Impact of Type 1 Diabetes on Productivity and Out-of-Pocket Costs of Adult Continuous Glucose Monitor Users in the United States: Results From a Cross-Sectional Survey in the United States

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INTRODUCTION

- Type 1 diabetes (T1D) is a life-limiting autoimmune condition characterized by the destruction of insulin-producing cells in the pancreas.[1] In the United States, T1D affects an estimated 1.4 million individuals.[2]
- Exogenous insulin is essential for the treatment of T1D but requires careful assessment of blood glucose due to its narrow therapeutic window.[3] Recent guidelines recommend Continuous Glucose Monitoring (CGM) as the first-line approach in the management of T1D.[4]
- Despite the use of advanced management technology including CGM and automated insulin delivery systems (such as hybrid closed-loop systems), many individuals with T1D are unable to reach glycemic targets.[5]
  - These individuals are at risk of acute and long-term consequences, including potential deleterious effects on their micro- and macrovascular systems,[6-9]
  - These individuals experience technology-related burden and life and work impairments[11]
- There is little evidence on the impact that T1D has on life and work productivity impairments and financial concerns, and few studies have investigated the productivity impairments using disease-specific patient-reported outcome measures.
- We aimed to evaluate the life and work productivity impairments and financial concerns among adults with T1D in the United States.

OBJECTIVE

- To quantify the T1D-related productivity impacts and out-of-pocket expenses in adults with T1D who use CGM in the United States

METHODS

Study Design

- An online cross-sectional survey was administered to patients with T1D from the T1D Exchange Registry who had previously consented to be contacted for research purposes.

Key Inclusion Criteria

- Self-reported clinical diagnosis of T1D ≥5 years
- Current CGM user
- Aged ≥18 years old

Survey Design & Administration

- Productivity impairments to life, work, short- and long-term goals were quantified using the Diabetes Productivity Measure (DPM).[12]
  - Life productivity: Assessed with 9 items (limiting daily activities, increased time for tasks, prevents accomplishing and concentrating, morning active challenges, hypoglycemia symptoms interfering with daily activities). Higher scores indicate higher productivity
  - Work Productivity: Assessed with 5 items (performing; emotions; productive; miss work; reschedule). Higher scores indicate higher productivity
    - Work productivity was calculated for the subset of participants who reported full- or part-time employment using the DPM
  - Two stand-alone "non-validated" items are included in the DPM and reported separately
    - Short-term goals: Assessed with 1 item; higher scores indicate fewer problems reaching short-term goals
    - Long-term goals: Assessed with 1 item; higher scores indicate fewer problems reaching long-term goals
- Out-of-pocket (OOP) expenses were quantified using bespoke questions.

Statistical Analyses

- For the DPM, total subscale scores were calculated according to the scaling and scoring instructions of the DPM.[11] Individual subscale scores are between 0 and 100.
- Descriptive analyses (mean [standard deviation (SD)]) of characteristics and patient-reported productivity outcomes are reported for the overall participant population.

RESULTS

Demographic Characteristics

- Participants' (N = 1847) mean age was 45.9 years, SD = 15.3. Most were female (67.5%), were White (90.7%), had a bachelor's degree or higher (71.4%), and/or were employed full- or part-time (n = 1266, 68.5%) (**Table 1**).

Table 1. Demographic Characteristics

	Adult CGM Users With T1D (N = 1847)
Age (years), mean (SD)	45.9 (15.3)
Gender, n (%)	
Male	582 (31.5%)
Female	1247 (67.5%)
Non-binary/genderqueer	15 (0.8%)
I prefer to self-identify	2 (0.1%)
I prefer not to answer	1 (0.1%)
Race, n (%)	
American Indian/Alaskan Native	10 (0.5%)
Asian	19 (1.0%)
Black/African-American	42 (2.3%)
Native Hawaiian or Other Pacific Islander	2 (0.1%)
North African/Middle-Eastern	9 (0.5%)
White	1676 (90.7%)
Mixed race	69 (3.7%)
Other	20 (1.1%)
Ethnicity, n (%)	
Hispanic or Latino	117 (6.3%)
Highest education, n (%)	
Some college (but no degree) or less	355 (19.2%)
Associate's degree	157 (8.5%)
Bachelor's degree	752 (40.7%)
Master's degree	444 (24.0%)
Doctoral or professional degree	122 (6.6%)
Other	16 (0.9%)
I prefer not to answer	1 (0.1%)
Employment status, n (%)	
Employed full-time (at least 32 hours per week)	1065 (57.7%)
Employed part-time (less than 32 hours per week)	201 (10.9%)
Unemployed	96 (5.2%)
Student only	53 (2.9%)
Unpaid caregiver	39 (2.1%)
Retired	294 (15.9%)
Disabled, not able to work	99 (5.4%)

Clinical Characteristics

- Mean duration of T1D was 29.0 years (SD = 15.1). Mean self-reported most recent HbA1c value was 6.7% (SD = 1.0) and 32.9% of participants were unable to achieve glycemic targets (HbA1c <7%) **(Table 2).**

Table 2. Clinical Characteristics

	Adult CGM Users With T1D (N = 1847)
Duration of T1D (years), Mean (SD)	29.0 (15.1)
Most recent HbA1c, Mean (SD)	6.7 (1.0)
HbA1c <7%, n (%)	
Yes	1240 (67.1%)
No	607 (32.9%)
Insulin delivery methods, n (%)	
Insulin pump	1543 (83.5%)
Daily injections	328 (17.8%)
Inhaled insulin	22 (1.2%)
Other[a]	8 (0.4%)
If pump users, automated insulin delivery features, n (%)	**(n = 1543)**
DIY	83 (5.4%)
Hybrid closed-loop	1119 (72.5%)
Low glucose suspend or predictive low glucose suspend	120 (7.8%)
Manual[b]	150 (9.7%)
N/A[c]	71 (4.6%)

BMI, body mass index; DIY, do-it-yourself looping system; NA, not applicable; SD, standard deviation.
[a]Participants could select more than one insulin delivery method. Open-text 'other' responses included patch pumps (*n* = 3), supplemental insulin injections (*n* = 3), or oral medications for lowering glucose levels (*n* = 1). Additionally, one participant (*n* = 1) wrote they were trying to transition to a patch pump. Of the participants who selected 'other,' 6 participants used multiple insulin delivery methods. The remaining (*n* = 2) exclusively used patch pumps.
[b]Refers to participants who have pumps with automated features but do not use them.
[c]Refers to participants who have pumps without any automated features.

DPM Results

- On average, participants reported lower perceived life productivity (lower mean DPM score; lower score indicating lower productivity) compared with work productivity **(Figure 1a)**
- On average, participants had slightly more problems reaching their long-term goals (lower mean DPM score; lower score indicating more problems attaining goals) than short-term goals **(Figure 1b)**

Figure 1a. Mean DPM Scores: Life and Work Productivity Impacts

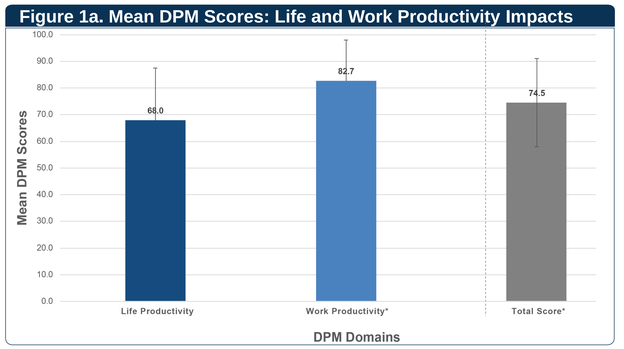
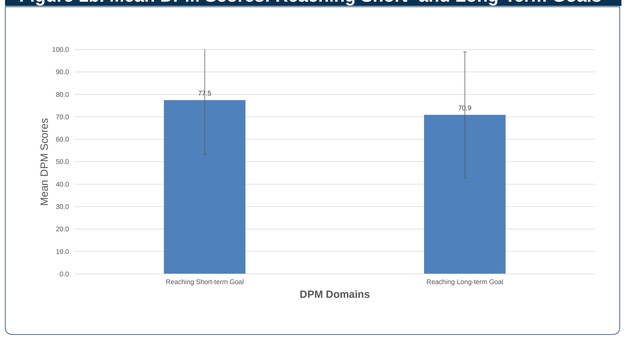


Figure 1b. Mean DPM Scores: Reaching Short- and Long-Term Goals



*Work productivity and DPM Total Scores were calculated for individuals who reported part or full-time employment (n = 1266). Individual subscale scores ranges from 0 and 100; higher scores indicate higher productivity

Self-Reported OOP Costs

- Participants reported spending an average of $2570 (SD = 4433) OOP on their T1D **(Table 3).**
- Most participants (52.2%) reported spending between $1000 and $4999 OOP on their T1D in the past 12 months **(Table 3).**

Table 3. Self-reported OOP costs in the past 12 months

OOP Costs (2023 US dollars)	Adult CGM Users (N = 1847)
OOP cost of T1D care, mean (SD)	$2570 (4433)
OOP cost of T1D care categories, n (%)	
$0	87 (4.7%)
$1 - $499	276 (14.9%)
$500 - $999	231 (12.5%)
$1,000 - $2,499	540 (29.2%)
$2,500 - $4,999	425 (23.0%)
$5,000 - $9,999	231 (12.5%)
≥$10,000	57 (3.1%)

LIMITATIONS

- Study participants were from the T1D Exchange online community, a cohort of individuals with T1D who tend to be highly engaged, have a high degree of diabetes technology use, and have historically been shown to be more likely to achieve glycemic targets.
- Study participants were mostly White, non-Hispanic, identified as female, highly educated, were self-selected and/or needed access to the internet and email, which may all impact the generalizability of these results.
- All data were self-reported; eligibility and clinical data were not verified by a clinician.

CONCLUSIONS

- Despite the high rates of advanced diabetes technology adoption among study participants, approximately 1/3 of participants did not meet the ADA recommended guideline of HbA1c <7.0%
- On the DPM, adult CGM users with T1D reported high impairments to life productivity and had more problems reaching long-term goals
- On average, participants incurred $2570 (SD: 4433) OOP expenses annually
- Collectively, these results demonstrate the economic burden among adult CGM users with T1D and highlight unmet need in this patient population.

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AUTHOR DISCLOSURES

This study was sponsored by Vertex Pharmaceuticals Incorporated. ABK, PC, KC, and DB and LC are employees of Vertex Pharmaceuticals Incorporated and may hold stock or stock options in the company.

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