
	Total	\$0.00	\$0.00	\$0.00	\$436.88
CGM–transmitter ⁸	Unit cost	\$0.00	\$0.00	\$0.00	\$894.78
	Warranty	0.5–1 year			
	Total	\$0.00	\$0.00	\$0.00	\$1,394.15
CGM–sensor ⁸	Unit cost	\$0.00	\$0.00	\$0.00	\$134.73
	Duration	6–7 days			
	Total	\$0.00	\$0.00	\$0.00	\$7,517.73
Subtotal		\$1,143.33	\$2,971.98	\$6,503.83	\$15,852.59
Grand total		\$7,265.95	\$9,861.10	\$11,969.45	\$21,318.21

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring; L, lispro; G, glargine.

¹The unit costs (except the pump battery) were based on the RED BOOK Online-Micromedex Solutions; Micromedex 2.0, (electronic version). Truven Health Analytics, Greenwood Village, Colorado, USA. Available at: <http://www.micromedexsolutions.com.proxy.lib.umich.edu/>. The unit costs of the pump battery were based on the sale price at <http://www.walmart.com>

²The unit costs of insulin were expressed as the per-unit cost, and the costs of vials and disposable pens were considered to estimate the unit costs of insulin.

³The unit costs of glucose meters were estimated based on the feature whether they can communicate with insulin pumps. For the glucose meters communicating with insulin pumps, their costs were based on the glucose meters manufactured by Lifescan and Bayer. For the glucose meters not communicating with insulin pumps, their costs were based on the glucose meters manufactured by Roche, Lifescan, Bayer, and Abbott.

⁴The unit costs of glucose test strips and lancets were based on the strips and lancets specific to each individual glucose meter that we have included in the analysis.

⁵The unit cost of insulin syringes was based on the 0.5-mL insulin syringes manufactured by Becton, Dickinson and Company.

⁶The unit cost of insulin pen needles was based on the pen needles manufactured by Becton, Dickinson and Company, Novo Nordisk, and Owen Mumford.

⁷The unit costs of insulin pumps, pump infusion sets, and pump cartridges/syringes were based on the products manufactured by Medtronic and Animas.

^{8.} The unit costs of CGM receivers, transmitters, and sensors were based on the products manufactured by Medtronic and Dexcom.

Appendix Table 5A.

Annual per person costs of healthcare provider visits, tests, procedures, medications, and equipment/supplies by DCCT treatment scenario

Category	Unit cost source	Conventional (R,N)	MDI (R,R,R,N)	Pump (R)
Healthcare providers	CMS ¹	\$627	\$1,030	\$1,030
Tests		\$157	\$331	\$331
Procedures		\$20	\$60	\$60
Medications	"average cost" ²	\$3,057	\$3,057	\$3,057
Equipment/supplies	"average cost" ²	\$888	\$2,841	\$6,504
Total	"average cost"^{1,2,3}	\$4,749	\$7,319	\$10,982

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; R, human regular insulin; N, human NPH insulin; CMS, Centers for Medicare and Medicaid Services.

^{1.} The unit costs were based on the Medicare reimbursement fee schedules. Available at: <http://www.cms.gov/Medicare/Medicare.html>

^{2.} The unit costs (except the pump battery) were based on the RED BOOK Online-Micromedex Solutions; Micromedex 2.0, (electronic version). Truven Health Analytics, Greenwood Village, Colorado, USA. Available at: <http://www.micromedexsolutions.com.proxy.lib.umich.edu/>. The unit costs of the pump battery were based on the sale price at <http://www.walmart.com>

^{3.} The unit costs were based on the ReliOn products if they were available, including: human regular insulin, human NPH insulin, glucose meters not communicating with insulin pumps (non-pump meters), glucose test strips for non-pump meters, lancets, insulin syringes, insulin pen needles, alcohol prep pads, and glucose tablets. Available at: <http://www.relion.com/products/>

Appendix Table 5B.

Annual per person costs of healthcare provider visits, tests, procedures, medications, and equipment/supplies by modern treatment scenario

Category	Unit cost source	Basic therapy	Intensive therapy		
		Modern Basic (L,L,L,G)	Modern MDI (L,L,L,G)	Modern Pump (L)	Modern Pump plus CGM (L)
Healthcare providers	CMS ¹	\$689	\$754	\$788	\$822
Tests		\$157	\$157	\$157	\$157
Procedures		\$20	\$20	\$20	\$20
Medications	"least expensive" ^{2,3}	\$6,123	\$6,889	\$5,466	\$5,466
	"average cost" ²	\$6,123	\$6,889	\$5,466	\$5,466
Equipment/supplies	"least expensive" ^{2,3}	\$405	\$971	\$6,381	\$15,729
	"average cost" ²	\$1,143	\$2,972	\$6,504	\$15,853
Total	"least expensive"¹⁻³	\$7,395	\$8,791	\$12,811	\$22,195
	"average cost"¹⁻³	\$8,133	\$10,792	\$12,935	\$22,318

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring; L, lispro; G, glargine; CMS, Centers for Medicare and Medicaid Services.

^{1.} The unit costs were based on the Medicare reimbursement fee schedules. Available at: <http://www.cms.gov/Medicare/Medicare.html>

². The unit costs (except the pump battery) were based on the RED BOOK Online-Micromedex Solutions; Micromedex 2.0, (electronic version). Truven Health Analytics, Greenwood Village, Colorado, USA. Available at: <http://www.micromedexsolutions.com.proxy.lib.umich.edu>. The unit costs of the pump battery were based on the sale price at <http://www.walmart.com>

³. The unit costs were based on the ReliOn products if they were available, including: human regular insulin, human NPH insulin, glucose meters not communicating with insulin pumps (non-pump meters), glucose test strips for non-pump meters, lancets, insulin syringes, insulin pen needles, alcohol prep pads, and glucose tablets. Available at: <http://www.relion.com/products/>

Abbreviations:

(DCCT)	Diabetes Control and Complications Trial
(EDIC)	Epidemiology of Diabetes Interventions and Complications
(T1DM)	type 1 diabetes mellitus
(HbA1c)	hemoglobin A1c
(MDI)	multiple daily injections
(CGM)	continuous glucose monitoring
(ICER)	incremental cost-effectiveness ratio

REFERENCES

1. Herman WH, Braffett BH, Kuo S, Lee JM, Brandle M, Jacobson AM, Prosser LA, Lachin JM; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Research Group. What are the Clinical, Quality-of-Life, and Cost Consequences of 30 Years of Excellent vs. Poor Glycemic Control in Type 1 Diabetes? (Submitted for publication)
2. The Diabetes Control and Complications Trial Research Group. Resource utilization and costs of care in the Diabetes Control and Complications Trial. *Diabetes Care* 1995;18:1468–78. [PubMed: 8722072]
3. American Diabetes Association. Standards of Medical Care in Diabetes 2017. *Diabetes Care* 2017;40(Suppl. 1):S1–S127. [PubMed: 27979885]
4. Hua X, Carvalho N, Tew M, Huang ES, Herman WH, Clarke P. Expenditures and prices of antihyperglycemic medications in the United States: 2002–2013. *JAMA* 2016;315:1400–2. [PubMed: 27046369]
5. Braithwaite RS, Meltzer DO, King JT Jr, Leslie D, Roberts MS. What does the value of modern medicine say about the \$50,000 per quality-adjusted life-year decision rule? *Med Care* 2008;46:349–56. [PubMed: 18362813]
6. Neumann PJ, Cohen JT, Weinstein MC. Updating cost-effectiveness - the curious resilience of the \$50,000-per-QALY threshold. *N Engl J Med* 2014;371:796–7. [PubMed: 25162885]
7. Dasbach EJ, Herman WH, Songer TJ, Thompson D, Crofford OB, for the DCCT Research Group: Lifetime benefits and costs of intensive therapy as practiced in the Diabetes Control and Complications Trial: An economic evaluation. *JAMA* 1996;276: 1409–1415. [PubMed: 8892716]
8. Yeh HC, Brown TT, Maruthur N, et al. Comparative effectiveness and safety of methods of insulin delivery and glucose monitoring for diabetes mellitus: a systematic review and meta-analysis. *Ann Intern Med* 2012;157:336–47. [PubMed: 22777524]
9. Acerini C The rise of technology in diabetes care. Not all that is new is necessarily better. *Pediatr Diabetes* 2016;17:168–73. [PubMed: 26854003]
10. Haviland N, Walsh J, Roberts R, Bailey TS. Update on clinical utility of continuous glucose monitoring in type 1 diabetes. *Curr Diab Rep* 2016;16:115. [PubMed: 27718171]

11. Toschi E, Wolpert H. Utility of continuous glucose monitoring in type 1 and type 2 diabetes. *Endocrinol Metab Clin N Am* 2016;45:895–904.
12. Beck RW, Riddlesworth T, Ruedy K, et al.; DIAMOND Study Group. Effect of continuous glucose monitoring on glycemic control in adults with type 1 diabetes using insulin injections: the DIAMOND randomized clinical trial. *JAMA* 2017;317:371–8. [PubMed: 28118453]
13. Lind M, Polonsky W, Hirsch IB, et al. Continuous glucose monitoring vs conventional therapy for glycemic control in adults with type 1 diabetes treated with multiple daily insulin injections: the GOLD randomized clinical trial. *JAMA* 2017;317:379–87. [PubMed: 28118454]
14. van Beers CA, DeVries JH, Kleijer SJ, et al. Continuous glucose monitoring for patients with type 1 diabetes and impaired awareness of hypoglycaemia (IN CONTROL): a randomised, open-label, crossover trial. *Lancet Diabetes Endocrinol* 2016;4:893–902. [PubMed: 27641781]
15. Rodbard D Continuous glucose monitoring: a review of successes, challenges, and opportunities. *Diabetes Technol Ther* 2016;18 Suppl 2:S3–S13.
16. Choudhary P, Rickels MR, Senior PA, Vantghem MC, Maffi P, Kay TW, et al. Evidence-informed clinical practice recommendations for treatment of type 1 diabetes complicated by problematic hypoglycemia. *Diabetes Care* 2015;38:1016–29. [PubMed: 25998294]
17. Bolinder J, Antuna R, Geelhoed-Duijvestijn P, Kröger J, Weitgasser R. Novel glucose-sensing technology and hypoglycaemia in type 1 diabetes: a multicentre, non-masked, randomised controlled trial. *Lancet* 2016;388:2254–63. [PubMed: 27634581]
18. Bilir SP, Li H, Wehler EA, Hellmund R, Munakata J Cost effectiveness analysis of a flash glucose monitoring system for type 1 diabetes (T1DM) patients receiving intensive insulin treatment in Europe and Australia. *Value in Health* 2016;19:A697–A698.
19. Weinstein MC. The costs of prevention. *J Gen Intern Med* 1990;5:S89–S92. [PubMed: 2231073]

Table 1.

Undiscounted and discounted^a DCCT treatment costs per person per year and over 30 years by treatment scenario

	DCCT Conventional	DCCT MDI	DCCT Pump
Undiscounted treatment costs			
Annual	\$4,749	\$7,319	\$10,982
30-year	\$124,466	\$204,001	\$306,112
Discounted treatment costs^a			
30-year	\$90,175	\$145,075	\$217,691

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy.

^aCosts were discounted at 3% per year.

Table 2.

Undiscounted and discounted^a modern treatment costs per person per year and over 30 years by treatment scenario

	Modern Basic	Modern MDI	Modern Pump	Modern Pump with CGM
Undiscounted treatment costs				
Annual	\$8,133	\$10,792	\$12,935	\$22,318
30-year	\$213,159	\$300,816	\$360,543	\$622,121
Discounted treatment costs^a				
30-year	\$154,432	\$213,925	\$256,400	\$442,420

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring.

^aCosts were discounted at 3% per year.

Differences in total discounted^a per person costs and quality-adjusted life-years, and the discounted^a incremental cost-effectiveness ratios by DCCT treatment scenario over 30 years

Table3.

	DCCT MDI		DCCT Pump
	Compared to: DCCT Conventional therapy		
Total cost ^b	\$-1,256		\$71,360
QALY	0.87		0.87
Total cost / QALY, \$ per QALY-gained	Cost-saving		\$82,018

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; QALY, quality-adjusted life-year.

^aCosts and QALYs were discounted at 3% per year.

^b Total cost = Diabetes treatment cost + Complication, comorbidity, and death cost, where Total cost, Diabetes treatment cost, and Complication, comorbidity, and death cost depicted the difference in the total discounted cost, discounted cost of diabetes treatment, and discounted cost of complications, comorbidities, and death, respectively, when comparing intensive therapy scenario to conventional therapy scenario.

Table 4.

Differences in total discounted^a per person costs and quality-adjusted life-years, and the discounted^a incremental cost-effectiveness ratios by modern treatment scenario over 30 years

	Modern MDI	Compared to: Modern Basic Therapy	
		Modern Pump	Modern Pump with CGM
Total cost ^b	\$3,337	\$45,812	\$231,833
QALY	0.87	0.87	0.87
Total cost / QALY, \$ per QALY-gained	\$3,835	\$52,654	\$266,457

Abbreviations: MDI, multiple daily injections; Pump, insulin pump therapy; CGM, continuous glucose monitoring; QALY, quality-adjusted life-year.

^aCosts and QALYs were discounted at 3% per year.

^b Total cost = Diabetes treatment cost + Complication, comorbidity, and death cost, where Total cost, Diabetes treatment cost, and Complication, comorbidity, and death cost depicted the difference in the total discounted cost, discounted cost of diabetes treatment, and discounted cost of complications, comorbidities, and death, respectively, when comparing intensive therapy scenario to basic therapy scenario.