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Construction of an IMB Model-Based Brain-Heart Health Manager-Led Intervention Pathway and Its Effects on Self-Management Behaviors in Patients with Diabetes: An Empirical Study

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Abstract

This study aimed to construct an intervention pathway led by brain-heart health managers based on the Information-Motivation-Behavioral Skills (IMB) model and to evaluate its effects on self-management behaviors and clinical outcomes in patients with diabetes. A randomized controlled intervention study was conducted among 120 patients with diabetes at high risk for stroke, who were randomly assigned to an intervention group (n = 60) or a control group (n = 60). The control group received routine nursing care, while the intervention group received an IMB model-based intervention in addition to routine care for six months. Outcomes included diabetes self-management behaviors, glycemic indicators, cognitive function, and nursing satisfaction. At 6 months, the intervention group had significantly better self-management behavior scores, glycemic indicators, cognitive function scores, and nursing satisfaction than the control group (all $P < 0.05$). These findings suggest that the IMB model-based intervention pathway led by brain-heart health managers may effectively promote self-management behaviors and improve selected health outcomes in patients with diabetes, providing a practical, theory-driven approach for chronic disease management.

Keywords

IMB Model, Brain-Heart Health Manager, Diabetes, Self-Management Behavior, Intervention Pathway

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1. Introduction

Diabetes mellitus is a chronic metabolic disease characterized by persistent hyperglycemia, which can lead to both microvascular and macrovascular complications and substantially increase the risk of stroke. Patients with diabetes frequently presion, dyslipidemia, and carotid atherosclerotic plaque, which interact synergistically to further elevate stroke risk [1]. Chronic hyperglycemia contributes to endothelial dysfunction and accelerates atherosclerosis, while hypertension and dyslipidemia exacerbate these pathological processes. Carotid plaque, as a direct manifestation of atherosclerosis, is considered an important early warning marker for stroke. Therefore, effective comprehensive management strategies targeting this high-risk population are critically needed [2].

The Information-Motivation-Behavioral Skills (IMB) model is a widely used theoretical framework for health behavior change, emphasizing the essential roles of accurate information acquisition, motivation enhancement, and behavioral skills development [3]. According to the IMB model, adequate health-related information forms the foundation for behavior change, sufficient intrinsic or extrinsic motivation drives individuals to initiate change, and practical behavioral skills enable the translation of intentions into sustained action. In the field of chronic disease management, the IMB model has been extensively applied to promote self-management behaviors, improve treatment adherence, and optimize health outcomes [4].

Brain-heart health managers represent an emerging professional role integrating medical expertise and health management competencies. They are capable of providing personalized health guidance through comprehensive assessment and individualized intervention planning [5]. By supporting lifestyle modification and self-management capacity, brain-heart health managers may play a particularly important role in managing patients with diabetes who are also at high risk for cerebrovascular disease [6]. Integrating the IMB model into a structured intervention pathway led by brain-heart health managers may facilitate the formation and maintenance of healthy behaviors in this population.

In summary, for patients with diabetes and a high risk of stroke, the development of an IMB model based intervention pathway led by brain-heart health managers holds substantial practical significance. Through structured information delivery, motivation activation, and behavioral skills training, this pathway has the potential to improve glycemic control, enhance self-management behaviors, support cognitive function, and improve long-term prognosis. This comprehensive management strategy provides a novel perspective for chronic disease care and warrants further exploration in clinical practice.

2. Materials and Methods

2.1. Inclusion and Exclusion Criteria

Inclusion criteria:

1) Adults diagnosed with type 2 diabetes mellitus;

2) High risk for stroke as defined by the "8 + 2" stroke risk assessment (meeting the prespecified threshold for high risk);

3) Able to communicate and complete questionnaires;

4) Voluntary participation with written informed consent.

Hypertension, dyslipidemia, and carotid plaque were ascertained and documented as key vascular risk factors for eligibility verification and baseline characterization. Verification of key risk factors (hypertension/dyslipidemia/carotid plaque): Hypertension: Hypertension was verified by documented physician diagnosis in the medical record and/or current use of antihypertensive medication, or by on-site blood pressure measurements meeting the diagnostic threshold (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg) on at least two separate readings.

Dyslipidemia: Dyslipidemia was verified by documented diagnosis in the medical record or current lipid-lowering therapy (e.g., statins), or by fasting lipid profile obtained within 12 weeks prior to enrollment (or during hospitalization), including any of the following: total cholesterol (TC) ≥6.2 mmol/L, triglycerides (TG) ≥2.3 mmol/L, or low-density lipoprotein cholesterol (LDL-C) ≥4.1 mmol/L.

Carotid plaque was verified by carotid ultrasonography performed within 3 months prior to enrollment (or during hospitalization). Plaque was defined as a focal structure protruding into the arterial lumen meeting the ultrasound reporting criteria of the imaging department. Carotid plaque was confirmed when the official ultrasound report explicitly documented "carotid plaque/atherosclerotic plaque.

Operational definition of high risk for stroke ("8 + 2"): High risk for stroke was defined by the "8 + 2" stroke risk assessment: participants with ≥3 of the 8 core risk factors (hypertension, dyslipidemia, diabetes, atrial fibrillation/valvular heart disease, smoking, overweight/obesity, physical inactivity, family history of stroke) or a history of stroke/TIA were classified as high risk.

Exclusion criteria:

Type 1 diabetes or gestational diabetes; history of severe cardiovascular or cerebrovascular events (myocardial infarction or stroke); malignant tumors or severe psychiatric disorders.

2.2. General Information

From January to June 2023, 120 hospitalized patients with diabetes who met the criteria for high stroke risk were recruited from the Department of Endocrinology, Jingzhou First People's Hospital. Participants were randomly assigned to the intervention group or control group using a random number table, with 60 patients in each group. Eligible participants were randomized (1:1) to the intervention or control group using a random number table prepared before enrollment by a researcher not involved in outcome assessment. Group assignment was disclosed only after eligibility confirmation and completion of baseline assessment to reduce selection bias.

In the intervention group, there were 28 males and 32 females, aged 51 - 73 years (mean ± SD: 61.48 ± 6.19 years). In the control group, there were 34 males

and 26 females, aged 41 - 78 years (61.47 ± 6.94 years). No statistically significant differences were observed in baseline demographic characteristics between the two groups ($P > 0.05$).

This study was approved by the Medical Ethics Committee of Jingzhou First People's Hospital, and all participants and their family members provided informed consent.

2.3. Intervention Procedures

Patients in the control group received routine diabetes health education, including dietary guidance and complication prevention, distribution of diabetes management manuals, and participation in standard hospital-organized health lectures, to ensure access to basic disease management knowledge.

Patients in the intervention group received routine care plus an IMB model-based intervention pathway led by brain-heart health managers. The pathway was structured around three core IMB components: information enhancement, motivation activation, and behavioral skills training, with specific intervention strategies implemented for each component. Brain-heart health managers were registered nurses with ≥10 years of diabetes care experience who completed structured training in stroke-risk screening and chronic disease health management (3 months). Each manager supervised approximately 6-8 participants and delivered the IMB components as follows: information sessions (education + risk feedback), motivation enhancement (motivational interviewing/counseling), and behavioral skills training (diet, exercise, SMBG skills), with endocrinologists available for clinical decision support.

The intervention was delivered over a 6-month period. Outcomes were assessed at baseline (T0) and at 6 months (T1). Throughout the study period, all participants continued to receive usual care according to contemporary clinical guidelines. The research team did not mandate a standardized medication regimen; glucose-lowering, antihypertensive, and lipid-lowering therapies were managed by the treating clinicians as clinically indicated.

Within the IMB framework, behavioral skills acquisition not only serves as a prerequisite for behavior change but may also reinforce motivation through early behavioral experiences. Accordingly, following information enhancement, this study prioritized behavioral skills training while simultaneously integrating motivation activation strategies.

2.3.1. Information Enhancement

An individualized health profile was established for each patient using a cerebrovascular disease big data platform, incorporating demographic characteristics, medical history, family history, and lifestyle factors. Risk stratification was conducted using the "8 + 2" stroke risk score, glycemic indicators, and cognitive function assessments, based on which personalized intervention plans were formulated. Health information was dynamically updated through regular laboratory testing and clinical evaluations to ensure accuracy and timeliness.

2.3.2. Behavioral Skills Training and Execution

Brain-heart health managers guided patients in translating health information into actionable self-management behaviors through face-to-face instruction, health lectures, and short educational videos covering diet management, physical activity, and blood glucose monitoring. Scenario-based approaches, such as visits to a diabetes complication experience center, were used as supplementary methods to enhance awareness of the consequences of unhealthy behaviors.

Patients were assigned home-based tasks, including daily recording of diet, exercise, and blood glucose values. A weekly "healthy dining table" challenge was implemented, in which patients prepared one meal based on provided healthy recipes and uploaded photographs to the management platform for feedback. One family member was designated as a "health partner" to participate in training, assist with task completion, provide emotional support, and enhance social support.

2.3.3. Motivation Activation

Motivational strategies included psychological counseling and group discussions aimed at addressing behavioral barriers, along with positive reinforcement mechanisms such as small incentives and commendation letters. Individualized education plans were developed based on patients' dietary habits, exercise preferences, and medication regimens. Patients were encouraged to maintain health behavior diaries and received targeted feedback to strengthen intrinsic motivation. Family members and peers were engaged to establish social support networks, including patient clubs, facilitating peer education. Behavioral activation strategies were used to encourage gradual participation in activities previously associated with enjoyment or achievement, thereby reinforcing sustained engagement through positive experiences.

2.3.4. Behavioral Maintenance and Internalization

In the extended behavioral skills phase, uploaded meal photographs were analyzed in conjunction with anthropometric and glycemic data to provide personalized dietary recommendations. Patients were encouraged to report daily emotional status and sleep quality, receiving tailored guidance accordingly. Traditional Chinese medicine-based five-element music therapy and related supportive measures were used as auxiliary interventions to promote emotional stability and sleep improvement, rather than as core intervention components. Emergency hypoglycemia management materials and scenario simulations were provided to enhance real-life coping abilities. Continuous analysis of health data enabled risk prediction and personalized feedback to support long-term behavior maintenance and internalization.

2.3.5. Supportive Brain-Heart Co-Management Measures

Additional supportive strategies included regular telephone follow-ups, multidisciplinary online communication groups for timely consultation, offline health lectures, online live courses, and the establishment of an integrated health data center

to enable dynamic intervention management. These measures served as implementation supports for the IMB model and worked synergistically with the information, motivation, and behavioral skills components to enhance self-management behaviors, glycemic control, and cognitive outcomes.

2.4. Outcome Measures and Statistical Analysis

2.4.1. Outcome Measures

Self-management behaviors:

Self-management behaviors were assessed using the Summary of Diabetes Self-Care Activities (SDSCA) scale [7]. The total score ranges from 0 to 42, with higher scores indicating better self-management. According to the total score, self-management levels were categorized as low (0 - 14 points), moderate (15 - 28 points), and high (29 - 42 points).

Glycemic indicators and cognitive function:

At each assessment time point, patients were instructed to remain fasting in the early morning. Venous blood samples were collected and centrifuged to measure fasting plasma glucose (FPG) and 2-hour postprandial plasma glucose (2hPG) levels. Cognitive function was evaluated using the Mini-Mental State Examination (MMSE) [8], which has a maximum score of 30 points, with higher scores indicating better cognitive function.

Nursing satisfaction:

Nursing satisfaction was evaluated using the Newcastle Satisfaction with Nursing Scales (NSNS) [9]. The total score ranges from 0 to 75 points. Scores ≥61 indicate complete satisfaction, scores of 46-60 indicate basic satisfaction, and scores ≤45 indicate dissatisfaction. Overall nursing satisfaction was calculated as follows:

$$\text{Nursing satisfaction}\left(\%\right)=\frac{n\left(\text{completely satisfied cases}\right)+n\left(\text{basically satisfied cases}\right)}{\text{totol number of cases}}$$

2.4.2. Timing and Standardization of Outcome Assessment

All endpoints were assessed at two prespecified time points: baseline (T0, within 24 - 48 h after enrollment) and post-intervention follow-up (T1, at 6 months, ±7 days). The same validated instruments and standardized assessment procedures were applied at both time points. SDSCA and nursing satisfaction were completed using uniform instructions (with assistance provided only for reading/comprehension when needed). MMSE was administered according to a fixed protocol in a quiet setting by trained assessors who were blinded to group allocation. For biochemical outcomes, venous blood samples were collected in the morning after an overnight fast (≥8 h) for FPG, and 2 hPG was measured 2 h after a meal under standardized conditions; all tests were performed in the same hospital laboratory using routine quality-controlled procedures.

2.4.3. Statistical Analysis

Blinding of participants and intervention providers was not feasible; however, outcome assessors (MMSE and nursing satisfaction) were blinded to group allo-

cation. To minimize assessment bias, all outcomes were assessed using standardized instruments and uniform instructions. Assessors received standardized training prior to the study. The MMSE was administered following a fixed protocol in a standardized environment. Nursing satisfaction questionnaires were completed independently (e.g., anonymously) to reduce social desirability bias.

Statistical analyses were performed using SPSS version 26.0. Continuous variables were assessed for normality. Normally distributed variables were expressed as mean ± standard deviation and compared using independent-sample t tests, whereas non-normally distributed variables were presented as median (interquartile range) and compared using the Mann-Whitney U test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or continuity correction where appropriate.

3. Results

3.1. Baseline Characteristics

A total of 120 patients were included in the analysis, with 60 patients in each group. No significant differences were observed between the intervention and control groups in terms of sex distribution, age, or baseline clinical characteristics ($P > 0.05$), indicating good baseline comparability (**Table 1**).

Table 1. Comparison of baseline characteristics between the two groups.

Group	N	Sex, n (%)		Age (years)
		Male	Female	
Intervention group	60	28 (46.70%)	32 (53.30%)	61.48 ± 6.19
Control group	60	34 (56.70%)	26 (43.30%)	61.47 ± 6.94
Statistic		$\chi^2 = 1.201$		$t = -0.014$
P value		0.273		0.989

Note: χ^2 indicates the chi-square test, and t indicates the independent-samples t test.

3.2. Implementation and Participation of the IMB-Based Intervention

During the intervention period, patients in the intervention group demonstrated high levels of participation in the IMB-based intervention components. Most patients completed the assigned health education activities, including viewing educational videos and engaging in scheduled learning tasks. Behavioral records related to diet, physical activity, and blood glucose monitoring were generally complete and maintained with good continuity. Family health partners actively participated in the intervention process, providing support and facilitating adherence to self-management tasks. These observations indicated satisfactory implementation fidelity and engagement with the intervention pathway.

3.3. Changes in Self-Management Behaviors and Cognitive Function

At baseline (T0), no significant differences were observed between the two groups in SDSCA scores or MMSE scores ($P > 0.05$). At 6-month follow-up (T1), the intervention group showed significantly higher SDSCA and MMSE scores than the control group ($P < 0.05$; Table 2). These findings indicate better self-management behaviors and cognitive performance in the intervention group at the post-intervention assessment.

Table 2. Comparison of self-management behavior scores and cognitive function scores between the two groups.

Group	N	Self-management behavior score		MMSE score	
		Before intervention	At 6 months (T1)	Before intervention	At 6 months (T1)
Intervention group	60	25 (24, 31)	34.48 ± 3.77	17 (15, 18)	23 (22, 24)
Control group	60	28 (24, 31)	31.85 ± 4.09	17 (15.25, 20.75)	21 (20, 23)
Statistic		z = −1.28	t = 3.67	z = −1.02	z = −5.53
P value		0.20	<0.001	0.31	<0.001

Note: Data are presented as mean ± standard deviation or median (interquartile range), as appropriate. t indicates the independent-samples t test, and z indicates the Mann-Whitney U test. MMSE, Mini-Mental State Examination.

3.4. Changes in Glycemic Indicators

Baseline levels of fasting plasma glucose and 2-hour postprandial glucose did not differ significantly between groups ($P > 0.05$). Following the intervention, FPG and 2hPG were significantly lower in the intervention group than in the control group ($P < 0.05$; Table 3).

Table 3. Comparison of glycemic indicators between the two groups.

Group	N	Fasting plasma glucose (mmol/L)		2-hour postprandial plasma glucose (mmol/L)	
		Before intervention	At 6 months (T1)	Before intervention	At 6 months (T1)
Intervention group	60	8 (7, 9.07)	5.72±0.61	10.7 (8.93, 12.28)	7.29±0.68
Control group	60	8.2 (7, 9.65)	6.26 ± 0.66	11.55 (9.23, 13.95)	8.49±1.13
Statistic		z = −0.77	t = −4.62	z = −0.97	t= −7.08
P value		0.44	<0.001	0.33	<0.001

Note: Data are presented as mean ± standard deviation or median (interquartile range), as appropriate. t indicates the independent-samples t test, and z indicates the Mann-Whitney U test.

3.5. Nursing Satisfaction

Nursing satisfaction assessed at 6-month follow-up (T1) was significantly higher in the intervention group than in the control group ($P < 0.05$). The total satisfac-

tion rate in the intervention group reached 98.3%, compared with 86.7% in the control group, indicating that the IMB-based intervention pathway led by brain-heart health managers was well accepted by patients (**Table 4**). Note that the satisfaction level before the intervention reflects the patients' overall assessment of the previous routine care services, and is merely used as a baseline description.

Table 4. Comparison of nursing satisfaction between the two groups.

Group	N	Nursing satisfaction score		Satisfaction level (n)			Overall satisfaction
		Before intervention	At 6 months (T1)	Fully satisfied	Basically satisfied	Dissatisfied	
Intervention group	60	58 (54, 64)	65.5 (64, 68)	54	5	1	98.30%
Control group	60	59 (56, 64)	63 (57.25, 65)	38	14	8	86.70%
Statistic		z = −1.10	z = −4.49				χ^{2a} = 4.32
P value		0.27	<0.001				0.04

Note: Data are presented as median (interquartile range), unless otherwise indicated. χ^2 indicates the chi-square test; [a]indicates results with continuity correction; z indicates the Mann-Whitney U test.

4. Discussion

This study constructed an intervention pathway led by brain-heart health managers based on the IMB model and explored its effects on self-management behaviors, glycemic control, cognitive function, and nursing satisfaction among patients with diabetes complicated by hypertension, hyperlipidemia, or carotid atherosclerotic plaques.

To contextualize these findings and support the rationale for applying IMB to a high stroke-risk diabetes population, we briefly relate our results to existing evidence on IMB-guided interventions. Recent IMB-based interventions have demonstrated benefits in diabetes self-management and metabolic control, and emerging evidence further suggests that IMB-guided lifestyle programs may also improve vascular surrogate outcomes (e.g., carotid atherosclerosis-related measures), which supports the plausibility of applying this pathway to patients with diabetes at high risk for stroke [10]-[13]. Taken together, this body of work supports the plausibility of extending an IMB-informed pathway to patients with diabetes at high risk for stroke.

Building on the observed intervention effects, this study examined the role of the core components of the IMB model from both process-related and outcome-related perspectives. The findings suggest that an intervention pathway developed within the IMB framework may play a positive role in promoting self-management behaviors and improving related health outcomes in patients with diabetes. Observations of patients' engagement, participation, and adherence during the intervention process further support the practical applicability of the IMB model in this context.

From the perspective of information delivery, brain-heart health managers provided patients with precise and individualized health information through personalized health records and risk stratification. This targeted provision of information not only helped patients better understand the importance of disease management but also enhanced their confidence in engaging in health management. The dynamic updating of health information ensured the timeliness and relevance of the intervention measures, thereby laying a solid foundation for subsequent behavior change.

Motivation enhancement constituted a key component of the intervention pathway. Through psychological support and positive reinforcement, brain-heart health managers addressed patients' behavioral barrier beliefs and strengthened their intrinsic motivation. In addition, the establishment of social support systems and the incorporation of peer education further facilitated the formation and maintenance of health-promoting behaviors, leading to improvements in self-management practices. Consistent with previous studies, behavioral theory-based interventions have demonstrated promising potential in chronic disease self-management [14]-[16]. Similar results were observed in the present study among patients with diabetes and coexisting cardiovascular and cerebrovascular risk factors, suggesting that the IMB model remains applicable in complex chronic disease management settings.

With regard to behavioral skills development, brain-heart health managers provided continuous behavioral guidance by analyzing patients' uploaded meal photographs, encouraging regular reporting of emotional status and sleep quality, and conducting simulated training for hypoglycemia emergency management. These strategies enabled patients to acquire practical self-management skills, including blood glucose monitoring, dietary regulation, and physical activity management, thereby facilitating the translation of theoretical knowledge into actual behavioral practice. The significantly better glycemic control observed in the intervention group further highlights the critical role of behavioral skills training in effective disease management.

Improvement in cognitive function was also an important outcome of this study. Prolonged hyperglycemia in patients with diabetes may adversely affect cognitive function, whereas effective glycemic control and healthy lifestyle behaviors are known to contribute to cognitive improvement. In this study, cognitive function scores in the intervention group increased significantly, indicating that the IMB-based intervention pathway not only improved health behaviors but also exerted a positive impact on cognitive function.

Nevertheless, several limitations should be acknowledged. This study was conducted in a relatively specific population with a limited sample size, which may affect the generalizability of the findings. In addition, the absence of long-term follow-up limits the evaluation of the sustainability of the intervention effects. Future studies with larger samples and longer follow-up periods are needed.

5. Limitations

Although both groups continued to receive usual care during follow-up, we did not systematically capture longitudinal changes in glucose-lowering, antihypertensive, or lipid-lowering regimens (e.g., initiation, discontinuation, switching, or dose adjustment). Therefore, residual confounding related to concomitant treatment modification cannot be fully excluded, particularly for metabolic outcomes such as FPG and 2hPG. Future studies should prospectively document medication changes and incorporate them into the analytic model to further strengthen causal inference.

6. Conclusion

In conclusion, the IMB model-based intervention pathway led by brain-heart health managers was associated with improvements in self-management behaviors, glycemic control, cognitive function, and nursing satisfaction among patients with diabetes at high risk for cerebrovascular disease. This theory-driven and practice-oriented approach offers a feasible framework for integrated chronic disease management and may inform the development of future interventions targeting complex, high-risk patient populations.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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