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Impact of the Diabetes Shared Care Program on Glycemic Control in Older Adults With Type 2 Diabetes

Chih-Yen Chang[a, b], Andrew Y.C. Huang[c], Hsiao-Chung Wang[d], Shen-Ming Lee[e], Ching-Sung Ho[f, g]

Abstract

Background: This study aimed to assess the impact of the Diabetes Shared Care Program (DSCP) on glycemic control among elderly patients with type 2 diabetes mellitus (T2DM) over 1 year and identify factors associated with A1C level outcomes.

Methods: A retrospective cohort study was conducted at a regional hospital in central Taiwan from 2016 to 2020. The study included 509 patients aged ≥ 65 years with a confirmed T2DM diagnosis who participated in the program for at least 1 year. A1C levels were analyzed using three thresholds (6.5%, 7%, and 8%), and sociodemographic and health-related factors were examined. Statistical analyses included paired *t*-tests, the McNemar test, and binary logistic regression models.

Results: After 1 year in the DSCP, the mean A1C level significantly decreased from 7.37 ± 1.30 to 7.11 ± 1.13 (P < 0.001). Glycemic control patterns varied across A1C thresholds, with the most significant improvements observed at the 8% threshold, while improvements were less pronounced at the 6.5% threshold. Abnormal waist circumference was significantly associated with poorer glycemic control, with odds ratios of 2.570 (95% confidence interval (CI): 1.409 - 4.690, P = 0.002) for A1C < 6.5%, 2.360 (95% CI: 1.362 - 4.087, P = 0.002) for A1C < 7%, and 3.169 (95% CI: 1.909 - 5.261, P < 0.001) for A1C < 8%.

Conclusions: The DSCP significantly improved glycemic control in elderly patients with T2DM. Targeted diabetes education interventions should be implemented for older adults at higher risk, particularly those with abnormal waist circumference.

Keywords: T2DM; Elderly; A1C; DSCP

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[a]Department of Nursing, Hsin Sheng Junior College of Medical Care and Management, Taoyuan, Taiwan, Republic of China
[b]Department of Nursing, Hungkuang University, Taichung, Taiwan, Republic of China
[c]School of Biological Sciences, University of California, San Diego, La Jolla, CA 92093, USA
[d]Graduate Program of Sustainable Tourism and Recreation Management, National Taichung University of Education, Taiwan, Republic of China
[e]Department of Statistics, Feng Chia University, Taichung, Taiwan, Republic of China
[f]Department of Long-Term Care, National Quemoy University, Jinning Township, Kinmen, Taiwan 89250, Republic of China
[g]Corresponding Author: Ching-Sung Ho, Department of Long-Term Care, National Quemoy University, Jinning Township, Kinmen, Taiwan 89250, Republic of China. Email: csho@nqu.edu.tw

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Introduction

Diabetes mellitus is a major global health challenge characterized by chronic hyperglycemia and progressive metabolic dysfunction. The World Health Organization (WHO) estimates that over 537 million adults worldwide are living with diabetes, highlighting the urgent need for effective diagnostic and management strategies [1, 2]. In the United States, diabetes is a significant cause of morbidity and mortality, with total expenditures reaching $327 billion in 2017, including $237 billion in direct medical costs and $90 billion in lost productivity [3]. WHO projects that by 2030, diabetes will become one of the world's leading causes of death, with the mortality rate expected to double between 2005 and 2030 [4]. Diabetes is also a critical public health issue in Taiwan. In 2021, it was the fifth leading cause of death, accounting for 11,450 fatalities [5]. As of 2020, there were approximately 1.74 million patients with diabetes, and the disease accounted for 4.66% of Taiwan's National Health Insurance (NHI) expenditures, ranking third in total medical costs. The total medical expenditure for diabetes in 2020 amounted to New Taiwan dollars (NT$) 36.4 billion [6].

Aging is a major risk factor for the development and progression of prediabetes and type 2 diabetes mellitus (T2DM). This is largely due to age-related declines in glucose tolerance and increased insulin resistance [7]. T2DM is one of the most prevalent chronic diseases among older adults and is associated with significantly higher morbidity and mortality compared to age-matched non-diabetic individuals [8]. Effective management requires lifelong medication adherence and self-care practices to maintain functional capacity, independence, and quality of life [9]. While pharmacological treatment is essential, self-care behaviors play a crucial role in preventing diabetes-related complications in older adults.

To improve diabetes care and reduce healthcare costs, Taiwan launched the Diabetes Shared Care Program (DSCP) in 2001 [10]. This program is a nationwide, multidisciplinary, and integrated care model aimed at enhancing diabetes management through structured collaboration and standardized clinical protocols. The program brings together primary care physicians, specialists, nurses, and dietitians, all of whom undergo targeted training and certification. Patients are issued diabetes passports to document their clinical progress, and care delivery is centered on the routine monitoring of key health indicators, including blood glucose, glycated hemoglobin (HbA1c), blood pressure, lipid profiles, and renal function. The DSCP places strong emphasis on patient education, self-management, and scheduled follow-ups, all of which are supported by a comprehensive health information system that facilitates appointment scheduling, monitors care quality, and ensures timely clinical interventions [11, 12]. DSCP also offers financial incentives to healthcare providers to encourage continuous follow-up visits and patient engagement in self-care education [13]. Given that diabetes is a complex metabolic disorder requiring ongoing medical supervision, many elderly patients struggle to adopt and sustain lifestyle modifications for effective diabetes management [14]. Therefore, evaluating the effectiveness of DSCP in glycemic control among older adults with diabetes is essential.

Several physical and behavioral factors influence T2DM management outcomes. Obesity, particularly central obesity, is a well-established risk factor for diabetes complications [15]. Waist circumference, a widely used measure of abdominal fat, is a strong predictor of T2DM progression [16]. However, evidence regarding the impact of alcohol consumption on diabetes control remains inconclusive. While some studies suggest that alcohol interferes with self-care behaviors and increases diabetes-related mortality [17], others indicate that moderate alcohol consumption may reduce cardiovascular mortality in diabetic patients [18].

A1C is a well-established marker of long-term glycemic control and is strongly associated with diabetes-related complications and mortality risk [19]. The HbA1c threshold of 6.5% serves as a diagnostic criterion for diabetes and is a key predictor of cardiovascular risk [20, 21]. The 7% threshold is the standard treatment target, balancing glycemic control and complication prevention, while the 8% threshold is often used in elderly or high-risk patients to minimize hypoglycemia-related complications [22-24]. This individualized approach reflects the evolving landscape of diabetes management, where glycemic targets are adjusted based on patient characteristics and clinical risk factors [25]. This stratified approach underscores the evolving understanding of diabetes management, highlighting the intricate relationship between glycemic thresholds, individual patient characteristics, and long-term health outcomes.

Despite the widespread implementation of DSCP, limited research has evaluated its effectiveness among older adults in Taiwan. This study aims to assess the impact of DSCP on glycemic control in elderly patients after 1 year of participation. Additionally, it examines the sociodemographic and health-related factors associated with A1C outcomes, including physical activity, alcohol consumption, body mass index (BMI), and waist circumference.

Materials and Methods

Study design

A retrospective cohort study was conducted to achieve the study's research objectives. The study sample consisted of patients enrolled in the DSCP at a regional hospital in central Taiwan between 2016 and 2020. Clinical data were extracted from medical records after 1 year of program participation.

A total of 509 elderly patients were included in the study. The inclusion criteria required participants to be aged 65 years or older, have a confirmed diagnosis of T2DM, and have participated in the DSCP for at least 1 year. An anonymous data analysis was used to ensure confidentiality, and the study protocol was approved by the Medical Ethics Committee of Jen-Ai Hospital (IRB no. 110-92) on February 18, 2022. The study was conducted in compliance with the ethical standards of the responsible institutional review board and with the principles of the Declaration of Helsinki.

Measurements

The A1C level was selected as the primary outcome variable. A1C was recorded at baseline (upon program enrollment) and subsequently every 3 months. This study compared A1C levels at the end of the first year with baseline values. A1C levels were classified using three clinically relevant thresholds: < 6.5%, < 7%, and < 8%. The independent variables in this study included demographic factors (age, gender, and educational level), health-related behaviors (alcohol consumption (current user vs. none/abstained), cigarette smoking (current user vs. none/abstained), and physical activity (less than three times per week vs. three or more times per week), and anthropometric measurements (BMI and waist circumference). BMI was classified according to the Taiwan Health Promotion Administration's criteria, with < 24 kg/m^2 considered healthy and ≥ 24 kg/m^2 classified as abnormal. Waist circumference was defined as abnormal if ≥ 90 cm in men and ≥ 80 cm in women.

Statistical analysis

Descriptive statistics, including frequency analyses, mean values, and standard deviations, were used to summarize A1C levels, sociodemographic characteristics, and health-related factors. To assess the association between A1C levels and related variables, paired *t*-tests were conducted to compare baseline and 1-year A1C levels, while the McNemar test was used to analyze changes in A1C classification over time. Additionally, binary logistic regression was performed to identify factors associated with A1C outcomes. All statistical analyses were conducted using SPSS version 27.0.

Results

Characteristics of the study sample

A total of 509 elderly patients with diabetes were included in this study. Table 1 summarizes the sociodemographic and clinical characteristics of the participants. The study population

Table 1. Distribution of A1C Level and Sociodemographic Factors in Elderly Diabetic Patients

	N	%
Gender		
Male	233	45.8
Female	276	54.2
Age	73.54 ± 6.93	
Educational level		
Illiteracy	85	16.7
≤ 6 years	202	39.7
7 - 12 years	157	30.8
≥ 13 years	65	12.8
Alcohol consumption		
None or abstained	467	91.7
Current users	42	8.3
Cigarette smoking		
None or abstained	459	90.4
Current users	49	9.6
Exercising (baseline)		
< 3 times/week	197	38.7
≥ 3 times/week	312	61.3
Exercising (end of 1 year)		
< 3 times/week	176	34.6
≥ 3 times/week	333	65.4
BMI value		
< 24 kg/m^2	174	34.2
≥ 24 kg/m^2	335	65.8
Waist circumferences		
Normal	144	28.3
Abnormal	365	71.7
Medication as prescribed		
Yes	495	97.2
No	14	2.8
Timing adherence to medication		
Yes	474	93.1
No	35	6.9
A1C level (baseline)	7.37 ± 1.30	
A1C level (end of 1 year)	7.11 ± 1.13	
Total	509	100

consisted of 276 females (54.2%) and 233 males (45.8%), with a mean age of 73.54 ± 6.93 years.

Regarding educational attainment, the majority of participants (39.7%) had 6 or fewer years of education, and 16.7% were illiterate. In contrast, only 12.8% had completed 13 or more years of education. Substance use was relatively low, with 91.7% of participants reporting no alcohol consumption and 90.4% identifying as non-smokers. As for physical activity, 61.3% of participants reported exercising at least three times per week at baseline, increasing to 65.4% at the 1-year follow-up; however, this difference was not statistically significant (P = 0.057) (Fig. 1).

BMI and waist circumference assessments indicated potential metabolic risks. Most participants (65.8%) had a BMI of 24 kg/m^2 or higher, and 71.7% exhibited abnormal waist circumferences.

Medication adherence was high, with 97.2% taking medication as prescribed and 93.1% adhering to prescribed timing.

Patient characteristics, health-related status, and A1C distribution

At baseline, the mean A1C level was 7.37 ± 1.30. After 1 year of participation in the DSCP, the mean A1C level decreased to 7.11 ± 1.13, a statistically significant reduction (P < 0.001). Differences in A1C level distribution among diabetes patients, as determined by Chi-square (χ^2) tests, are presented in Table 2.

Gender differences in glycemic control were observed. Males were more likely than females to achieve A1C < 6.5% (32.6% vs. 24.6%, P = 0.029). However, no significant differences were found between genders for A1C < 7% (P = 0.178) or A1C < 8% (P = 0.232).

Educational level was significantly associated with A1C control. Participants with higher education (≥ 13 years) had a greater proportion achieving A1C < 6.5% (43.1%) compared to those with lower education levels (illiterate: 22.4%, P = 0.001). Similar trends were observed for A1C < 7% (P = 0.032), but no significant association was found for A1C < 8% (P = 0.910).

Lifestyle factors also influenced glycemic control. Current alcohol users had significantly better glycemic control at the A1C < 7% threshold (73.8% vs. 50.1%, P = 0.002) but not at other thresholds. Smoking status was not significantly associated with A1C control at any threshold.

BMI and waist circumference played a crucial role in glycemic control. Participants with BMI < 24 kg/m^2 had significantly better A1C control at all thresholds (P < 0.05), with 39.1% achieving A1C < 6.5%, compared to 22.7% among those with BMI ≥ 24 (P < 0.001). Similarly, normal waist circumference was strongly associated with better glycemic control across all A1C thresholds (P < 0.01).

Physical activity also influenced glycemic control. Engaging in exercise ≥ 3 times per week was significantly associated with better A1C control at the A1C < 6.5% (P = 0.026) and A1C < 8% (P = 0.002) thresholds.

Regarding medication adherence, no significant differences in glycemic control were observed between participants who adhered to their prescribed medication or medication timing and those who did not.

These findings suggest that educational level, BMI, waist circumference, and exercise frequency play crucial roles in glycemic control after 1 year of participation in the DSCP.

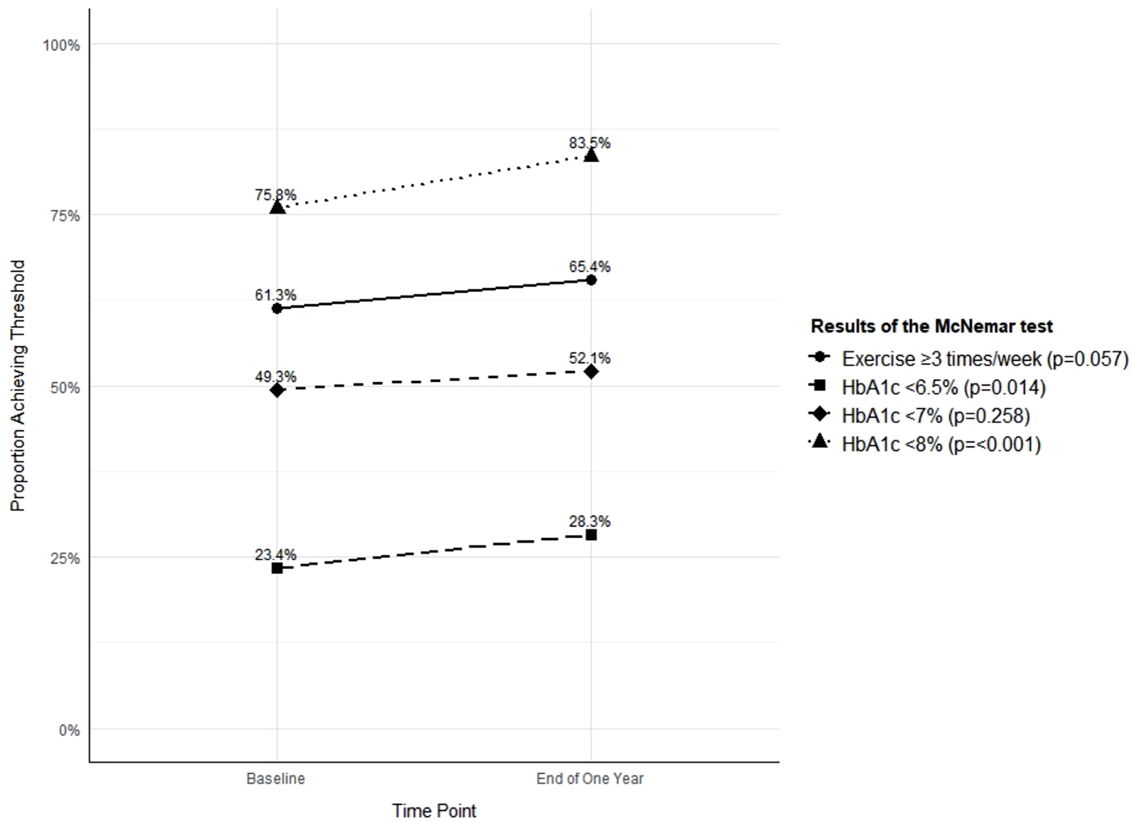

Figure 1. Comparison of health threshold achievement before and after DSCP. DSCP: the Diabetes Shared Care Program; HbA1c: glycated hemoglobin.

McNemar test for A1C levels

A1C levels at baseline and at the timepoint of follow-up after 1 year were compared using three threshold criteria (6.5%, 7%, and 8%). The McNemar test was performed to assess changes in glycemic control over time (Fig. 1).

At the 6.5% threshold, 69.7% (83/119) of participants with baseline A1C < 6.5% maintained good glycemic control at 1 year, while 30.3% (36/119) experienced deterioration to ≥ 6.5%. Among participants with baseline A1C ≥ 6.5%, 15.6% (61/390) improved to < 6.5%, while 84.4% (329/390) remained at ≥ 6.5%. By the end of 1 year, 28.3% (144/509) of participants had A1C < 6.5%, while 71.7% (365/509) had A1C ≥ 6.5%. McNemar test indicated a statistically significant improvement in glycemic control at this threshold (P = 0.014).

At the 7% threshold, 76.5% (192/251) of participants with baseline A1C < 7% maintained this level at 1 year, while 23.5% (59/251) increased to ≥ 7%. Among those with baseline A1C ≥ 7%, 28.3% (73/258) improved to < 7%, while 71.7% (185/258) remained at ≥ 7%. At 1 year, 52.1% (265/509) of participants had A1C < 7%, compared to 47.9% (244/509) with A1C ≥ 7%. The McNemar test showed no significant difference between baseline and 1-year measurements at this threshold (P = 0.258).

At the 8% threshold, 93.3% (360/386) of participants with baseline A1C < 8% maintained this level at 1 year, while only 6.7% (26/386) increased to ≥ 8%. Among those with baseline A1C ≥ 8%, 52.8% (65/123) improved to < 8%, while 47.2% (58/123) remained at ≥ 8%. By the end of 1 year, 83.5% (425/509) of participants had A1C < 8%, whereas 16.5% (84/509) had A1C ≥ 8%. The McNemar test demonstrated a highly significant improvement at this threshold (P < 0.001).

These findings indicate that glycemic control patterns varied significantly across different A1C thresholds. The most substantial improvements were observed at the 8% threshold, while moderate but significant changes occurred at the 6.5% threshold.

Binary logistic regressions

Table 3 presents the results of binary logistic regression analyses identifying factors associated with glycemic control at different A1C thresholds (8%, 7%, and 6.5%) at the timepoint of follow-up after 1 year.

For A1C < 6.5%, abnormal waist circumference was significantly associated with poorer glycemic control (odds ratio (OR) = 2.570, 95% confidence interval (CI): 1.409 - 4.690, P = 0.002). Baseline abnormal A1C levels showed the strongest association at this threshold (OR = 11.836, 95% CI: 7.718 - 19.517, P < 0.001). Gender, education level, BMI, alcohol consumption, and exercise frequency were not significantly

Table 2. Distribution of A1C Level at the Timepoint of Follow-Up After 1 Year in Different Factors

	A1C level at the end of 1 year								
	< 8%, n (%)	≥ 8%, n (%)	P	< 7%, n (%)	≥ 7%, n (%)	P	< 6.5%, n (%)	≥ 6.5%, n (%)	P
Gender			0.232			0.178			0.029
Male	191 (82.0)	42 (18.0)		127 (54.5)	106 (45.5)		76 (32.6)	157 (67.4)	
Female	234 (84.8)	42 (15.2)		138 (50.0)	138 (50.0)		68 (24.6)	208 (75.4)	
Education level			0.910			0.032			0.001
Illiteracy	71 (83.5)	14 (16.5)		38 (44.7)	47 (55.3)		19 (22.4)	66 (77.6)	
≤ 6 years	169 (83.7)	33 (16.3)		95 (47.0)	107 (53.0)		43 (21.3)	159 (78.7)	
7 - 12 years	129 (82.2)	28 (17.8)		93 (59.2)	64 (40.8)		54 (34.4)	103 (65.6)	
≥ 13 years	56 (86.2)	9 (13.8)		39 (60.0)	26 (40.0)		28 (43.1)	37 (56.9)	
Alcohol consumption			0.276			0.002			0.052
None or abstained	388 (83.1)	79 (16.9)		234 (50.1)	233 (49.9)		127 (27.2)	340 (72.8)	
Current users	37 (88.1)	5 (11.9)		31 (73.8)	11 (26.2)		17 (40.5)	25 (59.5)	
Cigarette smoking			0.087			0.275			0.540
None or abstained	338 (84.3)	72 (15.7)		237 (51.5)	223 (48.5)		130 (28.3)	330 (71.7)	
Current users	37 (75.5)	12 (24.5)		28 (57.1)	21 (42.9)		14 (28.6)	35 (71.4)	
BMI			0.033			0.003			< 0.001
< 24 kg/m^2	153 (87.9)	21 (12.1)		106 (60.9)	68 (39.1)		68 (39.1)	106 (60.9)	
≥ 24 kg/m^2	272 (81.2)	63 (18.8)		159 (47.5)	176 (52.5)		76 (22.7)	259 (77.3)	
Waist circumferences			0.006			< 0.001			< 0.001
Normal	130 (90.3)	14 (9.7)		103 (71.5)	41 (28.5)		67 (46.5)	77 (53.5)	
Abnormal	295 (80.8)	70 (19.2)		162 (44.4)	203 (55.6)		77 (21.1)	288 (78.9)	
Exercise (end of 1 year)			0.002			0.092			0.026
< 3 times/week	135 (76.7)	41 (23.3)		84 (47.7)	92 (52.3)		40 (22.7)	136 (77.3)	
≥ 3 times/week	290 (87.1)	43 (12.9)		181 (54.4)	152 (45.6)		104 (31.2)	229 (68.8)	
Medication as prescribed			0.414			0.334			0.593
Yes	414 (83.6)	81 (16.4)		259 (52.3)	236 (47.7)		140 (28.3)	355 (71.7)	
No	11 (78.6)	3 (21.4)		6 (42.9)	8 (57.1)		4 (28.6)	10 (71.4)	
Timing adherence to medication			0.203			0.273			0.552
Yes	398 (84.0)	76 (16.0)		249 (52.5)	225 (47.5)		134 (28.3)	340 (71.7)	
No	27 (77.1)	8 (22.9)		16 (45.7)	19 (54.3)		10 (28.6)	25 (71.4)	

BMI: body mass index.

Table 3. Logistic Regression Analysis of A1C Levels at the Timepoint of Follow-Up After 1 Year Across Different Thresholds

Variables	A1C < 8%	P value	A1C < 7%	P value	A1C < 6.5%	P value
	ORs (95% CI)		ORs (95% CI)		ORs (95% CI)	
Gender						
Male			-		Reference	
Female			-		0.943 (0.547 - 1.623)	0.831
Education level						
Illiteracy			1.208 (0.555 - 2.630)	0.634	1.722 (0.695 - 4.263)	0.374
≤ 6 years			1.190 (0.607 - 2.334)	0.612	2.145 (1.025 - 4.492)	0.114
7 - 12 years			0.888 (0.442 - 1.784)	0.739	1.271 (0.618 - 2.616)	0.852
≥ 13 years			Reference		Reference	
BMI		0.843		0.743		
< 24 kg/m^2	Reference		Reference		Reference	
≥ 24 kg/m^2	0.954 (0.599 - 1.520)		1.088 (0.656 - 1.806)		1.240 (0.705 - 2.179)	0.455
Waist circumference						
Normal	Reference		Reference		Reference	
Abnormal	3.619 (1.909 - 5.261)	< 0.001	2.360 (1.362 - 4.087)	0.002	2.570 (1.409 - 4.690)	0.002
Alcohol consumption						
None or abstained			-		Reference	
Current users			-		0.632 (0.281 - 1.419)	0.266
Exercise						
< 3 times/week	1.107 (0.742 - 1.653)	0.049	-		1.324 (0.795 - 2.205)	0.281
≥ 3 times/week	Reference		-		Reference	
A1C level (baseline)						
Normal	Reference		Reference		Reference	
Abnormal	5.620 (3.447 - 9.161)	< 0.001	8.150 (5.378 - 12.351)	< 0.001	11.836 (7.718 - 19.517)	< 0.001
Model fit	R^2 = 0.341		R^2 = 0.348		R^2 = 0.373	

OR: odds ratio; CI: confidence interval; BMI: body mass index.

associated with glycemic control at this level. The model explained 37.3% of the variance (R^2 = 0.373).

For A1C < 7%, abnormal waist circumference was a significant predictor of poorer glycemic control (OR = 2.360, 95% CI: 1.362 - 4.087, P = 0.002). Baseline A1C levels demonstrated an even stronger association (OR = 8.150, 95% CI: 5.378 - 12.351, P < 0.001). Education level and BMI were not significantly associated. The model explained 34.8% of the variance (R^2 = 0.348).

Across all three A1C thresholds, abnormal baseline A1C levels consistently exhibited the strongest association with poor glycemic control, with increasing ORs as the threshold became more stringent (from OR = 5.620 at < 8% to OR = 11.836 at < 6.5%). Similarly, abnormal waist circumference was consistently associated with poorer glycemic control, though its effect size decreased as the threshold became more stringent.

For A1C <8%, abnormal waist circumference was significantly associated with poorer glycemic control (OR = 3.169, 95% CI: 1.909 - 5.261, P < 0.001). Exercising fewer than three times per week showed a marginally significant association with poorer glycemic control compared to exercising ≥ 3 times per week (OR = 1.107, 95% CI: 0.742 - 1.653, P = 0.049). Baseline abnormal A1C levels strongly predicted continued poor glycemic control at 1 year (OR = 5.620, 95% CI: 3.447 - 9.161, P < 0.001). BMI ≥ 24 kg/m^2 was not significantly associated (OR = 0.954, 95% CI: 0.599 - 1.520, P = 0.843). The model explained 21.3% of the variance (R^2 = 0.213).

Discussion

This study evaluated the effectiveness of the DSCP in improving glycemic control among older adults with diabetes. Comparisons with previous studies on diabetes self-care education programs have yielded inconsistent findings. While Gagliardino et al reported improved A1C levels following a 1-year education program [26], another study found no significant change after a similar intervention [27]. Our results demonstrate that elderly diabetic patients in Taiwan experienced a significant reduction in HA1c levels after 1 year in the DSCP (7.37±1.30% vs. 7.11±1.13%, P < 0.001). However, A1C changes varied across different glycemic thresholds. The greatest improvement was observed at the 8% threshold, where 52.8% of participants with baseline A1C ≥ 8% achieved A1C < 8% at follow-up (P < 0.001). This success rate aligns with findings from the ACCORD trial, which reported that 50-55% of patients with baseline A1C ≥ 8% achieved values below this threshold after intensive intervention [28]. Notably, 93.3% of participants who attained A1C < 8% maintained this level, suggesting that preventing severe hyperglycemia is more feasible than sustaining stricter glycemic targets. This finding aligns with observations by Tricco et al (2018) in a systematic review of diabetes management strategies [29].

At the 7% threshold, which aligns with targets recommended by multiple diabetes associations [30], we observed no statistically significant difference between baseline and 1-year measurements (P = 0.258). Although 28.3% of participants with baseline A1C ≥ 7% improved to < 7%, a notable 23.5% of those with initially good control deteriorated to ≥ 7%, resulting in only a modest net improvement (52.1% vs. 47.9%). This improvement falls short of the 35-40% success rate reported by Blonde et al (2018) following the initiation of new therapies [31]. These discrepancies may reflect the challenges of maintaining glycemic control in real-world settings, where adherence and healthcare access differ from clinical trial conditions.

For the most stringent 6.5% threshold, we observed a statistically significant improvement (P = 0.014), though the pattern differed from that seen with the 8% threshold. While 15.6% of participants with baseline A1C ≥ 6.5% improved to < 6.5%, a concerning 30.3% of those with initially good control deteriorated to ≥ 6.5%. This trend mirrors findings from the VADT study, which highlighted the difficulty of maintaining tight glycemic control over time [32]. Similarly, Khunti et al (2018) reported that only 13-18% of patients sustain A1C < 6.5% over multiple years [33].

The declining success rates with increasingly stringent targets (52.8% at < 8%, 28.3% at < 7%, and 15.6% at < 6.5%) emphasize the progressive difficulty of achieving tight glycemic control. This phenomenon, termed "therapeutic inertia", reflects both physiological limitations and healthcare system challenges [34]. Notably, glycemic deterioration was more common at the 6.5% threshold (30.3%) than at the 7% (23.5%) or 8% (6.7%) thresholds, suggesting that maintaining very tight control requires more intensive monitoring and intervention, as noted by Davies et al (2022) [35].

These findings have important clinical implications. First, setting individualized glycemic targets based on patient characteristics and baseline control may be more effective than applying uniform thresholds. This approach aligns with the personalized recommendations of the American Diabetes Association and the European Association for the Study of Diabetes [36]. Second, the higher success rate at the 8% threshold suggests that prioritizing patients with the poorest glycemic control could provide the greatest population-level benefits. This observation is consistent with findings by Vijan et al (2014) [37]. Finally, the significant deterioration rate at the 6.5% threshold underscores the need for vigilant monitoring and more aggressive interventions for patients who initially achieve tight glycemic control.

Our logistic regression analysis revealed several important associations between various factors and glycemic control across different A1C thresholds (< 8%, < 7%, and < 6.5%). The most consistent and powerful predictor across all thresholds was the baseline A1C level. Patients with abnormal baseline A1C levels had significantly higher odds of maintaining elevated A1C levels at the timepoint of follow-up after 1 year, with ORs increasing progressively as the threshold became more stringent (OR = 5.620 at < 8%, OR = 8.150 at < 7%, and OR = 11.836 at < 6.5%; all P < 0.001). This strong association underscores the importance of early intervention and the challenges in achieving glycemic targets for patients who begin with poor glycemic control. These findings underscore the importance of early intervention, as previously demonstrated by Lachin et al (2014) [38], and the recommendations from the American Diabetes Association (2023) [30].

Waist circumference also emerged as a significant predictor across all thresholds. Patients with abnormal waist circumference had 2.36 - 3.62 times higher odds of elevated A1C levels at 1 year (all P ≤ 0.002). This aligns with established research linking central adiposity to insulin resistance and poor glycemic outcomes, independent of overall BMI. Similar findings were reported by Kodama et al (2012) in a meta-analysis of 15 prospective studies [39]. Interestingly, BMI itself was not significantly associated with A1C outcomes at any threshold (P > 0.05), suggesting that fat distribution, rather than total body mass, may be a more relevant metabolic risk factor [40]. This discrepancy between BMI and waist circumference as predictors of glycemic control has also been noted by Janiszewski et al (2008), who found that central adiposity was a stronger predictor of insulin resistance than BMI [41].

Exercise frequency showed a marginally significant association only at the < 8% threshold (P = 0.049), with patients exercising less than three times per week having slightly higher odds of elevated A1C levels. This association was not observed at the more stringent thresholds, suggesting that while physical activity may help patients achieve modest glycemic targets, additional interventions may be necessary for more intensive glycemic control. These results partially contrast with the findings of Colberg et al (2016), who reported more substantial benefits of regular exercise across all levels of glycemic control [42], suggesting that exercise intensity and type, not captured in our model, may play a role.

Regarding sociodemographic factors, neither gender nor education level showed consistent significant associations with glycemic outcomes, though there was a trend toward better outcomes in more educated patients at the < 6.5% threshold. This trend is consistent with findings from Walker et al (2020), who reported that higher education levels were associated with better diabetes self-management and glycemic control [43]. Similarly, alcohol consumption did not demonstrate a significant impact on glycemic control at the < 6.5% threshold (P = 0.266), which contrasts with some studies suggesting moderate alcohol consumption may improve insulin sensitivity [44]. Some studies have demonstrated that male diabetic patients exhibit better self-care practices than females [45, 46]. However, other research has indicated that gender does not result in differential levels of self-care [47]. Our study reveals that the normal rate distribution for the A1C level at the end of 1 year does not exhibit any significant gender difference. Further investigation is necessary to determine the influence of gender on diabetes disease control.

This study evaluates changes in HbA1c as the primary outcome before and after participation in the DSCP. Explanatory variables include data collected at the 1-year follow-up, as certain factors, such as gender and educational level, are fixed and not expected to change over time. Health-related behaviors and process indicators (e.g., medication adherence, substance use) were assessed only at the 1-year follow-up, with the aim of determining whether participants were adhering to appropriate diabetes self-care practices after completing 1 year in the DSCP.

It is well established that medication adherence plays a critical role in the regulation of A1C [48]. In our study, over 90% of elderly patients with diabetes reported taking their medication as prescribed, including proper timing and adherence. However, medication-related factors were not significantly associated with differences in the distribution of A1C thresholds. The impact of medication adherence on glycemic control warrants further investigation.

Our study possesses several strengths, including its retrospective design and long-term follow-up period, which facilitated the evaluation of the program's effect on the T2DM population and the longitudinal relationship between health behaviors and A1C levels. Our study examines glycemic control across multiple clinically relevant thresholds, providing a nuanced view of diabetes management outcomes.

However, this study has certain limitations. The study sample was derived from a single metropolitan-regional hospital in central Taiwan; therefore, the findings may not be generalizable to all older diabetic patients. These results should be interpreted in the context of certain limitations, including the lack of information about specific interventions, medication adherence, and lifestyle modifications that might have influenced glycemic trajectories [49]. The independent variables were retrieved at the end of 1 year, necessitating further exploration of the actual effects of factors relating to the A1C level. Future research should consider examining the relationship between patterns of obesity, such as waist circumference and BMI, or alcohol consumption, and changes in A1C levels. Future studies could expand on this work by incorporating longitudinal data and exploring additional covariates to refine these predictive models.

Conclusions

The DSCP effectively lowers A1C levels in elderly patients with diabetes. Given the positive correlation between education level and self-care behaviors in this population, health authorities should implement additional diabetes education interventions for less-educated patients.

Compared to BMI, waist circumference may serve as a more reliable predictor of diabetes control outcomes. Older adults with diabetes face a higher risk of chronic microvascular and macrovascular complications. Additionally, they may have fewer resources for managing their condition than younger individuals, highlighting the need for enhanced self-management support.

The identified critical thresholds warrant attention in clinical practice and serve as a foundation for further research aimed at optimizing patient outcomes through tailored interventions.

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Conflict of Interest

The authors declare that they have no competing interest.

Informed Consent

Not applicable

Author Contributions

Chih-Yen Chang: writing - original draft preparation, data curation, software, validation. Andrew Y.C. Huang: investigation, writing - reviewing and editing. Hsiao-Chung Wang: data curation, software, validation. Shen-Ming Lee: writing - reviewing and editing. Ching-Sung Ho: conceptualization, methodology, and visualization. All authors contributed to the preparation of the final manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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