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Socio-economic disparities in hospital care among Dutch patients with diabetes mellitus

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Abstract

Aim: Socio-economic status (SES) influences diabetes onset, progression and treatment. In this study, the associations between SES and use of hospital care were assessed, focusing on hospitalizations, technology and cardiovascular complications.

Materials and Methods: This was an observational cohort study comprising 196 695 patients with diabetes (all types and ages) treated in 65 hospitals across the Netherlands from 2019 to 2020 using reimbursement data. Patients were stratified in low, middle, or high SES based on residential areas derived from four-digit zip codes.

Results: Children and adults with low SES were hospitalized more often than patients with middle or high SES (children: 22%, 19% and 15%, respectively; $p < .001$, adults: 28%, 25% and 23%; $p < .001$). Patients with low SES used the least technology: no technology in 48% of children with low SES versus 40% with middle SES and 38% with high SES. In children, continuous subcutaneous insulin infusion (CSII) and real-time continuous glucose monitoring (rtCGM) use was higher in high SES {CSII: odds ratio (OR) 1.54 [95% confidence interval (CI) 1.35-1.76]; $p < .001$; rtCGM OR 1.39 [95% CI 1.20-1.61]; $p < .001$} and middle SES [CSII: OR 1.41 (95% CI 1.24-1.62); $p < .001$; rtCGM: OR 1.27 (95% CI 1.09-1.47); $p = .002$] compared with low SES. Macrovascular (OR 0.78 (95% CI 0.75-0.80); $p < .001$) and microvascular complications [OR 0.95 (95% CI 0.93-0.98); $p < .001$] occurred less in high than in low SES.

Conclusions: Socio-economic disparities were observed in patients with diabetes treated in Dutch hospitals, where basic health care is covered. Patients with low SES were hospitalized more often, used less technology, and adults with high SES showed fewer cardiovascular complications. These inequities warrant attention to guarantee equal outcomes for all.

KEYWORDS

cardiovascular disease, continuous glucose monitoring (CGM), CSII, diabetes complications, population study, real-world evidence

1 | INTRODUCTION

The global prevalence of diabetes mellitus has been perpetually rising during the last decades and this is expected to continue in the years to come. In 2021, an estimated 529 million people were living with diabetes worldwide, with a staggering $966 billion in estimated health care costs, making diabetes one of modern day's prominent health care challenges.[1,2] This results in ongoing pressure on health care systems and affects the distribution of limited health care resources. In both type 1 and type 2 diabetes mellitus, chronically elevated blood glucose levels significantly increase cardiovascular risk and reduce life expectancy. Therefore, optimal and personalized treatment of diabetes and modifiable cardiovascular risk factors is the cornerstone of contemporary diabetes care.[3,4]

Within diabetes care, health inequities are present between individuals from different environments, backgrounds and communities.[5] An important determinant is socio-economic status (SES), a multidimensional construct that includes social determinants of health such as education, occupation and economic status.[5] Evidence has been accumulating that low SES negatively affects the onset, progression and treatment outcomes of patients with diabetes. These findings stress that optimal diabetes treatment also entails effectively addressing SES-specific issues and warrants strategies to reduce the health inequities resulting from SES differences.

Among adults, the majority of patients worldwide are diagnosed with type 2 diabetes. In this patient group, SES inequity commences before the first stages of the disease, as SES is known to influence the prevalence of diabetes.[6] During their disease, patients with lower SES also more often face complications and a reduced life expectancy compared with their counterparts with a higher SES.[7,8] Focusing on type 1 diabetes, SES influences glycaemic control in both children and adults.[9,10] Use of diabetes technology, such as continuous subcutaneous insulin infusion (CSII) and continuous glucose monitoring (CGM), is, apart from reimbursement policies, also influenced by SES-related factors at all ages.[9,11–14] Targets for cardiometabolic risk factors are less often met, and life expectancy and years spent without complications are lower than in those living without diabetes.[15,16] In the Netherlands, most studies related to SES and diabetes focus on type 2 diabetes. It is known that people with diabetes more often have low SES than high SES.[17] Low SES in early life is linked to a higher risk of prediabetes and type 2 diabetes.[18] Individuals with low SES are at higher risk of undiagnosed type 2 diabetes and related complications.[19] The Dutch health care system provides equal access to health care for all patients, including primary care and different hospital care settings or clinics. To our knowledge, it is not known how resource use and hospital care are affected by SES in patients with diabetes of all ages in a nationwide study population.

We aimed to study the association between SES and hospital resource use in patients of all ages treated for diabetes in hospitals across the Netherlands using real-world reimbursement data.

2 | MATERIALS AND METHODS

2.1 | Study setting

This population-based, retrospective cohort study was conducted on administrative hospital data of patients with diabetes mellitus treated in hospitals across the Netherlands. In the Netherlands, basic health care insurance is mandatory for all citizens, and generally all hospital expenses, including diabetes care are reimbursed by insurance companies. Insurance companies are private institutions in a well-regulated system, with an obligation to accept all patients for equal fee and coverage, regardless of age, patient characteristics, medical history or employment. Hospitals are reimbursed for care provision through a national coding system called Diagnosis Treatment Combination (DBC) codes, which contain information on care characteristics such as medical specialty, diagnosis and treatment care activities. These DBCs are registered during both the inpatient and outpatient clinical care process of each patient, and information is stored per hospital to facilitate reimbursement. For this study, a dataset with routinely collected diabetes-related data from affiliated hospitals was obtained from a benchmark database serviced by LOGEX. The data source has been described in more detail before.[20] Data were deidentified before use and, therefore, not traceable to individual patients. Under Dutch law and regulations, the use of non-identifiable data is allowed for research purposes without ethical approval or informed consent. The analysis entailed 65 secondary and tertiary care hospitals (~88% of diabetes treating hospitals) and did not include primary care or independent diabetes treatment centres because of lack of affiliation with LOGEX. Independent treatment clinics treat an estimated 22% of all Dutch children with type 1 diabetes with a similar distribution in SES scores to hospitals, whereas the percentage of adults treated is estimated to be <1.5%. All children with diabetes in the Netherlands are treated in hospitals or diabetes treatment centres. Adults treated in hospitals either have type 1 diabetes, more complex type 2 diabetes, or comorbidity.

2.2 | Study population

Patients of all ages with a registered DBC claim for diabetes or diabetes-related morbidity from 1 January 2019 to 31 December 2019, were included. Each patient had a follow-up duration of 365 days after DBC registration, the end of the follow-up period being 31 December 2020. Diabetes DBC claims in the following six medical specialties were included: (a) paediatrics, (b) internal medicine, (c) ophthalmology, (d) gastroenterology, (e) surgery or (f) orthopaedics (diagnosis codes in Supporting Information). Patients who frequented more than one department were recorded for each medical specialty visited. Ophthalmology comprised retinopathy diagnoses, and surgery/orthopaedics diabetic foot diagnosis. Because of small patient numbers and similar care provision, gastroenterology (n = 36, <0.1%) was combined with internal medicine, and orthopaedics (n = 441, <1.0%) with surgery. A diabetes DBC code encompasses all diabetes

types, including type 1, type 2 and secondary diabetes, and does not distinguish between the various types. SES scores were derived from the Netherlands Institute for Social Research and were previously linked in the benchmark database with an individual's four-digit zip code. During the study period, the Netherlands Institute for Social Research was responsible for calculations of SES scores of the Dutch population.[21,22] The scores were previously ranked per zip code and divided in tertiles categorizing them into low, middle and high. The SES neighbourhood scores are derived from the average household income in a zip-code area, the percentage of individuals with low income, low levels of education or unemployed individuals. Therefore, this SES measure is a combined income, education and employment score. These SES scores are often used in health inequality studies from the Netherlands.[23,24] Information on sex, 5-year age categories and the hospital where the patient received treatment were also obtained.

2.3 | Outcome measures

All-cause hospitalization and technology use were primary outcomes related to hospital care utilization. Technology use consisted of CSII and real-time CGM (rtCGM); patients were classified as users of technology when ≥1 related health care activity of either CSII or rtCGM was registered. Flash glucose monitoring is not included in hospital reimbursement data. Hospital admissions were reported as absolute numbers and did not include emergency department visits. Hospitalization rates were calculated per 100 person-years by dividing the sum of hospitalizations by the number of patients per SES category and multiplying by 100, as all patients had a year of follow-up. Other outcome measures were complications, comorbidities and treatments (diagnosis and treatment activity codes in Supporting Information) related to all inpatient and outpatient visits. Cardiovascular complications were categorized into microvascular and macrovascular complications. Microvascular complications comprised nephropathy, retinopathy, neuropathy and diabetic foot diagnoses. Related microvascular treatments were dialysis, intravitreal injections and intra-ocular laser treatment. Macrovascular complications included acute coronary syndrome, heart failure, peripheral arterial disease and cerebrovascular accidents, i.e. haemorrhagic and ischaemic stroke. Related macrovascular treatments were coronary artery bypass grafting, percutaneous coronary intervention, percutaneous transluminal angioplasty, limb or digit amputations, and neurological thrombolysis or thrombectomy. Other comorbidities comprised obesity, hypertension, hypothyroidism, and anxiety or depression.

2.4 | Statistical analysis

Patient characteristics were reported for children (<18 years old) and for adults (≥18 years old) by SES categories. Categorical data were reported as frequencies and proportions, and continuous variables as median with range. Patients with no available SES score (n = 2619, 1.3%) were excluded from analyses. The SES score was unknown in the case of a missing zip code because of the absence of permanent Dutch residency. The remaining data only comprised complete and accurate claims; therefore, no missing data was present in the other variables. Differences between SES categories were tested using chi-squared tests, Fisher's exact test or Kruskal-Wallis, depending on the type of outcome. Multivariable logistic regression was used to study the associations between SES and resource use parameters with low SES as a reference, in children and adults separately, with adjustment for age categories (children: age 1-5, 6-10, 11-15, 16-17; adults: 18-40, 41-60, 61-80, >80) and for sex. Analyses for complications were only conducted in adults because of the low occurrence of complications in childhood. Sensitivity analysis using a mixed model with a random intercept for hospital did not change any of the modelled outcomes. Odds ratios (OR) and 95% confidence intervals (CIs) were graphically shown in forest plots. Statistical significance was defined as a two-sided *p*-value <.05. All analyses were conducted in R Statistical Software (v4.2.1; R Core Team 2021).

3 | RESULTS

3.1 | Study population

In total, 196 695 patients with diabetes were included from 65 hospitals across the Netherlands. Overall, the SES was classified as low in 74 754 patients (38%), middle in 66 575 patients (34%) and high in 55 366 patients (28%). Between 2019 and 2020, a total of 5454 children and 191 241 adults received in-hospital care for diabetes and diabetes-related morbidity. SES distribution varied across different hospital departments treating patients with diabetes (Figure 1). The surgery department (n = 7700), where patients received diabetes foot care, recorded the largest percentage of individuals with low SES (42%). In internal medicine (n = 118 881) and ophthalmology (n = 99 542), low SES was also most frequently found (38%), whereas the paediatrics department (6536) showed a slight predominance of patients with high SES (35%) versus middle and low SES (65%). Young children of 1-5 years old more often had low SES (8% versus 6% in middle SES and 5% in high SES), whereas adolescents and adults in younger age categories more often had high SES (Table 1). The

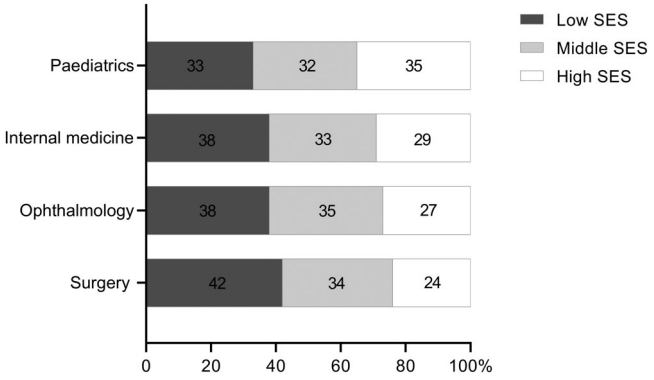

FIGURE 1 Socio-economic status (SES) categories by medical specialty in Dutch outpatients treated for diabetes in percentages (n = 196 695).

TABLE 1 Characteristics of children (n = 5454) and adults (n = 191 241) with diabetes by socio-economic status.

	Low	Middle	High	*p*-Value[a]
Patients <18 years (%)	1811 (33)	1735 (32)	1908 (35)	
Age (years)				
0	2 (0)	4 (0)	0 (0)	.008
1-5	136 (8)	101 (6)	99 (5)	
6-10	383 (21)	332 (19)	397 (21)	
11-15	834 (46)	821 (47)	862 (45)	
16-17	456 (25)	477 (28)	550 (29)	
Sex				
Male	918 (51)	894 (52)	1026 (54)	.149
Female	893 (49)	841 (49)	882 (46)	
Care characteristics				
Hospitalized patients (%)	398 (22)	323 (19)	282 (15)	<.001
1 hospitalization	324 (18)	259 (15)	232 (12)	<.001
≥2 hospitalizations	74 (4)	64 (4)	50 (3)	.040
Hospitalization rate (per 100PY)	28.1	24.2	18.9	<.001
Number of visits paediatrician	7 [0, 30]	7 [0, 34]	7 [0, 45]	.720
Paediatrician visit (≥1)	1736 (96)	1647 (95)	1821 (95)	.415
Number of visits, internal medicine	0 [0, 8]	0 [0, 18]	0 [0, 13]	.185
Internal medicine visit (≥1)	72 (4)	82 (5)	68 (4)	.201
Ophthalmology visit (≥1)	690 (38)	717 (41)	690 (36)	.006
Diabetes technology				
Patients with CSII (%)	906 (50)	1006 (58)	1147 (60)	<.001
Patients with rtCGM (%)	476 (26)	520 (30)	609 (32)	.001
Patients ≥18 years (%)	72 943 (38)	64 840 (34)	53 458 (28)	
Age (years)				
18-40	7672 (11)	6809 (11)	6280 (12)	<.001
41-60	19 852 (27)	17 121 (26)	15 213 (29)	
61-80	18 132 (25)	15 781 (24)	13 071 (25)	
>80 years old	27 287 (37)	25 129 (39)	18 894 (35)	
Sex				
Male	38 248 (52)	35 036 (54)	29 589 (55)	<.001
Female	34 695 (48)	29 804 (46)	23 869 (45)	
Care characteristics				
Hospitalized patients (%)	20 296 (28)	16 386 (25)	12 191 (23)	<.001
1 hospitalization	11 861 (16)	9782 (15)	7406 (14)	<.001
≥2 hospitalizations	8435 (12)	6604 (10)	4785 (9)	<.001
Hospitalization rate (per 100PY)	51.9	46.0	41.2	<.001
Internal medicine visit (≥1)	50 897 (70)	43 776 (68)	36 955 (69)	<.001
Number of visits, internal medicine	2 [0, 106]	2 [0, 155]	3 [0, 105]	<.001
Ophthalmology visit (≥1)	48 864 (67)	44 107 (68)	34 457 (65)	<.001
Surgery visit (≥1)	17 162 (24)	14 223 (22)	11 034 (21)	<.001
Cardiology visit (≥1)	18 892 (26)	15 548 (24)	11 357 (21)	<.001
Diabetes technology				
Patients with CSII (%)	2676 (4)	3257 (5)	3395 (6)	<.001
Patients with rtCGM (%)	2537 (4)	2910 (5)	3181 (6)	<.001

Note: Presented as absolute numbers with percentages, mean with SD or median with [range].
Abbreviations: CSII, continuous subcutaneous insulin infusion; PY, person-years; rtCGM, real-time continuous glucose monitoring.
[a]Differences were tested between socio-economic status categories.

number of paediatrician visits in a year did not differ significantly per SES category ($p = 0.415$). In adults, the number of visits to internal medicine was significantly higher in high SES, with a median of 3 versus 2 ($p < .001$). The percentage of included patients with diabetes with at least one cardiology visit was significantly higher in low SES (26% vs. 21% in high SES, $p < .001$).

3.2 | Hospitalizations

In children, the hospitalization rate was the highest in low SES with 28.1 per 100 person-years (PY) and lowest in high SES with 18.9/100PY ($p < .001$). After adjusting for sex and age, the OR for all-cause hospitalization was 0.63 (95% CI 0.54-0.75; $p < .001$) in high SES and 0.83 (95% CI 0.70-0.98; $p = 0.025$) in middle SES versus low SES, as shown in Figure 4A (details and crude ORs in Table S1). In adults, the number of hospitalized patients was highest in low SES (28%), with the highest hospitalization rate of 51.9/100PY in low SES versus 46.0 and 41.2/100PY in middle and high SES, respectively ($p < .001$). The adjusted OR (aOR) for hospitalization was 0.77 (95% CI 0.75-0.80; $p < .001$) in high SES and 0.86 (95% CI 0.84-0.89; $p < .001$) in middle SES versus low SES (Figure 4B).

3.3 | Technology use

Children with low SES most often used no technology (48%) and had the lowest percentage of CSII use alone (26%) or combined with rtCGM (24%), as shown in Figure 2A. Crude and aOR for technology use were higher in middle and high SES when compared with low SES (Figure 4A, Table S2), for both CSII [middle SES: OR 1.38 (95% CI 1.21-1.58); aOR 1.41 (95% CI 1.24-1.62); $p < .001$; high SES: OR 1.50 (95% CI 1.32-1.71); aOR 1.54 (95% CI 1.35-1.76); $p < .001$] and rtCGM use [middle SES: OR 1.20 (95% CI 1.04-1.39); aOR 1.27 (95% CI 1.09-1.47); $p = .002$; high SES: OR 1.32 (95% CI 1.14-1.52); aOR 1.39 (95% CI 1.20-1.61); $p < .001$]. In adults (Figure 2B), total technology use was lower (6%) in low SES than in high SES (10%), and the use of CSII, rtCGM or combined was lowest in low SES (2% in each category) and highest in high SES (CSII 4%, rtCGM or combined 3%). Adults with middle or high SES also had a higher OR for CSII use [middle SES: OR 1.39 (95% CI 1.32-1.46); aOR 1.44 (95% CI 1.37-1.52); $p < .001$; high SES: OR 1.78 (95% CI 1.69-1.88); aOR 1.75 (95% CI 1.66-1.85); $p < .001$] or rtCGM [middle SES: OR 1.30 (95% CI 1.24-1.38); aOR 1.35 (95% CI 1.27-1.42); $p < .001$; high SES: OR 1.76 (95% CI 1.66-1.85); aOR 1.72 (95% CI 1.63-1.82); $p < .001$].

3.4 | Vascular complications

Adult patients with low SES had no cardiovascular complications least often during follow-up (57% vs. 60% in middle SES and 64% in high SES; Figure 3). Both microvascular and macrovascular complications were most common in low SES (7% vs. 6% in middle SES and 5% in low SES). The OR for microvascular and macrovascular complications was lower for middle and high SES when adjusted for sex and age [-Figure 4B; microvascular: middle SES aOR 0.90 (95% CI 0.88-0.92); $p < .001$ and high SES aOR 0.78 (95% CI 0.76-0.80); $p < .001$; macrovascular: middle SES aOR 0.86 (95% CI 0.83-0.89); $p < .001$ and high SES aOR 0.77 (95% CI 0.75-0.80); $p < .001$]. The aOR for any vascular complication was 0.88 [(95% CI 0.86-0.90); $p < .001$] in middle SES and aOR 0.76 [(95% CI 0.74-0.78); $p < .001$] in high SES compared with low SES (details and crude ORs in Table S3). Almost all

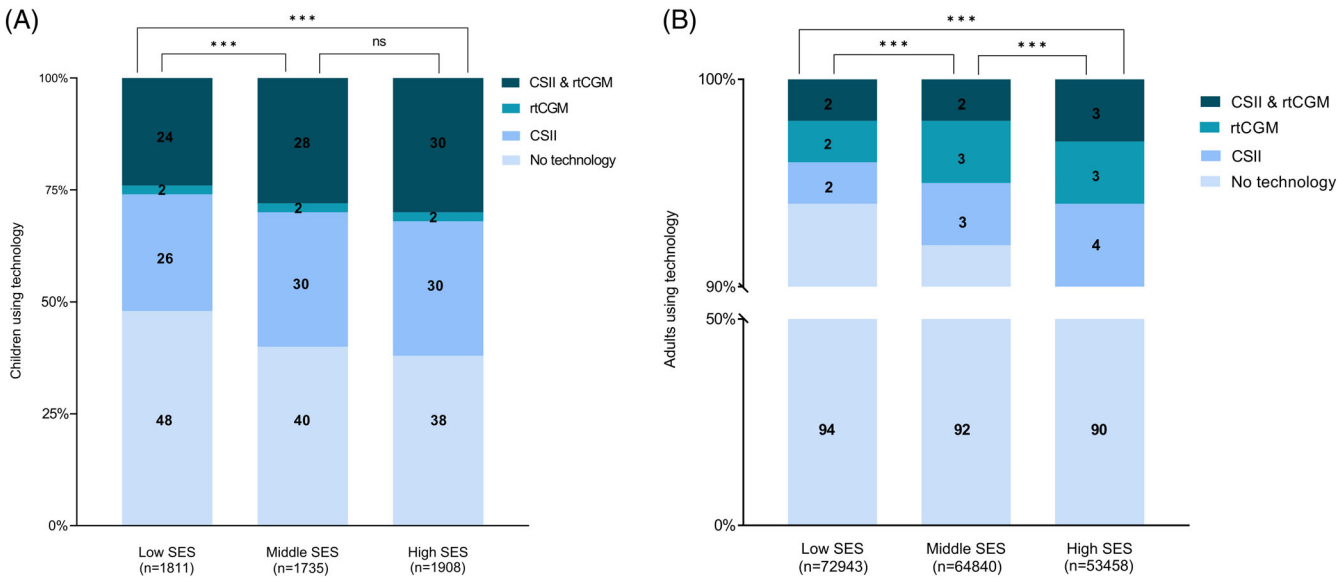

FIGURE 2 (A) Technology use in children by SES. (B) Technology use in adults by SES. † Flash glucose monitoring not included. Numbers in the bars are stated as percentages. ns, not significant, ***$p < .001$. CSII, continuous subcutaneous insulin infusion; rtCGM, real-time continuous glucose monitoring; SES, socio-economic status.

microvascular and macrovascular complications and related treatments were more common in low SES. Nephropathy, retinopathy and heart failure all had a >1% significant difference between low and high SES (Table S4, outcomes for hospitalized patients only in Table S5).

3.5 | Sex

Sex was a significant covariate in several outcomes. In children, the OR for CSII use was higher in females (aOR 1.1; $p = 0.017$); in rtCGM, the difference was not significant. Among adults, both CSII and rtCGM were more often used in females [CSII: aOR 1.57 (95% CI 1.51-1.64), $p < .001$; rtCGM: aOR 1.54 (95% CI 1.48-1.62), $p < .001$]. In addition, a small but significant difference was observed with fewer hospitalizations in females [aOR 0.96 (95% CI 0.94-0.98); $p < .001$]. The OR for macrovascular [aOR 0.67 (95% CI 0.66-0.70); $p < .001$] and microvascular complications [aOR 0.81 (95% CI 0.80-0.83); $p < .001$] was lower in females than in males.

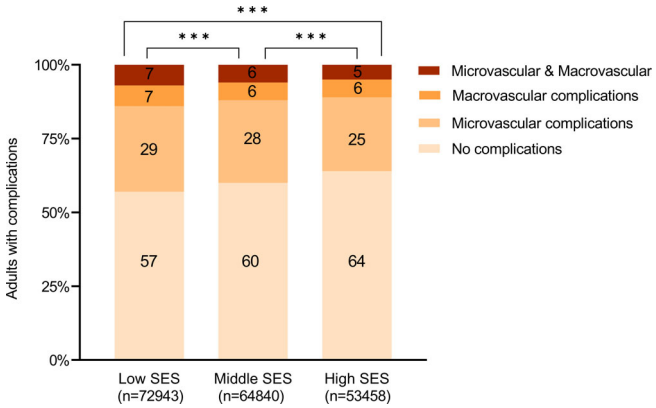

FIGURE 3 Macrovascular and microvascular complications in adult patients by socio-economic status (SES). † Numbers in the bars are stated as percentages. ***$p < .001$.

4 | DISCUSSION

This nationwide study used real-world reimbursement data of 196 695 paediatric and adult patients with all types of diabetes treated in hospitals across the Netherlands between 2019 and 2020; we found disparities in hospitalizations, diabetes technology use and cardiovascular complications across different SES categories among all ages. Hospitalization rates were highest in low SES and lowest in high SES in children and adults. Similarly, CSII and rtCGM use were lowest in low SES, particularly in children, with a 10% difference in technology users compared with high SES. The presence of macrovascular, microvascular, or any vascular complications was significantly lower in the middle and high SES group.

Our findings are in concordance with several other studies in various countries and settings. In children, studies from the United States and Germany have found lower CGM use in patients with low SES.[9] In Germany, the association of CGM with area deprivation was present in 2016 but was no longer significant in 2019.[25] In the United States, a difference in CSII use was observed in multiple studies, whereas there was a non-linear association in CSII use in Germany between area deprivation quintiles.[9,25–27] Similar to our findings, girls

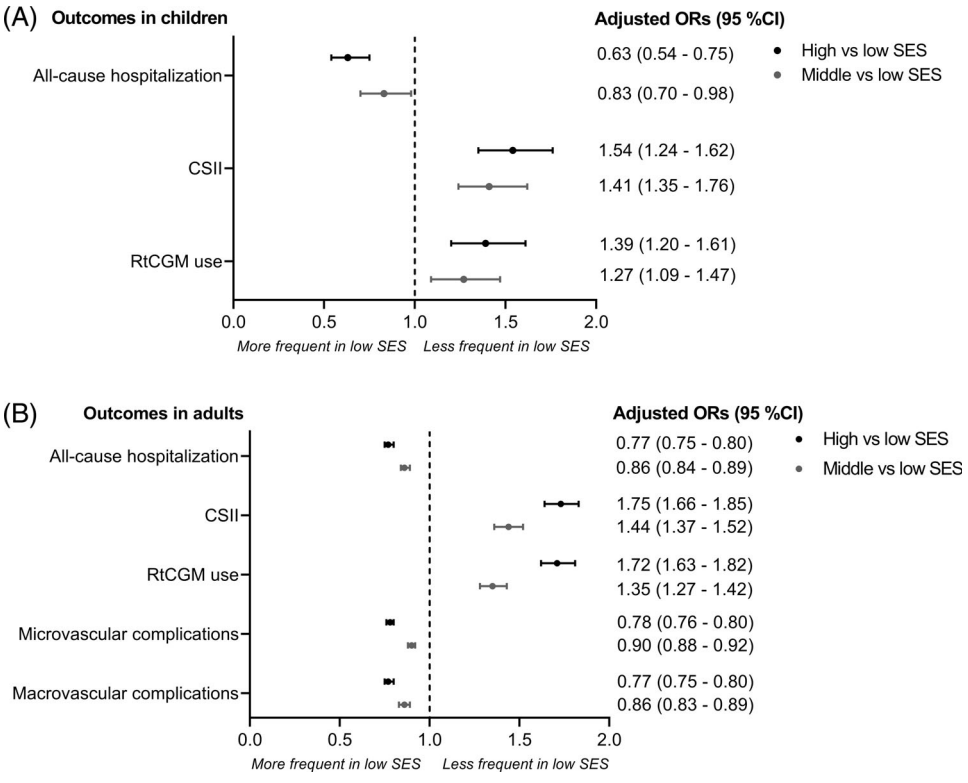

FIGURE 4 (A) Forest plot for diabetes care outcomes in children by SES. (B) Forest plot for diabetes care outcomes in adults by SES. OR are corrected for sex and age, using low SES as reference. *p*-Values and crude OR with CIs are stated in Tables S1-S3. CI, confidence interval; CSII, continuous subcutaneous insulin infusion; OR, odds ratio; rtCGM, real-time continuous glucose monitoring; SES, socio-economic status.

in Germany more often used CSII, and this was not significant for CGM use.[25] Sex differences in paediatric diabetes care, specifically in pump use and hospitalizations, have been reported in previous studies.[28] Concerning hospitalizations in children, it is plausible that a large share of the hospitalizations are diabetes-related as children tend to have fewer comorbidities. A study from the German DPV registry found a higher risk for hospitalizations in children with low SES-related social parameters such as parental education and migration background.[29] Similarly, associations between SES and diabetic ketoacidosis, glycaemic control and hypoglycaemia have previously been described.[30] Regarding adults, recent studies from the USA have reported lower CSII and CGM use in patients of all ages with lower SES or less generous insurance.[13,14,31] In New Zealand lower SES was also associated with lower CSII use in patients of all ages.[12] Moreover, a study from the United Kingdom evaluated the use of diabetes technology in adults and found less frequent use in participants from the most deprived neighbourhoods.[11] Comparing hospitalization patterns in adults is less straightforward, as this may also be related to the occurrence of complications or may be unrelated to diabetes, particularly among the elder age categories. However, other studies have also observed higher rates of hospitalizations for diabetic ketoacidosis or hyperglycaemic hyperosmolar state and severe hypoglycaemia in adults depending on area-level deprivation.[32] Other studies have also observed increased occurrence of cardiovascular complications in patients with diabetes with low SES. A study with nationwide data from Denmark in patients with type 2 diabetes found a higher 5-year risk of first-time major adverse cardiovascular events.[7] A systematic review on adults with type 1 diabetes found multiple studies with significant associations between SES and cardiovascular disease or events, such as renal disease, proliferative retinopathy, peripheral arterial disease and neuropathy.[10]

Future studies should further delve into these differences in the use of hospital care and how they are associated with clinical outcomes of patients with diabetes across SES categories, for example, with data from the Dutch Paediatric and Adult Registry of Diabetes (DPARD).[33] It is known from observational studies that SES influences clinical outcomes such as glycaemic control in type 1 diabetes.[10,30] In addition, a recent study has shown that CSII and rtCGM, mediate the association between SES and glycaemic control. Therefore, glycaemic outcomes may improve because of better access to diabetes technology, particularly in patients with low SES.[34] These results warrant strategies to improve equal access to technology for all patients. The complexity of reimbursement conditions, the additional time and hospital visits needed to start a new therapy form, and potential direct and indirect costs outside of insurance coverage may unequally affect patients from lower socio-economic backgrounds. Barriers may be limited in this patient group by targeted education to increase knowledge on diabetes self-management and reimbursement conditions, universal insurance coverage, or subsidiaries to cover unexpected costs. Another factor may be unconscious provider bias regarding the suitability of diabetes technology for a patient, circumstances, or potential language barriers, which requires awareness and time investment of diabetes teams. Moreover, the increased occurrence of cardiovascular complications in adults with low SES underscores the importance of SES-sensitive strategies to optimize specifically the treatment of cardiometabolic risk factors in lower SES individuals with diabetes. Improving targets for traditional cardiometabolic risk factors, such as glycated haemoglobin, body mass index, blood pressure, lipids and estimated glomerular filtration rate in type 2 diabetes, have been shown to reduce cardiovascular disease risk significantly to a level that equals control subjects without diabetes.[3] Screening and treatment of risk factors are generally performed according to guidelines, but additional guidance and education may help patients who repeatedly do not meet target levels. Consequently, when glycaemic control and technology access is improved, and cardiovascular complications are targeted, this may also lead to a lower hospitalization burden in patients with low SES.

Our study has several limitations. Because of the administrative nature of the data, no clinical information was available on diabetes type, glycaemic control, or unmeasured lifestyle-related confounders such as smoking and body mass index. In particular, the adult patient group is expected to have a larger proportion of type 2 diabetes, with an anticipated higher prevalence of low SES. Our findings indicate the presence of disparities in diabetes hospital care, yet do not show the implications on clinical outcomes, and show that linkage of clinical data to administrative data could be of great value. In addition, flash glucose monitoring is not structurally registered in Dutch reimbursement data and therefore there may be misclassification bias of flash glucose monitoring users in the no technology group. Because the data were limited to a year of follow-up, the presence of vascular complications is cross-sectional and only partially provides information on the medical history of a patient. The COVID-19 pandemic may also have influenced care patterns during follow-up. Moreover, registration errors could not be omitted. Regarding SES, the heterogeneity in SES determinants may hinder comparison with previous literature. Moreover, the possibility of ecological fallacy should be considered, indicating that outcomes of aggregated data do not necessarily translate well to individuals that are part of the population data. Finally, a SES score of a residential area may oversimplify the complex dimensions and interactions present within the construct SES and does not consider the variation of these factors within a residential area. However, to our knowledge, this study was the first in the Netherlands to evaluate SES and its association with hospital resource use in a large population of all ages and diabetes types. The results comprised all patients with diabetes in a hospital setting, which increases the generalizability to similar settings in other high-income countries. The population of all ages helps to create a total overview of SES in patients with diabetes treated in hospitals, whereas stratification in children and adults helps to interpret the outcomes in these clinically distinct patient groups. It was also the first study to assess diabetes technology use and its association with SES among Dutch patients. Moreover, area-level SES indices are commonly used and often most feasible and complete in population-based or registry data, and therefore increase comparability with other studies.

5 | CONCLUSIONS

Significant health inequities are present in diabetes care for patients treated in Dutch hospitals, regardless of a health care system with universal medical care coverage. Patients with low SES have an unfavourable diabetes care profile, encompassing more hospitalizations and less technology use. In addition, they more often have macrovascular and microvascular complications. These disparities warrant specific attention, specifically in children, to guarantee equality in diabetes-related outcomes later in life.

AUTHOR CONTRIBUTIONS

SAGdV, TCJS and CLV contributed to the conception and design of the study. JCGB and and CLV were involved in the acquisition of data. SAGdV performed the analysis. SAGdV, TCJS, CLV, DM and JCGB interpreted the data. SAGdV wrote the manuscript and all authors reviewed, revised and approved the final manuscript. MWJMW and MN advised on time-lines and supervised the work.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest relevant to this work.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/dom.15440.

DATA AVAILABILITY STATEMENT

The dataset that supports the findings of this study is not available due to the sensitive nature (licence restrictions, privacy regulations and commercial reasons) of the data. The dataset used is available only to other researchers, based on valid and reasonable requests and with permission granted by hospitals participating in the benchmark and LOGEX.

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REFERENCES

1. Ong KL, Stafford LK, McLaughlin SA, et al. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the global burden of disease study 2021. *Lancet*. 2023;402(10397):203-234. doi:10.1016/s0140-6736(23)01301-6
2. Sun H, Saeedi P, Karuranga S, et al. IDF diabetes atlas: global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract*. 2022;183:109119. doi:10.1016/j.diabres.2021.109119
3. Sattar N, McMurray J, Borén J, et al. Twenty years of cardiovascular complications and risk factors in patients with type 2 diabetes: a Nationwide Swedish cohort study. *Circulation*. 2023;147(25):1872-1886. doi:10.1161/CIRCULATIONAHA.122.063374
4. Rawshani A, Rawshani A, Sattar N, et al. Relative prognostic importance and optimal levels of risk factors for mortality and cardiovascular outcomes in type 1 diabetes mellitus. *Circulation*. 2019;139(16):1900-1912. doi:10.1161/CIRCULATIONAHA.118.037454
5. Hill-Briggs F, Adler NE, Berkowitz SA, et al. Social determinants of health and diabetes: a scientific review. *Diabetes Care*. 2021;44(1):258-279. doi:10.2337/dci20-0053
6. Cromer SJ, Lakhani CM, Mercader JM, et al. Association and interaction of genetics and area-level socioeconomic factors on the prevalence of type 2 diabetes and obesity. *Diabetes Care*. 2023;46(5):944-952. doi:10.2337/dc22-1954
7. Falkentoft AC, Zareini B, Andersen J, et al. Socioeconomic position and first-time major cardiovascular event in patients with type 2 diabetes: a Danish nationwide cohort study. *Eur J Prev Cardiol*. 2021;28(16):1819-1828. doi:10.1093/eurjpc/zwab065
8. Ling S, Zaccardi F, Issa E, Davies MJ, Khunti K, Brown K. Inequalities in cancer mortality trends in people with type 2 diabetes: 20 year population-based study in England. *Diabetologia*. 2023;66(4):657-673. doi:10.1007/s00125-022-05854-8
9. Addala A, Auzanneau M, Miller K, et al. A decade of disparities in diabetes technology use and HBA1c in pediatric type 1 diabetes: a transatlantic comparison. *Diabetes Care*. 2021;44(1):133-140. doi:10.2337/dc20-0257
10. Scott A, Chambers D, Goyder E, O'Cathain A. Socioeconomic inequalities in mortality, morbidity and diabetes management for adults with type 1 diabetes: a systematic review. *PloS One*. 2017;12(5):1-19. doi:10.1371/journal.pone.0177210
11. Fallon C, Jones E, Oliver N, Reddy M, Avari P. The impact of socioeconomic deprivation on access to diabetes technology in adults with type 1 diabetes. *Diabet Med*. 2022;39(10):e14906. doi:10.1111/dme.14906
12. McKergow E, Parkin L, Barson DJ, Sharples KJ, Wheeler BJ. Demographic and regional disparities in insulin pump utilization in a setting of universal funding: a New Zealand nationwide study. *Acta Diabetol*. 2017;54(1):63-71. doi:10.1007/s00592-016-0912-7
13. Bailey R, Donthi S, Markt S, Drummond C, Cullen J. Evaluating factors associated with continuous glucose monitoring utilization with the type 1 diabetes exchange registry. *J Diabetes Sci Technol*. 2022;17:1580-1589. doi:10.1177/19322968221091299
14. Everett EM, Wright D, Williams A, et al. A longitudinal view of disparities in insulin pump use among youth with type 1 diabetes: the SEARCH for diabetes in youth study. *Diabetes Technol Ther*. 2023;25(2):131-139. doi:10.1089/dia.2022.0340
15. Griggs S, Al-Kindi S, Hardin H, et al. Socioeconomic deprivation and cardiometabolic risk factors in individuals with type 1 diabetes: T1D exchange clinic registry. *Diabetes Res Clin Pract*. 2022;2023(195):110198. doi:10.1016/j.diabres.2022.110198
16. Höhn A, McGurnaghan SJ, Caparrotta TM, et al. Large socioeconomic gap in period life expectancy and life years spent with complications of diabetes in the Scottish population with type 1 diabetes, 2013–2018. *PloS One*. 2022;17(8 August):1-21. doi:10.1371/journal.pone.0271110
17. Horsselenberg M, Heins M, Leemrijse C, Nielen M, Korevaar J. *Diabetes Mellitus in Nederland: Prevalentie naar Migratieachtergrond en Sociaaleconomische Status*. Utrecht: Nivel, 2022.

18. Derks IPM, Koster A, Schram MT, et al. The association of early life socioeconomic conditions with prediabetes and type 2 diabetes: results from the Maastricht study. *Int J Equity Health*. 2017;16(1):1-7. doi:10.1186/s12939-017-0553-7
19. Zhu Y, Dekker LH, Mierau JO. Socio-economic gradients in diagnosed and undiagnosed type 2 diabetes and its related health complications. *Nutr Metab Cardiovasc Dis*. 2023;33(1):90-94. doi:10.1016/j.numecd.2022.09.018
20. de Vries SAG, Bak JCG, Stangenberger VA, et al. Use of hospital care among Dutch diabetes patients. *Diabetes Obes Metab*. 2023;(January):2268-2278:2268-2278. doi:10.1111/dom.15105
21. The Netherlands Institute for Social Research. Sociaal-Economische Status per postcodegebied. https://bronnen.zorggegevens.nl/Bron?naam=Sociaal-Economische-Status-per-postcodegebied. Published 2019. Accessed August 1, 2023
22. Knol F. Statusontwikkeling van wijken in Nederland 1998–2010. https://repository.scp.nl/handle/publications/661. Published 2012 Accessed November 24, 2023.
23. Burgos Ochoa L, Bertens LC, Garcia-Gomez P, Van Ourti T, Steegers EA, Been JV. Association of neighbourhood socioeconomic trajectories with preterm birth and small-for-gestational-age in The Netherlands: a nationwide population-based study. *Lancet Reg Heal – Eur*. 2021;10:100205. doi:10.1016/j.lanepe.2021.100205
24. Bongaerts THG, Büchner FL, De Munck L, Elferink MAG, Guicherit OR, Numans ME. Attendance characteristics of the breast and colorectal cancer screening programmes in a highly urbanised region of The Netherlands: a retrospective observational study. *BMJ Open*. 2023;13(6):1-8. doi:10.1136/bmjopen-2022-071354
25. Auzanneau M, Rosenbauer J, Maier W, et al. Heterogeneity of access to diabetes technology depending on area deprivation and demographics between 2016 and 2019 in Germany. *J Diabetes Sci Technol*. 2021;15(5):1059-1068. doi:10.1177/19322968211028608
26. Commissariat PV, Boyle CT, Miller KM, et al. Insulin pump use in young children with type 1 diabetes: sociodemographic factors and parent-reported barriers. *Diabetes Technol Ther*. 2017;19(6):363-369. doi:10.1089/dia.2016.0375
27. Lin MH, Connor CG, Ruedy KJ, et al. Race, socioeconomic status, and treatment center are associated with insulin pump therapy in youth in the first year following diagnosis of type 1 diabetes. *Diabetes Technol Ther*. 2013;15(11):929-934. doi:10.1089/dia.2013.0132
28. de Vries SAG, Verheugt CL, Mul D, Nieuwdorp M, Sas TCJ. Do sex differences in paediatric type 1 diabetes care exist? A systematic review. *Diabetologia*. 2023;66(4):618-630. doi:10.1007/s00125-022-05866-4
29. Icks A, Rosenbauer J, Strassburger K, Grabert M, Giani G, Holl RW. Persistent social disparities in the risk of hospital admission of paediatric diabetic patients in Germany-prospective data from 1277 diabetic children and adolescents. *Diabet Med*. 2007;24(4):440-442. doi:10.1111/j.1464-5491.2007.02105.x
30. Lindner L, Rathmann W, Rosenbauer J. Inequalities in glycaemic control, hypoglycaemia and diabetic ketoacidosis according to socioeconomic status and area-level deprivation in type 1 diabetes mellitus: a systematic review. *Diabet Med*. 2018;35(1):12-32. doi:10.1111/dme.13519
31. Everett EM, Wisk LE. Relationships between socioeconomic status, insurance coverage for diabetes technology and adverse health in patients with type 1 diabetes. *J Diabetes Sci Technol*. 2022;16(4):825-833. doi:10.1177/19322968211050649
32. Kurani SS, Heien HC, Sangaralingham LR, et al. Association of Area-Level Socioeconomic Deprivation with hypoglycemic and hyperglycemic crises in US adults with diabetes. *JAMA Netw Open*. 2022;5:1-15. doi:10.1001/jamanetworkopen.2021.43597
33. Bak JCG, Mul D, Serné EH, et al. DPARD: rationale, design and initial results from the Dutch national diabetes registry. *BMC Endocr Disord*. 2021;21(1):1-10. doi:10.1186/s12902-021-00782-x
34. Stanley JR, Clarke ABM, Shulman R, Mahmud FH. Mediating effects of technology-based therapy on the relationship between socioeconomic status and glycemic Management in Pediatric Type 1 diabetes. *Diabetes Technol Ther*. 2023;25(3):186-193. doi:10.1089/dia.2022.0388

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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