Life and Work Productivity Impairment in Adult Continuous Glucose Monitor Users with Type 1 Diabetes: Results from a Cross-Sectional Survey Study

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INTRODUCTION

- People with type 1 diabetes (pwT1D) require life long exogenous insulin therapy, and as per current guidelines, should aim to keep hemoglobin A1c (HbA1c) levels <7%[1]
- Despite using advanced insulin delivery methods, including continuous glucose monitors (CGM), education and/or support, many pwT1D do not meet the recommended HbA1c target of <7% and experience severe hypoglycemic events (SHEs)[1-6]
- SHEs, defined as medical emergencies requiring the assistance of a third person to recover, can lead to seizures, cardiac arrythmias, loss of consciousness, coma, or even death[7-11]
- Repeated episodes of SHEs can lead to impaired awareness of hypoglycemia (IAH), further increasing the risk of SHEs up to six-fold[12]
- PwT1D have impaired quality of life including diabetes distress and fear of hypoglycemia, because of complications associated with dysglycemia including SHEs/IAH, and the complex and challenging nature of T1D management[13-17]
- Few studies have described the impact of SHE frequency and IAH status on life and work productivity in adult CGM users using different insulin delivery methods

OBJECTIVE

To describe the impact of SHE frequency and IAH status on life and work productivity in adult CGM users using different insulin delivery methods

METHODS

Study Design

- An online cross-sectional survey was administered to people with T1D from the T1D Exchange Registry

Key Inclusion Criteria

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

Survey Design & Administration

- SHE frequency was collected through participant responses to the question:
  - "A severe hypoglycemic event (SHE) is a low blood sugar where you experience a change in your mental or physical status (like increased confusion or loss of consciousness) and where you need help from another person to recover. How many times did you experience a severe hypoglycemic event in the past 12 months?"
- IAH status was determined using established cutoffs from the modified Gold score.[18] The Gold score is a 1-item questionnaire that asks individuals to report their experience in detecting hypoglycemic events with responses ranging from 1 (always aware) to 7 (never aware) in a Likert type scale
  - A score of ≤2 = normal awareness (IAH−); 3 = borderline (undetermined); ≥4 suggests impaired awareness of hypoglycemia (IAH+)
- Work and life productivity impairment were quantified using the Diabetes Productivity Measure (DPM).[19] Individual subscale scores are between 0-100. Higher scores indicate higher productivity.
  - Work Productivity: Assessed with 5 items (performing; emotions; productive; miss work; reschedule)
    - Work Productivity was calculated for the subset of participants who reported full- or part-time employment using the DPM
- 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)

Cohort Definitions

- Cohorts were evaluated based on self-reported SHE frequency and IAH status in the past 12 months[20]

Table 1. Study Design

Cohort	Definition
Problematic SHEs	Individuals with SHE 1+/IAH+ or SHE 2+/IAH−
Single SHE, no-IAH	Individuals with 1 SHE and IAH−
Undetermined IAH	Individuals with SHE ≥0 and modified Gold score = 3
No-SHE	Individuals with 0 SHE and IAH+ or 0 SHE and IAH−

IAH: impaired awareness of hypoglycemia; SHE: severe hypoglycemic event

Statistical Analysis

- Descriptive analyses (mean, standard deviation [SD], counts, percentages) of participant demographics and clinical characteristics and DPM scores are reported for the Problematic SHEs and No-SHE cohorts
- For the DPM, total subscale scores were calculated according to the scaling and scoring instructions of the DPM[15]
- DPM work productivity was calculated for participants who reported part- or full-time employment
- Descriptive results are summarized by SHE/IAH cohorts and further stratified by insulin delivery method: Hybrid closed-loop system/do-it-yourself (HCLS/DIY), Predictive low glucose suspend (PLGS), Pump without automated insulin-delivery (pump no-AID) and multiple daily injections (MDI)

RESULTS

- Relative to the No-SHE cohort, participants in the Problematic SHEs cohort were slightly older (mean age = 49.0 [SD = 14.6] vs. 45.6 [SD=15.7] years) and fewer were employed full-time (45.9% vs. 61.5%) (Table 2)
- More participants in the No-SHE cohort used HCLS/DIY (69.0%) compared to the Problematic SHEs cohort (55.7%). Compared to the No-SHE cohort, more participants in the Problematic SHEs cohort reported medical emergency treatment for T1D (excluding SHEs) in the past year (13.9% vs. 5.8%) (Table 2)
- Participants with Problematic SHEs reported numerically higher rates of complications relative to the No-SHE cohort (Table 2)

Table 2. Participant Demographics & Clinical Characteristics[a]

	Problematic SHEs[b] (N=375, 20.3%)	No-SHE[b] (N=1033, 55.9%)
Age (years), mean (SD)	49.0 (14.6)	45.6 (15.7)
Gender, n (%)		
Male	108 (28.8)	354 (34.3)
Female	266 (70.9)	666 (64.5)
Non-binary / genderqueer	1 (0.3)	11 (1.1)
Prefer to self-identify	0 (0)	1 (0.1)
Prefer not to answer	0 (0)	1 (0.1)
Race, n (%)		
American Indian/Alaskan Native	3 (0.8)	5 (0.5)
Asian	1 (0.3)	10 (1.0)
Black/African American	21 (5.6)	13 (1.3)
Native Hawaiian or Other Pacific Islander	1 (0.3)	1 (0.1)
North African/Middle Eastern	1 (0.3)	7 (0.7)
White/Caucasian	324 (86.4)	958 (92.1)
Mixed Race	18 (4.8)	32 (3.1)
Other	6 (1.6)	7 (0.7)
Ethnicity – Hispanic or Latino, n (%)	23 (6.1)	55 (5.3)
Most recent HbA1c, mean (SD)	6.9 (1.1)	6.6 (0.9)
Employment status, n (%)		
Employed full-time (≥32 hours per week)	172 (45.9)	635 (61.5)
Employed part-time (<32 hours per week)	47 (12.5)	100 (9.7)
Unemployed	24 (6.4)	45 (4.4)
Student only	7 (1.9)	31 (3.0)
Unpaid caregiver	9 (2.4)	23 (2.2)
Retired	68 (18.1)	171 (16.6)
Disabled, not able to work	48 (12.8)	28 (2.7)
Medical emergency treatment for T1D (excluding SHEs) in the past 12 months, n (%)	52 (13.9)	60 (5.8)
Diabetes technology subtypes, n (%)		
HCLS/DIY	209 (55.7)	713 (69.0)
PLGS	33 (8.8)	55 (5.3)
Pump no-AID	52 (13.9)	119 (11.5)
MDI	81 (21.6)	146 (14.1)
Selected Complications, n (%)		
Microvascular		
Nephropathy	31 (8.3)	47 (4.5)
Neuropathy	92 (24.5)	108 (10.5)
Retinopathy	106 (28.3)	222 (21.5)
Macrovascular		
Cerebrovascular disease	8 (2.1)	24 (2.3)
Cardiovascular disease	47 (12.5)	57 (5.5)
Vascular disease	29 (7.7)	40 (3.9)
Hypothyroidism	90 (24.0)	275 (26.6)
Hypertension	152 (40.5)	317 (30.7)
Dyslipidemia	155 (41.3)	371 (35.9)
Joint or bone issues	191 (50.9)	366 (35.4)
Autoimmune disease	90 (24.0)	246 (23.8)
Sleep disorder	108 (28.8)	171 (16.6)
Depression	184 (49.1)	325 (31.5)
Anxiety	175 (46.7)	341 (33.0)

[a]Table 2 was previously presented elsewhere.
[b]The Overall sample also included Single SHE, no-IAH (n=102) and Undetermined IAH (n=337) cohorts.
AID: automated insulin delivery; HbA1c: hemoglobin A1c; HCLS/DIY: hybrid closed loop system/do-it-yourself; IAH: impaired awareness of hypoglycemia; PLGS: predictive low glucose suspend systems; MDI: multiple daily injection; SD: standard deviation; T1D: type 1 diabetes

- Participants with Problematic SHEs reported numerically lower total mean DPM scores compared to No-SHE cohort, regardless of insulin delivery method (Figure 1)
  - Largest numerical difference was observed in PLGS (64.2 vs. 79.0), followed by MDI (62.6 vs. 75.5), HCLS/DIY (67.3 vs. 78.8) and Pump no-AID users (73.2 vs. 75.8)

Figure 1. DPM Total Mean Scale Scores Between Problematic SHEs and No-SHE Cohorts & Stratified by Insulin Delivery Methods
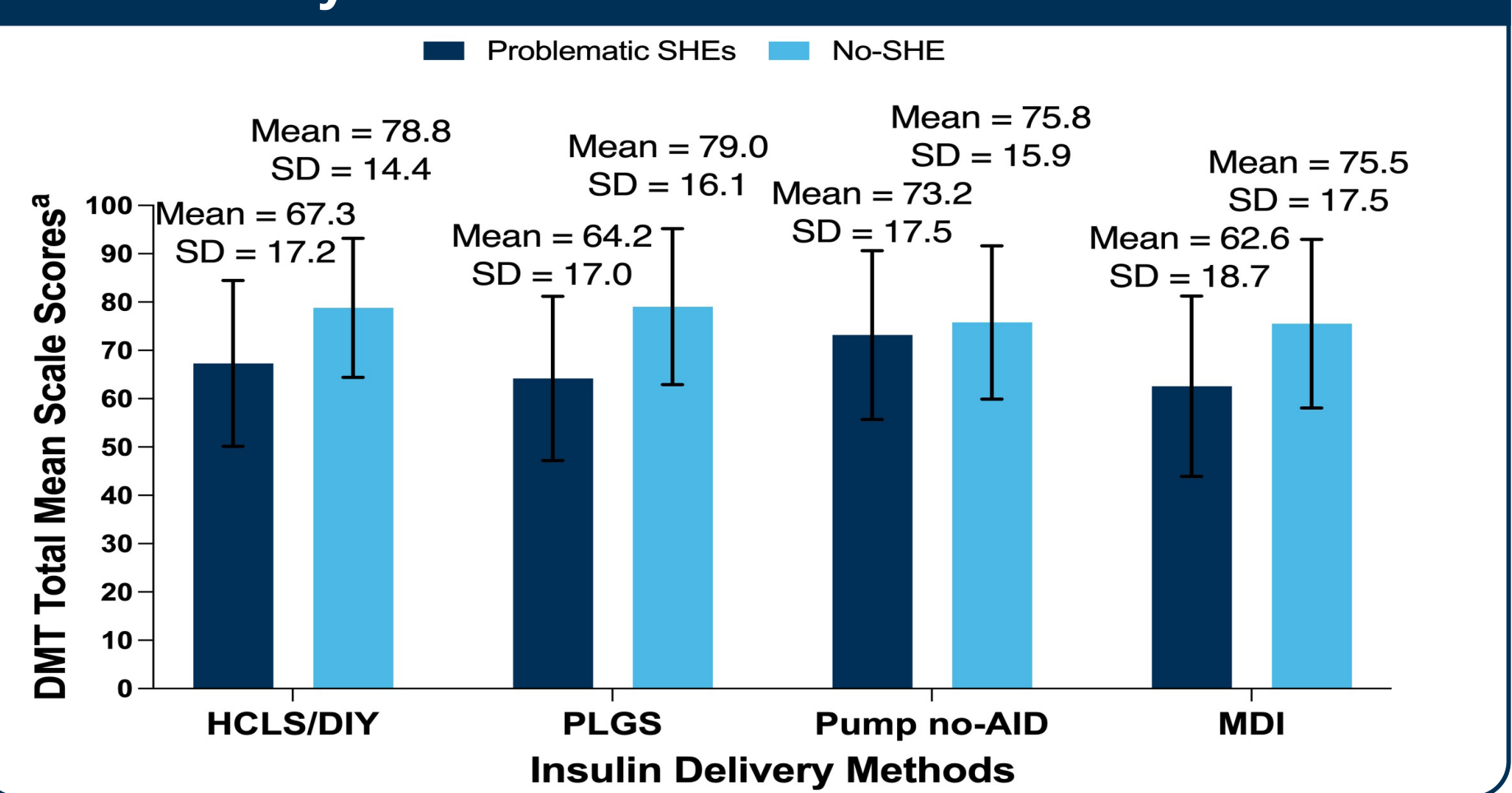
[a]DPM total scale scores was the mean of 14 items (including both life productivity and work productivity items). Stratification by insulin delivery methods resulted in the following sample size between cohorts: HCLS/DIY (Problematic SHEs [n=136], No-SHE [n=526]); PLGS (Problematic SHEs [n=22], No-SHE [n=36]); Pump no-AID (Problematic SHEs [n=23], No-SHE [n=76]); MDI (Problematic SHEs [n=38], No-SHEs [n=97]). Error bars = SD
AID: automated insulin delivery; DPM: Diabetes Productivity Measure; HCLS/DIY: hybrid closed loop system/do-it-yourself; MDI: multiple daily injection; PLGS: predictive low glucose suspend systems; SD: standard deviation; SHE: severe hypoglycemic event

- Compared to the No-SHE cohort, participants with Problematic SHEs reported numerically lower mean life productivity scores (i.e., lower total mean DPM scores) across insulin delivery methods (Figure 2)
  - Largest numerical difference was observed in PLGS (57.1 vs. 73.6), followed by HCLS/DIY (58.9 vs. 72.8), MDI (58.6 vs. 71.7) and Pump no-AID users (61.1 vs. 69.0)

Figure 2. DPM Mean Life Productivity Domain Scores Between Problematic SHEs and No-SHE Cohort and Stratified By Insulin Delivery Methods
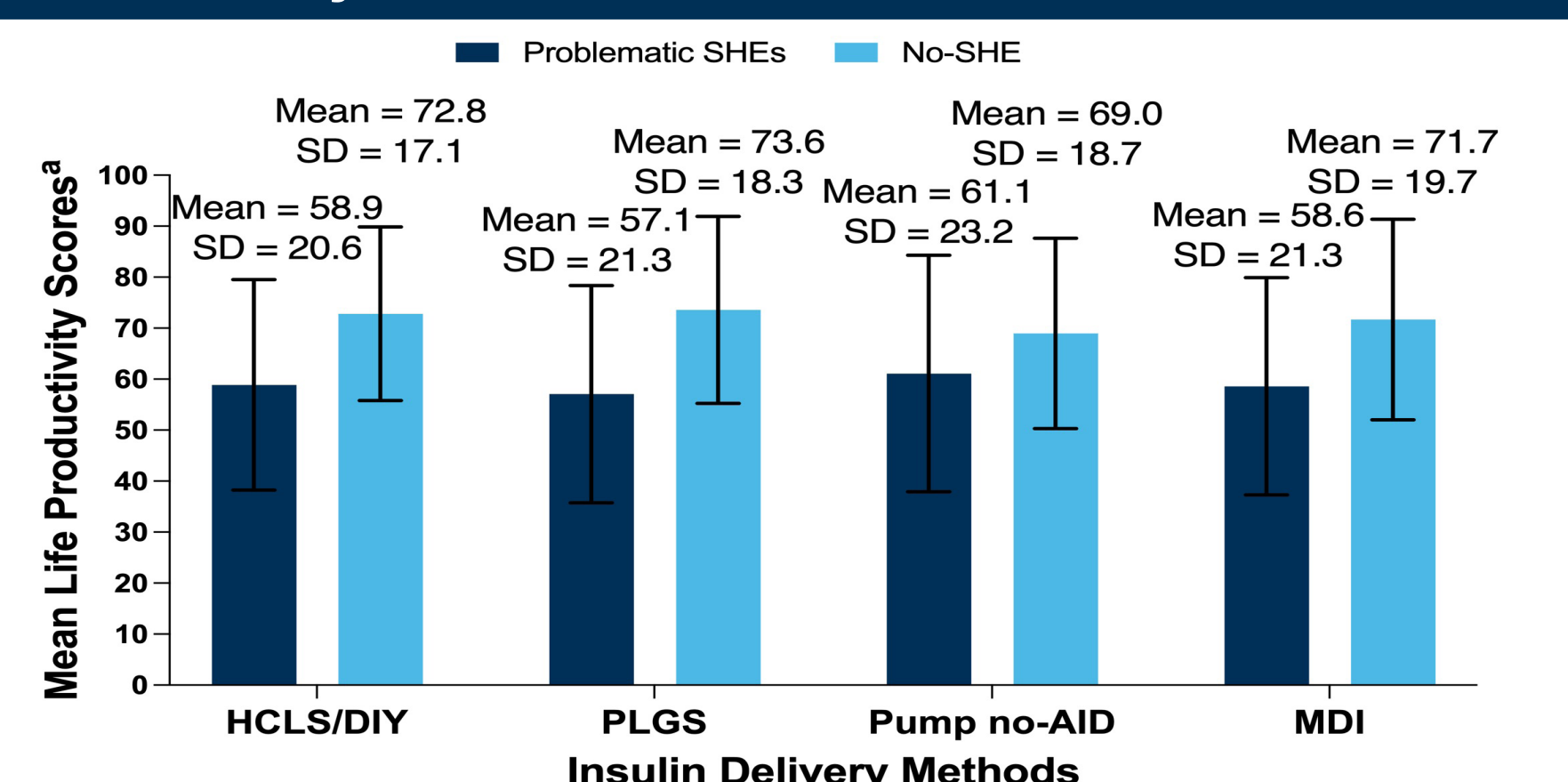
[a]Stratification by insulin delivery methods resulted in the following sample size between cohorts: HCLS/DIY (Problematic SHEs [n=209], No-SHE [n=713]); PLGS (Problematic SHEs [n=33], No-SHE [n=55]); Pump no-AID (Problematic SHEs [n=52], No-SHE [n=119]); MDI (Problematic SHEs [n=81], No-SHEs [n=146]).
Error bars = SD
AID: automated insulin delivery; DPM: Diabetes Productivity Measure; HCLS/DIY: hybrid close loop system/do-it-yourself; MDI: multiple daily injection; PLGS: predictive low glucose suspend systems; SD: standard deviation; SHE: severe hypoglycemic event

- Compared to the No-SHE cohort, participants with Problematic SHEs reported numerically lower mean work productivity scores across insulin delivery methods (Figure 3)
  - Largest numerical difference was observed in PLGS (73.0 vs. 85.8) followed by MDI (72.1 vs. 84.6), HCLS/DIY (76.1 vs. 86.6), and Pump no-AID users (80.9 vs. 82.6)

Figure 3. DPM Mean Work Productivity Domain Scores Between Problematic SHEs and No-SHE Cohort and Stratified By Insulin Delivery Methods
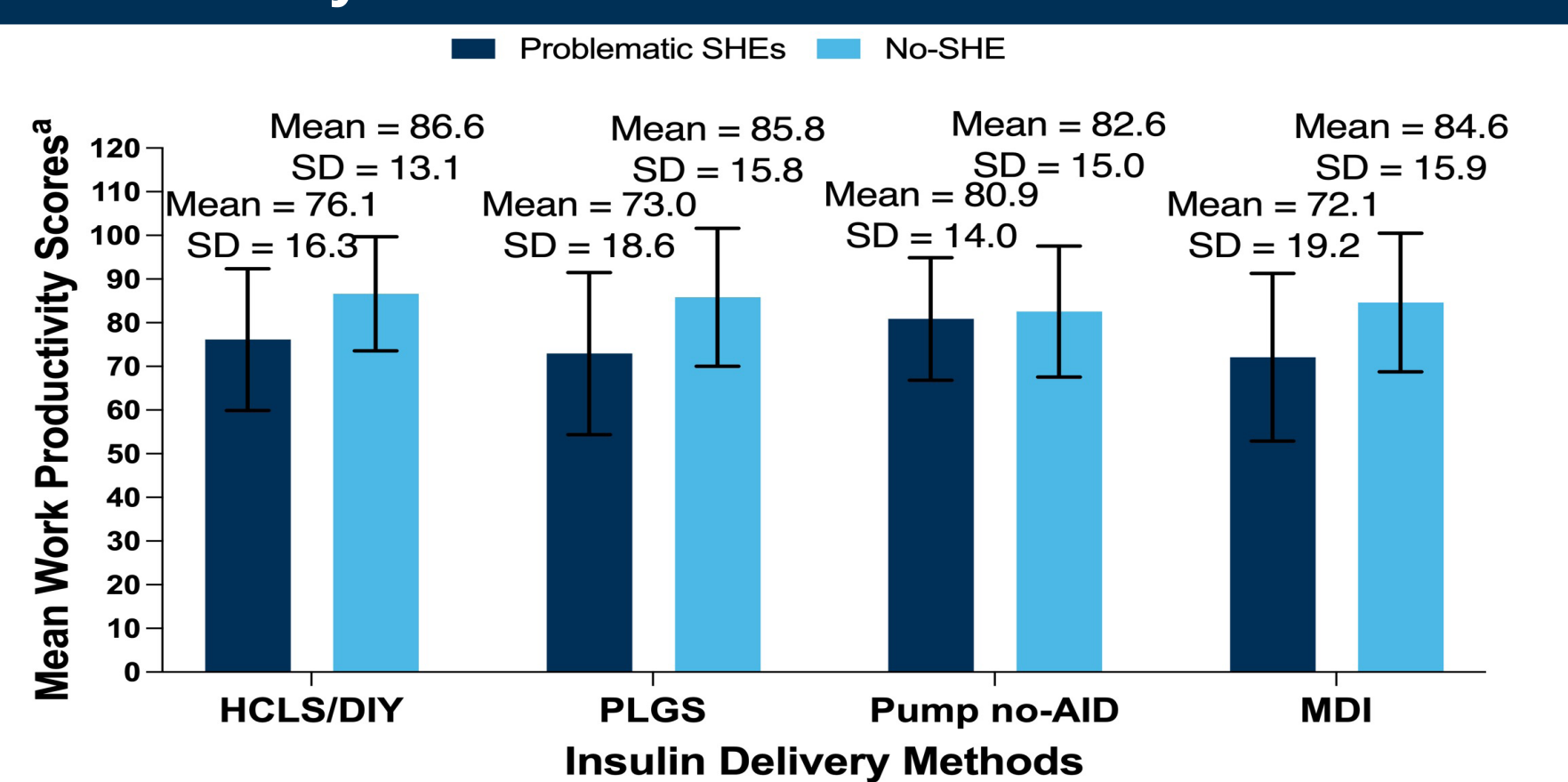
[a]DPM work productivity was calculated for participants who reported part- or full-time employment. Stratification by insulin delivery methods resulted in the following sample size between cohorts: HCLS/DIY (Problematic SHEs [n=136], No-SHE [n=526]); PLGS (Problematic SHEs [n=22], No-SHE [n=36]); Pump no-AID (Problematic SHEs [n=23], No-SHE [n=76]); MDI (Problematic SHEs [n=38], No-SHEs [n=97]). Error bars = SD
AID: automated insulin delivery; DPM: Diabetes Productivity Measure; HCLS/DIY: hybrid closed loop system/do-it-yourself; MDI: multiple daily injection; PLGS: predictive low glucose suspend systems; SD: standard deviation; SHE: severe hypoglycemic event

Limitations

- Study participants were from the T1D Exchange Registry, 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
- All data were self-reported; eligibility and clinical data were not verified by a clinician
- Study participants were mostly White, non-Hispanic or Latino, identified as female, highly educated, were self-selected and needed access to the internet and email, which may all impact the generalizability of these results
- All analyses were descriptive; associations between SHE frequency and IAH status and insulin delivery methods were not evaluated

CONCLUSIONS

- Relative to the No-SHE cohort, participants with Problematic SHEs self-reported higher medical emergency treatments (excluding SHEs), potentially suggesting higher frequency or more severe comorbidities
- Across insulin delivery methods, participants with Problematic SHEs reported numerically lower mean productivity scores (total scale, life productivity and work productivity) compared to No-SHE cohort, with slight numerical differences between insulin delivery methods
  - Largest numerical difference in DPM total mean life productivity domain scores was observed in PLGS followed by HCLS/DIY, MDI and Pump no-AID users
  - Largest numerical difference in DPM mean work productivity domain scores was observed in MDI followed by PLGS, HCLS/DIY, and Pump no-AID users
- Future studies should assess the association between SHE frequency and IAH status and productivity loss in pwT1D with Problematic SHEs using different insulin delivery methods
- These findings suggest that even with advanced diabetes technology, pwT1D experience SHEs and IAH that reduce their life and work productivity, highlighting the need for innovative therapies

References

1. Holt, R. et al. Diabetologia. 2021; 64:2609–2652.
2. Blauw, H. et al. Diabetes Care. 2021; 44:836–838.
3. The DCCT Research Group. N Engl J Med. 1993; 329:977–986.
4. DCCT/EDIC Study Research Group. N Engl J Med. 2005; 353, 2643–2653 (2005).
5. EASD. Consensus report. 2021
6. Pettus et al. Diabetes. 2022;71(Supplement_1):92-OP
7. Fider C et al. Journal of Medical Economics. 2011; 5:646–55
8. Cryer PE. Endocrinol Metab Clin N Am. 2010; 641–654
9. Nathan DM. Diabetes Care. 2013;37(1):9–16
10. Jacobson AM et al. The Lancet Diabetes & Endocrinology. 2021;9(7):436–45.
11. Lacy ME et al. Diabetes Care. 2020;43(3):541–8
12. Geddes, J. et al. Diabetic Med. 2008; 25: 501–504.
13. Chatwin, H et al. BMJ Open Diabetes Research and Care. 2021; 9:e002322.
14. Jensen, M et al. Diabetic Medicine. 2021 38, e14666.
15. Hendrieckx, C. et al. Diabetes Research and Clinical Practice. 2014; 103:430–436.
16. Gonder-Frederick, L. A. et al. Diabetic Medicine. 2013; 30, 603–609.
17. Cryer PE. et al. Endocrinology and Metabolism Clinics of North America. 2010;(3):641–54.
18. Gold AE et al. Diabetes Care. 1994; 17:697–703
19. Broad M et al. Qual Life Res. 2006;3;412:37(7):2004–54. 81-91
20. Choudhary, P et al. Diabetes Care. 2015; 38(6):1016-29.