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ORIGINAL RESEARCH

Psychosocial Self-efficacy and its Association with Selected Potential Factors Among Adults with Type 1 Diabetes: A Cross-Sectional Survey Study

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ABSTRACT

Introduction: The management of type 1 diabetes, a non-preventable chronic disease, leads to a high physical and psychological burden on the individual. Digital health technology can improve a person's psychosocial self-efficacy and thereby contribute to improved diabetes self-care. The aim of this study was to explore associations between psychosocial self-efficacy and demographic-, disease specific-, well-being as well as digital health technology (DHT) related factors among adults with type 1 diabetes.
Methods: A primarily web-based cross sectional survey was conducted among adults with type 1 diabetes in Sweden ($n = 301$). Psychosocial self-efficacy was assessed using the Swedish version of the Diabetes Empowerment Scale, Swe-DES-23. The survey also contained questions related to demographic-, disease specific-, well-being as well as digital health technology related variables.
Results: Higher well-being scores and lower HbA1c levels were associated with higher psychosocial self-efficacy in multiple linear regression analysis. In multivariate analysis, gender, body mass index, well-being scores, and HbA1c levels showed association with psychosocial self-efficacy. None of the DHT factors were found associated with psychosocial self-efficacy.
Conclusions: In this study, higher well-being score and lower self-reported HbA1c levels were associated with higher psychosocial self-efficacy in both univariate- and multivariate analysis and accounted for 30% of the variation in psychosocial self-efficacy in the regression model. Thus, measures to improve psychosocial self-efficacy in adults with type 1 diabetes may help maintain their psychological well-being and blood glucose control.

Keywords: Diabetes mellitus, type 1; Cross-Sectional Study; Digital technology; Patient reported outcome measures; Psychological well-being; Self efficacy; Surveys and questionnaires

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Key Summary Points
Why carry out this study?
Psychosocial self-efficacy is significantly associated with age, education level, glycated haemoglobin (HbA1c) levels, diabetes complications, psychological well-being, diabetes duration, self-care ability, and support from health-care professionals and relatives in various studies of people with type 2 diabetes and type 1 diabetes.
However, studies among adults with type 1 diabetes is limited.
Therefore the aim of this study was to explore associations between psychosocial self-efficacy and demographic-, disease specific-, well-being as well as digital health technology related factors among adults with type 1 diabetes.
What was learned from the study?
Higher well-being scores and lower self-reported HbA1c are associated with higher psychosocial self-efficacy among adults with type 1 diabetes.
Measures to improve psychosocial self-efficacy in adults with type 1 diabetes are essential to maintain their psychological well-being and blood glucose control.

INTRODUCTION

Type 1 diabetes, currently remains a non-preventable chronic disease [1] despite various ongoing research like pharmacologically enhanced regulatory hematopoietic stem cells [2] and targeted delivery of immune therapeutics using nanoparticles [3] to reduce or revert the progression of the disease. It is managed through complex medication regimens as well as other behavioural modifications leading to a high physical and psychological burden on the individual. Its management has considerably changed in recent years due to advancements in diabetes technology. However, people find achieving normal blood sugar targets difficult, which increases their risk of complications [4]. Living with type 1 diabetes also requires psychosocial adaptation to the changes that need to be made to normal life and routines, social interaction, and working life [5]. These involve adapting to having a chronic illness, dealing with attitudes about the illness, expectations of medical management and outcomes, available financial, social, and emotional resources, the need to adapt various life events, psychiatric history, and psychological reactions related to emotional burdens and worries specific to the management of a complicated and demanding chronic disease [6].

When compared globally, type 1 diabetes has a higher prevalence rate in Scandinavian countries [1], including Sweden. Sweden's public health-care system covers diabetes care [7] and the majority of people with type 1 diabetes receive specialist-team-based diabetes care at their regional hospital's endocrine clinic [8]. The aim of diabetes care is to support people with type 1 diabetes in living a long and healthy life [4]. Together with the patient, the diabetes team sets treatment goals and the patient is expected to take responsibility for their self-care [8]. Psychosocial skills that allow people to adjust their personal behaviour, manage social situations, and navigate the institutions that influence one's life play an important role in successful diabetes self-care [9] and are influenced by psychosocial self-efficacy [10].

Self-efficacy is defined as a person's perceived ability and willingness to engage in various behavioural modifications including those required for disease prevention or management. Self-efficacy in relation to diabetes focuses on psychosocial issues such as managing stress, obtaining family support, negotiating with health-care professionals and employers, and dealing with uncomfortable emotions [10]. Previous studies among people with type 2 diabetes have shown that psychosocial self-efficacy was associated with age, education level, glycated haemoglobin (HbA1c) levels, diabetes complications, well-being [11], diabetes duration, self-care ability, and support from health-care professionals and relatives [12]. Empowerment is another term used in relation to psychosocial self-efficacy [10] and is the discovery and development of one's inherent capacity to be responsible for one's own life [13].

Digital health technologies (DHT) for diabetes include digital devices such as blood glucose monitors, continuous subcutaneous insulin infusions (CSII), continuous glucose monitoring (CGM), automated insulin dosing/hybrid closed loop systems (AID), smart insulin pens along with their software, and mobile health applications (mHealth apps) [14]. mHealth apps for diabetes self-care in this study was defined as software applications that are used on mobile devices such as smartphones, tablets, smart watches and readers with continuous glucose meter. These DHTs can help ease the burden of self-care [8, 14]. Improved glucose outcomes have been obtained through the use of CGM, CSII, and AID systems [14], and their associated mHealth apps [15]. These devices display graphics and alert people of deviant glucose values, which allow them to review and act immediately to maintain normal glucose levels [16]. They also provide historical data for review and analysis that enables making informed decisions regarding the adjustments required in self-care [17], which are characteristics of empowerment-approach-based interventions [18]. In addition, the associated mHealth apps also have features such as graphs and continuous feedback that increase people's understanding of glucose variability [19]. Thus, DHT for diabetes self-care may be called empowerment-approach-based interventions, which enhance people's sense of psychosocial self-efficacy [18]. To date, a limited number of studies have reported higher self-efficacy with use of CGM among adolescents with type 1 diabetes [20]. However, with mHealth app use a number of studies did not find any significant improvement in self-efficacy [19].

There is only a limited number of studies looking at psychosocial self-efficacy among adults with type 1 diabetes in Sweden even though the type 1 diabetes prevalence rate is higher in Sweden than the global average. This study is also important in light of the results of a pan-European study showing a decline in the technological and psychological support provided to people with diabetes during the COVID-19 pandemic [21]. In addition, there are very few studies looking at the association of psychosocial self-efficacy and DHT use globally, and they have mixed results. Therefore, the aim of this study was to explore associations between psychosocial self-efficacy and demographic-, disease specific-, well-being as well as digital health technology related factors among adults with type 1 diabetes.

METHODS

This study had a cross sectional design and is reported as per STROBE guidelines [22].

Participants and Procedure

A convenient sample of adults with type 1 diabetes (≥ 18 years) who understand the Swedish language were recruited primarily through digital advertising. Pregnant women with type 1 diabetes were excluded from the study. An advertisement was posted in six identified Facebook groups exclusively for people with diabetes in Sweden (with weekly updating so the post was repeatedly made visible to group members) as well as via marketing features in Facebook in general. Additional digital advertisements were posted on the webpages of various diabetes associations in Sweden along with their Facebook, Instagram and Twitter pages. In addition, advertisement pamphlets on the study were left at the diabetes centre at a regional hospital and some paper surveys ($n = 30$) were placed there. There were plans for further replenishment of the paper surveys based on uptake numbers, but they were limited ($n = 2$).

The website link and QR code provided in the study advertisements directed participants to a pseudonymised web-based survey (via platform Survey&Report by Artisans Media). Participation in the survey was voluntary. After receiving informed consent (via the survey), participants were directed to three screening questions (regarding age, diabetes type, and pregnancy status) to assess eligibility before the main survey was made visible. If ineligible, the survey automatically closed ($n = 4$) and the reason for exclusion was cited. Participants could also opt to answer a paper-based survey that was sent to the address they provided via a digital survey tool or by contacting the researcher ($n=6$). This paper survey option was made available at the very beginning of the survey and if selected, the survey automatically closed preventing further responses from being made.

The survey was only available in Swedish and was part of a larger study. It had 64 questions in total, of which data from 51 are included in this study. The number of questions visible was adapted according to participants' responses and varied from 53 to 64. Participants took approximately 5–20 min to complete the survey. The survey remained open for approximately two months during the period September—November, 2022, until the desired sample size was reached. This study conforms to ethical standards as per the Declaration of Helsinki [23]. The Swedish ethical review authority reviewed and approved the pilot study (Dnr: 2021–05337-01) and the main study (Dnr: 2022–04079-02) before data collection commenced.

Data Measurement and Variables

Psychosocial self-efficacy was assessed using the previously validated Swedish version of the Diabetes Empowerment Scale (Swe-DES-23) [24]. The questionnaire include 23 questions to measure participants' psychosocial adjustment to diabetes [10]. Questions are grouped into four domains, namely goal achievement and overcoming barriers for goal achievement (10 items), self-awareness (4 items), managing stress (4 items), and assessing dissatisfaction and readiness to change (5 items). Each item is rated on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The Scale has an acceptable internal consistency (total Cronbach's alpha was 0.91 and varied between 0.68 and 0.91 for the four subscales) and inter-item correlation [24]. To calculate the mean Swe-DES-23 score that ranged between 1 and 5, the total score obtained from adding the items together was divided by the number of items. A higher Swe-DES-23 score indicates better psychosocial self-efficacy. In this study, both the mean total score and mean subscale scores for Swe-DES-23 were calculated and psychosocial self-efficacy was considered to be a continuous variable [18].

Well-being was assessed using the WHO (Five) Well-being Index (WHO-5) [25]. This five-item questionnaire is rated on a Likert scale, ranging from "at no time" (0) to "all of the time" (5), giving a total score ranging from zero to 25. This is then multiplied by 4 to convert it to a standardised 0–100 scale. A standardised score of 0 indicates the worst possible level of well-being and a score of 100 represents the best possible level of well-being [25]. This previously validated questionnaire has been used as a generic scale for well-being across various fields [26].

The survey also contained study-specific questions (23 items) that were related to demographic-, disease specific-, as well as DHT factors that were based on previous research. DHT usage also included mHealth app usage which was categorised into "users" i.e. those who use mHealth apps several times/week or every day or many times/day and "non-users" i.e. those who never use mHealth apps or use them only sometimes/month. To validate these study specific questions, the survey was pilot tested among nine adults with type 1 diabetes and four diabetes nurses. The questionnaire was revised based on suggestions received and therefore the data from the pilot testing was not used in this study. The variables from the survey included in this paper are listed in Table 1.

Study Size

The sample size was calculated using IBM SPSS version 28 based on an F-test at 20% predictability for the full model with 25 predictors at a power of 80% and with a 0.05 level of significance. As per this calculation, 270 participants were required in order to detect an existing regression (fixed) model. Data from a total of 301 participants were collected and included in the analyses.

Data Analysis

IBM SPSS version 28 was used for data analyses. Participant characteristics are described

Table 1 The variables included in the paper

1. Swedish version of the Diabetes Empowerment Scale (Swe-DES-23)	23 item validated questionnaire assessing psychosocial adjustment to diabetes i.e. psychosocial self-efficacy	Dependent/ outcome variable
2. Demographic variables	Age, gender, living situation (alone, with family or others), level of education, employment situation, level of income	Potential predictive variables
3. Disease specific variables	Diabetes duration, body mass index, diabetes complication, other illnesses, self-reported glycated haemoglobin (HbA1c), level of physical activity	
4. Well-being	WHO-5 well-being index	
5. Digital health technology related variables	Digital devices used for self-care, mHealth app use & frequency of use[a]	

[a]mHealth apps for diabetes self-care are software applications that are used on mobile devices such as smartphones, tablets, smart watches, readers with continuous glucose meter etc. Based on frequency of mHealth app use participants were classified as users & non-users of mHealth apps. Users are those who use mHealth apps several times/week or every day or many times/ day and non-users are those who never use apps or use them sometimes/ month

as mean and standard deviation or frequency and percentages as applicable. A multiple linear regression analysis (univariate) was performed to explore associations between the outcome variable psychosocial self-efficacy and potential predictor variables. Prior to this, the data was checked to ascertain if satisfying normal distribution, homoscedasticity and lack of multicollinearity. A multivariate analysis of variance (MANOVA) was used to explore associations between the four domains (subscales) of the Swe-DES-23 and potential predictor variables. A p-value of <0.05 was considered to be statistically significant.

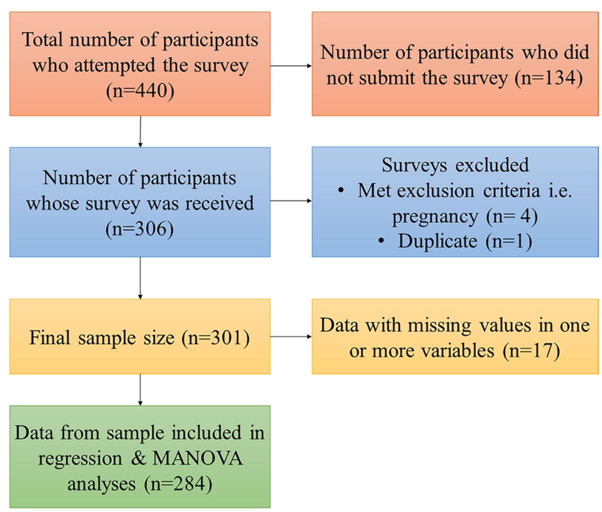

Fig. 1 Flowchart of participants included in the study and in various statistical analyses. *The survey completion rate, i.e. those who submitted the survey and were included in the final sample ($n=301$), divided by the total number who attempted the survey ($n=440$) was 68.41%. MANOVA: Multivariate analysis of variance

RESULTS

The survey completion rate, i.e. those who submitted the survey, was 68% (see Fig. 1 for more details). The majority of participants answered the survey digitally (98%). Participants were predominantly women (71%) and had a mean age of 43 ± 16 years and HbA1c level of 51.4 ± 11 mmol/mol (6.9 ± 3.2%). All participants used some form of DHT for self-care of their type 1 diabetes. In this sample, the mean Swe-DES-23 score was 3.8 ± 0.6 and WHO-5 score was 56 ± 19.9. See Table 2 for detailed baseline

Table 2 Baseline characteristics of the included participants ($n = 301$)

Predictors (categorical)		Frequency		
		n^a	n^b	%
Gender	Men	301	86	29
	Women		215	71
Living condition	Alone	301	73	24
	With a spouse/partner/another adult		131	44
	With a spouse/partner/another adult &/or with children		97	32
Education level[#]	Primary/secondary school	299	132	44
	University level education		167	56
Employment status	Studying	301	47	16
	Employed full/half time		191	63
	Unemployed/sick/ pensioner		63	21
Income level[#,$]	≤ 24,999 SEK	300	114	38
	25,000–34999 SEK		76	25
	35,000–44999 SEK		64	21
	≥ 45,000 SEK		46	16
Physical activity	≥ 5 days/week	301	170	56
	Several times/week		101	34
	≤ Several times/month		30	10
Diabetes complication	No complication	301	214	71
	1 complication		56	19
	2 or more complication		31	10
Multimorbidity[#]	No other illness	300	166	55
	1 other illness		78	26
	≥ 2 other illness		56	19
Number of digital devices used[#]	1 digital device	300	67	22
	2 digital device		160	53
	≥ 3 digital device		73	25
Type of digital devices used[€]	Glucose monitor[£]	300	286	95
	Insulin pump	301	102	34
	AID/Hybrid closed loop	301	71	24
	Smart insulin pens	301	28	9.3
mHeath app use	Users	301	241	80
	Non-users		60	20
Predictors (covariates)	**n[a]**	**Mean ± SD**	**Min**	**Max**
Age (years)	301	42.7 ± 15.8	18	86
Duration of diabetes (years)	301	21.7 ± 16.8	< 1	75
HbA1c[#] in mmol/mol (and %)	290	51.4 ± 11 (6.9 ± 3.2)	30 (4.9)	107 (11.9)
BMI (kg/m^2)[#]	300	26.7 ± 5.1	16.8	46.3
WHO-5 total score[#]	300	56 ± 19.9	4.0	100
Outcome	**n[a]**	**Mean ± SD**	**Min**	**Max**
Swe-DES-23 total	301	3.8 ± 0.6	2.0	5.0
Swe-DES-23 subscales				
Subscale 1: Goal achievement	301	3.8 ± 0.7	1.6	5.0
Subscale 2: Self awareness	301	4.1 ± 0.7	1.2	5.0

Table 2 continued

Outcome	n[a]	Mean ± SD	Min	Max
Subscale 3: managing stress	301	3.6 ± 0.7	1.5	5.0
Subscale 4: readiness for change	301	4 ± 0.6	1.4	5.0

[#]Total number of cases (*n*) is not 301 here due to missing values

[$]Refers to monthly income before tax deduction in Swedish Kronor (SEK)

[€]More than one device type may be used by a participant

[£]Includes both blood glucose monitor & Continuous glucose monitors

n[a] = total number of cases for each predictor

n[b] = number of cases within each category

AID Automated insulin dosing, *BMI* Body mass index, *HbA1c* Glycated haemoglobin, *mHealth app* Mobile health application, *Swe-DES-23* Swedish version of diabetes empowerment scale, *WHO-5* WHO-5 well-being index

characteristics of the participants. In this study, the Swe-DES-23 showed an acceptable reliability (α = 0.93) for the whole scale. The Cronbach's alpha values for the subscales varied between 0.72 (self-awareness) and 0.91 (goal achievement). The WHO-5 total score also showed acceptable reliability (α = 0.87).

Regression analysis and MANOVA could be performed only on data from 284 participants out of the included 301, as only cases with valid values for all variables could be included. The excluded cases ($n = 17$) had missing values in one or more variables included in the model. Regression analysis showed association of WHO-5 score and HbA1c with Swe-DES-23. Every unit increase in the WHO-5 score was associated with an increase in Swe-DES-23 by 0.01 units ($p < 0.001$). Similarly, every unit increase in HbA1c was associated with a decrease in Swe-DES-23 by 0.01 units ($p < 0.001$). DHT use, i.e. either digital device use or mHealth app use, was not associated with the Swe-DES-23 total score in this study. The regression model in this study explained 30% of the variation found in psychosocial self-efficacy (see Table 3).

Multiple linear regression models of each of the Swe-DES-23 subscales (see supplementary table S1) showed that HbA1c levels and the WHO-5 score were associated with the subscales goal achievement ($p < 0.001$ for both), with managing stress (HbA1c $p = 0.022$; WHO-5 $p < 0.001$), and assessing dissatisfaction and readiness to change (HbA1c $p = 0.003$; WHO-5 $p < 0.001$). Additionally, the WHO-5 score also showed an association with the self-awareness subscale ($p < 0.001$). Other than this, BMI ($p = 0.007$) was associated with the managing stress subscale and gender ($p = 0.028$) was associated with the self-awareness subscale. Every unit increase in the BMI was associated with an increase in managing stress subscale by 0.02 units. Men scored significantly lower (0.21 units) on the self-awareness subscale than women.

Table 4 displays a MANOVA analysis where subscales of Swe-DES-23 acted as the four outcome variables which together were computed to find associations with the predictor variables. The MANOVA analysis showed that gender ($p = 0.003$), HbA1c ($p < 0.001$), body mass index (BMI) ($p = 0.001$), and WHO-5 scores ($p < 0.001$) were associated with Swe-DES-23. No other predictors were found to have an association with Swe-DES-23 in the multivariate analysis.

DISCUSSION

This study aimed to explore associations between psychosocial self-efficacy and demographic-, disease specific-, well-being as well as digital health technology related factors among adults with type 1 diabetes. In this sample, the mean psychosocial self-efficacy score was 3.8 ± 0.6, which is slightly higher than in other studies using the same scale [24, 27]. It was found that an association exists between the

Table 3 Association between psychosocial self-efficacy (Swe-DES-23) and potential predictive variables using multiple linear regression ($n = 284$)

Predictors		B	SE	*p* value	95% CI
(Constant)		3.54	0.35	< 0.001	2.85, 4.23
Age (years)		0.00	0.003	0.889	− 0.005, 0.006
Gender	Men (Ref.)				
	Women	− 0.003	0.07	0.966	− 0.14, 0.14
Living condition	Alone (Ref.)				
	With a spouse/partner/another adult	0.04	0.08	0.587	− 0.11, 0.19
	With a spouse/partner/another adult &/or with children	0.01	0.08	0.876	− 0.15, 0.18
Education level	Primary/secondary school (Ref.)				
	University level education	0.07	0.07	0.264	− 0.06, 0.21
Employment status	Studying (Ref.)				
	Employed full/half time	0.02	0.12	0.883	− 0.22, 0.25
	Unemployed/sick/ pensioner	− 0.05	0.14	0.707	− 0.34, 0.23
Income level[a] (in SEK)	≤ 24,999 (Ref.)				
	25,000–34999	− 0.11	0.10	0.282	− 0.31, 0.09
	35,000–44999	− 0.004	0.11	0.969	− 0.22, 0.21
	≥ 45,000	0.09	0.12	0.457	− 0.15, 0.33
Diabetes complication	No complication (Ref.)				
	1 Complication	0.08	0.08	0.320	− 0.08, 0.25
	2 or more complication	0.18	0.12	0.125	− 0.05, 0.42
Multimorbidity	No other illness (Ref.)				
	1 other illness	− 0.01	0.07	0.844	− 0.15, 0.13
	≥ 2 other illness	0.02	0.08	0.856	− 0.15, 0.18
Physical activity	≥ 5 days/week	− 0.18	0.11	0.112	− 0.40, 0.04
	Several times/week	− 0.16	0.11	0.153	− 0.39, 0.06
	≤ several times/month (Ref.)				
Number of digital devices used	1 digital device (Ref.)				
	2 digital device	0.05	0.08	0.511	− 0.10, 0.20
	≥ 3 digital device	0.02	0.09	0.804	− 0.15, 0.20
mHealth app use	Users	0.04	0.08	0.614	− 0.11, 0.19
	Non users (Ref.)				

Table 3 continued

Predictors	B	SE	*p* value	95% CI
Duration of diabetes (in years)	− 0.001	0.002	0.650	− 0.01, 0.004
HbA1c (mmol/mol)	− 0.01	0.003	**< 0.001**	− 0.02, − 0.01
BMI (kg/m^2)	0.005	0.006	0.423	− 0.01, 0.02
WHO-5 total score	0.01	0.002	**< 0.001**	0.01, 0.02

For this regression model $R^2 = 0.30$, adjusted $R^2 = 0.24$

BMI Body mass index, *CI* Confidence interval, *HbA1c* Glycated haemoglobin, *mHealth app* Mobile health application, *Ref.* Reference group, *SE* Standard error, *SEK* Swedish Kronor, *Swe-DES-23* Swedish version of diabetes empowerment scale, Unstandardized beta value (B), *WHO-5* WHO-5 well-being index

[a]Income level refers to monthly income before tax deductions; *p* values indicated in bold are statistically significant

well-being score (WHO-5) and HbA1c levels and psychosocial self-efficacy. Similar to our findings, lower levels of HbA1c [11, 28] and a higher well-being score [11] were associated with higher psychosocial self-efficacy among people with type 2 diabetes [11] and children with type 1 diabetes [28]. Contrary to our findings, another study found no association between HbA1c levels and psychosocial self-efficacy in adolescents with type 1 diabetes [29]. In this study, for every unit increase in self-reported HbA1c and well-being score, change in psychosocial self-efficacy is approximately 1/6th and 1/5th respectively which is considerable. However, further studies are needed to determine clinical relevance of this finding.

Gender was the only demographic variable and BMI was the only disease-related variable associated with psychosocial self-efficacy in the multivariate analysis. In line with our findings, other studies also failed to find any association between age [12, 29] or diabetes duration [29], and psychosocial self-efficacy among people with type 2 diabetes [12] or adolescents with type 1 diabetes [29]. However, in contrast to our findings, a number of other studies have found an association between age, diabetes complications, education level [11], diabetes duration [12] and psychosocial self-efficacy among people with type 2 diabetes. In line with our findings in the multiple linear regression analysis of Swe-DES-23 subscales, another study found an association between HbA1c levels and the subscales goal achievement, managing stress, and assessing dissatisfaction and readiness to change [28]. In this study an increase in the BMI was associated with an increase in managing stress subscale which was an unexpected result and should be read with caution. However, the mean BMI in this study was only 26.7 ± 5.1 indicating a normal or overweight status [30].

In this study, DHT use was not associated with psychosocial self-efficacy. We could not find other studies investigating an association between general DHT use and psychosocial self-efficacy to compare our findings to. In this study, there was also an absence of an association between income level and psychosocial self-efficacy. A possible reason for this could be that diabetes care is subsidised by the public healthcare system in Sweden, including the cost of prescription medication and medical devices, through a nationally set high-cost protection scheme [7].

Methodology Discussion

This study has a number of strengths. The association between general DHT use and psychosocial self-efficacy in people with type 1 diabetes is less studied among adults. The study used previously validated questionnaires such

Table 4 Multivariate analysis (MANOVA) of association between subscales of Swe-DES-23 and potential predictive variables ($n = 284$)

Effect	Value[a]	F	df	p Value
Intercept	0.52	59.47	4	< 0.001
Age	0.98	1.58	4	0.180
Gender	0.94	4.05	4	**0.003**
Living condition	0.96	1.17	8	0.313
Education level	0.98	1.21	4	0.308
Employment status	0.94	1.91	8	0.056
Income level	0.95	1.19	12	0.287
Diabetes complication	0.95	1.52	8	0.146
Multimorbidity	0.97	0.88	8	0.535
Physical activity	0.97	0.91	8	0.510
Number of digital devices used	0.99	0.39	8	0.925
mHealth app use	0.99	0.52	4	0.720
Duration of diabetes	0.99	0.64	4	0.637
HbA1c	0.90	7.36	4	**< 0.001**
BMI	0.93	4.74	4	**0.001**
WHO-5 total score	0.80	16.08	4	**< 0.001**

BMI Body mass index in Kg/m^2, *df* Degrees of freedom, Income level is monthly income before tax in *SEK or* Swedish Kronor, *HbA1c* Glycated haemoglobin in mmol/mol, *mHealth app* Mobile health application, *Swe-DES-23* Swedish version of diabetes empowerment scale, *WHO-5* WHO-5 well-being index

[a]Multivariate analysis of variance (MANOVA) effects calculated using Wilks' Lambda value; Values indicated in bold are significant at $p < 0.05$; Age & duration of diabetes in years

as the Swe-DES-23 [24] and the WHO-5 well-being index [25]. These instrument also showed acceptable reliability in this study. The study-specific questionnaire on demographic-, disease specific- and digital health related variables were face- and content validated among people with type 1 diabetes and diabetes nurses. In this study people's perceived level of self-efficacy in performing self-care is captured which as per Anderson et al. is psychosocial self-efficacy [10]. Swe-DES-23 was chosen as it has been widely used in other Swedish studies [12, 28, 31].

This study was able to recruit a sufficient number of participants to achieve adequate power for regression analysis ($n = 284$). The survey completion rate was 68% in this study, which is higher than the average [32]. This may be because the survey was advertised in Facebook groups that were clearly defined for our targeted population of people with diabetes and this could have positively affected recruitment [32]. Some questions were marked mandatory and if they were not answered, they were highlighted and displayed by the survey tool and prevented participants from moving further on to the next page. This highly reduced the number of missing values in the digital survey. However, this strategy could also have led to the non-completion of surveys after consenting to participate ($n = 134$). A MANOVA has also been performed in addition to the multiple linear regression in order to capture associations after adjusting for the possible correlations between the four subscales of Swe-DES-23 [33].

This study also has its limitations, however. The survey was answered by more female participants than male participants despite type 1 diabetes being more prevalent in men [34], which could impact generalisability. There was a high rate of digital answers (98%) with only a small number of paper surveys being answered ($n = 6$). This was despite paper surveys being made available at a regional diabetes centre and information being included in advertisements that paper surveys were available on request. A possible reason for this could be that all participants were using some form of DHT to manage their diabetes and were digitally proficient. In Sweden, all people with type 1 diabetes are offered some form of DHT for self-care by the public health system [8]. In addition, the recruitment strategy focusing on advertising on social media may have led to the recruitment of more digitally active individuals. This high digital survey response rate poses a risk for "volunteer effect" leading to selection bias [35]. Due to this potential selection bias, the results of this study should be generalised with caution. The survey did not have questions on frequency of individual digital devices usage and this information could have added to the results. The survey had questions on frequency of mHealth app usage. A logistic regression was also attempted to find association between mHealth app use and psychosocial self-efficacy but a sufficient difference in users and non-users to run this could not be detected and therefore we decided not to include this analysis. Further studies in this area would be valuable.

CONCLUSION

In this study, higher well-being scores and lower self-reported HbA1c levels were associated with higher psychosocial self-efficacy in both univariate- and multivariate analysis. The above mentioned predictors accounted for 30% of the variation in psychosocial self-efficacy in the regression model. More studies in different settings are needed to validate these findings. Measures to improve psychosocial self-efficacy in adults with type 1 diabetes may help maintain their psychological well-being and blood glucose control.

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Data Availability Statement. The data that support the findings of this study are available from the authors upon reasonable request.

Declarations

Conflict of Interest. Divya Anna Stephen, Anna Nordin, Unn-Britt Johansson and Jan Nilsson declare having no conflict of interests.

Ethical Approval. This study conforms to ethical standards as per the Declaration of Helsinki [23]. The Swedish ethical review authority reviewed and approved the pilot study (Dnr: 2021–05337-01) and the main study (Dnr: 2022–04079-02) before data collection commenced. Participation in the survey was voluntary and informed consent was taken.

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