Nutrition, Metabolism & Cardiovascular Diseases (xxxx) xxx, xxx

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI)

Daan L. de Frel [a,1], Hope Wicks [a,1], Zsuzsa Bakk [b], Nicole van Keulen [a], Vrouwke van Adrichem [a], Nikki van Tussenbroek [a], Prof Douwe E. Atsma [a,*], Veronica R. Janssen [a,c]

[a] Department of Cardiology, Leiden University Medical Centre, Leiden, Netherlands
[b] Section of Methodology and Statistics, Department of Psychology, Leiden University, Leiden, the Netherlands
[c] Health, Medical and Neuropsychology, Leiden University, Leiden, the Netherlands

Received 24 April 2022; received in revised form 26 September 2022; accepted 27 September 2022
Handling Editor: A. Siani
Available online ■ ■ ■

KEYWORDS
Diet;
Behavior change;
Intention;
Validation study;
Health behavior;
Nudging

Abstract *Background and aims:* Diet is important in prevention and management of non-communicable disease and in particular, cardiovascular disease. Recently, more hospitals gear towards healthier dietary policies, however, a tool to assess the effect of these interventions in patient populations is currently lacking. The Theory of Planned Behavior (TPB) is generally used to assess health-related behavior and offers a framework for development of questionnaires. In this study, we aim to evaluate the reliability, internal consistency and preliminary construct validity of the newly developed Dietary Intention Evaluation Tool for In-hospital patients (DIETI) which is based on the TPB.

Methods and results: An expert panel constructed the item list of the DIETI. A total of 312 patients admitted to the cardiology ward filled out the DIETI. Explanatory- and confirmatory factor analysis showed that our tool adequately discerns five TPB-consistent factors regarding a healthy diet in hospitalized patients. ($N = 312$, for the CFA model $\chi^2 = 313.072$ ($df = 160$, $p < 0.001$, $CFI = 0.939$, $RMSEA = 0.058$). Subsequent analysis of reliability showed satisfactory to strong internal consistency of the questionnaire as a whole and all subscales (Cronbach's alpha for the subscales ranging between 0.65 and 0.88).

Conclusions: We conclude that the DIETI is an internally reliable tool to assess behavioral intentions regarding a healthy diet of in-hospital patients. Thus, this questionnaire can be used to evaluate the effect of dietary interventions aimed at hospitalized patients.

1. Introduction

Change towards a healthy lifestyle is notoriously difficult but of adamant importance in order to combat the rising mortality rates of non-communicable diseases (NCDs) and growing healthcare costs [1]. Of all lifestyle factors, diet is of great importance in type 2 diabetes, cancer and cardiovascular disease [2–4]. Therefore, improving dietary behavior forms a cornerstone of prevention of these NCDs [5,6]. For cardiovascular disease (CVD), the elimination of unhealthy risk behaviors such as unhealthy diet, smoking,

* Corresponding author.
E-mail address: d.e.atsma@lumc.nl (P.D.E. Atsma).
[1] Both authors contributed equally.

https://doi.org/10.1016/j.numecd.2022.09.019

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

or physical activity can prevent over 80% of disease [7]. Of these risk behaviors, diet has been the second largest influential factor [8]. Changing to a healthy diet alone could reduce the incidence of cardiovascular disease by as much as 30% [9]. Hospital admission forms an opportunity par excellence to influence patients' dietary behavior [10–13]. For example, such admissions may serve as 'teachable moments' where healthcare professionals can effectively influence patients' risk perceptions and beliefs regarding a healthy diet [10,11,14,15]. Furthermore, hospital food facilities offer opportunities for environmental changes aiming to influence dietary choices made by patients, visitors and staff, so called choice architecture. An effective example is traffic light signaling on menus that helps stimulate healthy food choices [16]. However, studies show that currently in-hospital secondary prevention is far from optimal [17,18]. Fortunately, many healthcare institutions adopt policies to improve the quality of the food they provide.

As hospitals gear towards healthier dietary policies, a validated tool is lacking to assess the effects of these interventions on patient populations. The Theory of Planned Behavior (TPB) is generally used to understand, analyze and predict health-related behavior and behavior change [19]. According to this theory, intention is the most influential factor on behavior change and can therefore give insight into the lifestyle people will adopt. To our knowledge, no adequate validated questionnaire exists to assess dietary behavior change specifically in a hospital setting [20,21]. It is common practice to develop a specific questionnaire based on the TPB using the instructions presented by Ajzen (2006) [22]. Previous studies have used the TPB as guide to create questionnaires assessing, for example, the intention to exercise, donate blood or to seek out mammography. A systematic review and appraisal shows that most TPB- based questionnaires are of high quality [23]. Therefore, using these instructions, we designed a novel questionnaire based on the TBP to assess various aspects of behavior involved in dietary decision making in hospitalized patients. In this study, we aim to evaluate the reliability, internal consistency and preliminary construct validity of this newly developed Dietary Intention Evaluation Tool for In-hospital patients (DIETI).

2. Methods

2.1. DIETI-survey development

A first concept of the questionnaire based on the TPB was drafted employing the instructions by Ajzen and Francis [22]. According to the TPB, the combination of attitude toward a behavior, subjective norm and perception of behavioral control leads to the formation of behavioral intention [22]. The intention scale was designed in terms of Target, Action, Context and Time according to the TACT principle [25]. The TACT principle provides preset questionnaire items where one can fill in the TACT elements (e.g. I intend to [A] in [C] with [Ta] in the next [T]). The target was defined as 'meal', the action as 'to eat healthy/healthier', the context as 'regularly' and the time as 'coming month' (e.g. I intend to regularly eat healthy/healthier meals in the next month). Independent judges agreed that these four items, measure the domain intention adequately, both in English and in Dutch, ($\kappa = 0{,}75$) [26].

The first draft of the questionnaire contained 34 items (4 x intention, 14 x attitude, 7 x subjective norm, 9 x behavioral control). The number of items formulated to assess each of the theory's major constructs differed according to the dimensions pertaining to that construct (e.g. 'intention' was covered by I plan/will eat healthier/for xx meals while 'attitude' spanned delicious/cheap/useful/healthy/difficult/pleasant) (see Supplementary Table 1). In a panel of seven experts, from the fields of outcome measurement development, psychology, dietology, cardiology and public health, the questionnaire was reviewed. In this first stage, mainly missing areas were added. Subsequently, the adapted questionnaire was reviewed again by all members of the panel. The experts gave multiple rounds of individual feedback on the list of items. In this second stage, the focus was more on removing repetitive items and simplifying sentences. After revising the questionnaire based on this second round of feedback the questionnaire was sent out again to the same experts. This third time, minimal modifications were made, and we finalized the questionnaire containing 23 items (4 x intention, 6 x attitude, 5 x subjective norm, 3 x self-efficacy, 5 x normative referent). Then, the questionnaire was tested clinically with four patients on the cardiology ward. Items that were difficult to comprehend were revised to improve readability. The final items of the DIETI and the stages of development are available in Supplementary Tables 1 and 2 respectively.

2.2. Study population

For this observational study, data was obtained at the cardiology ward of the Leiden University Medical Centre (LUMC), the Netherlands. As this study is without any risk for the patient, dispensation from statutory obligation from the accredited Medical Ethical Review Committee was given. All patients admitted to the cardiology ward between January 2020 and July 2021 were invited to participate in the study. The cardiology ward was selected as it is a ward in a large university hospital that admits many patients with a significant variety in for example age and disease. Researchers visited the cardiology ward daily to recruit newly admitted patients during their stay. Exclusion criteria were absence of email address, insufficient meal consumption, previous participation, inability to provide consent and language barrier. Participants were asked to fill out the questionnaire after their last evening meal in the hospital, this could be done in the hospital or at home. The majority did so in the hospital. Participation to the online survey was on voluntary basis and informed consent was obtained at the beginning of the survey. The online survey was anonymized and contained information about the aim and goal of the study. In total, 594 patients were screened for eligibility for participation.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

Based on the previous stated exclusion criteria, 100 patients were excluded (Fig. 1). Of the 494 patients who were invited to participate, 136 patients (27.5%) were non-responders and 46 patients (9.3%) failed to complete the survey. A total of 312 patients (63.1%) completed the survey. To gain insight in the demographic characteristics of the patient population, descriptive analysis was performed prior to the reliability testing. The mean and SDs for various patient characteristics were calculated.

2.3. Statistical methods

2.3.1. Data cleaning

Prior to the sample size calculation and statistical analysis, data cleaning was performed to optimize data quality. The data cleaning process consisted of three phases, namely a screening phase, a diagnostic phase and a treatment phase [27].

The screening phase was used to identify summary statistics, lack or excess of data, outliers, logical inconsistencies and strange patterns in distribution. This was executed at three points; prior to sample size calculation, during data collection and after the complete collection of a group. Various screening methods were used including data entry validation, statistical outlier detection and flatliner detection and fixed algorithms to identify logical inconsistencies [28–30]. Using the editrules package, the following logical inconsistencies were identified; age >100 years, a difference >3 between the number of breakfast-lunch- or evening meals, a difference >3 between the number of evening meals and total hospitalization period, a difference >3 between the amount of meal consumption

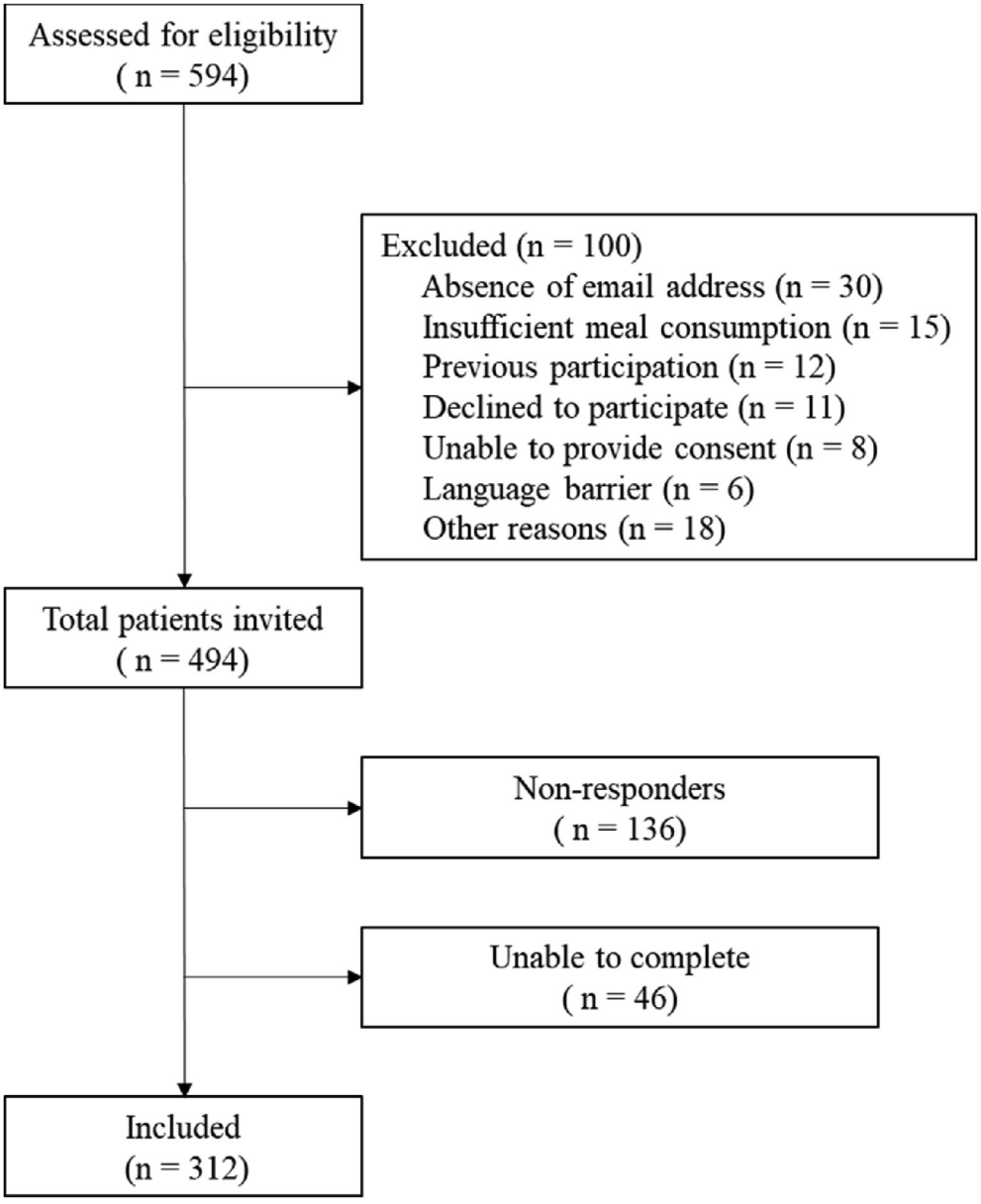

Figure 1 Overview of patient inclusion.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

and total duration (as these inputs were undoubtedly erroneous deeming the rest of the items inadequately reliable) and current healthy eating score eating [31]. Based on these fixed algorithms, suspicious outputs were detected and thereafter marked as erroneous. Moreover, graphical exploration of distributions was performed to detect erroneous inliers that often escape detection.

In the diagnostic procedure, individual patient data evaluation was used to identify whether a data point was an outlier or a true extreme. This was done by investigating other variables of the same patient. Each suspicious data point was either diagnosed as true normal, true extreme, erroneous or idiopathic. In the treatment phase, true outliers were removed from the dataset. Outputs that contained logical inconsistencies together with flatliners in the primary outcome were excluded from further analysis. Furthermore, outputs with multiple flatliners in secondary outcomes or flatliners in the normative referent subscale were disregarded as well.

2.3.2. Reliability and construct validity of the DIETI-survey

To evaluate the reliability of the DIETI-survey, explanatory factor analysis (EFA) was performed, and internal consistency were assessed using the Lavaan package in R [34]. The relationship between the various subscales of the questionnaire was assessed with the correlation coefficients calculated with Spearman's correlation.

To evaluate the various subscales, EFA was executed for the 23 questionnaire items. Based on Kaiser's rule, six underlying factors with eigenvalues above one were identified (Fig. 2) [32]. The proportion of the eigenvalues resulted in five-six meaningful factors. The first five factors explain 60% of the variance and after the sixth factor, the additional percentage of variance drops below 4%. So, the meaningful number of values found with the proportion of eigenvalues is in line with those found with Kaiser's rule (Supplementary Table 3). To identify which items correspond with an underlying factor, factor loadings were inspected for the 23 items for six factors. In accordance with best practice a factor loading of 0.4 was used as cut-off value [33]. The factor loadings were used to determine the usability of a specific subscale.

The constructed model based on EFA was tested with confirmatory factor analysis (CFA) conducted using the Lavaan package in R [34]. Based on four global fit indices (SRMR, RMSEA, CLI, TLI) and information criteria (AIC, BIC), the fit between the theoretical model and the data was assessed.

To assess internal consistency, Cronbach's alpha coefficient was used including a 95% confidence interval (95% CI). A value of >0.7 was interpreted as reliable whereas a value $>$ 0.9 indicates redundancy within the subscale [35,36]. Moreover, if the subscales had a width less than 4 items, a lower Cronbach's alpha value was considered acceptable due to the chance of underestimation [37,38].

According to the TPB, intention is shaped by attitude, self-efficacy and subjective norm. In order to assess the construct validity of the intention subscale, the means of the attitude, self-efficacy and subjective norm subscales were correlated with the intention subscale. This was also done for the intention subscale and the score patients rated the healthiness of their own current diet (from 1 to 10): the diet health score (DHS).

To test for a possible measurement bias for gender, measurement invariance was assessed by nested models with stricter and stricter rules of measurement non-invariance (namely configural-, metric-, scalar- and strict invariance models) using Lavaan package [34].All statistical analysis were performed using R Statistical Software (Version 4.0.3) Foundation for Statistical Computing, Vienna, Austria) [39].

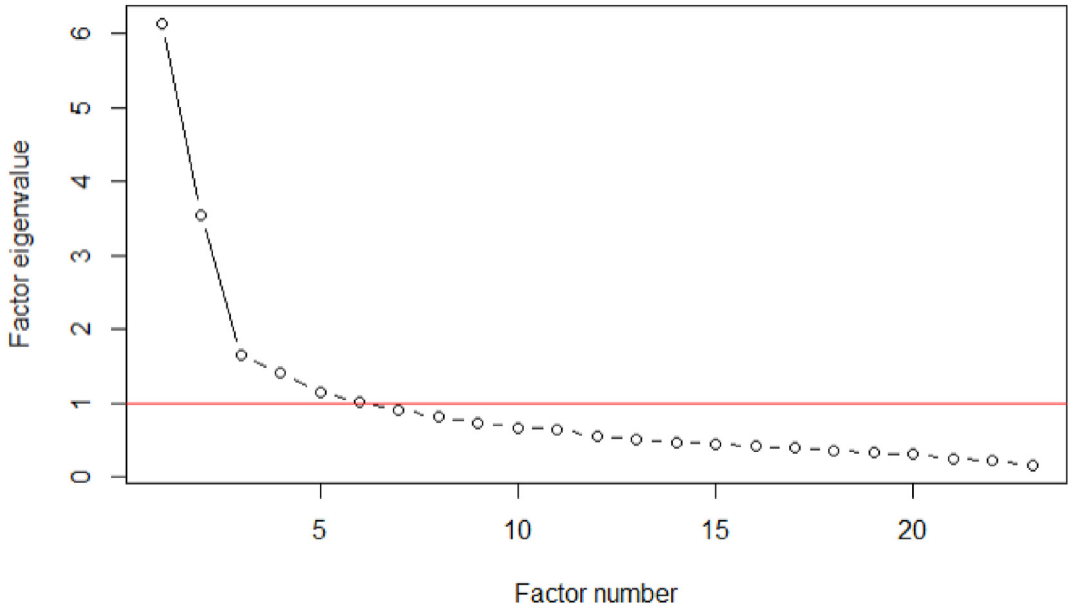

Figure 2 Five underlying factors in the DIETI-questionnaire. A scree plot of eigenvalues after factor analysis. The number of factors were identified by Kaiser's rule. Factors with eigenvalues <1.0 were disregarded.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

3. Results

In total, 312 patients were included in the study. After data cleaning, the data from 285 patients was used for further analysis. In sum, patients had a mean age of 63.0 ± 12.69 years, were admitted for 3.29 ± 3.79 days, were mainly male (68.8%) and the majority was admitted to the cardiology ward because of arrythmia (42.1%) (Table 1). An overview of means, standard deviation, skewness and kurtosis of the 23 DIETI items can be found in Supplementary Table 4.

Table 1 Characteristics of the study participants (n = 285).

Characteristic	Value
Total	285
Age (years), mean (SD)	63 (12.69)
Age, n (%)	
<50	38 (13.3)
50-69	141 (49.5)
70-89	106 (37.2)
Gender, n (%)	
Female	89 (31.2)
Male	196 (68.8)
Reason of admission, n (%)	
Arrhythmia	120 (42.1)
AP/MI	72 (25.3)
Hearfailure	17 (6.0)
Other	76 (26.7)
Admission duration (days), mean (SD)	3.29 (3.79)
Special diet, n (%)	30 (10.5)
Myocardial infarction in medical history, n (%)	77 (27.0)
Diet health score, mean (SD)	7.34 (1.2)

n, number of participants; SD, standard deviation; AP, angina pectoris; MI, myocardial infarction.

3.1. Five underlying dietary behavioral aspects in the DIETI-survey

The explanatory factor analysis showed that the factor loadings of the subscales normative referent (factor 1), intention (factor 2) and self-efficacy (factor 4) were in line with the originally designed subscales of the questionnaire (Table 2). Furthermore, the factor loadings of the attitude subscale (factor 3) revealed the incongruency of item 10, "Unhealthy eating increases the chance of recurrence of my disease.", that had a factor loading of 0.06. Therefore, item 10 was excluded from the attitude subscale and dismissed from further analysis. Moreover, the factor analysis revealed two underlying factors in the subjective norm subscale. However, due to the low loadings of item 14 and 15, "People in my direct environment eat healthy" and "People in my direct environment think that I should eat healthy" respectively, and the fact that item 14 has a high loading on factor 3 as well, these items were not included in further analysis. (Supplementary Table 5). The analysis of the EFA on a random sample of 70% of the study group resulted in the disregarding of item 10, 14 and 15 resulting in five underlying subscales which is in line with the initial analyses on the complete group (Supplementary Table 6).

Table 2 Factor analysis results for the 21 items on the DIETI-survey.

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Intention, 4 items (Cronbach's alpha = 0.86)					
I1. Willingness of intention	0.10	*0.87*	0.11	0.14	0.18
I2. Plan of intention	0.11	*0.87*	0.13	0.09	0.22
I3. Strength of intention	0.10	*0.81*	0.24	0.26	0.05
I4. Amount of intention	0.09	*0.61*	0.31	0.17	0.10
Attitude towards healthy diet, 6 items (Cronbach's alpha = 0.77)					
I5. Pleasantness	−0.09	0.16	*0.71*	0.36	0.10
I6. Tastefulness	−0.09	0.15	*0.71*	0.29	0.00
I7. Importance	0.07	0.20	*0.67*	−0.01	0.13
I8. Usefulness	0.02	0.15	*0.76*	0.28	0.05
I9. Fitness	0.00	0.25	*0.47*	0.40	0.38
I10. Disease recurrence	−0.03	0.19	0.04	0.28	0.47
Self-efficacy, 3 items (Cronbach's alpha = 0.65)					
I11. Knowledge	0.03	0.20	0.23	*0.73*	−0.03
I12. Influence	0.09	0.11	0.21	*0.76*	0.13
I13. Strength	−0.06	0.17	0.22	*0.56*	0.16
Subjective norm, 5 items (Cronbach's alpha = 0.62)					
I14 Motivation to comply 1	0.09	0.07	0.27	−0.10	*0.70*
I15 Injunctive norm 2	0.17	0.09	−0.26	0.15	*0.63*
I16 Motivation to comply 2	0.15	0.13	0.23	0.07	*0.69*
Normative referent, 5 items (Cronbach's alpha = 0.88)					
I17 Dietitian	*0.75*	0.07	0.10	−0.10	0.07
I18 Doctor	*0.82*	0.05	−0.13	0.07	0.02
I19 Food assistant	*0.83*	0.06	0.01	0.00	0.05
I20 Hospital	*0.85*	0.09	0.01	0.00	0.13
I21 Nutrition centre	*0.80*	0.07	−0.04	0.08	0.09

Overall Cronbach's alpha = 0.82, standardized alpha = 0.86, 21 items. Factor loadings >0.4 for each factor are italicized.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

3.2. Good overall fit of theoretical model

A confirmatory factor analysis (CFA) was carried out to evaluate the fit between the theoretical constructed model and the obtained data. Based on the outcomes of the EFA, the subjective norm factor contained item 16, 17 and 18. As stated earlier, since item 14 had a double loading and the sixth factor contained only two items, it was disregarded in further analysis since the minimum amount for a factor is three items. The CFA revealed the χ [2] = 313.072 (df = 160, p < 0.001) CFI (0.939), TLI (0.927), RMSEA (0.058) and SRMR (0.059). This shows a good overall fit of the model, even if the χ^2 shows a non-adequate fit, that is due to the sensibility of this statistic. All the standardized loadings are adequate between 0.405 for I17 and 0.905 for I2. After performing the second EFA on 70% of the study group, the remaining 30% was used for a second CFA. The CFA of random 30% showed a χ2 = 959.110 (df = 190, p < 0.001), CFI (0.897), TLI (0.878), RMSEA (0.076) and SRMR (0.076). This shows a good overall fit and is in line with the results of the CFA of the initial analyses.

3.3. Sufficient internal- and scale reliability of the DIETI-survey

The reliability of the overall questionnaire and the five different subscales was assessed with Cronbach's alpha including a 95% confidence interval (95% CI). To evaluate the importance of each individual question to its subscale, the range of item-scale correlations are presented of each subscale. The DIETI-survey had an overall mean of 4.35 (±0.82) on a 7-point Likert scale and a Cronbach's alpha of 0.82 which indicates an overall high reliability (Table 2).

More specifically, the subscales intention (α = 0.86), attitude (α = 0.81) and normative referent (α = 0.88) had a high internal reliability. In addition, the range item-scale correlations for the intention subscale were 0.63–0.88 indicating sound discrimination within the intention subscale. Moreover, the range item-scale correlation of the attitude- (0.55–0.79) and normative referent subscales (0.68–0.83) suggest accurate discrimination of the individual items as well. Hence, the subscales intention, attitude and normative referent can be viewed as trustworthy considering its profound internal reliability and the high range of item-scale correlation.

The self-efficacy subscale was considered reasonably reliable with a Cronbach's alpha of 0.65. Its range item-scale correlation of 0.50–0.67 is deemed adequate [40]. Thus, both internal- and scale reliability of the self-efficacy subscale can be described as sufficient. In addition, the subscale subjective norm showed an adequate internal reliability (α = 0.51) with an adequate scale reliability (0.49).

In sum, the Cronbach's alpha of the total questionnaire and the subscales intention, attitude and normative referent indicated strong internal consistency. In addition, the internal consistency of the subscales self-efficacy and subjective norm may be considered satisfactory.

3.3.1. Measurement invariance analysis

We checked for measurement invariance regarding gender of the final CFA model with 5 factors using MLM estimator in Lavaan. The measurement invariance analysis revealed that metric invariance was established. Both the overall fit of the model is acceptable (Robust χ [2] = 496.58 (df = 335, p < 0.001), TLI = 0.91 CFI = 0.92, RMSEA = 0.058 Robust RMSEA = 0.061) and the χ^2 Difference Test (Satorra, Bentler, 2001) of the configural and metric invariance model shows that the more restrictive model is tenable (χ^2 = 16.61, df = 15, p = 0.3424). The χ^2 Difference Test of nested models comparing the scalar and metric difference showed that the scalar invariance is a worth fit than the metric invariance model (χ^2 = 41.20, df = 15, p = 0.003). Based on the residual statistics an intercept was freed, namely the intercepts of item 17, was allowed to be different for male and female respondents. In this way Partial scalar invariance was established (Robust χ^2 = 512.50 (df = 349, p < 0.001), TLI = 0.92 CFI = 0.92, RMSEA = 0.058 Robust RMSEA = 0.060) and the χ^2 Difference Test of the partial scalar and metric invariance model shows that the more restrictive model is tenable (χ^2 = 14.51, df = 14, p = 0.413). Lastly, partial strict scalar invariance (keeping the intercept of I17 free and setting all loadings, residuals, and the other intercepts equal) was identified Robust χ^2 = 516.58 (df = 369, p < 0.001), TLI = 0.93 CFI = 0.93, RMSEA = 0.053 Robust RMSEA = 0.058) and the χ^2 Difference Test of the partial strict and partial invariance model shows that the more restrictive model is tenable (χ^2 = 18.48, df = 20, p = 0.555). In addition, measurement invariance based on mean age (63 years) was checked. This analysis revealed that strict invariance was established. The overall fit of the model is acceptable (Robust χ2 = 559.29 (df = 335, p = 0.06), TLI = 0.92, CFI = 0.93, SRMR = 0.078 and RMSEA = 0.061) and the χ2 Difference Test of the configural and metric invariance model displays a preference for the more restrictive model (χ2 = 24.37, df = 15, p = 0.05907). The χ2 Difference Test of nested models comparing the scalar and metric difference identified scalar invariance (χ2 = 10.668, df = 15, p = 0.7757). Ultimately, scalar invariance was identified (Robust χ2 = 640.84 (df = 370, p < 0.001), TLI = 0.93 CFI = 0.93, SRMR = 0.081 Robust RMSEA = 0.058) and the χ2 Difference Test of the partial strict and partial invariance model shows that the more restrictive model is tenable (χ2 = 20.06, df = 20, p = 0.4542). We present these final models in supplementary table 7 and 8 Thus, based on the measurement invariance analysis, no bias in group comparison based on gender and age is present.

3.4. Moderate relationships between various behavioral aspects subscales

To assess the relationship between the various subscales of the questionnaire, correlation coefficients were calculated with Spearman's correlation which revealed a moderate positive relationship between the subscales intention and attitude (0.5724). Moreover, the correlation

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

Table 3 Correlation coefficients among scores of the subscales of the DIETI-survey.

Scales	Intention	Attitude	Self-efficacy	Subjective norm	Normative referent
Attitude	***0.5724***				
Self-efficacy	*0.4781*	***0.5780***			
Subjective norm	*0.3702*	*0.3078*	*0.2692*		
Normative referent	*0.1557*	−0.0098	0.0021	0.2050	
DIETI-survey	***0.6277***	*0.4891*	*0.4298*	*0.5874*	***0.7458***

Italics indicate significant correlations among the subscales.
Bold font indicates moderate − strong relation among the subscales.

coefficient among the subscales attitude and self-efficacy showed an adequate relation as well (Table 3). Furthermore, a moderate relationship between the intention and self-efficacy subscales was identified. Thus, although the observed inter-subscale relationships appear small, the subscales are indeed connected to one another, yet sufficiently unique to measure different aspects of dietary behavior. In addition, the mean of the subscales associated with intention based on the TPB were correlated with the intention subscale to calculate the correlation of these latent variables. This was done as well for the intention subscale and the score patients rate the healthiness of their own current diet (from 1 to 10): the diet health score (DHS). The correlation between the latent variables of the intention subscale and the intention based on the TPB resulted in a high-moderate correlation of 0.575. This high moderate correlation could be evidence for preliminary construct validity. However, the intention subscale and DHS showed a weak correlation of 0.223.

4. Discussion

In this study, we developed and evaluated the internal reliability and preliminary construct validity of the DIETI, which is a TPB-based tool assessing healthy eating intentions in a hospital setting. Explanatory factor analysis, internal reliability assessment and establishing measurement invariance revealed that the tool discriminates between different behavior-related aspects. Subscales assessing patients' intention, attitude and normative referent are reliable and have a superlative internal consistency. Moreover, the measurement invariance analysis based on gender established strict invariance which strengthens the reliability of the constructs in the survey. Compared to other questionnaires based on the TPB, the intention and attitude subscales showed to have similar internal consistencies [20,21]. Also, the high-moderate correlation between the intention subscale and the mean of the attitude, self-efficacy and subjective norm subscales could signify preliminary construct validity of the intention subscale. The intention subscale and DHS showed a weak correlation of 0.223 which might be partially explained by the fact that people have inaccurate perceptions about their dietary intakes thereby overestimating the healthiness of their diet which negatively effects their intention to change their diet [41,42]. Taken together, these findings indicate that the newly created DIETI-survey is a reliable tool to evaluate behavioral intentions regarding a healthy diet of in-hospital patients.

Our findings are in line with other TPB-based questionnaires that assess various behavioral aspects in other populations [19,20]. Besides, our newly designed questionnaire also assesses the influence of multiple normative referents and subjective norms which is lacking in current questionnaires. Combined, these normative beliefs and subjective norms are often described as social influence, a critical part of the TPB [43−45]. This is of extra importance in a hospital setting since physicians and hospitals influence the health norm of patients [14,46−48].

Some limitations to this research should be considered. First, the newly developed questionnaire is in Dutch. For application in other languages the DIETI will have to be validated separately. Towards this purpose, an English translation of the DIETI can be found in the appendix. Second, the questionnaire is only evaluated for in-hospital cardiac patients. Testing this survey in various Dutch patient groups will provide insight if this questionnaire is valid for a broader patient spectrum. Third, our subjective norm subscale showed a Cronbach's alpha of 0.51. This could be due to the fact that the subjective norm subscale combines the assessment of motivating factors (e.g. environmental encouragement) and directive factors (e.g. healthcare instructions). Further research could consider extending the scale with directive factors and to separate the scale into two subscales.

Major strengths of this study include the diverse expert panel involved in the development of the questionnaire which enabled us to evaluate the questions through multiple (para)medic disciplines. Furthermore, testing the questionnaire with admitted patients resulted in a realistic outcome of the target population. Moreover, the large number of participants in this study contributes to the strength of the results [20,21].

Thus, our data showed that the newly created DIETI-survey is a internally reliable tool to determine intention, attitude, self-efficacy, subjective norm, and normative referent towards healthy diet in a hospital setting. Furthermore, a high-moderate correlation between intention and the means of attitude, self-efficacy and subjective norm could indicate preliminary construct validity. However, before this questionnaire can be used to

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

evaluate the effect of dietary interventions aimed at hospitalized patients further testing is required. Reliability testing using for example test-retest reliability can be performed and thorough validation should be performed. To assess validity, the DIETI could be compared to theoretically related constructs such as *self-efficacy* as constructed by Bandura et al. or *motivation* as constructed by Deci & Ryan [49,50].

Declaration of competing interest

The authors have declared that no competing interests exist.

Acknowledgements

The authors would like to express their gratitude to Jessica Kiefte, Michelle Brust, Laura Zwanenburg and Elske van den Akker for their contributions to the development of the Dietary Intention Evaluation Tool for in-hospital patients. Furthermore, the authors would like to thank Annika Schubert and Lot Slatman for their efforts concerning the patient inclusion.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.numecd.2022.09.019.

References

[1] Prevention, C. for D. C. and. Preventable deaths from heart disease & stroke. Available at: https://www.cdc.gov/vitalsigns/heartdisease-stroke/index.html.
[2] Esposito K, et al. A journey into a Mediterranean diet and type 2 diabetes: a systematic review with meta-analyses. BMJ Open 2015;5:e008222.
[3] Schwingshackl L, Schwedhelm C, Galbete C, Hoffmann G. Adherence to mediterranean diet and risk of cancer: an updated systematic review and meta-analysis. Nutrients 2017;9:1063.
[4] Roth GA, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019. J Am Coll Cardiol 2020;76:2982–3021.
[5] 3. Prevention or delay of type 2 diabetes: standards of medical care in diabetes—2021. Diabetes Care 2021;44:S34–9.
[6] Aykan NF. Red meat and colorectal cancer. Onco Rev 2015. https://doi.org/10.4081/oncol.2015.288.
[7] Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al. European guidelines on cardiovascular disease prevention in clinical practice: the sixth joint task force of the European society of cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of 10 societies and by invited experts) developed with the special contribution of the European association for cardiovascular prevention & rehabilitation (EACPR). Atherosclerosis 2016;252:207–74. 2016.
[8] Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of cardiovascular diseases and risk factors, 1990-2019. J Am Coll Cardiol 2020;76(25):2982–3021.
[9] Barbaresko J, Rienks J, Nöthlings U. Lifestyle indices and cardiovascular disease risk: a meta-analysis. Am J Prev Med 2018;55(4):555–64.
[10] Houlihan S. Dual-process models of health-related behavior and cognition: a review of theory. Publ Health 2018;156:52–9.
[11] Allan JL, Powell DJ. Prompting consumers to make healthier food choices in hospitals: a cluster randomised controlled trial. Int J Behav Nutr Phys Activ 2020;17:86.
[12] McCray S, Maunder K, Barsha L, Mackenzie-Shalders K. Room service in a public hospital improves nutritional intake and increases patient satisfaction while decreasing food waste and cost. J Hum Nutr Diet 2018;31:734–41.
[13] Kelly MP, Barker M. Why is changing health-related behavior so difficult? Publ Health 2016;136:109–16.
[14] Boudreaux ED, Bock B, O'Hea E. When an event sparks behavior change: an introduction to the sentinel event method of dynamic model building and its application to emergency medicine. Acad Emerg Med 2012;19:329–35.
[15] Katz DA, et al. Multiple risk factor counseling to promote heart-healthy lifestyles in the chest pain observation unit: pilot randomized controlled trial. Acad Emerg Med 2017;24:968–82.
[16] Thorndike AN, Riis J, Sonnenberg LM, Levy DE. Traffic-light labels and choice architecture. Am J Prev Med 2014;46:143–9.
[17] Haynes CL. Health promotion services for lifestyle development within a UK hospital – patients' experiences and views. BMC Publ Health 2008;8:284.
[18] Derrick JW, Bellini SG, Spelman J. Using the hospital nutrition environment scan to evaluate health initiative in hospital cafeterias. J Acad Nutr Diet 2015;115:1855–60.
[19] Riebl SK, et al. A systematic literature review and meta-analysis: the Theory of Planned Behavior's application to understand and predict nutrition-related behaviors in youth. Eat Behav 2015;18:160–78.
[20] Conner M, Norman P, Bell R. The theory of planned behavior and healthy eating. Health Psychol 2002;21:194–201.
[21] Payne N, Jones F, Harris PR. The impact of job strain on the predictive validity of the theory of planned behavior: an investigation of exercise and healthy eating. Br J Health Psychol 2005;10:115–31.
[22] Ajzen I. Constructing a theory of planned behavior questionnaire. 7. Available at: https://people.umass.edu/aizen/pdf/tpb.measurement.pdf; 2006 (Accessed: 20th May 2021).
[23] Oluka OC, Nie S, Sun Y. Quality assessment of TPB-based questionnaires: a systematic review. PLoS One 2014;9:e94419.
[25] Fishbein M, F M. Readings in attitude theory and measurement. Wiley; 1967.
[26] Huijg JM, Gebhardt WA, Crone MR, Dusseldorp E, Presseau J. Discriminant content validity of a theoretical domains framework questionnaire for use in implementation research. Implement Sci 2014;9:11.
[27] Van den Broeck J, Argeseanu Cunningham S, Eeckels R, Herbst K. Data cleaning: detecting, diagnosing, and editing data abnormalities. PLoS Med 2005;2:e267.
[28] Wickham Hadley, François Romain, Henry Lionel, Müller Kirill. Dplyr: a grammar of data manipulation. 2021.
[29] Wickham, et al. Welcome to the tidyverse. J. Open Source Softw. 2019;4:1686.
[30] RStudio Team. RStudio. Integrated Development for R.; 2020.
[31] de Jonge E, van der Loo M. Parsing, applying, and manipulating data cleaning rules. 2018.
[32] Kaiser HF. The application of electronic computers to factor Analysis. Educ Psychol Meas 1960;20(1):141–51.
[33] Osborne JW. Best practices in exploratory factor Analysis. CreateSpace Independent Publishing; 2014.
[34] Rosseel Y lavaan. An R package for structural equation modeling. J Stat Software 2012;48:1–36.
[35] Nunnally JC. Psychometric theory. McGraw-Hill Inc.; 1978.
[36] Streiner DL. Starting at the beginning: an introduction to coefficient alpha and internal consistency. J Pers Assess 2003;80:99–103.
[37] Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ 2011;2:53–5.
[38] Spiliotopoulou G. Reliability reconsidered: Cronbach's alpha and paediatric assessment in occupational therapy. Aust Occup Ther J 2009;56:150–5.
[39] R Core Team. R. A language and environment for statistical computing. 2020.
[40] Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. Res Sci Educ 2018;48:1273–96.
[41] Glanz K, Brug J, van Assema P. Are awareness of dietary fat intake and actual fat consumption associated?–a Dutch-American comparison. Eur J Clin Nutr 1997;51(8):542–7.
[42] O'Brien A, Fries E, Bowen D. The effect of accuracy of perceptions of dietary-fat intake on perceived risk and intentions to change. J Behav Med 2000;23(5):465–73.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019

[43] White KM, Smith JR, Terry DJ, Greenslade JH, McKimmie BM. Social influence in the theory of planned behavior: the role of descriptive, injunctive, and in-group norms. Br J Soc Psychol 2009;48:135–58.
[44] Rivis A, Sheeran P. Social influences and the theory of planned behavior: evidence for a direct relationship between prototypes and young people's exercise behavior. Psychol Health 2003;18:567–83.
[45] Northrup AA, Smaldone A. Maternal attitudes, normative beliefs, and subjective norms of mothers of 2- and 3-year-old children. J Pediatr Health Care 2017;31:262–74.
[46] NVVL. Voedseltrends. NFFEwG. 2015.
[47] Oberg E, Frank E. Physicians' health practices strongly influence patient health practices. J. R. Coll. Physicians Edinb. 2009;39:290–1.
[48] Sahud HB, Binns HJ, Meadow WL, Tanz RR. Marketing fast food: impact of fast food restaurants in children's hospitals. Pediatrics 2006;118:2290–7.
[49] Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 1977;84(2):191–215. https://doi.org/10.1037/0033-295X.84.2.191.
[50] Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol 2000;55(1):68–78. https://doi.org/10.1037//0003-066x.55.1.68.

Please cite this article as: de Frel DL et al., Development, internal reliability and preliminary construct validity of the Dutch Dietary Intention Evaluation Tool for In-patients (DIETI), Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2022.09.019