Health Education Research, 2024, **39**, 524–534
DOI: https://doi.org/10.1093/her/cyae030
Advance Access published 27 September 2024
Original Article

OXFORD

Characteristics of people with type 1 diabetes influence the educational process for starting insulin pump therapy: an observational study

Verónica Izquierdo[1,2], Marcos Pazos-Couselo[1,2,3,4], María González-Rodríguez[1], Alba-Elena Martínez-Santos[5], Paula Andujar-Plata[6], Olaia Díaz-Trastoy[6], Antía Fernández-Pombo[6], Sara Sigüeiro-Paulos[1] and Raquel Rodríguez-González[1,2,3]

[1]Faculty of Nursing, University of Santiago de Compostela, Santiago de Compostela, Spain, [2]Health Research Institute of Santiago de Compostela (IDIS), Santiago de Compostela, Spain, [3]Department of Psychiatry, Radiology, Public Health, Nursing and Medicine, University of Santiago de Compostela, Santiago de Compostela, Spain, [4]Research Methods (RESMET), Health Research Institute of Santiago de Compostela (IDIS), Santiago de Compostela, Spain, [5]Faculty of Nursing and Podiatry, Health Sciences Department, University of A Coruña, Ferrol, Spain and [6]Department of Endocrinology and Nutrition, Complexo Hospitalario Universitario de Santiago de Compostela, Santiago de Compostela, Spain

Correspondence to: M. Pazos-Couselo E-mail: marcos.pazos@usc.es

Abstract

Limited data exist on educational programs for people using insulin pump (IP) therapy or those considering its initiation, and the influence of individual characteristics on their educational pathway remains unclear. Our aim was to analyze the characteristics of people with type 1 diabetes (T1D) referred for IP therapy and how these characteristics may influence their educational process. A retrospective descriptive observational study was carried out on people with T1D referred for participation in a structured pre-IP educational program in a hospital setting. Educational, sociodemographic and clinical variables were collected and analyzed. Participants were followed up 5 years after IP placement. Seventy-one people finalized the educational program, of whom 10 experienced major barriers to completing it. People with lower educational level required more sessions and weeks to complete it compared to those with higher educational levels. People referred due to suboptimal metabolic control and hypoglycemia also required more time to complete the process. It is essential for diabetes educators to recognize the diversity of characteristics, needs and challenges among the participants in an educational program. Based on this, they must adapt strategies to provide more effective, person-centered diabetes education and support, fostering positive and sustained outcomes and engagement for participants.

Introduction

Managing type 1 diabetes (T1D) as a chronic condition is challenging [1, 2], since people living with T1D rely on insulin for survival while also striving to meet glycemic goals to minimize long-term microvascular and macrovascular complications [2]. The use of insulin pumps (IPs) continues to grow in the management of T1D in people of all age groups [3] as an alternative to multiple daily injections (MDIs) [4]. The benefits of optimal IP usage in appropriately educated and supported people [5] include the ability to adjust basal insulin levels [6], improved glycemic con-

Received on 28 August 2023; accepted on 2 September 2024

trol, decreased severe hypoglycemia episodes, enhanced quality of life and self-management [7–9], as well as its cost-effectiveness [10].

However, no device used in diabetes management works optimally without education, training and follow-up [1]. Improvements in glycemic outcomes are affected by how effectively the IP is used [9] and how well the person applies their knowledge and skills from the beginning of therapy [11]. Therefore, specific early IP education is key for adherence to IP therapy [11].

Advances in pump technology make the use of the device more complex, which along with the constant development of diabetes technology and its integration into everyday life pose challenges for both people with diabetes and healthcare providers [1]. As nurses play a central role in diabetes care, management and education, it is essential for them to identify and understand their target populations' demographics and social determinants of health to align the education with their needs and preferences [12]. Additionally, people with T1D initiating IP therapy must undergo a thorough selection process to assess multidimensional aspects likely to impact therapy adherence [5, 8, 13, 14].

No consensus on the core requirements of an educational program or a structure for IP therapy is outlined in the literature [8]. Several authors have reported a lack of studies regarding IP-structured education tailored for people with T1D [5, 9, 11, 14, 15]. Notable among the few robust scientific studies are the Insulin Pump Treatment (INPUT) [9] and the Relative Effectiveness of Pumps Over MDI and Structured Education (REPOSE) [6] randomized controlled trials (RCT), as well as two systematic reviews [8, 11]. Furthermore, educational interventions for people with T1D prior to initiating IP therapy are almost absent in the scientific literature. One study [5] assessed a comprehensive program, including education, for selecting candidates for sensor-augmented insulin pump (SAP) therapy. Another RCT compared IP with MDI, with both groups receiving high-quality structured education [6].

Therefore, there is inadequate availability of IP educational programs and limited understanding of how the characteristics of persons with diabetes might facilitate or hinder the completion of a pre-IP educational process and therapeutic engagement. Addressing this knowledge gap could aid healthcare planners, providers and diabetes educators, such as nurses, dietitians, endocrinologists and multidisciplinary teams in tailoring person-centered educational approaches and improving good clinical practices. To this end, this study aimed to analyze the characteristics of candidates who were about to initiate IP therapy, as well as the influence of those characteristics on the educational process.

Methods

This manuscript was prepared following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [16].

Design

A retrospective descriptive observational study was carried out on persons with T1D referred between April 2008 and March 2017.

Participants and setting

Eligible participants were people who (i) were aged ≥16 years with T1D, (ii) had initiated the educational program for IP therapy as of April 2008 and (iii) were not using or had not previously used IP. Participants who did not complete the educational process at the time of data collection and/or had incomplete educational records were excluded. The cut-off age was 16 years since it is the vital stage at which people transition from the Pediatric Unit to the Endocrine Unit.

The study was conducted in the Diabetes Technology Unit of the University Hospital of Santiago de Compostela, Spain, where an interdisciplinary structured educational program was initiated as one of the requirements people with diabetes must meet to qualify for an IP financed by the Public Health System [17].

Intervention

The intervention consisted of a structured individual educational program based on a person-centered and collaborative-care approach. It comprised a basic diabetes education module and an IP therapy module. Participants were required to complete the basic module before advancing to the IP module (Fig. 1). Upon completion of both modules, they became eligible to initiate IP therapy.

The program was led by a nurse and a nutritionist, both of whom are diabetes educators in the hospital's Diabetes Technology Unit. A counseling session was conducted with each IP candidate, actively engaging them in discussion regarding the transition from MDI to IP, lifestyle modifications, and the associated risks, benefits and limitations. Discussions also addressed the roles, responsibilities and expectations from both the participants and the diabetes educators as well as allowing for any questions the participants may have had regarding the educational program.

The diabetes educators, in collaboration with the participant, tailored the program (e.g. language, level of complexity, didactic and supporting materials, number, frequency, pace, repetition of the sessions) according to their needs, characteristics and expectations

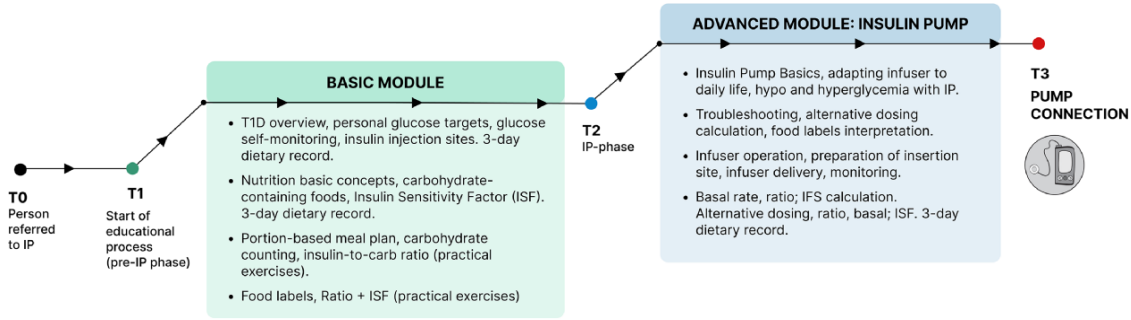

Fig. 1. Flowchart of participants' progression through the educational process and overview of the curricular content.

throughout the educational process. The characteristics of the educational program are shown as supplementary material (Supplementary Files 1 and 2).

Each session included a segment for participants to share their experiences, concerns, barriers, and facilitators related to the educational program and its application in their daily lives. They were also encouraged to give feedback regarding the educational program. Diabetes educators systematically registered the information provided by each participant to ensure a correct follow-up.

Data collection

To achieve the objectives, data were collected over 5 years from each participant's workbook, electronic clinical records, protocolized session records and a knowledge/skills checklist that diabetes educators completed during every session.

Educational and sociodemographic variables

The variables included age, gender, educational level (classified according to one of three levels: primary, secondary, or post-compulsory studies), occupation (classified according to the International Standard Classification of Occupations [ISCO] from the International Labor Organization [18]) and the distance between home and medical center. The participants' educational process variables were also collected: the duration and number of sessions to complete the program and contents that posed significant challenges for the participants.

Diabetes educators identified participants who showed and/or self-reported 'major barriers', hindering their educational process. We determined that a participant faced major barriers to completing the educational process when they struggled with learning and applying theoretical and/or practical concepts and needed additional sessions to consolidate specific concepts. These barriers were identified by the diabetes educator through the participant's performance in theoretical and practical exercises during the sessions, as well as feedback reported by the participants. Barriers could include issues related to literacy, numeracy, comprehension, solving workbook exercises, or performing practical tasks such as using an IP. In these cases, diabetes educators documented the situations in the participant's individual record and engaged in open discussions with the participant to collaboratively develop strategies to address them.

Clinical variables

Diabetes duration, metabolic control (HbA1c) and referral criteria to initiate IP therapy were reported. The HbA1c levels were determined by high-performance liquid chromatography using a Menarini Diagnostics HA-8140 analyzer. All HbA1c values were converted to Diabetes Control and Complications Trial aligned values [19]. HbA1c levels were measured at three timepoints: at referral (T0); within the first month after completing the educational program (T1) and 5 years after IP placement (T2). Continuity of IP therapy 5 years after IP placement and its association with certain characteristics or variables of the educational process were also assessed.

Participants were categorized into five groups (Fig. 2): (i) those who dropped out during the educational program; (ii) those who completed the educational program 'without major barriers' and initiated IP therapy; (iii) those who completed the educational program 'with major barriers' and initiated IP therapy; (iv) those who discontinued IP therapy within the first 5 years; and (v) those who continued with IP therapy at the 5-year follow-up.

Statistical analysis

We conducted a preliminary analysis of the data by performing a normality test using the Kolmogorov–Smirnov test, supplemented by an evaluation of

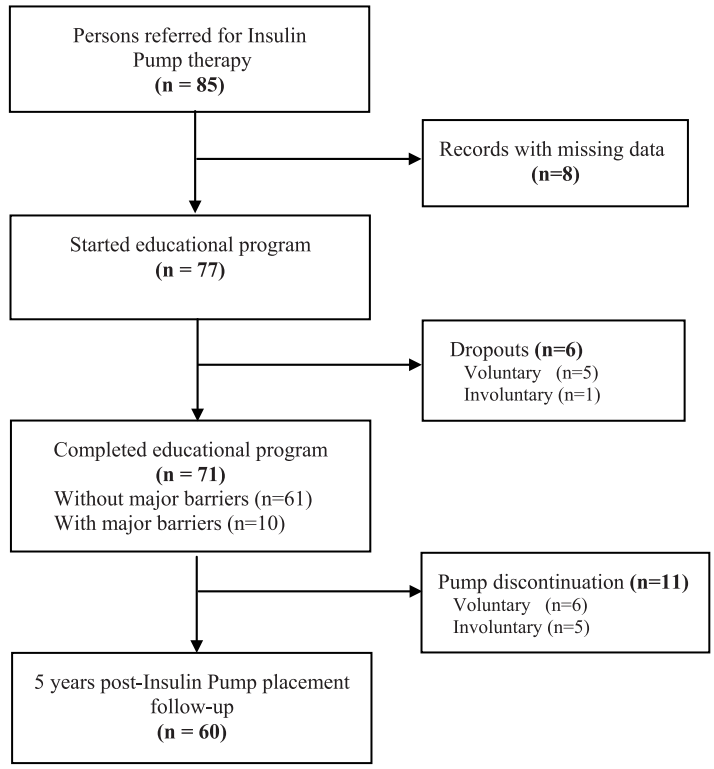

Fig. 2. Flowchart showing the selection of eligible participants for the study.

histograms. The mean was used as a measure of centralization and standard deviation to measure dispersion. To test for differences in the number of visits and program duration across educational levels, we used a Kruskal–Wallis test, followed by a Bonferroni-corrected *post hoc* analysis. The same approach was used to assess differences in program duration between referral criteria. For comparisons of HbA1c levels in participants who continued insulin pump therapy 5 years after placement ($n = 60$), at baseline (T0), within 1 month of completing the educational program (T1) and 5 years post-placement (T2), we used a Friedman test followed by Bonferroni-corrected *post hoc* analysis. Statistical analysis was performed using R statistical software environment (version 4.1.2; R Foundation, http://www.r-project.org) with the 'ggplot2' package and SPSS version 25 (SPSS Inc., Chicago, IL, USA). *P* values <0.05 were considered as the nominal threshold for statistical significance.

Ethical considerations

All participants signed two written informed consents: one to participate in the IP program and another for the use of their data for research purposes. Both were approved by the Clinical Research Ethics Committee (CEIC 2008/278). Participant data were kept anonymous by assigning an identification number following current national and European regulations on data protection.

Results

Patient selection

Eighty-five persons were referred to the Diabetes Unit to assess the initiation of IP therapy. Seventy-seven met the inclusion criteria and started the educational process, of whom 71 (92%) completed it and initiated IP therapy (Fig. 2).

Baseline characteristics

Seventy-one participants completed the structured IP educational program, with a mean age of 36.3 years (range from 17 to 61 years), of whom 64.8% were female. Their mean diabetes duration was 15.4 years and 83.1% had completed secondary or post-compulsory studies. They required a mean of 6.4 ± 1.7 sessions (range 3–10 visits) in 12.9 ± 9.6 weeks (range 1–44 weeks) to finalize the program (Table I). The most prevalent indications for IP therapy referral were hypoglycemia (46.0%) and suboptimal metabolic control

Table I. Socio-demographic and clinical characteristics of the participants

	IP educational process				5 years post-IP follow up	
Characteristic	Completed ($n = 71$)	Major barriers[a] ($n = 10$)	No major barriers ($n = 61$)	Dropouts[b] ($n = 5$)	Discontinuity[b] ($n = 6$)	Continuity ($n = 60$)
Female (n) (%)	46 (64.8%)	6 (60.0%)	39 (63.9%)	1 (20.0%)	3 (50.0%)	38 (63.3%)
Age (years)	36.3 ± 12.1	40.8 ±13.3	35.6 ±11.8	33.4 ±14.5	34.2 ±15.4	36.8 ±11.7
Diabetes duration (years)	15.4 ± 10.5	13.5 ±9.6	15.7 ± 10.7	9.2 ±4.3	12.7 ±9.5	15.1 ±10.0
Highest completed education, n (%)[c]						
Primary studies	12 (16.9%)	5 (50.0%)	7 (11.5%)	1 (20.0%)	0	12 (20.0%)
Secondary studies	29 (40.8%)	5 (50.0%)	24 (39.3%)	4 (80.0%)	4 (66.7%)	23 (38.3%)
Post-compulsory studies	30 (42.3%)	0	30 (49.2%)	0	2 (33.3%)	25 (41.7%)
Main indication for IP						
Suboptimal metabolic control	32 (45.0%)	4 (40%)	28 (46%)	5 (100%)	4 (66.6%)	23 (38.3%)
Hypoglycemia	33 (46.0%)	6 (60%)	27 (44%)	0	1 (16.7%)	32 (53.3%)
Pregnancy	4 (6.0%)	0	4 (7.0%)	0	1 (16.7%)	3 (5.0%)
Quality of life	2 (3.0%)	0	2 (3.0%)	0	0	2 (3.3%)
Number of sessions	6.4 ± 1.7	8 ±2.1	6.1 ±1.5	1.4 ±0.6	6.2 ±1.2	6.4 ±1.8
Duration (weeks)	12.9 ± 9.6	19.5 ±12.4	11.8 ±8.8	1.6 ±3.6	13.0 ±12.7	12.9 ±9.8
HbA1c (%)						
Before education program (%) (T0)	8.6 ± 1.5	8.5 ±1.4	8.6 ±1.5	9.8 ±1.9	9.2 ±1.5	8.3 ±1.3
At IP placement (%) (T1)	7.8 ± 1.5	7.9 ±1.0	7.9 ±1.6	N/A	8.2 ± 2.1	7.7 ± 1.1
5 years post-IP (%) (T2)	–	–	–	–	–	7.6 ±1.2
Change between T0 and T1 (%)	–	–	–	–	–	−0.5
Change between T0 and T2 (%)	–	–	–	–	–	−0.7
Occupation, n (%)[d]						
Professionals and Managers	16 (22.5%)	0	16 (26.2%)	0	0	14 (23.3%)
Service and sales workers	14 (19.7%)	0	14 (22.9%)	0	0	14 (23.3%)
Student	10 (14.0%)	1 (10.0%)	9 (14.8%)	2 (40.0%)	2 (33.3%)	7 (11.7%)
Clerical support workers	6 (8.5%)	1 (10.0%)	5 (8.2%)	0	2 (33.3%)	4 (6.7%)
Craft and related trades workers	6 (8.5%)	2 (20.0%)	4 (6.6%)	3 (60.0%)	1 (16.2%)	5 (8.3%)
Homemaker	6 (8.5%)	2 (20.0%)	4 (6.6%)	0	0	6 (10.0%)
Elementary occupations	6 (8.5%)	1 (10.0%)	5 (8.2%)	0	1 (16.2%)	5 (8.3%)
Not working (unemployed, retired)	4 (5.6%)	1 (10.0%)	3 (4.9%)	0	0	2 (3.3%)
Skilled agricultural and fishery workers	2 (2.8%)	2 (20.0%)	0	0	0	2 (3.3%)
Technicians, associate professionals	1 (1.4%)	0	1 (2%)	0	0	1 (1.7%)
Home distance from medical center, n (%)						
<5 km	21 (29.6%)	3 (30.0%)	18 (29.5%)	1 (20.0%)	3 (50.0%)	17 (28.3%)
5–19 km	11 (15.5%)	3 (30.0%)	8 (13.1%)	1 (20.0%)	0	11 (18.3%)
20–29 km	11 (15.5%)	0	11 (18.1%)	1 (20.0%)	0	11 (18.3%)
30–49 km	22 (30.9%)	4 (40.0%)	18 (29.5%)	1 (20.0%)	3 (50.0%)	18 (30.0%)
50 km or more	6 (8.5%)	0	6 (9.8%)	1 (20.0%)	0	3 (5.0%)

Values presented as mean ± SD or n (%). HbA1c: glycated hemoglobin, N/A: not applicable.
[a]When both participant and diabetes educator considered the participant showed and/or self-reported significant barriers (literacy, numeracy, comprehension, performing theoretical and practical exercises or others) that hindered their educational process.
[b]Voluntarily dropped out or discontinued. Involuntary dropouts ($n = 1$) and discontinuity ($n = 5$) are not shown.
[c]Primary studies refer to the initial stage of formal education, typically during childhood. Secondary studies refer to intermediate education, providing additional generalist non-vocational training, typically during adolescence. Post-compulsory education refers to education beyond compulsory schooling, including technical education or higher education at college or university.
[d]Classification according to the ISCO from the International Labor Organization.

(SMC) (45.0%). HbA1c prior to the education course was 8.6% ± 1.5.

Participants' characteristics

Among the 71 participants previously described, 14% ($n = 10$) required additional sessions to consolidate their knowledge or skills and 86% ($n = 61$) did not present major barriers to completion (Fig. 2).

Ten participants (14%) required reinforcement sessions to complete the process (Table I). They had an average age of 40 years (ranging from 20 to 59 years) and 60% were female. They had been living with T1D for 13.5 ± 9.6 years. Half had completed only primary schooling, while the remaining 50% had accomplished secondary studies. Common occupations among them included housekeeping and manual labors. They were referred for hypoglycemia (60%) and for SMC (40%). Compared to the group with no major barriers, an additional 1.9 sessions and 7.7 more weeks were needed to complete the educational program. The most challenging topics for these participants were carbohydrate counting, insulin-carbohydrate ratio, insulin sensitivity factor and using the insulin pump, particularly in hyperglycemia.

On the other hand, 61 participants (86%) completed the process without major barriers (Table I). Their mean age was 35.6 years (ranging from 17 to 61 years), 63.9% were female and they had been living with T1D for 15.7 ± 10.7 years. Regarding their highest educational level, 11.5% had completed only primary studies, 39.3% secondary studies and 49.2% had post-compulsory studies. Their most frequent occupations were professionals/managers and services/sales workers. The criteria by which they were referred were SMC 46%, hypoglycemia 44%, pregnancy 7% and quality of life 3%. The average number of sessions to complete the process was 6.1 ±1.5 in 11.8 ± 8.8 weeks.

Five (6.5%) out of the 77 participants who initiated the program voluntarily dropped out before IP placement (Table I). Among these, 80% were male participants, with a mean age of 33.4 years (range 19–56 years) and an average duration of 9.2 ± 4.0 years living with T1D. In terms of education, 80% had completed secondary studies, while 20% had only primary education. According to the ISCO classification, 60% held elementary occupations and 40% were students. All participants in this group were referred for SMC, reported not wanting to use an IP and dropped out during the Basic diabetes module.

Within 5 years of initiating IP therapy, 11 out of 71 (15.5%) participants who completed the program discontinued the treatment. Of these 11 participants, 5 discontinued due to reasons unrelated to the program (such as changing medical centers or death from natural causes), while 6 discontinued by personal choice (incompatibility with their lifestyle and self-reported failures in the IP). Their mean age was 34.2 years (range 17–54 years), with an average duration of 12.7 ± 9.5 years living with T1D. There was no significant gender difference. Educational level varied, with 4 participants (66.7%) having completed secondary studies and 2 (33.3%) post-compulsory studies. Their occupations were heterogeneous. Of these participants, 4 (66.6%) were referred for SMC, 1 (16.7%) for hypoglycemia and 1 (16.7%) for pregnancy. None of these participants who discontinued had major barriers to finish the pre-IP educational process, and none of them were referred to IP therapy for quality-of-life improvement.

After 5 years, 60 out of the 71 (84.5%) participants who initiated IP therapy continued in the therapy (Fig. 2). The overall dropout rate was 17 out of 77 (22.1%), from which with 11 out of 17 (65%) of these dropouts being voluntary and the rest due to external causes.

Effect of participants' characteristics in adherence to the educational process

The mean number of sessions (visits) of the total sample who completed the educational process was 6.4 ± 1.7 and mean duration was 12.9 ± 9.6 weeks.

Number of educational sessions

A greater number of educational sessions to initiate IP therapy was associated with a lower educational level. Participants with only primary studies required more sessions compared to those with secondary studies ($P = 0.012$) and those with post-compulsory studies ($P < 0.001$) (Fig. 3a). The main criterion for referral to IP did not show statistically significant differences related to the number of sessions required.

Duration to complete the educational program

Participants with primary studies showed a significant difference in the duration of the process compared to those with higher levels of education ($P = 0.03$) (Fig. 3b). Those referred for SMC ($P = 0.004$) and hypoglycemia ($P = 0.034$) required more time to complete the process than those referred for pregnancy, presenting a significant difference (Fig. 3c).

Metabolic control

HbA1c was measured 1 month prior to the educational program, within 1 month after the end of the educational program/IP placement and 5 years later. We analyzed the evolution of HbA1c levels in the 60

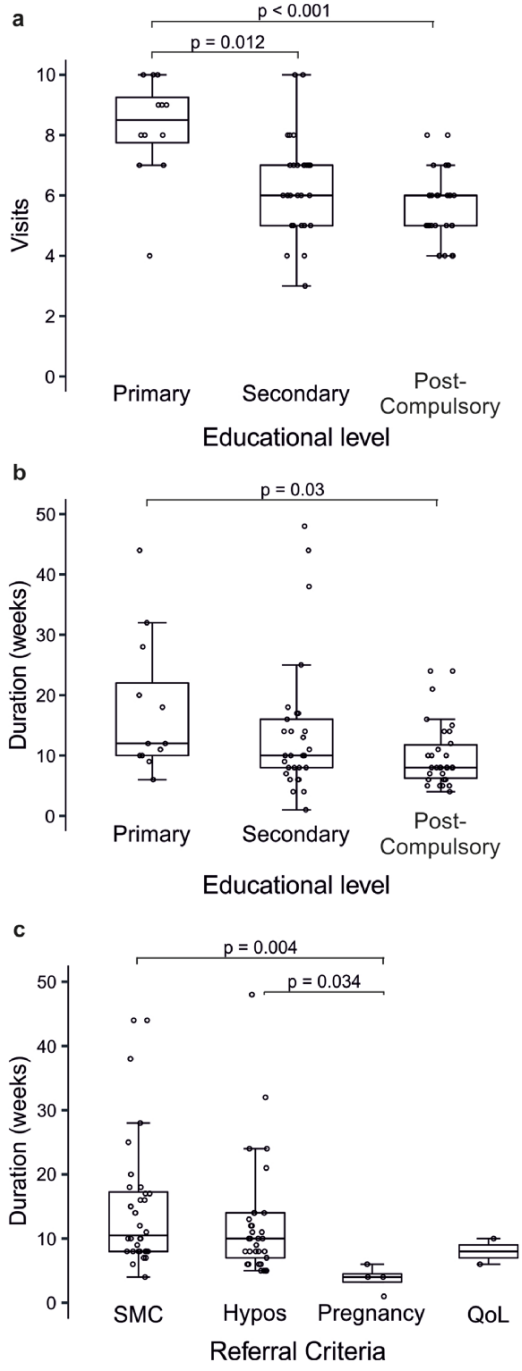

Fig. 3. Educational process variables. (**a**) Number of sessions required to complete the process, according to educational level. (**b** and **c**) Duration according to educational level and insulin pump referral criteria.

participants whose treatment was evaluated at 5 years. HbA1c was significantly lower ($P = 0.009$) within the first month following the completion of the educational process and 5 years after pump placement ($P = 0.001$) (Fig. 4). In this group of participants, HbA1c decreased −0.54% between the start and the completion of the educational program and −0.7% between IP placement and 5 years later.

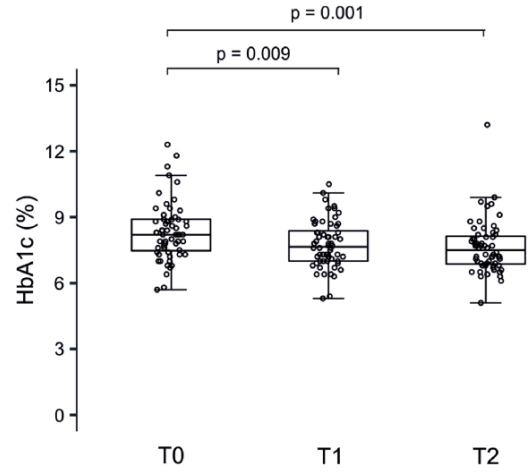

Fig. 4. HbA1c levels of participants who continued insulin pump therapy 5 years after placement ($n = 60$).

Discussion

Structured diabetes educational programs tailored for specific populations and their needs are scarce in the scientific literature. Despite the constant progress of diabetes self-management devices, IP therapy education continues to receive minimal research [8]. To the best of our knowledge, this is the first study that aims to describe and analyze the characteristics of individuals referred to an educational program tailored for people with T1D who are candidates for initiating IP therapy.

Participant selection

Our research shows that between 2008 and 2017, 85 people were referred to our Diabetes Technology Unit to initiate a selection protocol for IP therapy. Proper patient selection [1, 5, 14, 20–22] and adequate patient education and training are critical components of IP therapy [23]. Similar to other studies [5, 24], in our clinical setting, completing an educational process was a prerequisite to initiate therapy with a diabetes technology device, which in our case, resulted in a drop of 6.5% of the initially referred prospective IP users. In a study in which candidates for SAP therapy underwent a comprehensive program including structured education, there was a reduction of 52.4% of the initial candidates mainly owing to non-adherence issues [5].

Effect of participants' characteristics on engagement with the educational process

In line with our results, previous studies have reported that more than 50% of participants had completed at least secondary education [5, 11, 25] and the main referral criteria were SMC and hypoglycemia [5, 15, 26, 27].

It is worth highlighting three aspects of the participants who had major barriers finishing the educational program: (i) their educational level was lower, with none having pursued post-compulsory studies, (ii) they were predominantly referred for hypoglycemia and SMC and (iii) none of them abandoned either prior to or 5 years after IP placement. We consider that the individualized and collaborative care approach between the diabetes educators and the participants may have contributed to preventing dropouts. Nevertheless, it is essential that the training team identify potential challenges early and address them together with the person with T1D.

Despite the lack of other studies of participants with major barriers to finishing a diabetes educational program, it is striking that no one in this group had completed higher education. This would suggest that having higher education could contribute to having a better prognosis of finishing the program without major barriers.

Although our sample of participants was small, significant differences were found, which reinforce the influence of specific characteristics such as education and IP referral criteria on the educational process.

Among participants who dropped out, sociodemographic and clinical differences were observed based on the stage at which they quit. Those who quit during the pre-IP educational process exhibited more homogeneous characteristics: predominantly men, fewer years living with diabetes, secondary education as the most common educational level, all referred for SMC and all abandoned due to personal reasons. In contrast, the characteristics of the participants who discontinued within 5 years after initiating IP therapy were not associated with gender, had a higher educational level (none with only primary studies) and, although main referral criteria was SMC, there were also participants referred for hypoglycemia or pregnancy. In our Unit, as part of the protocol, pregnant women were given the option to continue or not with IP therapy after giving birth. This heterogeneity in the cohort that discontinued within 5 years may be attributed to not achieving the personal goals or meeting expectations.

Regardless of the stage, participants who quit the program had higher baseline HbA1c levels, while participants who were students and had occupations in crafts and related trades had the highest dropout rates. Previous studies have reported a high proportion of IP discontinuation among adolescents, young adults and females in older age groups [28], although the mean age of participants of other studies was between 40 and 43 years [6, 9, 29]. A lower level of education has also been described in previous studies [30].

The low dropout rate (8.5% at 5 years) in our program could have been positively influenced by the individualized sessions to address participants' needs, the reinforcement sessions, the multidisciplinary team support, collaborative care approach and the nutritional follow-up. The TID Exchange Clinic Registry reported 3% of pump discontinuation during the first year following enrollment [11], while a Spanish study reported 9.5% at 3 years [27]. Unlike our participants, whose main reason for discontinuation was poor adherence, other studies reported problems with insertion, skin reactions and pump discomfort [11] or therapy failure and personal reasons [27], underlining the importance of addressing these barriers in pre-IP education [11]. In a comprehensive program for candidates to initiate SAP therapy, the overall non-adherence rate was 33.3% [5].

The diabetes technology aims to simplify user experience and facilitate self-management. However, these aspects remain challenging for both people with diabetes and educators. Nevertheless, as demonstrated by a recent study [31], satisfaction among individuals with T1D can significantly improve with the initiation of integrated therapy. Therefore, it is important for diabetes educators to prioritize person-centered education [32] and take the initiative to adapt and develop new strategies that facilitate the transfer of knowledge, skills and empowerment to people with diabetes, considering the human factor in technology adoption and utilization.

Effect of participants' characteristics in the completion of the educational process

Participants in our program needed a mean of 6.4 sessions and 3.2 months (12.9 weeks) to complete the program, enabling them to initiate IP therapy for the first time. The Comprehensive Diabetes Program also required completion of an educational program as a prerequisite for initiating SAP therapy, involving 10 sessions within 6 months [5]. The sole publication addressing pre-IP education is the REPOSE trial, which consisted of five sessions conducted within 1 week [6].

We consider that the time and duration for completion of our program could be reduced if the participants had good basic knowledge of diabetes self-management and nutrition. Many participants in our program lacked knowledge about basic nutritional concepts, such as carbohydrate counting, which they would be expected to already minimally master,

considering the fact that they had already lived with T1D for a mean of 13.5 years. In some countries, diabetes educational programs for people with T1D are more common, such as the Dose Adjustment for Normal Eating (DAFNE) in United Kingdom [2], which expects the participants to reach a certain degree of knowledge and training. Nevertheless, in Spain access to and availability of such programs are limited.

Metabolic control

According to our results, HbA1c was significantly lower after completion of the educational program and 5 years after pump placement. Considering that HbA1c reflects metabolic control over the previous 2–3 months, it can be suggested that participation in basic diabetes education positively influenced participants' self-management, leading to improvements in HbA1c levels.

In our study, participants who continued IP therapy at 5 years achieved a reduction of 0.54% in HbA1c upon completion of the educational process and immediately prior to IP placement. Additionally, they demonstrated a further reduction of 0.7% in their HbA1c when comparing measurements taken immediately after the educational process with those obtained 5 years after IP placement. This aligns with the findings of the REPOSE RCT, which demonstrated that structured education contributed to improving HbA1c by 0.85% [9]. Other DSMES, such as standard DAFNE or Bournemouth Type 1 Intensive Education also demonstrated that appropriate education and support are effective in improving glucose outcomes in motivated people, with HbA1c reductions of between 0.2 and 0.7%, respectively [5]. These consistent outcomes reinforce the positive impact of structured education on metabolic control.

Since the inception of our pre-IP program in 2008, the educational content has been updated to align with clinical and technological advancements, including new IP models, functionalities and terminology, primarily related to continuous glucose monitoring. Our updated educational resources (theoretical guide, workbook, knowledge/skills checklists) are currently undergoing intellectual property registration.

Strengths and limitations

The strength of our study's research design lies in the realistic clinical practice setting, as all the persons in the clinical setting who met the inclusion criteria were included. For instance, there was no selection bias. However, this also represents a limitation as the sample size was small. The observational design of the study has limitations. It does not allow us to differentiate between the effects of the educational intervention and those of the use of IP and it inherently entails the influence of confounding factors on the observed outcomes. Another limitation of this study is the lack of additional patient-reported variables.

Regarding the teaching design, the main strength is that education was carried out by the clinical setting healthcare team rather than of industry representatives, which allowed the personalization of the program. A potential improvement of our program is the inclusion of behavioral aspects and attitudes toward IP therapy, which may have an effect on the outcome of educational interventions [9].

Conclusions

The profile of the persons with T1D can influence their educational process, underscoring the critical importance of diabetes care and educators to invest in recognizing the comprehensive characteristics, individual needs and human factors of each participant. With this understanding, diabetes educators should proactively adapt strategies to provide more effective and person-centered diabetes education and support, fostering positive sustained outcomes and engagement among participants.

Supplementary data

Supplementary data are available at *HEAL* online.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflict of interest statement

None declared.

References

1. American Diabetes Association. Standards of medical care in diabetes 2023. *Diabetes Care* 2022; **46**.
2. McKnight JA, Ochs A, Mair C *et al*. The effect of DAFNE education, continuous subcutaneous insulin infusion, or both in a population with type 1 diabetes in Scotland. *Diabetic Med* 2020; **37**: 1016–22.
3. Heinemann L, Fleming GA, Petrie JR *et al*. Insulin pump risks and benefits: a clinical appraisal of pump safety standards, adverse event reporting and research needs. A joint statement of the European Association for the Study of Diabetes and the American Diabetes Association Diabetes Technology Working Group. *Diabetologia* 2015; **58**: 862–70.

4. Pala L, Dicembrini I, Mannucci E. Continuous subcutaneous insulin infusion vs modern multiple injection regimens in type 1 diabetes: an updated meta-analysis of randomized clinical trials. *Acta Diabetol* 2019; **56**: 973–80.
5. Botero JF, Vásquez LM, Blanco VM *et al*. The effectiveness of a comprehensive diabetes program for glycemic control and adherence, and the selection of candidates for sensor-augmented insulin pump therapy. *Endocrinología, Diabetes Y Nutrición (English Ed)* 2021; **68**: 735–40.
6. REPOSE Study Group. Relative effectiveness of insulin pump treatment over multiple daily injections and structured education during flexible intensive insulin treatment for type 1 diabetes: cluster randomised trial (REPOSE). *BMJ* 2017; **356**: j1285.
7. Thomas MG, Avari P, Godsland IF *et al*. Optimizing type 1 diabetes after multiple daily injections and capillary blood monitoring: pump or sensor first? A meta-analysis using pooled differences in outcome measures. *Diabetes Obes Metab* 2021;**23**: 2521–8.
8. Jayasekara RS, Munn Z, Lockwood C. Effect of educational components and strategies associated with insulin pump therapy: a systematic review. *Int J Evid Based Healthc* 2011; **9**: 346–61.
9. Ehrmann D, Kulzer B, Schipfer M *et al*. Efficacy of an education program for people with diabetes and insulin-pumptreatment (INPUT): results from a randomized controlled trial. *Diabetes Care* 2018; **41**: 2453–62.
10. Madsen KP, Olsen KR, Rytter K *et al*. Effects of initiating insulin pump therapy in the real world: a nationwide, register-based study of adults with type 1 diabetes. *Diabet Res Clin Pract* 2023; **196**: 1–8.
11. Rytter K, Schmidt S, Rasmussen LN *et al*. Education programmes for people with type 1 diabetes using an insulin pump: a systematic review. *Diabetes Metab Res Rev* 2021; **37**: 1–15.
12. Davis J, Fischl AH, Beck J *et al*. 2022 National standards for diabetes self-management education and support. *Sci Diabetes Self-Manage Care* 2022; **48**: 44–59.
13. Association of Diabetes Care & Education Specialists. Continuous Subcutaneous Insulin Infusion (CSII) without and with sensor integration. 2021.
14. Peters AL, Ahmann AJ, Battelino T *et al*. Diabetes technology-continuous subcutaneous insulin infusion therapy and continuous glucose monitoring in adults: an endocrine society clinical practice guideline. *J Clin Endocrinol Metab* 2016; **101**: 3922–37.
15. Quirós C, Jansà M, Viñals C *et al*. Experiences and real life management of insulin pump therapy in adults with type 1 diabetes. *Endocrinología, Diabetes Y Nutrición (English Ed)* 2019; **66**: 117–23.
16. von Elm E, Altman DG, Egger M *et al*. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; **370**: 1453–7.
17. Ministerio de Sanidad y Consumo España. Orden SCO/710/2004, de 12 de marzo, por la que se autoriza la financiación de determinados efectos y accesorios con fondos públicos. *Boletín Oficial Del Estado (BOE)* 2004, 19–21.
18. European Union. *The ESCO classification*. Available at: https://esco.ec.europa.eu/en/classification. Accessed: 8 December 2022.
19. Hoelzel W, Weykamp C, Jeppsson JO *et al*. IFCC reference system for measurement of hemoglobin A1c in human blood and the national standardization schemes in the United States, Japan, and Sweden: a method-comparison study. *Clin Chem* 2004; **50**: 166–74.
20. American Association of Diabetes Educators. Education for continuous subcutaneous insulin infusion pump users. *Diabetes Educ* 2003; **29**: 97–9.
21. Lawton J, Kirkham J, Rankin D *et al*. Who gains clinical benefit from using insulin pump therapy? A qualitative study of the perceptions and views of health professionals involved in the relative effectiveness of pumps over MDI and structured education (REPOSE) trial. *Diabetic Med* 2016; **33**: 243–51.
22. Cleal B, Nexø MA, Schmidt S *et al*. Values and control in type 1 diabetes beyond glycemic outcomes: a qualitative interview study of everyday life with an insulin pump. *Chronic Illn* 2021; **18**: 620–33.
23. Grunberger G, Handelsman Y, Bloomgarden ZT *et al*. American Association of Clinical Endocrinologists and American College of Endocrinology 2018 position statement on integration of insulin pumps and continuous glucose monitoring in patients with diabetes mellitus. *Endocr Pract* 2018; **24**: 302–8.
24. White D, Waugh N, Elliott J *et al*. The relative effectiveness of pumps over MDI and structured education (REPOSE): study protocol for a cluster randomised controlled trial. *BMJ Open* 2014; **4**: e006204.
25. Ozgen Saydam B, Yilmazmis F, Aydin N *et al*. SIII the effect of retraining on treatment success, quality of life, and metabolic parameters in patients with Type 1 diabetes using an insulin pump. *Med Princ Pract* 2017; **26**: 325–30.
26. Coronel-Restrepo N, Blanco VM, Palacio A *et al*. Real-world effectiveness and safety of sensor-augmented insulin pump therapy in adults with type 1 diabetes: long-term follow-up. *Endocrinol Diabetes Nutr* 2021; **68**: 567–72.
27. Beato-Víbora P, Chico-Ballesteros A, Giménez M *et al*. A national survey on the efficacy and safety of continuous subcutaneous insulin infusion in patients with type 1 diabetes in Spain. *Diabet Res Clin Pract* 2018; **137**: 56–63.
28. Wong JC, Boyle C, Dimeglio LA *et al*. Evaluation of pump discontinuation and associated factors in the T1D exchange clinic registry. *J Diabetes Sci Technol* 2017; **11**: 224–32.
29. Bergis D, Ehrmann D, Albrecht C *et al*. Comparison of the efficacy of an education program for people with diabetes and insulin pump treatment (INPUT) in a randomized controlled trial setting and the effectiveness in a routine care setting: results of a comparative effectiveness study. *Patient Educ Couns* 2019; **102**: 1868–74.
30. Strandberg RB, Nilsen RM, Pouwer F *et al*. Lower education and immigrant background are associated with lower participation in a diabetes education program - Insights from adult patients in the Outcomes & Multi-morbidity In

Type 2 diabetes cohort (OMIT). *Patient Educ Couns* 2023; **107**: 1–17.
31. Beato-Víbora PI, Chico A, Moreno-Fernandez J *et al*. A multicenter prospective evaluation of the benefits of two advanced hybrid closed-loop systems in glucose control and patient-reported outcomes in a real-world setting. *Diabetes Care* 2024; **47**: 216–24.
32. Isaacs D, Cox C, Schwab K *et al*. Technology integration: the role of the diabetes care and education specialist in practice. *Diabetes Educ* 2020; **46**: 323–34.