Title
Changing costs of type 1 diabetes care among US children and adolescents

Journal
Pediatric Diabetes, 21(4)

ISSN
1399-543X

Authors
Crossen, Stephanie
Xing, Guibo
Hoch, Jeffrey S

Publication Date
2020-06-01

DOI
10.1111/pedi.12996

Peer reviewed

HHS Public Access
Author manuscript
Pediatr Diabetes. Author manuscript; available in PMC 2021 June 01.

Published in final edited form as:
Pediatr Diabetes. 2020 June ; 21(4): 644–648. doi:10.1111/pedi.12996.

Changing Costs of Type 1 Diabetes Care Among U.S. Children and Adolescents

Stephanie S. Crossen[1,2], **Guibo Xing**[3], **Jeffrey S. Hoch**[3,4]

[1]Division of Pediatric Endocrinology and Diabetes, Department of Pediatrics, University of California, Davis

[2]OptumLabs Visiting Fellow, Cambridge, MA

[3]Center for Healthcare Policy and Research, University of California, Davis

[4]Division of Health Policy and Management, Department of Public Health Sciences, University of California, Davis

Abstract

Background: Modern therapy for type 1 diabetes (T1D) increasingly utilizes technology such as insulin pumps and continuous glucose monitors (CGMs). Prior analyses suggest that T1D costs are driven by preventable hospitalizations, but recent escalations in insulin prices and use of technology may have changed the cost landscape.

Methods: We conducted a retrospective analysis of T1D medical costs from 2012-2016 using the OptumLabs Data Warehouse, a comprehensive database of de-identified administrative claims for commercial insurance enrollees. Our study population included 9,445 individuals aged ≤ 18 years with T1D and ≥ 13 months of continuous enrollment. Costs were categorized into ambulatory care, hospital care, insulin, diabetes technology, and diabetes supplies. Mean costs for each category in each year were adjusted for inflation, as well as patient-level covariates including age, sex, race, census region, and mental health comorbidity.

Results: Mean annual cost of T1D care increased from $11,178 in 2012 to $17,060 in 2016, driven primarily by growth in the cost of insulin ($3,285 to $6,255) and cost of diabetes technology ($1,747 to $4,581).

Conclusions: Our findings suggest that the cost of T1D care is now driven by mounting insulin prices and growing utilization and cost of diabetes technology. Given the positive effects of pumps and CGMs on T1D health outcomes, it is possible that short-term costs are offset by future savings. Long-term cost-effectiveness analyses should be undertaken to inform providers, payers, and policy-makers about how to support optimal T1D care in an era of increasing reliance on therapeutic technology.

Corresponding Author Dr. Stephanie Crossen, 2516 Stockton Blvd, Sacramento, CA 95817, scrossen@ucdavis.edu.
Author Contributions
S.S.C. designed the study and wrote the manuscript. G.X. performed the data manipulation and statistical analyses. J.S.H. assisted in devising the analytic plan, interpreting the data, and critically revising the manuscript. All authors read and approved the final manuscript.

Keywords

Diabetes Mellitus, Type 1; Health Care Costs; Pediatrics; United States

Introduction

Type 1 diabetes (T1D) is one of the three most common chronic diseases of youth,[1] affecting over 160,000 children and adolescents in the United States.[2] Incidence of T1D continues to rise by ≥1.4% annually,[3] such that by 2050 over 500,000 youth will have T1D if current trends continue.[4] Unlike type 2 diabetes, T1D cannot be managed with lifestyle change or oral medications. Patients with T1D are dependent on exogenous insulin, which is delivered via multiple daily injections or insulin pump. Insulin doses are calibrated to blood glucose levels and dietary intake, and even brief gaps in insulin therapy can lead to diabetic ketoacidosis (DKA), a life-threatening condition. T1D management has become increasingly technology-driven over the last two decades with the advent of insulin pumps[5] and continuous glucose monitors (CGMs),[6] and recent data demonstrate high utilization of these devices among youth – 63% and 30%, respectively, with even higher use among the youngest age groups.[7]

Due to the need for daily insulin, risk of costly short-term complications such as DKA, and increasing use of expensive technology, the costs of T1D care are formidable. Total annual costs for T1D in the U.S. in 2010 were estimated at $14.4 billion.[8] A 2015 analysis of T1D expenditures in publicly insured youth found hospitalizations to be the primary cost driver,[9] but more recent data for privately insured adults and children with T1D showed the cost of insulin to be the biggest contributor.[10] Interestingly, the latter publication did not evaluate cost of diabetes devices (insulin pumps and CGMs); the former publication looked at cost of pumps, but only 18% of the study population was using pumps during the study period, and it did not evaluate cost of CGMs. Therefore, there is a need for comprehensive analysis of the costs of current diabetes technology use in the T1D population.

We evaluated the costs of care from 2012-2016 for privately insured pediatric T1D patients included in the OptumLabs Data Warehouse, a comprehensive repository of de-identified administrative claims data for commercial insurance enrollees. Our analyses focused on the relative cost contributions of ambulatory care, hospital care, insulin, diabetes technology, and other diabetes supplies, and the changes in these cost contributions over the study period. We hypothesized that from 2012 to 2016 among privately insured youth with T1D the utilization of insulin pumps and CGMs would increase, and that the per-person costs of these technology in our study population would increase due to both increased utilization and the fact that newer devices are more expensive.[11] We also hypothesized that over this time frame the per-person cost of insulin among our study population would increase due to insulin price increases,[12] while the costs of other diabetes care – including ambulatory care, hospital care, and other diabetes supplies – would not change significantly.

Methods

Data Source

This study used de-identified administrative claims data with linked socioeconomic status information from the OptumLabs Data Warehouse (OLDW). The OLDW includes medical and pharmacy claims, laboratory results, and enrollment records for commercial insurance enrollees, representing a mixture of ages, ethnicities and geographical regions across the United States.[13] All data used in this analysis were de-identified prior to access; therefore, this study was deemed exempt from review by the University of California, Davis Institutional Review Board.

Study Population

For this analysis we included patients in the OLDW between January 1, 2012 and December 31, 2016 with (1) age ≤18 years, (2) ≥2 claims associated with a diagnostic code of type 1 diabetes (ICD9 250.x1 or 250.x3 or ICD10 E10.1-E10.9) occurring ≥30 days apart, (3) ≥1 pharmacy claim for insulin and no pharmacy claims for metformin within a consecutive 365-day period starting 30 days after the initial T1D claim, and (4) continuous medical and pharmacy benefits for the consecutive 365 days starting 30 days after the initial T1D claim. Patients with a diagnosis of neonatal diabetes, monogenic diabetes, medication-induced diabetes, or cystic fibrosis-related diabetes were excluded due to the assumption that their medical costs would not be representative of the T1D population.

Study Period

While the overall study period encompassed 2012-2016, the period of data collection – referred to as the "follow up period" hereafter – for each individual was defined as the consecutive 365 days starting 30 days after the initial T1D claim that occurred during the study period. This was done to avoid capturing costs at the time of initial T1D diagnosis, and to standardize the observation period for each patient to one year's time.

Covariates

Patient-level demographic variables were collected from OLDW including age, sex, race, and census region. Of note, race data included in the OLDW are not patient-reported, but instead are assigned based on consumer marketing data from various sources combined with patient-level information including name and geographic location. In addition, we defined the presence of "mental health comorbidity" within our study population as ≥1 inpatient or ≥2 outpatient claims during the follow up period that were associated with diagnostic codes for mental health disorders (ICD-9 290.xx-319.xx or ICD-10 F00.xx-F99.xx).

Outcomes

Primary outcomes for this study were the total costs (insurer-paid and patient-paid) during the follow up period for each of the following categories: **(1) ambulatory care**, defined as outpatient and office visit claims associated with a primary or secondary diagnosis of T1D, **(2) hospital care**, defined as hospital or emergency department (ED) claims, **(3) insulin**, defined as pharmacy claims associated with insulin NDC codes, **(4) diabetes technology**, defined as claims associated with NDC, CPT or HCPCS codes for CGMs or insulin pumps and their associated supplies, and **(5) diabetes supplies**, defined as claims associated with NDC, CPT or HCPCS codes for glucose meters or test strips, lancets or lancing devices, ketone strips, or glucagon. For a complete list of NDC, CPT and HCPCS codes employed for categories 3-5, please see Appendix 1. Hospital and ED costs were not restricted to those claims associated with a diagnosis of T1D due to difficulty in determining which encounters were truly for diabetes-related complaints and for which the diagnosis of T1D had simply been associated as a chronic condition. However, patients whose total hospitalization costs ranked above the 99 percentile among our population were excluded from the hospital cost category due to concern that their hospitalizations were dramatically misrepresentative of typical diabetes care. This led to exclusion of <11 individuals from the hospital care cost category. Upon review, each of these individuals was found to have a non-diabetes-related, high-cost comorbid condition such as leukemia, solid malignancy, sickle cell disease or quadriplegia with anoxic brain damage.

Analysis

Study population characteristics including demographics, mental health comorbidity, insulin pump and CGM use were analyzed and presented categorically. Cell sizes <11 were censored to comply with OptumLabs data policies. Changes in costs of T1D care for this population over time were explored by comparing data for each year 2012 through 2016. Costs were categorized by the year in which the patient's follow up period began. For example, patients entering the study population in 2012 with subsequent follow up periods stretching from 2012 to 2013 formed the cohort for cost data listed under 2012. Mean per-person costs were calculated for each of the care categories 1-5 listed above (i.e., ambulatory care, hospital care, insulin, diabetes technology, and other diabetes supplies) in each year 2012-2016, and inflation-adjusted to mid-2012 levels using the published consumer price index for medical care for July of each year.[14] Because the sub-cohort of patients contributing cost data for each year varied, the mean per-person costs for each year were then adjusted for patient-level covariates of age, race, sex, census region and mental health comorbidity via regression with robust standard errors. To further explore changes over time in the costs of certain care subtypes that were not universally utilized, we next evaluated the adjusted cost per year *among users* for hospital care, insulin pumps, and CGMs. This analysis was likewise inflation-adjusted, and conducted via regression with robust standard errors and inclusion of patient-level covariates of age, race, sex, census region and mental health comorbidity.

Results

The study population included 9,445 individuals, of which the majority were male, adolescent, of White race, and from the Midwest or South census region (Table 1). Our population had a low prevalence of mental health comorbidity (5%). Overall rates of CGM use (25%) and insulin pump use (53%) during the study period were comparable to those recently reported for a larger U.S. population of T1D patients.[7]

Comparison of the adjusted mean per-person costs by year revealed that total costs increased from $11,178 in 2012 to $17,060 in 2016 (Figure 1). The primary drivers of this cost increase were insulin – nearly doubling in mean per-person annual cost from $3,285 in 2012 to $6,255 in 2016 – and diabetes technology, whose mean per-person annual cost in our study population more than doubled from $1,747 in 2012 to $4,581 in 2016. The adjusted mean costs of ambulatory care and diabetes supplies increased slightly during this time (from $2,571 to $2,717 and $2,366 to $2,717, respectively), while the adjusted mean per-person cost of hospital care in our population decreased from $1,209 to $790.

A closer look at hospital care revealed that from 2012 to 2016 the prevalence of hospitalization and the mean adjusted cost of hospitalization among users each decreased slightly – from 7% to 6% and from $16,996 to $14,017, respectively (Table 2). In contrast, insulin pump use increased significantly (42% to 52%) and CGM use increased dramatically (8% to 46%) from 2012 to 2016. Furthermore, the per-person mean adjusted cost among users for these devices skyrocketed during our study period, from $2,760 to $4,033 for insulin pumps, and from $2,103 to $4,220 for CGMs.

Discussion

This analysis demonstrates that the costs of T1D care among privately insured youth have changed markedly from 2012-2016. Specifically, while hospital costs have decreased and the costs of both ambulatory care and diabetes supplies have increased slightly, the cost of insulin and the cost of diabetes technology (insulin pumps and CGMs) have each risen dramatically. The increasing costs of diabetes technology observed in our study population appear to be due to a combination of increased utilization and increased per-person costs of both pumps and CGMs among users. While rising costs of insulin[12] and increased utilization of diabetes technology[7] are well-described in the literature, to our knowledge this is the first publication to characterize the rising per-person costs of diabetes technology in a large T1D population.

The patient population for this study – which was privately insured, 81% White, and 95% unaffected by comorbid mental health conditions – represents a demographically and clinically low-risk cohort. It is possible that the cost profile for other T1D populations looks quite different. For example, an analysis by Lee et al of 2009-2012 cost data among publicly insured pediatric T1D patients demonstrated much higher hospital costs (median of $5,603 per year, making up 59% of total expenditures).[9] However, their estimates for the annual costs of insulin ($2,930) and insulin pump therapy ($2,162)[9] were quite similar to the adjusted mean costs of insulin ($3,285) and insulin pumps ($2,760) among users for our study population in 2012. Insulin pump use in Lee et al's study population was much lower (18%) than in our population in 2012 (43%), which likely accounts for much of the difference in total annual costs - $7,654 for their population versus $11,178 for our population in 2012. A recent analysis of cost data from 2012-2016 among privately insured adults and children with T1D by the Health Care Cost Institute demonstrated very similar findings to ours for the annual costs of insulin, outpatient care, inpatient care, and non-insulin diabetes supplies, as well as the changes in these costs from 2012 to 2016.[10] However, this report did not evaluate the use and costs of diabetes technology.

In addition to the unique demographics of our study population, the generalizability of our findings is limited by our lack of clinical data – including disease duration and hemoglobin A1c (HbA1c) values – which would allow us to better characterize the clinical population. While the OLDW does include a linked laboratory database, this database does not include point-of-care HbA1c values measured during clinic encounters. For that reason, <20% of our study population had one or more HbA1c values available during the follow up period, making it unfeasible to include this as a covariate in our analysis. Disease duration likewise could not be determined because most patients in our population were not present in the OLDW database for a sufficient length of time prior to the study period to capture their diagnostic encounters.

Despite these potential limitations in generalizability, our findings are an important characterization of current T1D costs among privately insured youth. Furthermore, this privately insured cohort with ample access to ambulatory care, insulin, and modern technologies gives us a glimpse into the likely future cost landscape of T1D, as use of insulin pumps and CGMs continues to expand and providers work to eliminate preventable hospitalizations. Although modeling the long-term cost effectiveness of insulin pumps and CGMs falls outside the scope of this analysis, research has now demonstrated benefits of diabetes technology among youth for improving both glycemic control[15] and microvascular complication rates[16], which are primary drivers of long-term expenditures among diabetes patients. It is therefore possible that the rising costs of diabetes technology illustrated in our analysis are more than offset by long-term cost savings. This possibility should be explored in future research, as it will be an important consideration for providers, payers and device manufacturers moving forward.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

This work was conducted using the OptumLabs® Data Warehouse (OLDW), a repository of de-identified retrospective administrative claims data. Access to OLDW was provided to the authors as part of a partnership between the University of California and OptumLabs. Funding for this project was provided by the UC Davis Clinical and Translational Science Center, UC Davis Department of Pediatrics, and UC Davis Center for Healthcare Policy and Research. The authors have no conflicts of interest to disclose relevant to this work. This project did not receive any extramural funding.

References:

1. Stanescu DE, Lord K, Lipman TH. The epidemiology of type 1 diabetes in children. Endocrinology and metabolism clinics of North America. 2012;41(4):679–694. [PubMed: 23099264]
2. Pettitt DJ, Talton J, Dabelea D, et al. Prevalence of diabetes in U.S. youth in 2009: the SEARCH for diabetes in youth study. Diabetes Care. 2014;37(2):402–408. [PubMed: 24041677]
3. Mayer-Davis EJ, Lawrence JM, Dabelea D, et al. Incidence Trends of Type 1 and Type 2 Diabetes among Youths, 2002–2012. The New England journal of medicine. 2017;376(15):1419–1429. [PubMed: 28402773]
4. Imperatore G, Boyle JP, Thompson TJ, et al. Projections of type 1 and type 2 diabetes burden in the U.S. population aged <20 years through 2050: dynamic modeling of incidence, mortality, and population growth. Diabetes Care. 2012;35(12):2515–2520. [PubMed: 23173134]

5. Hofer S, Meraner D, Koehle J. Insulin pump treatment in children and adolescents with type 1 diabetes. Minerva Pediatr. 2012;64(4):433–438. [PubMed: 22728614]

6. 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(11):115. [PubMed: 27718171]

7. Foster NC, Beck RW, Miller KM, et al. State of Type 1 Diabetes Management and Outcomes from the T1D Exchange in 2016–2018. Diabetes Technol Ther. 2019;21(2):66–72. [PubMed: 30657336]

8. Tao B, Pietropaolo M, Atkinson M, Schatz D, Taylor D. Estimating the cost of type 1 diabetes in the U.S.: a propensity score matching method. PloS one. 2010;5(7):e11501. [PubMed: 20634976]

9. Lee JM, Sundaram V, Sanders L, Chamberlain L, Wise P. Health Care Utilization and Costs of Publicly-Insured Children with Diabetes in California. The Journal of pediatrics. 2015;167(2):449–454 e446. [PubMed: 26028286]

10. Biniek JF, Johnson W. Spending on Individuals with Type 1 Diabetes and the Role of Rapidly Increasing Insulin Prices. In. Health Care Cost Institute Brief 1 2019.

11. Martin CT, Criego AB, Carlson AL, Bergenstal RM. Advanced Technology in the Management of Diabetes: Which Comes First-Continuous Glucose Monitor or Insulin Pump? Curr Diab Rep. 2019;19(8):50. [PubMed: 31250124]

12. Luo J, Kesselheim AS, Greene J, Lipska KJ. Strategies to improve the affordability of insulin in the USA. Lancet Diabetes Endocrinol. 2017;5(3):158–159. [PubMed: 28189654]

13. OptumLabs. OptumLabs and OptumLabs Data Warehouse (OLDW) Descriptions and Citation. Cambridge, MA 5 2019.

14. Consumer Price Index for All Urban Consumers: Medical Care. Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/CPIMEDSL. Accessed August 14, 2019.

15. Sherr JL, Tauschmann M, Battelino T, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Diabetes technologies. Pediatr Diabetes. 2018;19 Suppl 27:302–325. [PubMed: 30039513]

16. Zabeen B, Craig ME, Virk SA, et al. Insulin Pump Therapy Is Associated with Lower Rates of Retinopathy and Peripheral Nerve Abnormality. PLoS One. 2016;11(4):e0153033. [PubMed: 27050468]

Author Manuscript
Author Manuscript
Author Manuscript

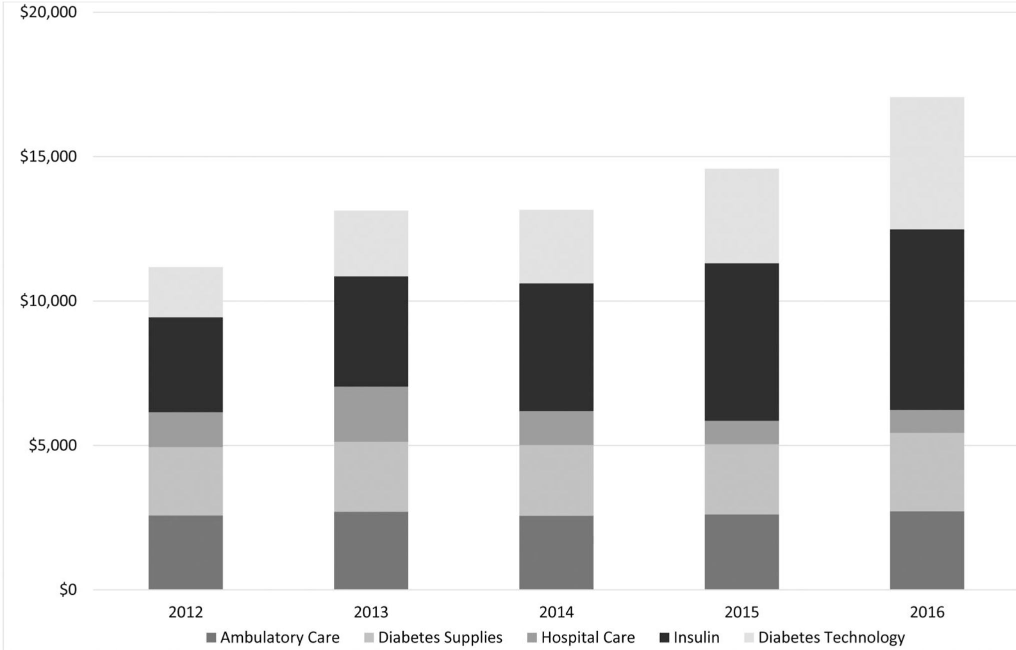

Figure 1. Adjusted Mean Costs of Care 2012-2016.

Mean per-person inflation-adjusted costs of type 1 diabetes care by year and care category, adjusted for differences in age, sex, race, census region, and mental health comorbidity between sub-populations contributing data in each year.

Table 1.

Study Population (N=9,445)

	N	%
Age in Years		
≤6	869	9
7-12	3,248	34
13-18	5,328	56
Sex		
Female	4,444	47
Male	>4,990	>53
Unknown	<11	<0.1
Race		
Asian	171	2
Black	650	7
Hispanic	687	7
White	7,666	81
Unknown	271	3
Census Region		
Midwest	2,935	31
Northeast	812	9
South	>3,816	>40
West	1,871	20
Unknown	<11	<0.1
Mental Health Comorbidity	445	5
Insulin Pump Use	5,013	53
Continuous Glucose Monitor Use	2,370	25

Table 2.

Utilization and Cost* Among Users for Hospitalizations and Diabetes Technology

	Hospitalizations		Insulin Pumps		Continuous Glucose Monitors	
Year	**Prevalence of Use**	**Adjusted Mean Cost Per User**	**Prevalence of Use**	**Adjusted Mean Cost Per User**	**Prevalence of Use**	**Adjusted Mean Cost Per User**
2012	7%	$16,996	43%	$2,760	8%	$2,103
2013	7%	$29,430	44%	$3,300	17%	$2,742
2014	7%	$15,878	43%	$3,274	22%	$3,410
2015	6%	$13,921	46%	$3,451	31%	$3,501
2016	6%	$14,017	52%	$4,033	46%	$4,220

*Costs adjusted for inflation, and for covariates of age, sex, race, census region, and mental health comorbidity