Asian Nursing Research 14 (2020) 249–256

Contents lists available at ScienceDirect

Asian Nursing Research

journal homepage: www.asian-nursingresearch.com

Research Article

A New Self-management Scale with a Hierarchical Structure for Patients with Type 2 Diabetes

Eun-Hyun Lee,[1,*] Young Whee Lee,[2] Duckhee Chae,[3] Kwan-Woo Lee,[4] Jin Ook Chung,[5] Seongbin Hong,[6] So Hun Kim,[6] Eun Hee Kang[1]

[1] Graduate School of Public Health, Ajou University, Suwon, Republic of Korea
[2] Department of Nursing, Inha University, Incheon, Republic of Korea
[3] College of Nursing, Chonnam National University, Gwangju, Republic of Korea
[4] Department of Endocrinology and Metabolism, School of Medicine, Ajou University, Suwon, Republic of Korea
[5] Department of Internal Medicine, Chonnam National University Medical School, Gwangju, Republic of Korea
[6] Department of Internal Medicine, School of Medicine, Inha University, Incheon, Republic of Korea

A R T I C L E I N F O

Article history:
Received 11 May 2020
Received in revised form
10 July 2020
Accepted 3 August 2020

Keywords:
diabetes
patient-reported outcome measures
reliability
self-management
validity

S U M M A R Y

Purpose: The aims of this study were to develop a new instrument for measuring self-management with a hierarchical structure [the Diabetes Self-Management Scale (DSMS)] in patients with type 2 diabetes, and evaluate its psychometric properties.
Method: The DSMS instrument was developed in three phases: (1) conceptualization and item generation; (2) content validity and pilot testing; and (3) field testing of its psychometric properties. A convenience sample of 473 participants was recruited in three university hospitals and one regional health center, South Korea.
Results: Exploratory and confirmatory factor analyses yielded two second-order component models explaining the common variance among six first-order factors. Principal axis factoring with a varimax rotation accounted for 60.88% of the variance. Confirmatory factor analysis of the hierarchical structure revealed the following fit indices: χ^2/df = 1.373, standardized root-mean-square residual = .050, goodness-of-fit index = .935, incremental fit index = .975, comparative fit index = .974, and root-mean-square error of approximation = .039. All Cronbach' α values for internal consistency exceeded the criterion of .70. All of the intraclass correlation coefficients for test–retest reliability exceeded .70 except that for the taking-medication subscale. The components of the DSMS were moderately correlated with the comparator measures of self-efficacy and health literacy administered for convergent validity.
Conclusion: The DSMS is a new instrument for measuring the complex nature of self-management in patients with type 2 diabetes, comprising 17 items scored on a five-point Likert scale. The DSMS exhibits satisfactory psychometric properties for five reliability and validity metrics, and so is a suitable instrument to apply in both research and clinical practices.
© 2020 Korean Society of Nursing Science. Published by Elsevier BV. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

Diabetes is a major global health problem being faced this century. The disease affects approximately 463 million people in the world, which is estimated to reach 700 million by 2045 [1]. Type 2 diabetes reportedly accounts for 90.0–95.0% of all cases of diabetes [2]. Self-management is regarded as the cornerstone treatment for improving metabolic control and quality of life, and reducing the risk of complications and health care expenditure [1]. Therefore, the assessment of diabetes self-management by health professionals is crucial for patients with type 2 diabetes.

Eun-Hyun Lee: https://orcid.org/0000-0001-7188-3857; Young Whee Lee: https://orcid.org/0000-0003-1430-9300; Duckhee Chae: https://orcid.org/0000-0003-3259-7385; Kwan-Woo Lee: https://orcid.org/0000-0002-7965-9662; Jin Ook Chung: https://orcid.org/0000-0001-8084-0752; Seongbin Hong: https://orcid.org/0000-0002-8189-395X; So Hun Kim: https://orcid.org/0000-0002-2554-3664; Eun Hee Kang: https://orcid.org/0000-0001-9709-7328

* Correspondence to: Eun-Hyun Lee, RN, PhD, Graduate School of Public Health, Ajou University, 164 Worldcup-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 443-380, Republic of Korea.

E-mail addresses: ehlee@ajou.ac.kr, ywlee@inha.ac.kr, dheechae@jnu.ac.kr, LKW65@ajou.ac.kr, imagine-jjo@hanmail.net, sbhongmd@inha.ac.kr, shoney@inha.ac.kr, hl2dvr@hanmail.net

https://doi.org/10.1016/j.anr.2020.08.003
p1976-1317 e2093-7482/© 2020 Korean Society of Nursing Science. Published by Elsevier BV. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

The past two decades have seen the development of various self-reported instruments measuring diabetes self-management in patients with type 2 diabetes. The most popular and frequently used instrument [3] is the Summary of Diabetes Self-Care Activities—Revised (SDSCA-R), which has 11 items asking the frequency of performing particular diabetes self-care activities over the last 7 days [4]. The SDSCA-R is shorter than other instruments, which improves the feasibility of using it in practice. However, the SDSCA-R is criticized as being out of date, and so needs to be updated based on recently acquired health knowledge [5]. Moreover, Lee et al [3] noted that it may be difficult for the patients with low health numeracy levels to complete the SDSCA-R, because the instrument uses a frequency-based response format that requires a certain level of health numeracy (e.g., for comprehending and calculating numerical values). Crucially, rigorous evidence for its validity is not available [6].

Psychometric problems are not limited to the SDSCA-R instead also applying to most of the other instruments that are currently used to measure diabetes self-management. Recent narrative and systematic reviews of the psychometric properties of instruments for patients with type 2 diabetes have consistently suggested the need for the further development of instruments exhibiting strong psychometric properties [3,6,7].

The conceptualization of a target construct is a basic step when developing a new instrument [8]. Nevertheless, many instrument developers have not clearly defined the diabetes self-management measures, and only in rare cases they have grounded the underlying concept on a theory [5]. Content validity—referring to the extent to which the content of an instrument reflects the construct to be measured—is the most important measurement property because it impacts other properties [9]. The systematic review study of Lee et al [3] found only very-low- to moderate-quality evidence for the content validity of diabetes self-management instruments, implying poor trustworthiness of the results for other measurement properties (e.g., structural validity).

Diabetes self-management is considered to be a multidimensional construct, but no universally accepted domains exist [6]. The most commonly identified domains/subscales have been diet, exercise, taking medications, self-monitoring of blood glucose, and foot care, in addition to less common domains such as psychological coping [6,10]. However, how the domains are mutually structured has been controversial. The Diabetes Self-Management Instrument (DSMI) was originally demonstrated to have a first-order multifactor structure [11]. Its subsequent short version, the DSMI-29, yielded single second-order structure [12]. The SDSCA-R has been demonstrated to have a first-order multifactor structure (with 4–6 factors) [13–15]; however, a single-order structure was recently suggested by Jannoo and Khan [16]. While these structural discrepancies need to be further explored, an appropriate instrument must also have a clear definition and rigorous content validity.

The scoring methods of instruments also need to be considered. Some researchers have noted that the domains of diabetes self-management instruments are not strongly related to each other, therefore requiring scoring separately in each domain [4]. Other authors have asserted the need for a total score combined across all domains as well as scores in the separate domains [16–19]. However, the optimal scoring method may be affected by how the domains of diabetes self-management are related to each other: if an instrument is conceptually hypothesized and empirically demonstrated to have a first-order structure, each domain is scored separately, while if it has a single higher-order structure, each domain and the total score across domains can both be reasonably scored [20].

Based on all the aforementioned issues, the aims of the present study were to develop a new instrument for measuring self-management in patients with type 2 diabetes and evaluate the following psychometric properties: content validity, structural validity, internal consistency, test–retest reliability, and convergent validity.

Methods

Phase I: Conceptualization and item generation

The term self-management has been widely explored over the past three decades, but there is still no consensus on its definition. Self-management has been used interchangeably with the term self-care in the literature [21], and the two terms are similar in being related to an individual engaging in behaviors on their own to achieve health outcomes [22]. However, the conceptual range represented by the two terms differs: self-care is considered a broader concept expressing the healthy lifestyle behaviors required for optimal human growth and development [23], whereas self-management involves health behaviors that are more specific to particular conditions [24]. In a similar vein, Jones et al [25] noted that self-management relates to the condition-specific behaviors of patients with a long-term condition, and the term self-management is mentioned more frequently in the literature on chronic diseases [26]. Another difference is the degree of involvement of health professionals, with some researchers differentiating between self-care being performed by individuals independently of health professionals (e.g., toileting and general bathing) and self-management being carried out by patients in conjunction with health professionals [21,27]. The terms self-care and self-management are sometimes used interchangeably with self-monitoring, referring to the monitoring of physiological parameters or symptoms of a health condition [28]. However, it is preferable for self-monitoring to fall within the domain of self-care or self-management [23,29]. Thus, diabetes self-management was conceptualized in the present study as behaviors that are performed intentionally by a patient with diabetes in daily life to control or reduce the impact of the disease on their health. Moreover, the behaviors represent the tasks planned in collaboration with health professionals.

A review of broad literature, including the latest Association of Diabetes Care and Education Specialists [30] and American Diabetes Association [31], was explored to specify behaviors of diabetes self-management. Then, the following potential behaviors were identified with a consensus among authors: physical exercise, diet, body weight checking, emotional coping, taking medication, self-monitoring of blood glucose, symptom regulation, and foot inspections. In general, self-management behaviors are clustered into healthy lifestyle behaviors (e.g., exercise and healthy diet) and disease-controlling behaviors (e.g., medication adherence and detecting/avoiding symptom triggers) [32]. Empirical studies of diabetes have found lifestyle behaviors (e.g., physical exercise and diet) to be correlated more strongly with one another than with disease-regimen behaviors (e.g., self-monitoring of blood glucose and foot inspections) [13,14,33]. Based on the clustering pattern, diabetes self-management was hypothesized in the present study as two second-order hierarchical components (later named as lifestyle and regimen behavioral components) with their corresponding lower-order potential behaviors (domains). Based on a review of a large amount of literature, we derived 32 attributes of the potential behavioral domains. Then, three experts (2 nursing professors and 1 diabetes nurse educator) confirmed which of the attributes were related to the potential behavioral domains of the diabetes self-management defined in this study.

The attributes were rephrased for each item in accordance with the reading levels of the sixth grade of elementary school or the first grade of middle school [8]. A five-point Likert scale was used for the response options for each item with the following verbal descriptors: never, rarely, sometimes, very often, and always. For the direction of the item timeframe, the recall period was set as the previous month, because a 1-month recall period was found to be more accurate than 3- and 7-day recall periods for self-reported measures in diabetes [34].

Phase II: Content validity and pilot testing

The content validity of the expert agreement was assessed using the item-level content validity index (I-CVI) [8]. A panel of seven experts (4 diabetes nurse educators and 3 professors in nursing) was asked to rate how relevant the 32 items were to the constructs of diabetes self-management on the following four-point scale: 1, not relevant; 2, somewhat relevant; 3, quite relevant; and 4, highly relevant. The I-CVIs were computed as the proportion of experts who agreed that the item was either quite or highly relevant. An I-CVI value of >.78 was considered evidence that the item exhibited adequate relevance. In addition, comprehensiveness and comprehensibility (jargon, reading level, and clarity) of the items were assessed using open questions [8]. For pilot testing, 20 participants with type 2 diabetes and older than 19 years were recruited at a university hospital.

Phase III: Field testing of psychometric properties

1. Study design

A psychometric evaluation was conducted to assess the structural validity, internal consistency, test–retest reliability, and convergent validity of the newly developed Diabetes Self-Management Scale (DSMS).

2. Sample and data collection

A sample of 473 participants was recruited from April to October 2019 at outpatient clinics in three university hospitals and one regional health center. The inclusion criteria for participants were being diagnosed with type 2 diabetes, administered diabetes medications, aged at least 19 years, and articulate in the Korean language. The exclusion criterion was having gestational diabetes. Health professionals (nurses) working at the hospitals screened the participants by applying the study inclusion and exclusion criteria. Potential participants were met at outpatient clinics by trained research assistants. The participants who agreed to participate were asked to sign an informed consent form, and they were then asked to complete questionnaires in a small room at the outpatient clinic. To assess the test–retest reliability of the DSMS, 75 participants were consecutively recruited from among those who had already completed questionnaires at the outpatient clinics in the three university hospitals, and invited to complete the DSMS again 1 week later. Those who agreed were asked to take a stamped and self-addressed envelope that contained a paper version of the DSMS to their home, complete it 1 week later [20], and then post it in the return envelope to the study researchers.

3. Ethical considerations

This study was approved by the institutional review boards of the Ajou, Inha and Chonnam university hospitals (Approval no. AJIRB-MED-SUR-18-535, INHAUH 2019-03-017-001, and CNUH-2019-105). All participants were informed about the purpose and voluntary nature of their participation, and the right to refuse and withdraw from participating in the study, and then signed an informed consent form and received remuneration for participating in the study.

4. Measurements

The Diabetes Management Self-Efficacy Scale (DMSES) [35] and the Diabetes Health Literacy Scale [36] were used as comparator tools for assessing the convergent validity of the DSMS, because these two scales measuring self-efficacy and health literacy have been empirically reported to exhibit moderate correlations with diabetes self-management [37,38].

The original version of the DMSES comprises 21 items in four subscales [35]. The present study used the Korean version of the DMSES (K-DMSES), which comprises 16 items in four subscales [39]. The K-DMSES exhibited satisfactory content validity, structural validity, concurrent validity, and internal consistency (Cronbach's α = .92), and also test–retest reliability [intraclass correlation coefficient (ICC) = .85] in 440 patients with type 2 diabetes [39]. Each K-DMSES item is scored on a 11-point scale, with higher scores implying greater self-efficacy for self-management.

Table 1 *General Characteristics of the Participants (N = 473).*

Variable	Total sample (*N* = 473)	Subsample 1 (*n* = 219)	Subsample 2 (*n* = 254)
	n (%)	*n* (%)	*n* (%)
Gender			
Men	247 (52.2)	126 (57.5)	121 (47.6)
Women	226 (47.8)	93 (42.5)	133 (52.4)
Age (yrs)			
≤30	2 (0.4)	1 (0.5)	1 (0.4)
31–40	12 (2.6)	4 (1.8)	8 (3.1)
41–50	55 (11.6)	33 (15.1)	22 (8.7)
51–60	149 (32.0)	68 (31.0)	81 (31.9)
61–70	169 (35.2)	72 (32.9)	97 (38.2)
≥71	86 (18.2)	41 (18.7)	45 (17.7)
Marital status			
Married/living together	381 (80.5)	180 (82.1)	201 (79.1)
Divorced/widowed	75 (16.0)	32 (14.6)	43 (16.9)
Unmarried	12 (2.5)	5 (2.3)	7 (2.8)
Other	3 (0.6)	1 (0.5)	2 (0.8)
Data missing	2 (0.4)	1 (0.5)	1 (0.4)
Employed			
Yes	240 (50.7)	116 (53.0)	124 (48.8)
No	232 (49.1)	102 (46.5)	130 (51.2)
Data missing	1 (0.2)	1 (0.5)	–
Education			
Elementary school	62 (13.1)	24 (11.0)	38 (15.0)
Middle school	77 (16.2)	37 (16.9)	40 (15.7)
High school	189 (40.0)	85 (38.8)	104 (40.9)
College and above	138 (29.2)	71 (32.4)	67 (26.4)
Other	6 (1.3)	2 (0.9)	4 (1.6)
Data missing	1 (0.2)	–	1 (0.4)
Treatment regimen			
Oral hypoglycemic agent	363 (76.7)	172 (78.5)	191 (75.2)
Insulin	14 (3.0)	2 (2.3)	9 (3.5)
Oral hypoglycemic agent + insulin	96 (20.3)	45 (19.2)	54 (21.3)
Glycemic control			
Controlled, HbA1c≤6.5%	116 (24.5)	52 (23.7)	64 (25.2)
Uncontrolled, HbA1c >6.5%	357 (75.5)	167 (76.3)	190 (74.8)
	Mean±SD	Mean±SD	Mean±SD
Duration of disease (yr)	11.5±9.2	11.7±9.7	11.2±8.6

Note. HbA1c = hemoglobin A1c; SD = standard deviation; Yrs = years.

The Diabetes Health Literacy Scale is a comprehensive instrument measuring diabetes-related informational, numeracy, and communication health literacy. It comprises 14 items scored on a five-point Likert scale, with higher scores indicating better health literacy. The instrument exhibited excellent content, structural validity, convergent validity, criterion validity, and internal consistency (Cronbach's α = .85–.90) and also test–retest reliability (ICC = .80–.85) in 462 patients with diabetes [36].

5. Data analysis

Data were analyzed using the SPSS for Windows (version 25, IBM Corp., Armonk, NY, USA) and AMOS software (version 25, IBM Corp., Armonk, NY, USA). For the cross-validation of structural validity, the total sample (Table 1) was randomly split into two subsamples using the SPSS random-assignment function, and subsample 1 ($n = 219$) and subsample 2 ($n = 254$) were then used for exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), respectively. The number of subsamples satisfied the required number of cases, which was seven times the number of items for EFA and at least 200 cases for CFA [9].

EFA was performed to reduce items and to provide the number of potential factors for CFA. Before performing EFA, a zero-order correlation matrix for all items was computed to determine whether the matrix was factorable. Items with only a weak or no correlation between them ($r < .30$) were eliminated because they would share too little common variance and so potentially yield excessive number of factors [40]. Bartlett's test of sphericity and the Kaiser–Meyer–Olkin test were also performed to assess the factorability of the data for EFA. EFA was performed using principal axis factoring (PAF) with a varimax rotation. The number of factors for which the eigenvalues were >1 was determined, and the cumulative percentage of variance extracted by the factors was at least 60.0% [40]. The criterion for a meaningful factor loading was set as >.50, and the criterion for item communality (h^2) was >.40 [41].

For CFA, the missing data were replaced using expectation–maximization estimation. The assumption of multivariate normality for CFA was tested using Mardia's normalized estimate of multivariate kurtosis. Because of the violation of the assumption, bootstrapping on 1000 samples using a maximum likelihood estimation and bias-corrected confidence intervals (90% CIs) was performed [42]. The hypothesized hierarchical structure with two second-order components and first-order factors derived from the PAF was evaluated using CFA with the following fit indices: $\chi^2/df < 2$, standardized root-mean-square residual <.08 [43], goodness-of-fit index >.90, incremental fit index >.95, comparative fit index >.95, and root-mean-square error of approximation <.05 [42,44].

Internal consistency was assessed using the corrected item-total correlation coefficient with a criterion of .31–.80, and Cronbach's α with a criterion of .70 [40]. Test–retest reliability was tested using the ICC with a criterion of ≥.70 [9]. Convergent validity with self-efficacy and health literacy were analyzed using Pearson 's correlation.

Results

Content validity and pilot testing

Five items were eliminated because I-CVI was <.78, and seven items were rephrased to improve the comprehensibility. A professor majoring in Korean language and literature refined the semantics used to present the items. Participants in the pilot study were aged 59.9 ± 13.1 years, 35.0% of them were women, and 80.0% of them used an oral hypoglycemic agent. They were asked to complete the 27 content-validated items and were also interviewed about the relevance and comprehensibility of the items. One item (“nutritional information label”) was refined to improve its comprehensibility. The content-validated DSMS was produced, which contained 27 items scored using a five-point Likert scale ranging from 0 to 4, with higher scores indicating better self-management.

Structural validity

1. EFA with subsample 1

A zero-order correlation matrix for all items revealed that three items were not significantly or only weakly correlated (r <.30) with most other items (88.9–92.6%), so those items were eliminated.

Table 2 *EFA Results and Cronbach's α Values with Subsample 1 (n = 219).*

No.	Abridged item description	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	h^2
1	Amount of aerobic exercise	.06	.05	**.69**	.15	.03	.05	.51
2	Intensity of aerobic exercise	.24	.05	**.70**	.13	−.06	−.03	.57
3	Muscular exercise	.10	.11	**.62**	−.07	.18	.11	.45
4	Move my body in daily life	−.05	.11	**.61**	.08	.24	.23	.50
5	Avoid high-calorie foods	.16	.04	.14	.10	**.84**	.06	.77
6	Consider the types and amounts of foods	.24	.19	.16	.20	**.54**	.20	.49
7	Positive attitude	.23	.16	.04	.24	.10	**.68**	.61
8	Divert myself when stressed	.12	.02	.20	.05	.09	**.72**	.59
9	Take or inject prescribed medication at the correct time	.17	.13	.14	**.82**	.11	.22	.79
10	Take or inject the correct dose of prescribed medication	.18	.10	.12	**.81**	.14	.07	.73
11	Regular blood glucose tests	.15	**.77**	.09	.10	.00	.08	.64
12	Record blood glucose levels	.18	**.81**	.07	.06	.11	.02	.71
13	Compare measured blood glucose level with goal level	.27	**.75**	.14	.09	.11	.11	.68
14	Attention to symptoms of hypoglycemia	**.68**	.25	.05	.18	.15	.03	.58
15	Bring along first aid foods for symptoms of hypoglycemia	**.68**	.15	.03	.13	.03	.07	.50
16	Attention to any changes in symptoms (e.g., thirst or frequent urination)	**.78**	.11	.18	−.01	.11	.20	.71
17	Foot inspections	**.62**	.18	.14	.15	.18	.14	.51
	Eigenvalue	2.31	2.06	1.93	1.58	1.24	1.23	
	Percentage of the variance	13.56	12.13	11.37	9.29	7.28	7.25	
	Cronbach's α	.82	.86	.76	.76	.73	.71	

Factor 1, self-regulation; Factor 2, blood glucose monitoring; Factor 3, physical exercise; Factor 4, taking medication; Factor 5, diet; Factor 6, stress alleviation; h^2, item communality.
Boldface indicates factor loadings that exceed the criterion of .50.
Note. EFA = exploratory factor analysis.

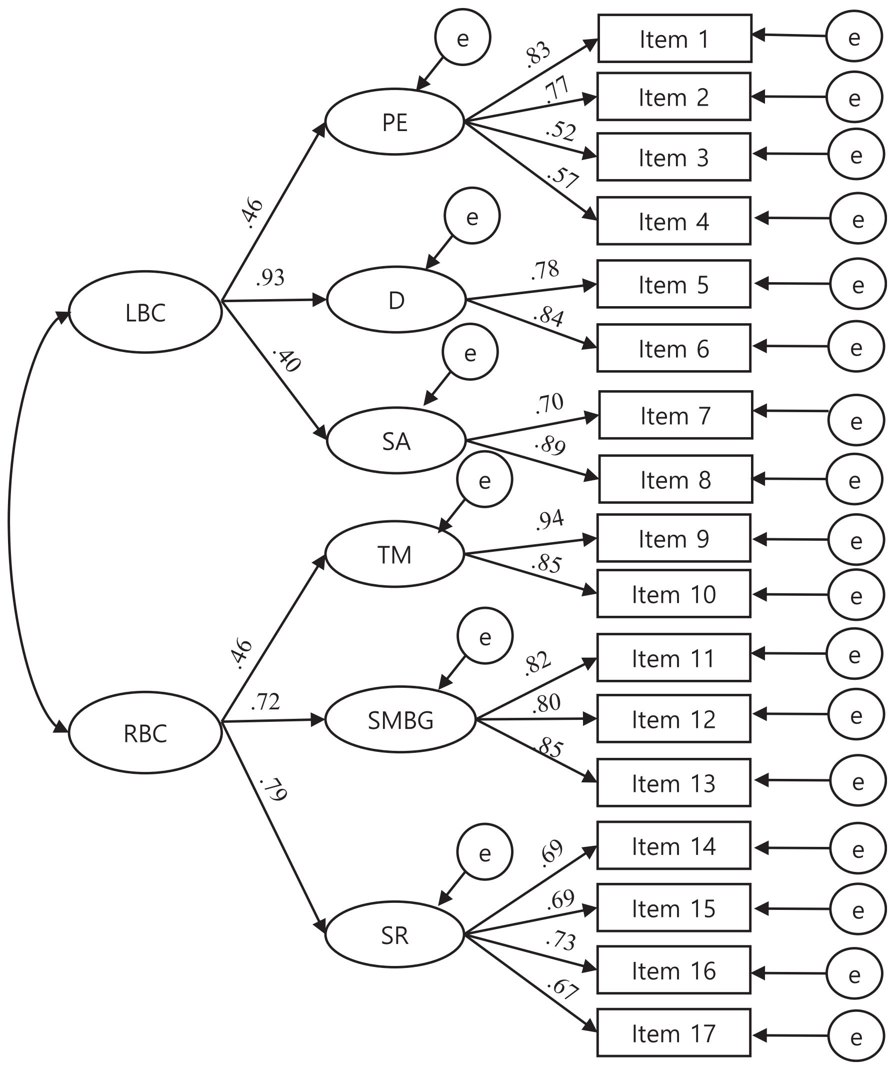

Figure 1. Two second-order components of the six-factor model of the DSMS. *Note.* D = diet; *e* = measurement error; LBC = lifestyle behavioral component; PE = physical exercise; RBC = regimen behavioral component; SA = stress alleviation; SMBG = self-monitoring of blood glucose; SR = self-regulation; TM = taking medication.

PAF with 24 items in subsample 1 extracted a six-factor solution with eigenvalues >1, and six items that did not load at a criterion of >.50 onto any factor. After removing these items, PAF with 18 items extracted the following six factors that accounted for 62.3% of the total variance in the items: physical exercise (4 items), diet (2 items), stress alleviation (3 items), taking medication (2 items), self-monitoring of blood glucose (3 items), and self-regulation (4 items). However, one item that loaded on the stress-alleviation factor exhibited a corrected item-total correlation coefficient of .82, implying item redundancy, and so that item was eliminated. Finally, PAF with 17 items extracted six factors that accounted for 60.88% of the total variance, and all items of the DSMS loaded meaningfully onto one of these six factors, while there were no cross-loadings >.50 (Table 2). The communality (h^2) exceeded .40 for all the items. Bartlett's test of sphericity was significant (χ^2 = 1741.62, p < .001), and the Kaiser–Meyer–Olkin value was good, at .85, implying that the data were suitable for factor analysis [44]. The six factors were significantly correlated with one another, ranging from r = .21 (between stress alleviation and self-monitoring of blood glucose) to r = .42 (between self-monitoring of blood glucose and self-regulation).

2. CFA with subsample 2

CFA was performed to assess whether the hierarchical structure of the two second-order components (lifestyle and regimen behavioral components) was predicted to account for corresponding the six first-order factors derived from the PAF, as presented in Figure 1. This model provided a good fit: χ^2/df = 1.373, standardized root-mean-square residual = .050, goodness-of-fit index = .935, incremental fit index = .975, comparative fit index = .974, and root-mean-square error of approximation = .039 (90% CI of root-mean-square error of approximation = .022–.053). Three factors (physical exercise, diet, and stress alleviation) loaded significantly on the second-order lifestyle behavioral component, and the remaining three factors (taking medication, self-monitoring of blood glucose, and self-regulation) also loaded significantly on the second-order regimen behavioral component. All the bootstrapped standardized items loaded significantly on their corresponding first-order factors, ranging from .52 to .94 (Figure 1). The proportion of the second-order components that explained the first-order factors ranged from 86.0% (diet subscale) to 16.0% (stress-alleviation subscale). The second-order components were moderately correlated with each other (r = .55, p < .001).

Table 3 *Internal Consistency and Test–Retest Reliability of the DSMS.*

	Internal consistency ($N = 473$)		Test–retest reliability ($n = 75$)
	Corrected item-total correlation coefficient	Cronbach's α	ICC
First-order subscales			
Physical exercise	.49–.63	.76	.86
Diet	.62	.76	.80
Stress alleviation	.59	.74	.73
Taking medication	.78	.88	.66
Self-monitoring of blood glucose	.73–.74	.86	.94
Self-regulation	.60–.65	.80	.87
Second-order components			
Lifestyle behavioral component	.31–.54	.76	.92
Regimen behavioral component	.39–.61	.84	.84

Note. DSMS = Diabetes Self-Management Scale; ICC = intraclass correlation coefficient.

Internal consistency and test–retest reliability

Table 3 indicates that the DSMS satisfied internal consistency. The corrected item-total correlation coefficients for the components and subscales ranged from .31 to .78. Cronbach's α values for the components ranged from .76 to .84, and those for the subscales ranged from .74 to .88. All the ICCs for components and subscales supported the satisfactory test–retest reliability of the DSMS (ICC >.70), with the exception of the taking-medication subscale (ICC = .66).

Convergent validity with a total sample

The lifestyle component of the DSMS was moderately correlated with health literacy ($r = .43$, $p < .001$) and self-efficacy ($r = .54$, $p < .001$), and the regimen component was correlated with health literacy ($r = .40$, $p < .001$) and self-efficacy ($r = .43$, $p < .001$), thereby satisfying convergent validity. Each subscale was also correlated with both health literacy and self-efficacy, with coefficients ranging from $r = .30$ to $r = .44$ ($p < .001$).

Descriptive statistics of each item with a total sample

The proportion of missing values for each item ranged from 0% to 1.1%. More than half of the participants responded "always" to the item 9 ("take or inject prescribed medication at the correct time") and item 10 ("take or inject the correct dose of prescribed medication") (63.6% and 56.0%, respectively). These items had the highest and the second-highest scores (3.48 ± 0.87 and 3.39 ± 0.88), implying the presence of ceiling effects (Supplementary Table 1).

Discussion

Psychometric properties

The DSMS is a newly developed and validated instrument that comprises 17 items scored on a five-point Likert scale. The term diabetes self-management has been considered to be a multidimensional concept [6]. Nevertheless, most of the existing instruments have been criticized for measuring restricted domains of the concept, in particular excluding the emotional-coping and/or medication domains [6,19]. The DSMS developed in the present study covers these domains, and so it can be considered a more comprehensive instrument.

It was originally considered that the structures underlying most instruments that assess diabetes self-measurement comprised first-order multidimensions. However, subsequent re-explorations and ancillary analyses of some instruments considered hierarchical structures (a single second-order construct with multiple dimensions) to investigate the more-complex nature of the constructs, such as the SDSCA-R [16], DSMI-29 [12], and DHPSC [19]. However, these investigations did not clearly describe the conceptual definitions or empirical/theoretical backgrounds that had been initially defined when developing the instruments. In contrast, the DSMS was originally developed from the conceptualization of a hierarchical structure based on empirical backgrounds. In addition, the two second-order components (lifestyle and regimen behavioral components) differentiate the DSMS from previous instruments with a single second-order construct of the overall diabetes self-management. In a similar vein, Corbin and Strauss [45] also suggested the possibility of multiple second-order constructs of the concept of self-management. The two second-order components of the DSMS empirically supported that the six subscales can be scored either individually or together in their corresponding two components. In other words, scoring different subscales or components individually might be more informative when assessing diabetes self-management, rather than scoring an entire scale.

All the Cronbach's α values of the DSMS components and subscales demonstrated ranged from .74 to .88, which implies that (1) the DSMS satisfied internal consistency because of the criterion value of ≥.70, and (2) there was no redundancy of items because none of the Cronbach's α values exceeded .90, and there was no need to determine whether any items needed to be combined or deleted [46].

The test–retest reliability of the DSMS remained stable over a 1-week interval, with the exception of the taking-medication subscale. There were ceiling effects for the two items of the taking-medication subscale. Considering that a ceiling effect can negatively affect an estimate of reliability [8], the marginally unsatisfactory test–retest reliability of the taking-medication subscale (ICC = .66) might have been due to the ceiling effect on its items.

Convergent validity refers to the degree to which the scores of a focal instrument (self-management in this study) are correlated with the scores of comparators that they should be correlated with [20]. Self-efficacy is a well-known predictor of diabetes self-management [47], and health literacy is an emerging and important predictor of it [48]. Using the predictors as comparators, the DSMS exhibited satisfactory convergent validity.

Strengths and limitations

This study had some specific strengths. From the perspective of contents, the DSMS comprehensively measures the concept of diabetes self-management and reflects the current usage of technology in medical environments. Most people now use smartphones, and so patients with diabetes can use a smartphone-linked blood glucose meter and record their blood glucose levels in applications [50]. To the best of our knowledge, such a recording attribute with glucose meter usage has not been included in other psychometrically validated self-reported instruments. From a methodological point, a cross-validation approach was used to assess the structural validity of the DSMS using EFA and CFA in different subsamples. In particular, the present study is the first to suggest and demonstrate a hierarchical structural instrument with two second-order components for measuring the more-complex nature of diabetes self-management. The DSMS uses a Likert scale as the response format. When considering that a frequency-based format requires a certain level of health numeracy [3], the DSMS has the advantage of being less affected by the level of health numeracy.

The first limitation of this study is that responsiveness was not evaluated, referring to the ability to detect changes over time. It is therefore recommended for future studies to longitudinally investigate interventions (e.g., diabetes self-management education) that can induce changes in diabetes self-management. The second limitation was the DSMS only being applied to patients in Korea with type 2 diabetes, so that its cross-cultural validity could not be evaluated. It is recommended to assess the DSMS in other languages to determine whether or not the translated items adequately reflect the original items of the DSMS. The third limitation was that the date on which participants completed the DSMS might not have corresponded to the date of the hemoglobin A1c (HbA1c) examination, because the most recent HbA1c values were collected from the participants' medical records. These mean that the HbA1c could not be used as a comparator for assessing the convergent validity of the DSMS. Future studies should therefore match assessments between the two measures for convergent validity. Criterion validity was not evaluated in this study because there is no gold standard for diabetes self-management [5].

Implication for practice

Self-management is the cornerstone treatment for diabetes, taking place in daily life at the home or workplace. This means that it is impractical to make direct observations of patient adherence; instead, health professionals in clinical practices directly ask how their patients are taking care of themselves. In a busy clinical setting, the use of the reliable and valid DSMS will help health professionals to assess self-management by patients in a time-efficient manner. The scores derived from the DSMS may be used to facilitate provider–patient communication in implementing educational interventions tailored to the needs of individual patients.

Conclusion

This study developed the DSMS for measuring self-management in patients with type 2 diabetes, which comprises 17 items scored on a five-point Likert scale. The DSMS is a comprehensive instrument measuring the more-complex nature of the hierarchical structure of diabetes self-management. The instrument exhibited good psychometric properties of content validity, structural validity, convergent validity, internal consistency, and test–retest reliability. The instrument may be less affected by the health numeracy levels of respondents compared with instruments using frequency-based item responses. These characteristics mean that the DSMS may make it possible for health professionals to accurately assess the self-management levels of patients in practice, and for researchers to accurately assess the effect of self-management intervention in patients with type 2 diabetes.

Funding source

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2018R1A2B6001719). The funder did not play any role in the conduct or publication of the study.

Author contributions

E.-H.L. conceived the study. E.-H.L., Y.W.L, and D.C. analyzed the data, and were involved in writing the manuscript. K.-W.L., J.O.C., S.H., S.H.K., and E.H.K. were responsible for data collection. All authors contributed to and approved the final submitted version.

Conflict of interest

The authors have no potentially relevant conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anr.2020.08.003.

References

1. International Diabetes Federation. IDF diabetes atlas [Internet]. 9th ed. Belgium: International Diabetes Federation; 2019 [cited 2019 December 19]. Available from: http://www.diabetesatlas.org
2. American Diabetes Association. Classification and diagnosis of diabetes: standards of medical care in diabetes–2019. Diabetes Care. 2019;42:S13–28. https://doi.org/10.2337/dc19-S002
3. Lee J, Lee E-H, Chae D, Kim C-J. Patient-reported outcome measures for diabetes self-care: a systematic review of measurement properties. Int J Nurs Stud. 2020;105:103498. https://doi.org/10.1016/j.ijnurstu.2019.103498
4. Toobert DJ, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measures: results from 7 studies and a revised scale. Diabetes Care. 2000;23(7):943–50. https://doi.org/10.2337/diacare.23.7.943
5. Ausili D, Barbaranelli C, Riegel B. Generalizability of the self-care of diabetes inventory across cultures and languages: Italy and the United States. Eval Health Prof. 2019;43(1):41–9. https://doi.org/10.1177/0163278719840689
6. Lu Y, Xu J, Zhao W, Han H-R. Measuring self-care in persons with type 2 diabetes: a systematic review. Eval Health Prof. 2016;39(2):131–84. https://doi.org/10.1177/0163278715588927
7. Caro-Bautista J, Martín-Santos FJ, Morales-Asencio MM. Systematic review of the psychometric properties and theoretical grounding of instrument evaluating self-care in people with type 2 diabetes mellitus. J Adv Nurs. 2014;70(6): 1209–27. https://doi.org/10.1111/jan.12298
8. Polit DF, Yang FM. Measurement and the measurement of change. Philadelphia, PA: Wolters Kluwer; 2016. p. 35–40.
9. de Vet HCW, Terwee CB, Mokkink LB, Knol DL. Measurement in medicine: a practical guide (Practical guides to biostatistics and epidemiology). London: Cambridge University Press; 2011. p. 154.
10. Schmidt-Busby J, Wiles J, Exeter D, Kenealy T. Understanding 'context' in the self-management of type 2 diabetes with comorbidities: a systematic review and realist evaluation. Diabetes Res Clin Pract. 2018;142:321–34. https://doi.org/10.1016/j.diabres.2018.06.003
11. Lin CC, Anderson RM, Chang CS, Hagerty BM, Loveland-Cherry CJ. Development and testing of the diabetes self-management instrument: a confirmatory analysis. Res Nurs Health. 2008;31(4):370–80. https://doi.org/10.1002/nur.20258
12. Tahmasebi R, Noroozi A. Cross-cultural validation of the diabetes self-management scale in Iranian patients. HealthMED. 2012;26(8):2635–41.
13. Choi EJ, Nam M, Kim SH, Park CG, Toobert DJ, Yoo JS, et al. Psychometric properties of a Korean version of the summary of diabetes self-care activities measure. Int J Nurs Stud. 2011;48(3):333–7. https://doi.org/10.1016/j.ijnurstu.2010.08.007
14. Kamradt M, Bozorgmehr K, Krisam J, Freund T, Kiel M, Qreini M, et al. Assessing self-management in patients with diabetes mellitus type 2 in Germany: validation of a German version of the Summary of Diabetes Self-Care Activities measure (SDSCA-G). Health Qual Life Outcome. 2014;12:185. https://doi.org/10.1186/s12955-014-0185-1
15. Kav S, Akman A, Dogan N, Tarakci Z, Bulut Y, Hanoglu Z. Turkish validity, and reliability of the summary of diabetes self-care activities measure for patients with type 2 diabetes mellitus. J Clin Nurs. 2010;19(19-20):2933–5. https://doi.org/10.1111/j.1365-2702.2010.03329.x
16. Jannoo Z, Khan NM. Summary of Diabetes Self-care Activities: a confirmatory factor analytic approach. Prim Care Diabetes. 2018;12(5):425–31. https://doi.org/10.1016/j.pcd.2018.04.004
17. Bukhsh A, Lee SWH, Pusparajah P, Schmitt A, Khan TM. Psychometric properties of the diabetes self-management questionnaire (DSMQ) in Urdu. Health Qual Life Outcome. 2017;15:200. https://doi.org/10.1186/s12955-017-0776-8
18. Schmitt A, Gahr A, Hermanns N, Kulzer B, Huber J, Haak T. The Diabetes Self-Management Questionnaire (DSMQ): development and evaluation of an instrument to assess diabetes self-care activities associated with glycaemic

control. Health Qual Life Outcome. 2013;11:138. https://doi.org/10.1186/1477-7525-11-138
19. Wang RH, Lim LY, Cheng CP, Hus MT, Kao CH. The psychometric testing of the diabetes health promotion self-care scale. J Nurs Res. 2012;20(2):122–9. https://doi.org/10.1097/jnr.0b013e318254eb47
20. Furr RM. Psychometrics: an introduction. 3rd ed. Thousand Oaks, California: Sage; 2018. p. 78–81.
21. Wilkinson A, Whitehead L. Evolution of the concept of self-care and implications for nurses: a literature review. Int J Nurs Stud. 2009;46(8):1143–7. https://doi.org/10.1016/j.ijnurstu.2008.12.011
22. Ryan P, Sawin KJ. The individual and family self-management theory: background and perspectives on context, process, and outcomes. Nurs Outlook. 2009;57(4):217–25. https://doi.org/10.1016/j.outlook.2008.10.004
23. Richard AA, Shea K. Delineation of self-care and associated concepts. J Nurs Scholarsh. 2011;43(3):255–64. https://doi.org/10.1111/j.1547-5069.2011.01404.x
24. Wilson PM, Kendall S, Brooks F. Nurse's responses to expert patients: the rhetoric and reality of self-management in long-term conditions: a grounded theory study. Int J Nurs Stud. 2006;43(7):803–18. https://doi.org/10.1016/j.ijnurstu.2005.10.011
25. Jones MC, MacGillivray S, Kroll T, Zohoor AR, Connaghan J. A thematic analysis of the conceptualization of self-care, self-management and self-management support in the long-term conditions management literature. J Nurs Healthc Chronic Illn. 2011;3(3):174–85. https://doi.org/10.1111/j.1752-9824.2011.01096.x
26. Lorig KR, Holman HR. Self-management education: history, definition, outcomes, and mechanism. Ann Behal Med. 2003;26(1):1–7. https://doi.org/10.1207/S15324796ABM2601_01
27. Becker G, Gates RJ, Newsom E. Self-care among chronically ill African-Americas: culture, health disparities, and health insurance status. Am J Publ Health. 2004;94:2066–73. https://doi.org/10.2105/AJPH.94.12.2066
28. Wilde MH, Garvin S. A concept analysis of self-monitoring. J Adv Nurs. 2007;57(3):339–50. https://doi.org/10.1111/j.1365-2648.2006.04089.x
29. Song M, Lipman TH. Concept analysis: self-monitoring in type 2 diabetes mellitus. Int J Nurs Stud. 2008;45(11):1700–10. https://doi.org/10.1016/j.ijnurstu.2008.04.005
30. ADCES. AADE7 self-care Behaviors® [Internet]. Chicago, IL: Association of Diabetes Care and Education Specialists [cited 2020 March 03]. Available from: https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors.
31. American Diabetes Association. Lifestyle management: standards of medical care in Diabetes–2019. Diabetes Care. 2019;42:S46–60. https://doi.org/10.2337/dc19-S005
32. Audulv A, Packer T, Hutchinson S, Roger KS, Kephart G. Coping, adapting or self-managing – what is the difference? A concept review based on the neurological literature. J Adv Nurs. 2016;72(11):2629–43. https://doi.org/10.1111/jan.13037
33. Peyrot M, Bushnell DM, Best JH, Martin ML, Cameron A, Patrick DL. Development and validation of the self-management profile for type 2 diabetes (SMP-T2D). Health Qual Life Outcome. 2012;10:125. https://doi.org/10.1186/1477-7525-10-125
34. Gonzalez JS, Schneider HE. Methodological issues in the assessment of diabetes treatment adherence. Curr Daib Rep. 2011;11:472–9. https://doi.org/10.1007/s11892-011-0229-4
35. van der Bijl JV, Poelgeest-Eeltink AV, Shortridge-Baggett L. The psychometric properties of the diabetes management self-efficacy scale for patients with type 2 diabetes mellitus. J Adv Nurs. 1999;30(2):352–9. https://doi.org/10.1046/j.1365-2648.1999.01077.x
36. Lee E-H, Lee YW, Lee K-W, Nam M, Kim SH. A new comprehensive diabetes health literacy scale: development and psychometric evaluation. Int J Nurs Stud. 2018;88:1–8. https://doi.org/10.1016/j.ijnurstu.2018.08.002
37. Lee E-H, Lee YW, Moon SH. A structural equation model linking health literacy to self-efficacy, self-care activities, and health-related quality of life in patients with type 2 diabetes. Asian Nurs Res. 2016;10(1):82–7. https://doi.org/10.1016/j.anr.2016.01.005
38. Ishikawa H, Takeuchi T, Yano E. Measuring functional, communicative, and critical health literacy among diabetes patients. Diabetes Care. 2008;31(5): 874–9. https://doi.org/10.2337/dc07-1932
39. Lee E-H, van der Bijl JV, Shortridge-Baggett LM, Han SJ, Moon DH. Psychometric properties of the diabetes management self-efficacy scale in Korean patients with type 2 diabetes. Internet J Endocrinol. 2015:780701. https://doi.org/10.1155/2015/780701
40. Pett MA, Lackey NR, Sullivan JJ. Making sense of factor analysis. Thousand oaks, California: Sage; 2003. p. 172.
41. Costello AB, Osborne JW. Best practices in exploratory analysis: four recommendations for getting the most from your analysis. Practical Assess Res Eval. 2005;10.
42. Byrne BM. Structural equation modeling with AMOS: basic concepts, applications, and programming. 2nd ed. New York, NY: Taylor and Francis Group; 2016. p. 73–83, 331-3.
43. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model. 1999;6(1):1–55. https://doi.org/10.1080/10705519909540118
44. Tabachnick BG, Fidell LS. Using multivariate statistics. 6th ed. Boston: Pearson; 2013. p. 720–5.
45. Corbin JM, Strauss A. Understanding work and care: managing chronic illness at home. San Fransisco, CA: Jossey-Bass; 1988. p. 135–7.
46. Devellis RR. Scale development: theory and application. Newbury Park, CA: Sage; 2012. p. 144–6.
47. Brown SA, García AA, Brown A, Becker BJ. Biobehavioral determinants of glycemic control in type 2 diabetes: a systematic review and meta-analysis. Patient Educ Counsel. 2016;99(10):1558–67. https://doi.org/10.1016/j.pec.2016.03.020
48. Gonzalez JS, Tanenbaum ML, Commissariat PV. Psychosocial factors in medication adherence and diabetes self-management: implications for research and practice. Am Psychol. 2016;71(7):539–51. https://doi.org/10.1037/a0040388
50. Jung J. Diabetes management according to blood glucose measurement trend. J Kor Diabetes. 2017;18(1):37–42. https://doi.org/10.4093/jkd.2017.18.1.37. Korean.