

Real-World Evidence of Healthcare Utilization and Costs for Type 1 Diabetes and Severe Hypoglycemia by Age in Germany

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INTRODUCTION

- The prevalence of type 1 diabetes (T1D) in Germany was estimated to be 422,087 total and 382,070 in individuals ≥20 years in 2021.¹
- The remaining life expectancy if diagnosed at age 10 years was estimated to be 64 years in Germany in 2021.¹
- It was estimated that only 39.9% of patients with T1D in Germany between age 15-24 years and 52.4% age ≥25 years reached HbA1c level of <7.5% between 2016 and 2020, indicating a need for improvement.²
- A severe hypoglycemic event (SHE) is defined by neurocognitive impairment requiring the assistance of another person for recovery, is associated with increased risk of death, and is a major limiting factor in achieving glycemic control in T1D.³
- For older individuals with T1D, age-typical functional limitations and high vulnerability create special needs that go beyond blood glucose control and the management of cardiovascular risk factors or diabetes-typical complications.⁴

OBJECTIVE

To evaluate the healthcare resource utilization (HCRU) and costs for people with T1D and those with severe hypoglycemia in Germany by age.

METHODS

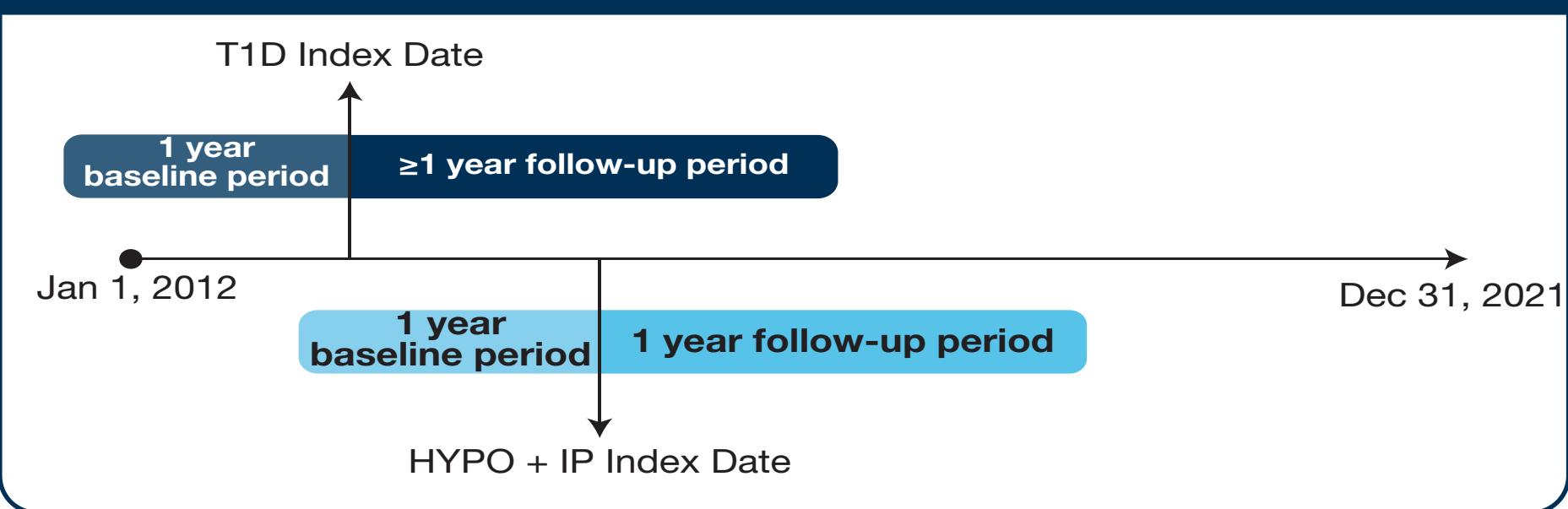
Patient Selection

- Adults (≥18 years old) with T1D were selected from a German BKK (Betriebskrankenkassen) claims database between January 1, 2013 and December 31, 2020.
- T1D was defined as ≥1 specific diagnostic code (ICD-10) in ≥2 quarters of a year (M2Q), a ratio of >0.5 for T1D over T1D and type 2 diabetes (T2D) M2Q diagnoses, ≥1 insulin prescription, and no non-insulin glucose-lowering drug prescriptions except for off-label use.
- The T1D index date was defined as date of the first observed T1D diagnosis code after 12 months' continuous enrollment for the T1D population.
- The SHEs identified in this study were defined as hospital visits with a primary hypoglycemia diagnosis or secondary hypoglycemia diagnosis with a concurrent Diagnosis Related Group (DRG) code for diabetes (K60).
- A subpopulation with T1D and severe hypoglycemia (HYPO + inpatient [IP] cohort) was indexed on date of the first observed hypoglycemia-associated hospital admission (proxy of severe hypoglycemia; HYPO + IP index date).

Study Design

- Baseline demographics and clinical characteristics were examined during the 12-month pre-index period; age was determined as of the index date.
 - Charlson Comorbidity Index (CCI) was used to examine burden of comorbidities; adapted Diabetes Complications Severity Index (aDCSI) was used to examine T1D severity.
- For the T1D population, patients were required to have at least 12 months' continuous enrollment after the T1D index date (except for death) and followed from the T1D index date (inclusive of the index date) until end of continuous enrollment, end of study period, or death, whichever occurred first.
- For the HYPO + IP cohort, patients were required to have 12 months' continuous enrollment after the HYPO + IP index date as the follow-up period (inclusive of the index date; except for death).
- Age-stratified per patient per year (PPPY) HCRU and cost outcomes were examined descriptively during the follow-up period.

Figure 1. Study Design



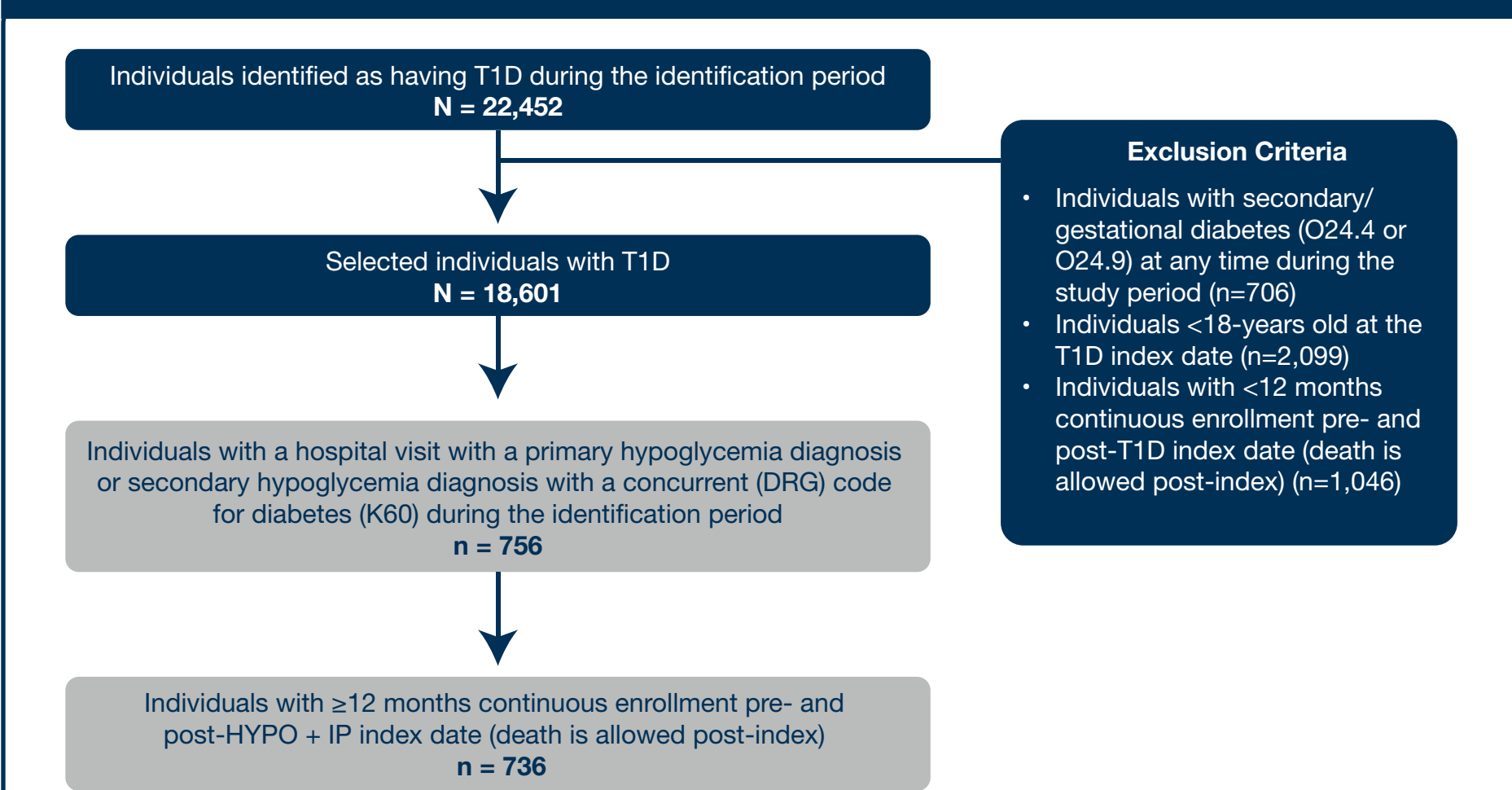
HYPO + IP: severe hypoglycemia + inpatient cohort; T1D: type 1 diabetes

Statistical Methods

- Frequency (n), percentage (%), mean, and standard deviation (SD) were used in descriptive analyses.
- Per patient per year HCRU and costs were examined. Costs were reported in EUR and adjusted for inflation using the 2021 German consumer price index as a reference.

RESULTS

Figure 2. Patient Selection



DRG: Diagnosis Related Group; HYPO + IP: severe hypoglycemia + inpatient cohort; ICD-10-GM: International Classification of Diagnoses, 10th revision, German modification; SHE: severe hypoglycemic event; T1D: type 1 diabetes; T2D: type 2 diabetes

Patient Selection

- After applying the inclusion and exclusion criteria, a total of 18,601 individuals with T1D were selected for the T1D population between January 1, 2013 and December 31, 2020.
- A total of 736 individuals with T1D and SHE were identified and included in the HYPO + IP cohort.

Baseline Demographic and Clinical Characteristics for the Type 1 Diabetes Population

- A total of 8,548 (46.0%), 7,270 (39.0%), and 2,783 (15.0%) people with T1D were in the 18-44, 45-64, and ≥65 years age groups, respectively.
- A total of 63% of the people in the 18-44 and 45-64 years age groups and 53% of the people in the ≥65 years age group were male.
- T1D severity, defined by aDCSI scores, and comorbidity burden, defined by CCI scores, increased with age (Table 1).
 - Notably, all T1D-related microvascular (retinopathy, neuropathy, and nephropathy) and macrovascular (coronary artery disease, cerebrovascular disease, peripheral vascular disease, myocardial infarction, and angina) complications increased with age.

Table 1. Patient Baseline Demographic and Clinical Characteristics for the Type 1 Diabetes Population

	18-44 years (n = 8,548)	45-64 years (n = 7,270)	≥65 years (n = 2,783)
	N (%) / mean (SD)	N (%) / mean (SD)	N (%) / mean (SD)
Demographics			
Male	5399 (63.2%)	4567 (62.8%)	1472 (52.9%)
Clinical Characteristics			
Mean CCI score	1.67 (1.0)	2.46 (1.5)	3.85 (2.2)
Mean aDCSI	0.69 (1.1)	1.42 (1.6)	2.72 (2.0)
Comorbidities			
Hypertension	1410 (16.5%)	3843 (52.9%)	2370 (85.2%)
Anxiety	459 (5.4%)	500 (6.9%)	162 (5.8%)
Depression	995 (11.6%)	1322 (18.2%)	494 (17.8%)
Epilepsy / seizure	217 (2.5%)	178 (2.4%)	60 (2.2%)
Autoimmune disease	1008 (11.8%)	940 (12.9%)	270 (9.7%)
Hyperlipidemia	1300 (15.2%)	2954 (40.6%)	1500 (53.9%)
Heart failure	63 (0.7%)	305 (4.2%)	566 (20.3%)
T1D-related Complications			
Retinopathy	1258 (14.7%)	2289 (31.5%)	1306 (46.9%)
Neuropathy	1049 (12.3%)	2508 (34.5%)	1387 (49.8%)
Nephropathy	677 (7.9%)	1140 (15.7%)	775 (27.8%)
Coronary artery disease	130 (1.5%)	776 (10.7%)	1046 (37.6%)
Cerebrovascular disease	78 (0.9%)	451 (6.2%)	632 (22.7%)
Peripheral vascular disease	210 (2.5%)	741 (10.2%)	576 (20.7%)
Myocardial infarction	30 (0.4%)	216 (3.0%)	268 (9.6%)
Angina	28 (0.3%)	132 (1.8%)	130 (4.7%)
Diabetes ketoacidosis	646 (7.6%)	250 (3.4%)	59 (2.1%)

aDCSI: adapted Diabetes Complication Severity Index; CCI: Charlson Comorbidity Index; SD: standard deviation; T1D: type 1 diabetes

Baseline Demographic and Clinical Characteristics for the HYPO + IP cohort

- A total of 393 (53.4%), 275 (37.4%), and 68 (9.2%) people in the HYPO + IP cohort were in the 18-44, 45-64, and ≥65 years age groups, respectively.
- Around 50% of the people were male in the three age groups.
- Similar age trend was observed for T1D severity, defined by aDCSI scores, and comorbidity burden, defined by CCI scores, in the HYPO + IP cohort (Table 2).

Table 2. Patient Baseline Demographic and Clinical Characteristics for the HYPO + IP cohort

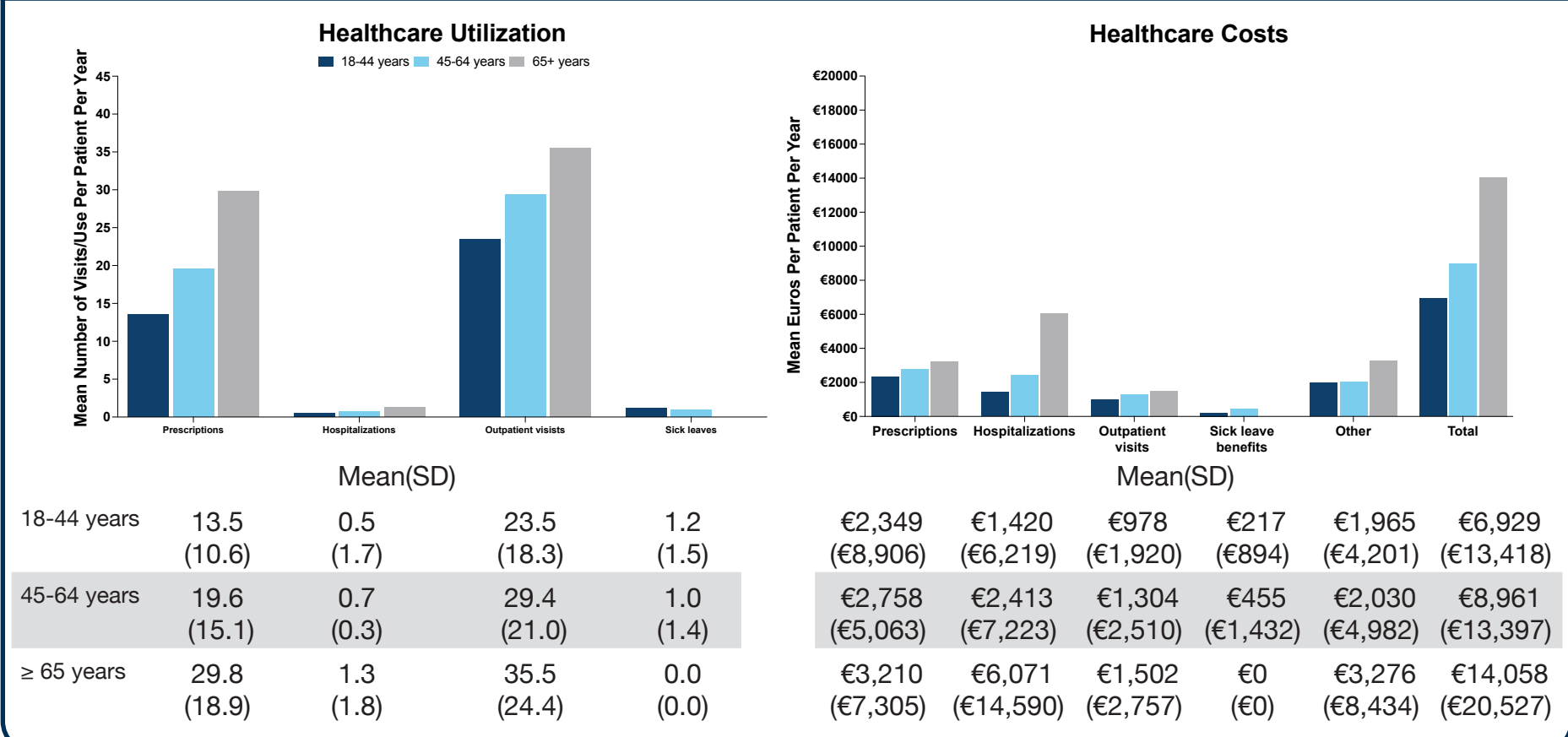
	18-44 years (n = 393)	45-64 years (n = 275)	≥65 years (n = 68)
	N (%) / mean (SD)	N (%) / mean (SD)	N (%) / mean (SD)
Demographics			
Male	205 (52.2%)	148 (53.8%)	36 (52.9%)
Clinical Characteristics			
Mean CCI score	1.87 (1.2)	2.68 (1.6)	4.19 (2.4)
Mean aDCSI	0.87 (1.3)	1.63 (1.6)	3.01 (1.9)
Comorbidities			
Hypertension	60 (15.3%)	147 (53.5%)	57 (83.8%)
Anxiety	39 (9.9%)	26 (9.5%)	9 (13.2%)
Depression	76 (19.3%)	78 (28.4%)	15 (22.1%)
Epilepsy / seizure	18 (4.6%)	7 (2.5%)	5 (7.4%)
Autoimmune disease	57 (14.5%)	52 (18.9%)	11 (16.2%)
Hyperlipidemia	59 (15.0%)	111 (40.4%)	40 (58.8%)
Heart failure	2 (0.5%)	13 (4.7%)	13 (19.1%)
T1D-related Complications			
Retinopathy	65 (16.5%)	94 (34.2%)	39 (57.4%)
Neuropathy	53 (13.5%)	124 (45.1%)	50 (73.5%)
Nephropathy	48 (12.2%)	64 (23.3%)	16 (23.5%)
Coronary artery disease	4 (1.0%)	25 (9.1%)	21 (30.9%)
Cerebrovascular disease	5 (1.3%)	23 (8.4%)	19 (27.9%)
Peripheral vascular disease	15 (3.8%)	29 (10.5%)	12 (17.6%)
Myocardial infarction	0 (0.0%)	7 (2.5%)	5 (7.4%)
Angina	2 (0.5%)	5 (1.8%)	0 (0.0%)
Diabetes ketoacidosis	49 (12.5%)	16 (5.8%)	4 (5.9%)

aDCSI: adapted Diabetes Complication Severity Index; CCI: Charlson Comorbidity Index; SD: standard deviation; HYPO + IP: severe hypoglycemia + inpatient cohort; T1D: type 1 diabetes

Healthcare Resource Utilization and Cost Outcomes for the Type 1 Diabetes Population

- The average (SD) follow-up time was 6.5 (2.7) years.
- In the T1D population, the numbers of inpatient visits, outpatient visits, and prescriptions increased with age (Figure 3).
- The mean (SD) PPPY healthcare costs are provided in Figure 3.
 - Note that the mean (SD) hospitalization costs increased drastically with age (18-44: €1,420 [€6,219], 45-64: €2,413 [€7,223], and ≥65: €6,071 [€14,590]).

Figure 3. Healthcare Resource Utilization and Cost Outcomes for the Type 1 Diabetes Population



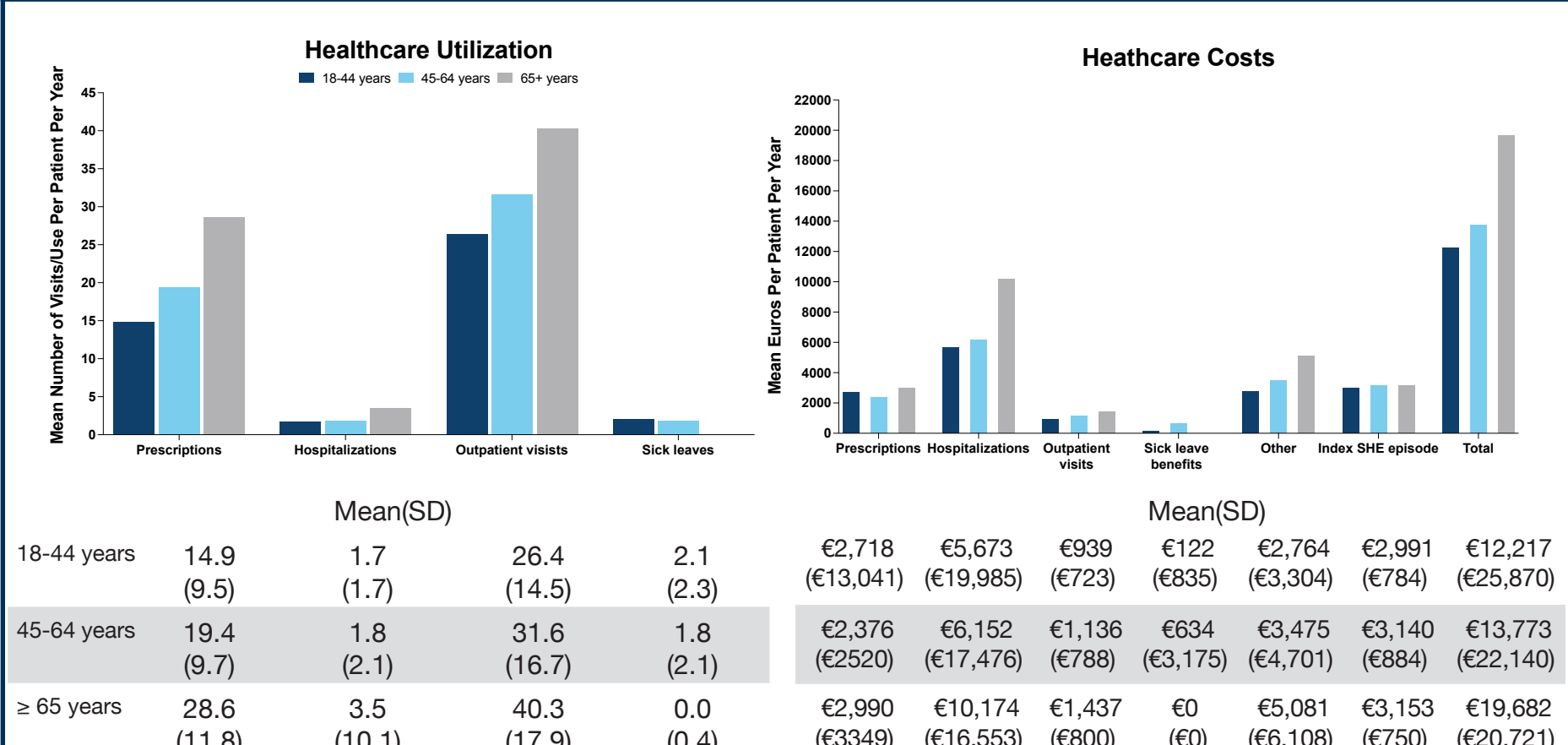
SD: standard deviation; T1D: type 1 diabetes

Note: diabetes technologies, such as continuous glucose monitors, insulin pumps, and hybrid closed-loop systems, are not available in the data and thus not included.

Healthcare Resource Utilization and Cost Outcomes for the HYPO + IP cohort

- During follow up, hospitalizations, outpatient visits, and pharmacy prescriptions were more frequent with increasing age.
- As a result, the PPPY mean (SD) total healthcare costs increased with age (Figure 4).
 - The main driver of the total healthcare costs was hospitalizations.
- Note that the costs for index SHE were similar in all age groups (Figure 4).

Figure 4. Healthcare Resource Utilization and Cost Outcomes for the HYPO + IP cohort



HYPO + IP: severe hypoglycemia + inpatient cohort; SD: standard deviation; SHE: severe hypoglycemic event

Note: diabetes technologies, such as continuous glucose monitors, insulin pumps, and hybrid closed-loop systems, are not available in the data and thus not included.

Limitations

- This study is subject to inherent limitations of retrospective observational studies involving administrative healthcare data
- Possible misclassification of T1D and T2D has been a main challenge in research using claims data. In differentiating T1D and T2D, our study developed a robust algorithm based on published articles.
- It was estimated that only 8.6% of SHE in T1D were treated in the hospital, 23.6% by medical professionals, while majority (67.8%) were family-treated.⁵ In this study, SHE was restricted to the inpatient setting, i.e., the most severe type of hypoglycemia.
- T1D disease duration, quality of diabetes control (e.g., HbA1c), and use of diabetes technologies are not available in the data.

CONCLUSIONS

- This study showed descriptively that adults with T1D living in Germany have high burden of HCRU and costs that increase with age.**
 - Those with T1D and severe hypoglycemia have higher burden of HCRU and costs that increase with age.**
- The results indicated that optimization in disease management and novel interventions are warranted for people with T1D, especially for those with severe hypoglycemia, to avoid later life complications.**

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Author Disclosures

CV is a consultant to NIMH and NIH, an employee of IQVIA Germany, and has received honoraria from CUNY and Gutenberg University of Mainz. EGP is an employee of Team Gesundheit GmbH. RZ has served on advisory boards, received honoraria, and travel expenses from Abbott, Dexcom, Lilly, MySugr, Medtronic, Novo Nordisk, Roche Diabetes Care, Sanofi, VitalAire/Tandem, Vertex, and Ypsomed. WR has received honoraria from Novo Nordisk. QZ, PK, AD, and LC are employees of Vertex Pharmaceuticals Incorporated and may own stock/stock options in the company

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