



Structural equation modeling of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with type 2 diabetes

Chun-Chin Tsai^a, Hui-Shan Chan^b, Wei-Li Lien^c, Hui-Ying Chu^d, Mei-Fang Chen^{e,*}

^a Department of Refrigeration, Air-Conditioning and Energy Engineering, Far East University, Tainan, Taiwan, ROC

^b Department of Applied Cosmetology, National Tainan Junior College of Nursing, 78, Sec. 2, Min-Tsu Rd., Tainan City 700, Taiwan, ROC

^c Department of Internal Medicine, Kaohsiung Municipal United Hospital, Kaohsiung, 19F., No. 201, Shennong Rd., Gushan Dist., Kaohsiung City 804, Taiwan, ROC

^d Department of Living Services Industry, Tainan University of Technology, Tainan, 529, Zhong-zheng Rd., Yongkang District, Tainan City 71002, Taiwan, ROC

^e Department of Nursing, National Tainan Junior College of Nursing, Tainan, 78, Sec. 2, Minzu Rd., Tainan City 700, Taiwan, ROC

ARTICLE INFO

Keywords:

Self-care behavior
Mindfulness
Internal environment
External environment
Type 2 diabetes

ABSTRACT

Background: To achieve suitable diabetes care, understanding the factors that affect self-care behaviors is necessary.

Objective: To construct a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with diabetes.

Design and methods: This cross-sectional study analyzed a convenience sample of 311 people with type 2 diabetes in Taiwan. Data were collected through questionnaires, including the Diabetes Symptoms Checklist, Emotional Distress Scale, Empowerment Process Scale, Interpersonal Communication Scale and Self-Care Behavior scale.

Results: Structural equation modeling indicated that a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in the patients with diabetes best fit the data. Dispositional mindfulness ($\beta = 0.39$), internal environmental factors ($\beta = 0.52$), and external environmental factors ($\beta = 0.71$) directly influenced self-care behaviors in the patients with diabetes. Dispositional mindfulness significantly indirectly affected self-care behaviors via internal and external environmental factors.

Conclusions: To improve self-care behaviors, interventions should consider mindfulness training, and also include internal environmental factors and external environmental factors in the mindfulness training.

What is already known about the topic?

- To maintain stable diabetes control, people with type 2 diabetes mellitus require effective self-care.
- Few studies have performed structural equation modeling of dispositional mindfulness and self-care behaviors.

What this paper adds

- This study constructed a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in patients with type 2 diabetes.
- Self-care behaviors are directly influenced by internal environmental factors (i.e., physical distress, emotional distress), external

environmental factors (i.e., empowerment process, interpersonal communication), and dispositional mindfulness.

- Dispositional mindfulness significantly indirectly affected self-care behaviors via internal and external environmental factors.

1. Introduction

Self-care behaviors which can reduce disease burden and improve quality of life are the cornerstones of diabetes care (American Association of Diabetes Educators, 2020). However, researchers have indicated that $>1/3$ of patients with diabetes need to improve self-care behaviors (Huang, Lin, Chang, & Lee, 2017). Therefore, it is important to understand the factors that affect self-care behaviors. At present, personal (such as self-efficacy) and environmental (such as empowerment process) factors are considered to affect self-care behaviors (Chen, Wang, &

* Corresponding author at: Department of Nursing, National Tainan Institute of Nursing, 78, Sec. 2, Minzu Rd., Tainan City 700, Taiwan, ROC.

E-mail address: meifang0302@gmail.com (M.-F. Chen).

Hung, 2015). However, in the context of high rates of comorbidities and mortality associated with diabetes (Forbes, 2020; National Health Research Institutes, 2019), it is important to investigate whether there are other unexplored factors. Recently, mindfulness has been shown to be an important factor for diabetes care, and therefore relationships among mindfulness, personal factors, environmental factors and behavior are worth exploring.

Mindfulness is a transformative process, where one develops an increasing ability to experience being present with awareness, acceptance and attention (White, 2014). Dispositional mindfulness refers to the natural tendency to be mindful in daily life, and includes observation (the tendency to observe internal and external experiences), description (describe and differentiate emotional experiences), mindful actions (awareness of what one is doing), non-judgment (not making judgments about whether you are good or bad, encouraging thinking as thinking, not as fact), and non-reactivity (not reacting directly to an event, reacting to an event consciously rather than emotionally) (Fanning, Osborn, Lagotte, & Mayberry, 2018; Huang et al., 2015). Dispositional mindfulness differs from individual to individual, and mindfulness training has been shown to be helpful in nurturing and modifying the level of mindfulness (Brown, Ryan, & Creswell, 2007; Loucks et al., 2016). Mindfulness involves both the mind and body, and it has been shown to self-regulate awareness and attention, thereby lowering reactivity to stressors and being better able to manage feelings and thoughts (Kabat-Zinn, 2013). Individuals should be able to focus on the present moment, through awareness of experienced feelings of self and internal and external environment, with an attitude of acceptance and without judgment (Chen, Chou, & Wang, 2016). Internal environmental factors refer to personal or self-system-related factors, including emotions, values and feelings. External environment refers to factors outside one's physiology. Person (family members, friends, peers, and other health professionals) and surroundings can be considered external environmental factors (Chen, Chou, & Wang, 2016; Chen, Wang, Lin, Hsu, & Chen, 2015). Mindfulness is a modifiable trait that adjusts one's behavior by being aware of one's interactions with the internal and external environment (Loucks et al., 2016). Mindfulness directly influences self-care behaviors and adjusts internal and external environmental factors to indirectly influence self-care behaviors.

With regards to diabetes, mindfulness means encouraging people with diabetes to be aware of their automatic behaviors, and then put aside past unhealthy habits and attachments, change the way they view their diabetes, calmly face life with an attitude of acceptance without judgment, focus on living in the moment, and then improve the ability of self-care behaviors (Ni, Ma, & Li, 2020). Symptom distress and emotional distress are common internal environmental factors related to diabetes. Symptom distress refers to the subjective experience of diabetes-related symptoms and changes as a result of medical treatment (Arbuckle et al., 2009). Emotional distress refers to the patient's perceptions about the emotional burden of diabetes control (Huang, Courtney, Edwards, & McDowell, 2010). Interpersonal communication and empowerment processes are common external environmental factors related to diabetes. Interpersonal communication included external perception (i.e., an individual's ability to interact with others), and internal disservice (i.e., one's desire to remove the distance between the individual with whom they are communicating) (Campbell & Atas Akdemir, 2016). In a patient with diabetes, the empowerment process is defined as the perception of a series of actions of healthcare professionals to assist in developing and using their ability and rights to take control of their diabetes (Chen et al., 2011). Current research has found that mindfulness is inversely related to symptom distress and emotional distress (Liu et al., 2021). Symptom distress and emotional distress have been negatively correlated with self-care behaviors, and mindfulness has been positively correlated with interpersonal communication, empowerment process, and self-care behaviors (Cottingham et al., 2019; Fanning, Osborn, Lagotte, & Mayberry, 2018). In addition, interpersonal communication and the empowerment process have been positively

correlated with self-care behaviors (Chen, Wang, Lin, Hsu, & Chen, 2015). Most of these studies have explored the relationship between two factors, however few studies have used a constructive approach to explore the causal relationships between these factors and mindfulness, and thus are less able to build systematic knowledge. If health professionals can understand the causal relationships between mindfulness, internal and external environments, and self-care behaviors in people with diabetes, they may be able to establish a model. This model may then help to design appropriate strategies to help patients establish mindful self-care behaviors to achieve better health. Therefore, the aim of this study was to construct a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with type 2 diabetes (Fig. 1).

2. Methods

2.1. Design and population

We conducted this cross-sectional survey from April 2021 to February 2022 using self-reported measures. The study was approved by the Human Research Ethics Committee of National Cheng Kung University (approval number: NCKU HREC-E-109-549-2). A convenience sample of people with type 2 diabetes mellitus was recruited from the endocrinology clinics of two hospitals in Southern Taiwan. The enrollment criteria were as follows: (a) clear mental status and able to communicate, (b) age above 18 years old, (c) literate and able to write, (d) independent and able to perform self-care, and (f) completion of four 1-h diabetes education classes within the past year. The exclusion criteria were any history of cancer or any history of mental disease. Potential candidates were screened for eligibility by physicians, and the aims and procedures of the study were explained in detail. Eligible participants were then enrolled if they agreed to participate.

The required sample size was estimated using G*Power (version 3.1.9.4; Germany) software (Faul, Erdfelder, Lang, & Buchner, 2007). According to a pilot study of 60 samples, the effect size calculated by R^2 was 0.15. Given an effect size of 0.15, an α level of 0.05, and a power of 0.95, at least 119 participants were required.

2.2. Hypothesis

- H1.** : Mindfulness has a negative impact on internal environmental factors.
- H2.** : Mindfulness has a positive impact on internal environmental factors.
- H3.** : Internal environmental factors have a negative impact on self-care behaviors.
- H4.** : External environmental factors have a positive impact on self-care behaviors.
- H5.** : Mindfulness has a positive impact on self-care behaviors.
- H6.** : Mindfulness indirectly influences self-care behaviors via internal and external environmental factors.

2.3. Data collection and questionnaires

The subjects completed anonymous questionnaires when they visited the clinics. Reliability and construct validity have been established for all scales used in this study.

2.3.1. Dispositional mindfulness

The dispositional mindfulness of the participants was assessed using the Taiwanese version of the Five Facet Mindfulness Questionnaire (Huang et al., 2015). This 39-item scale includes five subscales: observation (8 items), description (8 items), mindful actions (8 items), non-

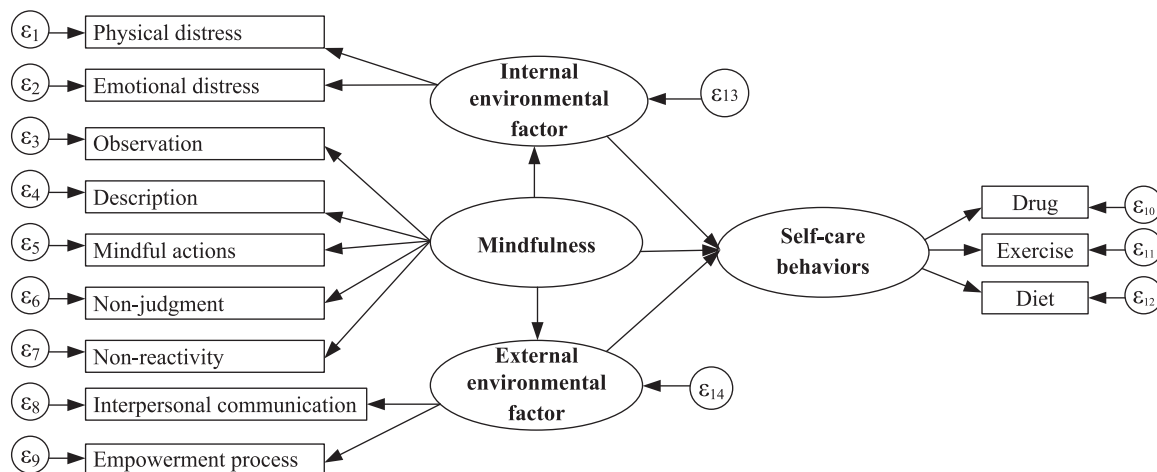


Fig. 1. Mindfulness theoretical framework.

judgmental (8 items), and non-reactivity (7 items). For items 3, 5, 8, 10, 12, 13, 14, 16, 17, 18, 22, 23, 25, 28, 30, 34, 35, 38, and 39, the scores were rated using a Likert scale from 1 (strongly agree) to 5 (strongly disagree). The other items were rated using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The higher the score, the better the dispositional mindfulness. The total possible score ranges from 39 to 195. The Taiwanese version of the Five Facet Mindfulness Questionnaire has been shown to provide a reliable and valid assessment of dispositional mindfulness and mindfulness in people receiving an 8-week mindfulness-based stress reduction intervention (Huang et al., 2015). In this study, the content validity index was 0.96, and Cronbach's α was 0.87.

2.3.2. Internal environmental factors

Internal environmental factors were measured using the Physical Distress Scale (34 items), and Emotional Distress Scale (20 items).

2.3.3. Physical distress

Physical distress was measured using the Diabetes Symptoms Checklist (DSC) (Arbuckle et al., 2009). The DSC was developed to capture the subjective experience of diabetes-related symptoms and changes as a result of medical treatment. The 34 items of the DSC are grouped into eight symptom clusters or domains, each measuring a different aspect of diabetes symptomatology: hyperglycemic, hypoglycemic, psychological-cognitive, psychological-fatigue, cardiovascular, neurological-pain, neurological-sensory, and ophthalmologic. For each item, the participants are asked if they have experienced the symptom in the past 4 weeks, and if yes, how troublesome that particular symptom is for them. The items are rated on a Likert scale from 1 (not at all) to 5 (very distressing). The item scores are summed to form domain scores, and all items of the DSC are summed to form a total score. Higher scores indicate greater symptom burden. The DSC was tested on 4286 patients with type 2 diabetes, and the results showed that the scale had good construct validity and criterion-related validity. The Cronbach's alpha values of the total scale and subscales were 0.69–0.87.

2.3.4. Emotional distress

Emotional distress was measured using the Chinese version of Problem Areas in Diabetes (PAID-C) scale. The PAID-C is a reliable and valid measurement to determine diabetes-related emotional distress in Chinese people with type 2 diabetes (Huang, Courtney, Edwards, & McDowell, 2010). The PAID scale is a 20-item one-factor self-reported instrument. It measures patient perceptions about the emotional burden of diabetes control, including diabetes-related emotional problems, treatment-related problems, food-related problems, and social support-related problems. The items are rated on a Likert scale from 0 (not a

problem) to 4 (serious problem). Higher scores indicate higher diabetes-related emotional distress. The construct and concurrent validity and test-retest reliability of this scale have been established in a Taiwan population of diabetes patients. In this study, Cronbach's α was 0.89.

2.3.5. External environmental factors

External environmental factors were measured using the Interpersonal Communication Scale (7 items) and Empowerment Process Scale (15 items).

Interpersonal communication

The Interpersonal Communication Scale (ICS), developed by Campbell and Atas Akdemir (2016), was used to measure interpersonal communication of the participants. The 7-item ICS is composed of two subscales: External Perception, and Internal Disseverance. External Perception evaluates an individual's ability to interact with others (items 1–4); for example, "I encourage others to tell me how they feel". Internal Disseverance evaluates one's desire to remove the distance between the individual with whom they are communicating (items 5–7); for example, "I use examples to help me explain what I am talking about". The questionnaire is answered using a 7-item Likert scale. The higher the score, the better the interpersonal communication. In this study, the content validity index was 0.96, and Cronbach's α was 0.73 for the overall scale.

2.3.6. Empowerment process

Empowerment process was assessed using the Chinese version of the Diabetes.

Empowerment Process Scale (Chen et al., 2011). The scale includes 15 self-rated items which assess raising awareness (4 items), mutual participation (4 items), providing necessary information (3 items), and open communication (4 items) from healthcare providers. The instrument requires the patient to respond to each item on a 5-point Likert scale ranging from 1 point (strongly disagree) to 5 points (strongly agree). For this scale, construct and concurrent validity, an acceptable Cronbach's alpha (range = 0.73–0.91) and test-retest reliability (range = 0.75–0.83) have been established in a Taiwan population of diabetes patients (Chen et al., 2011). In this study, the Cronbach's alpha was 0.87.

2.3.7. Diabetes self-care behavior

Self-care behaviors were assessed using the Chinese version of three subscales of the Diabetes Self-care Scale (Liu, Tai, Hung, Hsieh, & Wang, 2010), which assesses diet (6 items), exercise (4 items), and medication (3 items) behaviors. Responses are rated from 1 point (complete non-performance) to 5 points (complete performance). Higher scores indicate better self-care behaviors. The total possible score ranges from 13 to

65.

Construct validity and an acceptable Cronbach's alpha (range = 0.87) for the Diabetes Self-care Scale have been established in a Taiwan population with type 2 diabetes (Chen, Wang, Lin, Hsu, & Chen, 2015). The Cronbach's alpha was 0.89 in this study.

2.3.8. Demographic characteristics

The demographic data collected in this study included age, body mass index (BMI) and socioeconomic status (SES).

2.4. Statistical analyses

IBM SPSS version 21.0 and IBM AMOS version 21.0 (SPSS Inc., Chicago, IL, USA) were used for all statistical analyses. Factor analysis of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors was performed to examine construct validity. Pearson's correlation analysis was performed to quantify the relationships between dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors. Structural equation modeling was used to test the model regarding the relationships between mindfulness, physical distress, emotional distress, empowerment process, interpersonal communication, and self-care behaviors in the patients with type 2 diabetes. Confirmatory factor analysis was used to evaluate the factor structures of the above instruments.

Model fit was evaluated using the criteria proposed by March and Balla (1994). Goodness of fit (GFI) was considered acceptable if the X^2 did not significantly ($p > 0.05$) differ and if $CMIN/DF$ was ≤ 3 (chi-square/df). The normal fit index (NFI), incremental fit index (IFI), and Tucker-Lewis index (TLI) all exceeded 0.95. The root mean square residual (RMR) was <0.05 , and the root mean square error of approximation (RMSEA) was <0.08 .

3. Results

3.1. Distribution of individual characteristics

Overall, 311 participants completed the questionnaires, of whom most were women (51.8 %, $n = 161$), 61–70 years of age (46 %, $n = 143$), married (65 %, $n = 202$), had a senior high school education level (38.9 %, $n = 121$), and received oral hypoglycemic agent (OHA) treatment (91.3 %, $n = 284$). The mean mindfulness score was 120.54 (SD = 12.87). Of the internal environmental factors, the mean physical distress score was 63.36 (SD = 28.76), and the mean emotional distress score was 27.5 (SD = 10.05). Of the external environmental factors, the mean interpersonal communication score was 63.36 (SD = 28.76), and the mean empowerment process emotional distress score was 27.5 (SD = 10.05). Of the self-care behaviors, the highest average mean score was for drug behaviors (mean = 11.94, SD = 3.36), and the lowest average mean score was for exercise behaviors (mean = 11.83, SD = 4.53) (Table 1).

3.2. Construct validity of mindfulness, internal environmental factors, external environmental factors, and self-care behaviors

The factor loading of mindfulness, internal environmental factors, external environmental factors, and self-care behaviors were 0.50–0.97, and construct reliability value (CR value) of all variables was >0.6 . These findings further supported the construct validity of the mindfulness, internal environmental factors, external environmental factors, and self-care behavior scales (Table 2).

Table 1
Distribution of individual characteristics (N = 311).

Variables	n (%)	Mean (SD)	Range
Sex			
Male	150 (48.2)		
Female	161 (51.8)		
Age (years)		66.3 (10.9)	41–93
41–50	21 (6.8)		
51–60	70 (22.5)		
61–70	143 (46)		
71–80	36 (11.6)		
>81	41 (13.2)		
Marital status			
Single	20 (6.4)		
Married	202 (65)		
Divorced	36 (11.6)		
Widowed	53 (17)		
Education level			
Junior college or above	46 (14.8)		
Senior high school	121 (38.9)		
Junior high school	63 (20.3)		
Elementary school	66 (21.2)		
No formal education	15 (4.8)		
Religion			
Buddhism	126 (40.5)		
Taoism	134 (43.1)		
Christianity	16 (5.1)		
None	25 (8.0)		
Employment status			
Employed	93 (29.9)		
Retired	144 (46.3)		
Unemployed	74 (23.8)		
Tobacco use			
Yes	77 (75.2)		
No	234 (24.8)		
Alcohol use			
Yes	51 (16.4)		
No	260 (83.6)		
BMI (kg/m ²)			
<18.5	21 (6.8)		
18.5–24	102 (32.8)		
>24			
Duration of DM (years)	188 (60.4)	6.77 (6.02)	0.3–30
<3	82 (26.4)		
3.1–5	125 (40.2)		
5–10	51 (16.4)		
11–15	31 (10.0)		
>15	22 (7.1)		
Chronic diseases			
HTN	152 (48.9)		
Renal disease or GI tract disease	6 (1.9)		
None	153 (49.2)		
Treatment method			
OHA	284 (91.3)		
Insulin	21 (6.8)		
OHA + Insulin	6 (1.9)		
Mindfulness		103.23 (27.51)	39–194
Observation		23.81 (7.73)	8–40
Description		20.86 (5.61)	8–40
Mindful actions		21.09 (6.51)	8–39
Non-judgment		18.63 (5.52)	8–40
Non-reactivity		18.84 (5.57)	7–35
Internal environmental factors			
Physical distress		63.36 (28.76)	0–110
Emotional distress		27.5 (10.05)	0–37.5
External environmental factors			
Interpersonal communication		24.44 (6.91)	7–35
Empowerment process		59.68 (11.09)	32–75
Self-care behaviors		43.20 (11.48)	13–64
Diet		19.43 (5.71)	6–30
Exercise		11.83 (4.53)	4–20
Drug		11.94 (3.36)	3–15

BMI, body mass index; HTN, hypertension; GI, gastrointestinal; DM, diabetes mellitus; OHA, oral hypoglycemic agent.

Table 2

Construct validity and reliability of mindfulness, internal environmental factors, external environmental factors, and self-care behaviors.

Observation variables		Latent variables	Factor loading	Construct reliability value
Observation	←	Mindfulness	0.893	0.83
Description	←	Mindfulness	0.782	
Non-judgment	←	Mindfulness	0.503	
Mindful actions	←	Mindfulness	0.843	
Non-reactivity	←	Mindfulness	0.863	
Physical distress	←	Internal environmental factors	0.803	0.65
Emotional distress	←	Internal environmental factors	0.604	
Interpersonal communication	←	External environmental factors	0.635	0.70
Empowerment process	←	External environmental factors	0.506	
Medication	←	Self-care behaviors	0.502	0.78
Diet	←	Self-care behaviors	0.976	
Exercise	←	Self-care behaviors	0.699	

3.3. A model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with type 2 diabetes

As shown in Fig. 2, mindfulness, internal environmental factors, and external environmental factors were significantly correlated with self-care behaviors ($r = 0.474$ to 0.629 , $p < 0.01$). Mindfulness was significantly correlated with internal environmental factors ($r = 0.331$, $p < 0.01$) and external environmental factors ($r = 0.331$, $p < 0.01$).

As shown in Fig. 3, mindfulness, internal environmental factors, and external environmental factors directly influenced self-care behaviors. Mindfulness ($B = 0.39$, $p < 0.001$), internal environmental factors ($B = 0.52$, $p < 0.001$) and external environmental factors ($B = 0.71$, $p < 0.001$) positively significantly influenced self-care behaviors. These findings indicated that more mindfulness resulted in increased scores of symptom distress, emotional distress, personal communication, empowerment process, and self-care behaviors. Moreover, mindfulness significantly indirectly affected self-care behaviors via internal environmental factors ($B = 0.55$, $p < 0.001$), and external environmental

factors ($B = 0.57$, $p < 0.001$). All parceled factors were significantly loaded on their corresponding latent construct.

The fit indices for the model were $\chi^2 = 93.310$, $p < 0.001$, $df = 33$, $RMSEA = 0.067$, $AGFI = 0.901$, $CMIN/df = 2.828$, $NFI = 0.967$, $IFI = 0.978$, $TLI = 0.956$, $RMR = 0.049$, and $GFI = 0.956$, indicating that the model fit the data well. Mindfulness, internal environmental factors, and external environmental factors explained 70.96 % of total variance for self-care behaviors.

4. Discussion

In this study, we constructed a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors. Dispositional mindfulness, internal environmental factors, and external environmental factors directly influenced self-care behaviors. Dispositional mindfulness may indirectly influence self-care behaviors via internal environmental factors and external environmental factors, as supported by our results.

Our results showed that dispositional mindfulness directly influenced self-care behaviors, which is consistent with studies indicating that mindfulness could predict better self-care behaviors (Miller, Kristeller, Headings, & Nagaraja, 2014). The mechanism by which mindfulness influences self-care behaviors may be that mindfulness does not emphasize restricting self-care behaviors, but rather emphasizes that where the body is, the mind is also. Mindfulness guides a patient to detect the needs and changes of their body, such as hunger, satiety, changes in breathing and heartbeat, increases in exercise flexibility, muscle strength and balance, thereby enhancing the practice of better diet and exercise self-care behaviors. In addition, mindfulness allows a person to be aware of the original behavioral pattern and habitual reaction, and then to gradually and flexibly adjust or change these behaviors and practice self-care behaviors without involving emotions (Cox, Ullrich-French, Cole, & D'Hondt-Taylor, 2016; Medina et al., 2017).

Regarding the relationships among dispositional mindfulness, internal

environmental factors, and self-care behaviors, dispositional mindfulness may influence self-care behaviors via internal environmental factors. In this study, symptom and emotional distress are major of internal environmental factors. Surprisingly, our results showed that a higher level of dispositional mindfulness was associated with greater symptom and emotional distress. In turn, greater symptom and emotional distress resulted in an increase in self-care behaviors. These results are inconsistent with other studies which have reported that a higher level of mindfulness was associated with less symptom and emotional distress, and that the less symptom and emotional distress were associated with an increase in self-care behaviors (Zimmaro et al., 2020). A possible explanation is that the people enrolled in our study adopted more observation than non-judgmental and non-reactivity of the mindfulness technique. Consequently, they noticed their sensations (observation) rather than have an attitude of acceptance (non-judgmental) and peaceful mind (tolerate distressing thoughts without engaging in escape and avoidance actions) (non-reactivity). The mindfulness technique includes observation, description, mindful actions, non-judgment and non-reactivity (Huang et al., 2015). Different mindfulness techniques have different outcomes. Future studies could test the relationships among different types of mindfulness, internal environmental factors, and self-care behaviors. Moreover, the symptoms in this study were none to mild, while in another study they were moderate (Liu et al., 2021). Milder symptom distress would not interfere with practicing the patient's self-care behaviors, but instead remind the patient to perform self-care behaviors to reduce symptoms.

Regarding the relationships among dispositional mindfulness, external environmental factors, and self-care behaviors, dispositional mindfulness may influence self-care behaviors via external environmental factors. In this study, personal communication and

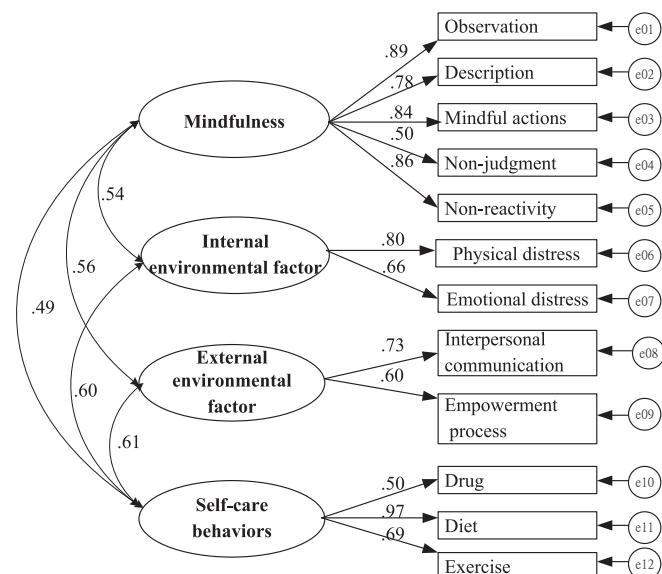


Fig. 2. Confirmatory factor analysis.

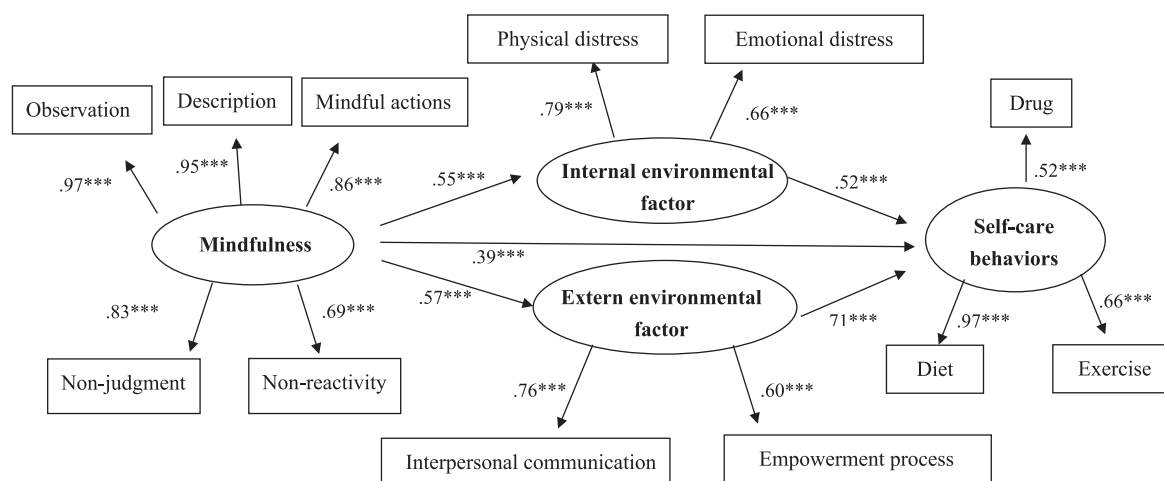


Fig. 3. The model of mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with diabetes. Note: *** $p < 0.001$.

empowerment process are major of external environmental factors. A higher level of dispositional mindfulness was associated with higher personal communication and empowerment process scores, which in turn were associated with more self-care behaviors. These results are consistent with other reports that mindfulness promotes relationships with the external environment, which in turn promotes self-care behaviors (Huang, 2019). In addition, mindfulness clients have reported positive changes in their relationships with their primary caregivers after mindfulness training, listening to each other's feelings, noticing love for each other, bringing each other closer, and finding it easier to communicate (Cottingham et al., 2019; Huang, 2019). The proposed mechanism is that after pulling the client's mind back to this moment, they become aware of the experience and feeling of the interaction between their behavior and the external environment (including interpersonal communication and empowerment process with health professionals), and aware of their habitual response to the external environment and automatic behavior patterns. They then adjust their interaction with the external environment, thereby enhancing self-care behaviors (Cottingham et al., 2019; Huang, 2019).

There are several limitations to this study. First, the participants were recruited from only two hospitals in southern Taiwan, which may limit the generalizability of the results. Further studies are needed to evaluate larger populations recruited from other areas of Taiwan or from other countries. Second, this study only tested dispositional mindfulness in people not receiving mindfulness training. The people in this study adopted more observation than non-judgmental and non-reactivity of the mindfulness technique. This limited the relationships among mindfulness, internal environmental factors, external environmental factors, and self-care behaviors. Further studies are needed to evaluate mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in people with type 2 diabetes receiving mindfulness training. Third, the symptoms in this study were none to mild, and so the results are not generalizability to people with moderate and severe symptoms. Future studies could test the relationships among different mindfulness techniques, different levels of internal environmental factors, and self-care behaviors.

In summary, this study constructed a model of dispositional mindfulness, internal environmental factors, external environmental factors, and self-care behaviors in patients with diabetes. To improve self-care behaviors, interventions should consider mindfulness training and also include internal environmental factors and external environmental factors in the mindfulness training.

Funding

No external funding.

CRediT authorship contribution statement

Chun-Chin Tsai and Mei-Fang Chen made contributions to the study conception and design. Mei-Fang Chen and Wei-Li Lien made contributions to data collection. Hui-Shan Chan and Hui-Shan Chan contributed to data analysis and interpretation. Mei-Fang Chen and Chun-Chin Tsai contributed to the draft and critical revision of the manuscript. All authors approved the final manuscript for publication.

Declaration of competing interest

None.

Data availability

The datasets generated and/or analyzed during the present study are not publicly available, but they are available from the corresponding author on reasonable request.

References

- American Association of Diabetes Educators. (2020). An effective model of diabetes care and education: Revising the AADE7 Self-care Behaviors®. *The Diabetes Educator*, 46, 139–160.
- Arbuckle, R. A., Humphrey, L., Vardeva, K., Arondekar, B., Danten-Viala, M., Scott, J. A., & Snoek, F. J. (2009). Psychometric evaluation of the Diabetes Symptom Checklist-Revised (DSC-R)—A measure of symptom distress. *Value in Health*, 12, 1168–1175.
- Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry*, 18, 211–237.
- Campbell, J. M., & Atas Akdemir, O. (2016). The development of interpersonal communication scale: The study of validity and reliability. *Electronic Turkish Studies*, 11, 859–872.
- Chen, M. F., Wang, R. H., Cheng, C. P., Chin, C. C., Stocker, J., Tang, S. M., & Chen, S. W. (2011). Diabetes Empowerment Process Scale: Development and psychometric testing of the Chinese version. *Journal of Advanced Nursing*, 67, 204–214.
- Chen, M. F., Wang, R. H., & Hung, S. L. (2015). Predicting health-promoting self-care behaviors in people with pre-diabetes by applying Bandura social learning theory. *Applied Nursing Research*, 28, 99–304.
- Chen, M. F., Wang, R. H., Lin, K. C., Hsu, H. Y., & Chen, S. W. (2015). Efficacy of an empowerment program for Taiwanese patients with type 2 diabetes: A randomized controlled trial. *Applied Nursing Research*, 28, 366–373.
- Chen, T. L., Chou, F. H., & Wang, H. H. (2016). Mindfulness: A concept analysis. *The Journal of Nursing*, 63, 113–119.
- Cottingham, A. H., Beck-Coon, K., Bernat, J. K., Helft, P. R., Schmidt, K., Shields, C. G., ... Johns, S. A. (2019). Addressing personal barriers to advance care planning: Qualitative investigation of a mindfulness-based intervention for adults with cancer and their family caregivers. *Palliative & Supportive Care*, 17, 276–285.

- Cox, A. E., Ullrich-French, S., Cole, A. N., & D'Hondt-Taylor, M. (2016). The role of state mindfulness during yoga in predicting self-objectification and reasons for exercise. *Psychology of Sport & Exercise*, 22, 321–327.
- Fanning, J., Osborn, C. Y., Lagotte, A. E., & Mayberry, A. E. (2018). Relationships between dispositional mindfulness, health behaviors, and hemoglobin A1c among adults with type 2 diabetes. *Journal of Behavioral Medicine*, 41, 798–805.
- Forbes, A. (2020). Reducing the burden of mortality in older people with diabetes: A review of current research. *Frontiers in Endocrinology*, 17, 133.
- Fual, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191.
- Huang, C. H., Lin, P. C., Chang, M., & Lee, P. H. (2017). A study on self-care behaviors and related factors in diabetes patients. *The Journal of Nursing*, 64, 61–69.
- Huang, F. Y., Wu, C. W., Bhikshu, H., Shih, G., Chao, Y. P., & Dai, C. T. (2015). Validation of the Taiwanese version of the Five Facet Mindfulness Questionnaire (T-FFMQ). *Psychological Testing*, 62, 231–260.
- Huang, H. Y. (2019). A practical review of mindfulness mechanisms on mindfulness education in Taiwan. *Research in Applied Psychology*, 70, 41–76.
- Huang, M. F., Courtney, M., Edwards, H., & McDowell, J. (2010). Validation of the Chinese version of the Problem Areas in Diabetes (PAID-C) scale. *Diabetes Care*, 33, 38–40.
- Kabat-Zinn, J. (2013). *Full catastrophe living, revised edition: How to cope with stress, pain and illness using mindfulness meditation*. Hachette UK.
- Liu, M. Y., Tai, Y. K., Hung, W. W., Hsieh, M. C., & Wang, R. H. (2010). Relationships between emotional distress, empowerment perception and self-care behavior and quality of life in patients with type 2 diabetes. *The Journal of Nursing*, 57, 49–60.
- Liu, Z., Li, M., Jia, Y., Wang, S., Wang, C., & Chen, L. (2021). Relationship between mindfulness and psychological distress in patients with hepatocellular carcinoma: The mediation effect of self-regulation. *American Journal of Health Behavior*, 45, 1041–1049.
- Loucks, E. B., Gilman, S. E., Britton, W. B., Gutman, R., Eaton, C. B., & Buka, S. L. (2016). Associations of mindfulness with glucose regulation and diabetes. *American Journal of Health Behavior*, 40, 258–267.
- March, H. W., & Balla, J. R. (1994). Goodness of confirmatory factor analysis: The effect of sample size and model parsimony. *Quality & Quantity: International Journal of Methodology*, 28(2), 185–217.
- Medina, W. L., Wilson, D., de Salvo, V., Vannucchi, B., de Souza, E. L., Lucena, L., ... Demarzo, M. (2017). Effects of mindfulness on diabetes mellitus: Rationale and overview. *Current Diabetes Reviews*, 13, 141–147.
- Miller, C. K., Kristeller, J. L., Headings, A., & Nagaraja, H. (2014). Comparison of a mindful eating intervention to a diabetes self-management intervention among adults with type 2 diabetes: A randomized controlled trial. *Health Education & Behavior*, 41, 145–154.
- National Health Research Institutes. (2019). *Taiwan Diabetes Yearbook — 2019 type 2 diabetes*. <https://lib.nhri.edu.tw/NewWeb/nhri/ebook/39000000450002.pdf>.
- Ni, Y., Ma, L., & Li, J. (2020). Effects of mindfulness-based stress reduction and mindfulness based cognitive therapy in people with diabetes: A systematic review and meta-analysis. *Journal of Nursing Scholarship*, 52, 379–388.
- White, L. (2014). Mindfulness in nursing: An evolutionary concept analysis. *Journal of Advanced Nursing*, 70, 282–294.
- Zimmaro, L. A., Carson, J. W., Olsen, M. K., Sanders, L. L., Keefe, F. J., & Porter, L. S. (2020). Greater mindfulness associated with lower pain, fatigue, and psychological distress in women with metastatic breast cancer. *Psycho-Oncology*, 29, 263–270.