

# Development and Validation of a Questionnaire to Assess the Determinants of Dietary Adherence Among Patients After Bariatric Surgery

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**Purpose:** This study was aimed to develop a questionnaire to assess the determinants of dietary adherence among patients after bariatric surgery based on the attitude-social influence-efficacy (ASE) model and to evaluate its psychometric properties.

**Patients and Methods:** According to semi-structured interview, Delphi expert consultation and pilot study, the initial questionnaire was formed and applied to investigate 319 patients after bariatric surgery in a tertiary hospital in Jiangsu Province, China. The reliability and validity of the scale were tested.

**Results:** The 28-item of the attitude-social influence-efficacy questionnaire after bariatric surgery (ASEQBS) was formed. The results of exploratory factor analysis showed that four factors, including intention, attitude, social influence, and self-efficacy, could be extracted, and the cumulative variance contribution rate reached 59.98%. Confirmatory factor analysis showed the model fit well. The content validity index of each item was 0.800–1.000, and the content validity index of the ASEQBS was 0.857. The total Cronbach's  $\alpha$  of the ASEQBS was 0.920, the split-half reliability was 0.774, and the retest reliability was 0.922.

**Conclusion:** The results suggest that ASEQBS is a valid and reliable measure of determinants of dietary adherence. It may be useful to evaluate the influence factors of dietary adherence and helpful to evaluate the efficacy of tailored dietary intervention programs.

**Keywords:** bariatric surgery, dietary adherence, attitude-social influence-efficacy model, questionnaire, validation

## Introduction

Obesity is defined as abnormal or excessive fat accumulation and has been classified as a disease by the World Health Organization (WHO), which presents a risk to an individual's health.<sup>1</sup> It is related to the development of cardiovascular diseases, endocrine diseases, and cancers.<sup>2,3</sup> With the increasing prevalence around the world, obesity has become a globally public health problem.<sup>4</sup> According to the WHO, it was estimated that the prevalence of obesity had been over 13% in 2016 and it will be increased by 33% by 2030.<sup>1</sup> The Report on the Nutrition and Chronic Disease Status of Chinese Residents indicated that more than 50% of adult residents were overweight or obese in China.<sup>5</sup> Due to the large population base, there are the most obese people in China and the total number of severe obese people is second only to the United States.<sup>6</sup> Therefore, effective treatments are needed to reduce the negative impact of obesity on patients' health and the economic burden on society.

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Bariatric surgery (BS) has been considered a sustainable and effective treatment for severe obesity or related comorbidities, specifically Type 2 diabetes mellitus (T2DM).<sup>7</sup> The most commonly used surgical procedures are sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB).<sup>8</sup> The alterations of gastrointestinal anatomy lead to food restriction and nutrient malabsorption to some extent, which may cause nutrition problems among postoperative patients.<sup>9</sup> Anemia, dumping syndrome, osteoporosis, or even neurological problems are common in post-bariatric patients.<sup>10</sup> In order to lose more weight and avoid postoperative complications, patients are advised sufficient protein, micronutrient supplementation, less carbohydrate and fat intake.<sup>11,12</sup> However, patients' adherence to these dietary recommendations was not good and needed to be improved.<sup>13</sup> Previous studies have revealed that postoperative patients generally suffered from insufficient water intake, failure to supplement vitamins and trace elements as required, and excessive intake of carbohydrates and fats.<sup>14</sup> It was also demonstrated that patients with better adherence had a greater decrease in BMI, which meant adherence to recommended rules predicted the positive outcomes of bariatric surgery.<sup>15</sup> Notwithstanding the fact that bariatric surgery has been increasingly popular in China,<sup>16</sup> representative data on people's reasons for following dietary recommendations is still limited. Consequently, a greater understanding of determinants is important to take effective measures to improve dietary adherence.

Dietary adherence is a reflection of various factors, including socio-demographic factors, disease-related factors and psychosocial factors, among which psychosocial factors are the most important intervenable factors.<sup>17</sup> Health behavior change theory is useful in explaining behavior through psychosocial factors, and interventions targeting these factors are often more effective.<sup>18</sup> Specifically, Attitude-Social influence-Efficacy (ASE) model can help to systematically identify intrapersonal factors and interpersonal factors that can support behavioral modifications, making it easier to achieve the desired improvements. ASE model had been proposed by Dr. Hein de Vries in 1988, which integrated elements of the social learning theory and theory of planned behavior.<sup>19</sup> It argues that people's intention to perform a behavior is the main predictor of actual behavior performance and intention depends on the individual's attitude, social influence, and self-efficacy.<sup>20,21</sup> Intention to perform a behavior refers to the person's readiness to perform a behavior.

Attitude consists of the advantages and disadvantages of a particular behavior and could be assessed by measuring the beliefs that are associated with a particular behavior and the evaluations of these beliefs.<sup>22</sup> Social influence could be defined as the subjective norm, injunctive norm, and descriptive norm. The subjective norm means that people have with respect to the specific behavior. Injunctive norm refers to a person's perception of support from others to perform or refrain from the behavior. Descriptive norm refers to a person's perception of whether the important people actually performs or refrains a certain behavior themselves.<sup>23</sup> Self-efficacy can be seen as a person's belief whether he or she could perform the behavior and cope with barriers. Many studies have used the ASE model as a theoretical framework to analyze the determinants of eating behavior or adherence. Brug et al<sup>23</sup> applied this model to explore the psychosocial determinants affecting Dutch people's fruit and vegetable consumption, and the results proved that low self-efficacy and less positive attitudes may lead to lower consumption of food. Pajor et al<sup>24</sup> also demonstrated socio-cognitive factors in the ASE model are associated with dietary supplement use. Based on the ASE model, Zhang et al<sup>25</sup> found that the intention of rational eating behavior was affected by attitude, social influence, and self-efficacy, and these were important factors that can be interfered with. Bolman et al<sup>26</sup> also used the ASE model in exploring the influencing factors of medication adherence in asthma patients, and it could explain medication adherence well. All above studies suggested the feasibility and advantages of using the ASE model to analyze the determinants of dietary adherence. By using the ASE model, it could not only provide a theoretical framework for researchers to explain the mechanism of dietary adherence, but also provide a theoretical basis for clinical staff to design a tailored nutrition education plan for patients.

In the ASE model, since intention, attitude, social influence, and self-efficacy are latent variables, appropriate and effective instruments are needed to measure these factors. After measuring these factors accurately, it could be known about the extent of intention, attitude, social influence, and self-efficacy. Most studies have adopted general measurement tools, such as the Multidimensional Scale of Perceived Social Support<sup>17</sup> and the General Perceived Self-efficacy Scale,<sup>27</sup> but the concepts measured by these tools are inconsistent with the ASE model. In addition, the questionnaire applicable to the assessment of eating self-efficacy in patients undergoing bariatric

surgery, such as the Weight Efficacy Lifestyle Questionnaire-Short Form,<sup>28</sup> has not been verified in the Chinese post-bariatric patients, and this questionnaire mainly targets overeating, which is not completely consistent with the concept of dietary adherence defined by this study. What's more, only a few studies provided information about reliability and construct validity. Since these questionnaires are either combinations of different structures of other questionnaires or failure to use all of the ASE model constructs, or content irrelevance, there is a need for developing a culturally relevant questionnaire targeted post-bariatric population.

As a consequence, there still lacks a standardized measure of determinants of dietary adherence for Chinese patients after bariatric surgery based on the ASE model. To address this gap in knowledge, the purpose of this study is to develop a reliable and valid instrument to identify the determinants of dietary adherence and facilitate the improvement of adherence.

## Methods

Two phases were conducted to develop a reliable and valid measurement tool, which was called Attitude-Social influence-Efficacy Questionnaire after Bariatric Surgery (ASEQBS). Phase 1 included the development of the initial version of the questionnaire by semi-structured interviews and the process of expert consultation using the Delphi method. Phase 2 entailed a formal cross-sectional survey to test the reliability and validity of the questionnaire.

### Phase I: Development of the Initial Version of ASEQBS

#### Item Pool Formation

Firstly, we conducted semi-structured interviews with 20 participants who had undergone bariatric surgery at least three months, which included 10 males and 10 females aged from 22 to 58 years. The participants were selected purposefully by maximum diversity sampling (eg, age, occupation, marital status, surgical method) to ensure independence and representativeness until data saturation. All interviews were conducted face-to-face individually by the first author (HFZ). The interview guiding questions included the following: (1) How well do you follow the dietary recommendations? (2) What are the advantages or disadvantages of following these dietary recommendations? (3) Who will influence you to follow the dietary

recommendations? How do you think these people's thoughts or behaviors influence you? (4) What factors or circumstances will make it easy or difficult to adhere to dietary recommendations? (5) In addition to the above, what other reasons do you think will influence you to follow the dietary recommendations? For the development of the questionnaire, dietary adherence was defined as the extent to which patients follow dietary recommendations by health care professionals or dietitians, such as nutrient intake, water intake, eating habits and so on.<sup>21</sup> For data analysis, all interviews were tape-recorded after obtaining informed consent. The interviews were conducted and transcribed in Chinese, and the transcriptions were used for content analysis. Themes were extracted using a deductive approach, which has three main phases, preparation, organization, and reporting.<sup>29</sup> In the preparation phase, the whole text was read to immerse in the data and fully understand the data. Next, the organizing phase includes coding, creating categories, and abstraction.<sup>29</sup> Finally, in the reporting phase, interpretation and analysis of results generated items of the questionnaire. Data analysis was independently performed by two of the researchers (HFZ and KZ), and consensus on results was achieved through discussion sessions among them. The details of the interview results are presented in the previous study.<sup>30</sup> After discussion and revision repeatedly in research group, a list of 28 candidate items formed the first draft of the questionnaire, and each item was measured using a five-point Likert scale ranging from 1 to 5.

#### Expert Consultation

Two rounds of Delphi anonymous consultation were conducted to test the content of the initial questionnaire. In the two rounds of expert consultation, 14 and 12 experts were invited respectively, and 12 experts agreed to participate. Therefore, a total of 12 experts evaluated the initial scale, and the same experts participated in the two rounds. The active coefficients of the experts in the two rounds were 85.71%, 100%, respectively. 12 experts in surgery, nutriology, nursing, and health education were included, which comprised 2 males and 10 females, aged 24–54 ( $41.58 \pm 7.59$ ) years old, who had worked in their role for an average of  $17.50 \pm 8.92$  years, and 8 of them had master's or higher degrees. The anonymous consultation questionnaires were sent to the experts by email, which included the introduction of the study and the evaluation part of the ASEQBS. The evaluation part contained the importance and linguistic expression of each item. The importance

was rated on a Likert-type scale from 1 (very unimportant) to 5 (very important). Comments and suggestions for item improvement were provided by the experts. The expert authority coefficient was 0.93, and the Kendall concordance coefficients were 0.28 and 0.41 for each round. According to the results of expert consultation, two items “When I have a strong appetite, I can adhere to the diet” and “My fellow patients can adhere to the diet” were removed because the average score of importance assignment <4.00 or coefficient of variation >0.25. Four items were modified to make the item content more appropriate. Three items were added according to the experts’ suggestions, “When I am in a good mood, I can adhere to the diet”, “I intend to adhere to the diet”, “I would like to make the effort to adhere to the diet”. Finally, a draft ASEQBS including 29 items was generated.

### Pilot Study

The pilot study was conducted to ensure that the items were comprehensible and unambiguous, which involved 20 participants through face-to-face investigation. After completing the questionnaire, the clarity of the items, the format of the questionnaire, and the time needed to complete were evaluated. Participants considered all the items in the questionnaire were clearly expressed and easy to understand. Thus, no other major adjustments had to be made. The mean time for completing the questionnaire was about 5 min.

## Phase 2: Psychometric Tests of the Draft ASEQBS

### Participants and Study Setting

The participants were recruited by convenience sampling at the Department of Bariatric and Metabolic Surgery in a tertiary hospital in Jiangsu province from May to September 2020. Inclusion criteria were: (1) met the surgical criteria of the Chinese Guidelines for the Surgical Treatment of Obesity and Type 2 Diabetes: body mass index (BMI)  $\geq 32.5$  kg/m<sup>2</sup> or  $27.5 \leq \text{BMI} < 32.5$  with comorbidities; (2) underwent BS at least 3 months; (3) age  $\geq 18$  years old. Exclusion criteria were: patients who (1) experienced serious complications, such as gastrointestinal bleeding, anastomotic fistula, or intestinal obstruction; (2) suffered from other serious diseases affecting eating behavior, such as hyperthyroidism, hypothyroidism, malignant tumors, or cardiovascular events; (3) were pregnant or lactating women; (4) underwent revisional surgery. The sample size was calculated according to the requirement

of factor analysis, which required at least 5–10 participants per item.<sup>31</sup> Besides, the sample size of exploratory factor analysis (EFA) should be at least 100, and that of confirmatory factor analysis (CFA) should be at least 150. Considering 10% of the invalid questionnaires, the total sample size needed for this study was at least 315. Ethical approval was granted from the ethical committee of the First Affiliated Hospital of Nanjing Medical University (Ethical Approval Code: 2020-SR-247). All participants signed an informed consent form for participating in the study. This study was conducted in compliance with the Declaration of Helsinki.

### Instrument

The participants’ demographic information was collected via self-reported, including age, gender, educational level, occupational status, and marital status. Anthropometric data, such as height and weight were also reported by participants and then BMI was calculated. Disease-related information was obtained from the electronic medical record.

The first draft of the 29-item ASEQBS was applied to assess the determinants of post-bariatric patients’ dietary adherence during the last month. This questionnaire was self-reported and each item was rated from 1 to 5 points. Total scores ranged from 29 to 145, with higher scores in each dimension indicating better intention, attitude, social influence, or self-efficacy.

### Data Collection

Questionnaires were distributed face-to-face. A text explaining the purpose of the survey and data privacy would be informed to the participants. After obtaining informed consent, data was collected by two uniformly trained researchers (HFZ and KZ). All questionnaires were completed by the participants themselves, or with the help of the investigator. If participants did not understand the questionnaire well or were unable to fill it in by themselves, the investigator read each item in turn without any suggestion, and then recorded the choices made by the participants. The investigator collected the questionnaires immediately after participants filled them out, and then checked the completeness. If the participant randomly made the choice (in wavy or linear form) or gave up answering the questionnaire halfway, the questionnaire was considered to be invalid.

### Item Selection

Item analysis was used to analyze and screen the item, and the criteria were as follows:<sup>32</sup>(1) items with no statistically

significant difference in scores between high and low groups or with a critical ratio < 3; (2) items with standard deviation < 0.75; (3) item–total correlation or corrected item–total correlation coefficient < 0.4; (4) overall Cronbach's  $\alpha$  for the questionnaire increased after deleting an item; (5) factor loading value < 0.4 or communalities value < 0.2. If the item meets at least three of the above six criteria for deletion, it will be deleted.<sup>33</sup>

### Reliability and Validity Test

Construct and content validity were evaluated for the questionnaire. Construct validity was evaluated by EFA and CFA. Prior to conducting EFA, the Kaiser-Meyer-Olkin (KMO) measurement of sampling adequacy and Bartlett's sphericity test were performed to verify the factor ability of the data. Then, EFA was conducted with principal components analysis and varimax rotation to identify the underlying factor structure of the questionnaire. The number of factors extracted was determined by eigenvalue  $\geq 1.0$ . CFA was performed using the factor structure obtained in EFA. If the cumulative explanatory variation of common factors extracted in the exploratory factor analysis was > 50%,  $\chi^2/df$  in the confirmatory factor analysis was < 3, the root mean square error of approximation (RMSEA) was < 0.05, confirmatory fit index (CFI), goodness-of fit index (GFI), incremental fit index (IFI), Tucker-Lewis index (TLI) were > 0.9, the construct validity of the questionnaire was considered good.<sup>32</sup>

The item-level content validity index (I-CVI), scale-level content validity index/universal agreement (S-CVI/UA), and scale-level content validity index/average (S-CVI/AVE), which calculated from expert consultation was utilized to quantify content validity. 10 experts evaluated the relevance of each item and rated using a 4-point Likert scale (1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = highly relevant). According to Polit et al,<sup>34</sup> it was recommended that I-CVI  $\geq 0.78$ , S-CVI/UA  $\geq 0.8$ , and S-CVI/AVE  $\geq 0.9$  indicated a good content validity.

Internal consistency reliability, split-half reliability, and test–retest reliability were used to evaluate the questionnaire reliability. Cronbach's  $\alpha$  coefficients were estimated to examine internal consistency (criterion 0.70). The split-half reliability of the questionnaire was tested using Guttman split-half coefficient (criterion 0.70). The test–retest reliability was assessed by the randomly selected participants completing questionnaires twice within a mean interval of two weeks (criterion 0.70).<sup>32</sup>

### Statistical Analysis

Statistical analysis was performed using the SPSS 25.0 and Amos 23.0. The data was divided into two samples randomly. Sample 1 (n= 167) was training dataset and sample 2 (n= 152) was confirmatory dataset. Sample 1 was used for item analysis and EFA, while sample 2 was used for CFA, reliability and validity test. The continuous variables were described by mean and standard deviation and the categorical variables were described by frequency and percentage. Statistical significance for all analyses was set at  $P < 0.05$ .

## Results

### Characteristics of the Participants

A total of 326 questionnaires were distributed, and 319 were effectively collected, representing an effective response rate of 97.85%. The 319 participants had a mean age of 33.52 $\pm$ 9.12 years. Most participants (63.32%) were female. Nearly half of participants had sleeve gastrectomy (49.84%) or sleeve gastrectomy plus surgery (42.32%), with the remainder reporting gastric bypass surgery (7.84%). Most participants (65.83%) had comorbidities and the average BMI was 27.58 $\pm$ 6.65 kg/m<sup>2</sup>. All participants underwent bariatric surgery at least 3 months in the past. The basic characteristics of the participants are shown in Table 1.

### Item Analysis and Selection

Items were selected according to six indexes including critical ratio, standard deviation, item–total correlation or corrected item–total correlation coefficient, Cronbach's  $\alpha$  after item deletion, factor loading value, and communalities value. The item that met at least three of the above six criteria for deletion was deleted. The overall Cronbach's  $\alpha$  for the questionnaire was 0.931. No items were deleted after the analysis according to the item deletion criteria and all items were included for further analysis. The results of items analysis are presented in Table 2.

### Validity Analysis

#### Construct Validity

According to the KMO and Bartlett's sphericity test, the KMO value was 0.864 and the Bartlett's sphericity test was significant ( $\chi^2=3536.197$ ,  $P<0.001$ ), indicating the appropriateness for EFA. After principal components analysis and varimax rotation, four factors with eigenvalues > 1 were identified, accounting for 59.98% of the cumulative



**Table 1** Characteristics of the Participants (n=319)

Characteristics	Category	Means±SD (±s)/n(%)
Age(years)		33.52±9.12
Gender	Male	117(36.68%)
	Female	202(63.32%)
Education	Junior school or less	52(16.30%)
	High school	75(23.51%)
	College or above	192(60.19%)
Occupational status	Employed	222(69.59%)
	Unemployed	74(23.20%)
	Retired	23(7.21%)
Marital status	Married	188(58.93%)
	Unmarried	112(35.11%)
	Divorce or widowhood	19(5.96%)
Type of surgery	LSG	159(49.84%)
	LRYGB	25(7.84%)
	LSG-JJB	62(19.44%)
	LSG-DJB	73(22.88%)
Comorbidity	Yes	210(65.83%)
	No	109(34.17%)
BMI(kg/m <sup>2</sup> )		27.58±6.65
Time since surgery(months)	3-<6	82(25.71%)
	6-<12	104(32.60%)
	12-<24	63(19.75%)
	≥24	70(21.94%)

**Abbreviations:** LSG, laparoscopic sleeve gastrectomy; LRYGB, laparoscopic Roux-en-Y gastric bypass; LSG-JJB, jejunojunal bypass with laparoscopic sleeve gastrectomy; LSG-DJB duodenal-jejunal bypass with laparoscopic sleeve gastrectomy.

variance (Table 3). The item “When I am in a good mood, I can adhere to the diet” which had dual loadings (loadings greater than 0.40 on two factors) was deleted. The factors were self-efficacy (7 items), social influence (10 items), intention (4 items), and attitude (7 items). Table 4 lists the factors loading of the ASEQBS based on the exploratory factor analysis after deleting the item.

The results of the confirmatory factor analysis (N=152) found an optimal model that included 28 items spread among the previously identified four factors. The model fit statistics indicated a good fit of the theoretical model to the empirical model:  $\chi^2/df=1.517$ , CFI=0.936, GFI=0.928, IFI=0.937, TLI=0.923, RMSEA=0.049. These results provide support for the structural validity of the four-factor ASEQBS.

### Content Validity

According to experts' evaluation, the I-CVI was between 0.800 and 1.000. The S-CVI/UA and S-CVI/Ave was 0.857, 0.979, respectively.

## Reliability Analysis

Cronbach's  $\alpha$  for the 28-item ASEQBS in sample 2 (N=152) was 0.907, indicating good internal consistency. Cronbach's  $\alpha$  obtained for each dimension was from 0.807 to 0.935. The split-half coefficient value for all domains was 0.774 and each dimension was from 0.701 to 0.923, which revealed acceptable internal consistency among items in the questionnaire. In terms of the 2-week test-retest reliability assessment, the intra-class correlation coefficient for the total questionnaire was 0.922 and the four domains ranged from 0.844 to 0.923. These results suggested satisfactory reliability and stability of the 28-item ASEQBS (Table 5).

## Discussion

To the best of our knowledge, the current study is a novel one to use the ASE model as a theoretical framework to develop and validate a questionnaire to assess the determinants of dietary adherence among patients after bariatric surgery. In summary, the final version of the ASEQBS consisted of 28 items, which showed good psychometric properties in a Chinese population. The validity and reliability, including construct validity, content validity, and internal consistency, indicated that the psychometric properties of the ASEQBS were shown to be appropriate. Each item is scored from 1 to 5 to provide the scores of each dimension. A linear transformation was used to calculate scores ranging from 28 to 140, where higher scores in each dimension indicate better intention, attitude, social influence, or self-efficacy.

While bariatric surgery is the most effective and sustainable treatment available for severe obesity, weight regain is still common. It has been reported that approximately 5%–20% of individuals who underwent bariatric surgery fail to maintain sufficient weight loss.<sup>35</sup> In Wakayama et al's study,<sup>36</sup> they found that poor dietary adherence at 6 months postoperatively was a significant predictor of higher BMIs. Yanos et al<sup>37</sup> also found that dietary adherence was inversely associated with the likelihood of significant weight regain. In addition, poor dietary adherence has also been proven to be linked to a variety of adverse postoperative outcomes, including gastrointestinal symptoms, vitamin D deficiency, anemia, and poor weight outcomes.<sup>38–40</sup> As dietary adherence is fundamental to medical and surgical outcomes, it is important for patients to adhere to a specific healthy diet for long-term weight loss maintenance.

**Table 2** Item Analysis Results (n=167)

Item	CR	CV	ITC	Cronbach's $\alpha$ After Item Deletion#	Communalities	Factor Loading	Included Items
1	5.722**	0.688	0.425**	0.930	0.246	0.496	√
2	9.582**	0.667	0.595**	0.928	0.474	0.689	√
3	9.873**	0.691	0.575**	0.928	0.456	0.676	√
4	8.844**	0.678	0.586**	0.928	0.458	0.676	√
5	7.131**	0.694	0.525**	0.929	0.313	0.560	√
6	9.439**	0.876	0.624**	0.928	0.408	0.639	√
7	6.256**	0.739	0.462**	0.930	0.237	0.487	√
8	3.214**	0.800	0.316**	0.931	0.208	0.429	√
9	5.242**	0.924	0.466**	0.930	0.247	0.497	√
10	7.080**	1.016	0.505**	0.929	0.308	0.555	√
11	10.199**	0.825	0.67**	0.927	0.439	0.662	√
12	6.531**	1.008	0.547**	0.929	0.267	0.517	√
13	7.093**	1.027	0.586**	0.929	0.289	0.538	√
14	7.128**	1.029	0.562**	0.929	0.250	0.500	√
15	7.023**	0.878	0.491**	0.930	0.200	0.447	√
16	7.160**	0.763	0.584**	0.929	0.306	0.553	√
17	6.857**	0.881	0.551**	0.929	0.242	0.492	√
18	8.656**	0.723	0.601**	0.929	0.318	0.564	√
19	7.551**	1.160	0.579**	0.929	0.273	0.522	√
20	8.133**	1.136	0.629**	0.928	0.349	0.591	√
21	8.982**	1.234	0.629**	0.929	0.337	0.581	√
22	10.872**	0.924	0.717**	0.927	0.537	0.733	√
23	9.724**	0.963	0.702**	0.927	0.507	0.712	√
24	9.417**	0.928	0.679**	0.927	0.493	0.702	√
25	5.876**	0.813	0.461**	0.930	0.209	0.458	√
26	10.771**	0.954	0.681**	0.927	0.483	0.695	√
27	12.181**	0.979	0.706**	0.926	0.551	0.743	√
28	12.120**	0.919	0.725**	0.926	0.567	0.753	√
29	10.058**	0.779	0.690**	0.927	0.508	0.712	√

**Notes:** #Overall Cronbach's  $\alpha$  for the scale was 0.931; \*\* $P < 0.001$ ; √the item were included for further analysis.

**Abbreviations:** CR, critical ratio; CV, coefficient of variation; ITC, item-total correlation.

Identifying the possible determinants becomes a critical measure to improve dietary adherence. Previous studies have revealed that psychosocial factors were associated with dietary adherence but they did not use a specific, reliable, and valid measurement.<sup>41,42</sup> In this study, we developed a 28-item questionnaire with high reliability and good construct validity to measure the determinants of dietary adherence based on the ASE model. A systematic approach has been adopted to ensure the scientific process and robustness of the results. When developing questionnaires, semi-structured interviews and the Delphi method were used to produce the initial items. Besides, participant inclusion in the phase of pilot study might have improved the resulting questionnaire's acceptability and relevance for the target group. Our rigorous development procedure and psychometric evaluation ensured that the ASEQBS is effective and convincing.

Construct validity refers to the degree to which an instrument fully assesses or measures the construct of interest.<sup>32</sup> In this study, exploratory factor analysis and confirmatory factor analysis were conducted to determine factor structure. Construct validity of the ASEQBS was approved as we found the four-factor solution as the clearest pattern of factor loadings, which accounted for a large proportion (59.98%) of all variance between the items. In confirmatory factor analysis, the indexes including  $\chi^2/df$ , GFI, CFI, IFI, TLI, RMSEA suggested the data fit the model well. The findings supported the conceptual framework of the ASE model which encompasses the four constructs of self-efficacy, social influence, intention, and attitude. Content validity refers to the extent to which the items of an instrument adequately represent the concept to be measured.<sup>43</sup> By calculating the content validity index, it was found that the I-CVI of each item was  $>0.78$ , S-CVI/

**Table 3** Contribution Rates of Characteristic Root Variance and Cumulative Variance of the Factors (n=167)

Factor	Name	Eigenvalue	Variance Contribution Rate (%)	Cumulative Variance Contribution Rate(%)
Factor 1	Self-efficacy	10.483	36.147	36.147
Factor 2	Social influence	2.924	10.081	46.229
Factor 3	Intention	2.479	8.549	54.778
Factor 4	Attitude	1.509	5.205	59.983

**Table 4** Factors Loading of the ASEQBS Based on the Exploratory Factor Analysis After Deleting the Item (n=167)

Item	Factor 1	Factor 2	Factor 3	Factor 4
1. I am willing to adhere to the diet	0.095	0.042	<b>0.681</b>	0.326
2. I plan to adhere to the diet	0.236	0.168	<b>0.859</b>	0.25
3. I intend to adhere to the diet	0.263	0.153	<b>0.825</b>	0.233
4. I would like to make the effort to adhere to the diet	0.273	0.169	<b>0.835</b>	0.187
5. I think adhering to the diet make my gastrointestinal tract comfortable	0.099	0.23	0.218	<b>0.675</b>
6. I think adhering to the diet make me feel good	0.169	0.231	0.388	<b>0.595</b>
7. I think adhering to the diet is beneficial to my weight loss	0.254	0.047	0.062	<b>0.654</b>
8. I think adhering to the diet is beneficial to my disease remission(eg diabetes, polycystic ovary syndrome, fatty liver, obstructive sleep apnea syndrome)	0.032	-0.013	0.042	<b>0.694</b>
9. I think the diet tastes delicious	0.088	0.227	0.209	<b>0.579</b>
10. I think it is difficult to cook according to the dietary recommendations	0.275	0.156	0.221	<b>0.526</b>
11. I think adhering to the diet make my life interesting	0.253	0.322	0.263	<b>0.547</b>
12. I think the pressure from my family can make me adhere the diet	0.125	<b>0.666</b>	0.154	0.069
13. I think the pressure from my friends can make me adhere the diet	0.13	<b>0.697</b>	0.079	0.128
14. I think the pressure from my fellow patients can make me adhere the diet	0.047	<b>0.71</b>	0.1	0.105
15. I think the pressure from healthcare personnel can make me adhere the diet	0.07	<b>0.431</b>	0.158	0.225
16. My family is supportive of me to adhere to the diet	0.221	<b>0.688</b>	-0.075	0.189
17. My friends are supportive of me to adhere to the diet	0.165	<b>0.795</b>	-0.203	0.119
18. My fellow patients is supportive of me to adhere to the diet	0.272	<b>0.622</b>	-0.056	0.196
19. My family can cook food for me according to the dietary recommendations	0.116	<b>0.616</b>	0.179	0.118
20. My family had made a healthy diet change	0.179	<b>0.67</b>	0.288	0.023
21. My friends had made a healthy diet change	0.204	<b>0.663</b>	0.272	-0.015
22. My fellow patients adhered to the diet	<b>0.808</b>	0.226	0.189	0.114
23. When I am depressed (or down), I can adhere to the diet	<b>0.826</b>	0.228	0.124	0.106
24. When I am tired, I can adhere to the diet	<b>0.882</b>	0.103	0.151	0.123
25. When I am hungry, I can adhere to the diet	<b>0.825</b>	0.223	0.121	0.058
26. When I am in a social situation (such as at a party), I can adhere to the diet	<b>0.767</b>	0.214	0.183	0.218
27. When I go out (such as on a business trip or travel), I can adhere to the diet	<b>0.809</b>	0.21	0.162	0.209
28. When the season or the weather changes, I can adhere to the diet	<b>0.715</b>	0.146	0.137	0.325

**Note:** Bold font represents the factor loading value of the item on its factor.

UA and S-CVI/Ave were  $>0.8$ , which indicated that the questionnaire could evaluate the content needed to be measured well. The results of reliability analysis indicated that the total Cronbach's  $\alpha$  of ASEQBS was 0.920, suggesting the ASEQBS had good internal consistency. The test-retest reliability refers to the temporal stability of a questionnaire. In this study, the correlation coefficient of ASEQBS was 0.922, indicating that the questionnaire was stable.

The ASE model has been used to understand dietary behaviors in previous studies. However, there are many differences in its application and no model instrument has been validated in the Chinese population, which contributed to no exemplary approaches to follow. In this study, the ASE model has been applied as a theoretical framework to develop the questionnaire, which provided a valid instrument to promote dietary adherence in post-bariatric patients. As proposed by the ASE model, psychosocial



**Table 5** Internal Consistency and Test–Re-Test Reliability Analysis Results (n=152)

Dimension	Cronbach's $\alpha$	Spearman-Brown Coefficient	Test-Retest Reliability
Intention	0.907	0.923	0.859**
Attitude	0.807	0.701	0.844**
Social influence	0.857	0.758	0.923**
Self-efficacy	0.935	0.875	0.889**
ASEQBS	0.920	0.774	0.922**

Notes: \*\* $P < 0.01$ .

factors, including intention, attitude, social influence, and self-efficacy are major determinants of health-related behavior.<sup>44</sup> Furthermore, the behavioral intention may be a mediator between the influence of attitude, social influence, self-efficacy, and behavior.<sup>24</sup> After developing the theory-supported questionnaire, it is possible to understand the mechanism of specific behavior and identify factors necessary to change health-related behavior. What's more, an understanding of the determinants that cause poor dietary adherence among post-bariatric patients is essential for health professionals to develop interventions. For instance, health professionals could not only fully inform patients of the benefits of following dietary recommendations to enhance their positive attitude, but also pay attention to patients with negative attitudes to help them identify the barriers to improving dietary adherence.

## Implication

This study developed a new theory-based tool to measure the determinants of dietary adherence in Chinese post-bariatric patients. It is useful to assess intention, attitude, social influence, and self-efficacy, which provides an appropriate instrument for future research. The relationship between the ASE model constructs and dietary adherence needs to be explored and understood by using this questionnaire. Besides, this questionnaire would assist in identifying relevant determinants and in planning theory-based interventions that might result in improving dietary adherence in health behavior change programs. This study also provides guidance on how to develop effective measurements based on the ASE model for future work.

In the clinical setting, nutritionists and nurses play important roles to provide dietary recommendations and intervention in hospitals and other healthcare centers. This questionnaire can help to understand patients' intention, attitude, social influence, and self-efficacy, which provide the basis to change their irrational eating behavior and improve dietary adherence during the postoperative

follow-up. Nutritionists and nurses can intervene early as part of a multidisciplinary healthcare team to assess dietary adherence and related factors and to provide tailored health education with the goal of improving surgical outcomes.

## Limitation

Some limitations need to be acknowledged. Firstly, the participants in this study were all recruited from one hospital in Jiangsu Province with convenience sampling, which may limit the representativeness of the findings. In the future, samples from different regions, countries, and settings need to be selected to test the psychometric properties of the questionnaire. Furthermore, in conducting our interviews and analysis based on the ASE model, constructs may have limited the emergence and identification of determinants not contemplated in this theory. Hence, it is suggested that future studies could focus on more determinants to further improve dietary adherence. Finally, for the data analysis, the criterion validity was not tested because there was no appropriate criterion to measure the determinants of dietary adherence for Chinese post-bariatric patients. Therefore, future research to evaluate the criterion validity of the questionnaire should be explored and a further validation study could promote use of the questionnaire.

## Conclusion

The final 28-item questionnaire provides a theory-based instrument for evaluating the determinants of dietary adherence among patients after bariatric surgery, which indicated appropriate validity and reliability. The ASEQBS contained 4 dimensions consistent with the ASE model, which were intention, attitude, social influence, and self-efficacy. Given the importance of following dietary recommendations in improving weight loss outcomes, the development of this questionnaire demonstrates an effective step toward evaluating the facilitators and

barriers of dietary adherence. What's more, it is useful to apply a reliable and valid tool to understand the behavior of interest correctly, as well as determine the relative importance and relationship between constructs. It also provides a means for researchers and clinical staff to design and evaluate the efficacy of tailored dietary intervention programs.

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## Disclosure

The authors declare that they have no competing interests.

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