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Psychometric properties of the Brief Mishel Uncertainty in illness scales for patients with advanced cancer and their family caregivers

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Abstract

Background This study comprehensively examined the psychometric properties of the Brief Mishel Uncertainty in Illness Scale for patients (MUIS-P) managing advanced cancer and their caregivers (MUIS-Cg).

Methods The MUIS-P and MUIS-Cg scales were developed based on the Mishel Uncertainty in Illness Scale-Adult. We conducted a secondary analysis to test the acceptability, factor structure, reliability, and validity of the brief uncertainty scales for patients with advanced cancer ($N=484$) and their caregivers ($N=484$) using data from a randomized clinical trial.

Results The 9-item MUIS-P and MUIS-Cg show goodness of fit for a two-factor structure (unpredictability and ambiguity) with adequate to acceptable internal consistency (Cronbach's alpha 0.66–0.78 for patients and 0.70–0.72 for caregivers and McDonald's omega 0.72–0.84 for patients and 0.76–0.79 for caregivers). The MUIS-P and MUIS-Cg scores correlated with negative appraisals of illness/caregiving, hopelessness, and avoidant coping, demonstrating convergent validity. The discriminant validity of the MUIS-P and MUIS-Cg was evidenced by their significant correlations with self-efficacy and active coping. The baseline MUIS-P and MUIS-Cg scores were significantly associated with quality of life, hopelessness, depression, distress, and avoidant coping at the 3-month follow-up, indicating their strong predictive validity.

Conclusion This study comprehensively evaluated the psychometric properties of the MUIS-P and MUIS-Cg, laying a foundation for their use in research and clinical practice among patients and caregivers managing demanding symptoms and care.

Keywords Illness uncertainty, Advanced cancer, Caregiver, Reliability, Validity, Psychometric properties

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Background

Illness uncertainty is prevalent among patients with cancer and their family caregivers [1]. Defined as "a person's inability to determine the meaning of illness-related events [2]", illness uncertainty can persist from diagnosis through survivorship until the end of life. Research has shown 26% [3] to 36.4% [4] of patients with cancer and metastatic cancer reported unmet needs related to coping with uncertainty, respectively, especially those with comorbid cardiovascular diseases and low functions [4]. Research indicates that cancer patients' family caregivers also experience illness uncertainty [1]. Increased illness uncertainty increases cancer patients' anxiety, depression and post-traumatic distress [5] and adversely affects their psychological adjustment [6], health behaviors [7], and patient and caregiver quality of life [8, 9]. There is a pressing need to identify patients and caregivers who experience significant illness uncertainty, to support them in managing uncertainty, and ultimately to improve their health outcomes during cancer survivorship.

Given the importance of uncertainty in oncologic care, access to a psychometrically sound measure is a critical first step to accurately assess illness uncertainty and identify those in need of supportive cancer care. In 1981, Dr. Mishel published the first Mishel Uncertainty in Illness Scale for Adults (MUIS-A) to assess illness uncertainty in hospitalized patients during acute maladies [10]. The MUIS-A scale groups 33 items into four domains: ambiguity (the absence of cues or vagueness of cues concerning the illness), complexity (cues about treatment and the system of care are multiple and varied), inconsistency (information changes frequently or not in accord with information previously received), and unpredictability (inability to make a daily or future prediction concerning symptom and illness outcome) [11]. Mishel later modified the MUIS-A and created the Mishel Uncertainty in Illness Scale-Community form (MUIS-C) to assess the enduring uncertainty among non-hospitalized patients with chronic illness [12]. She also developed the Parent Perception of Uncertainty Scale (PPUS) (31 items) [13] and the family member version of the PPUS (PPUS-FM) (31 items) to measure family caregivers' illness uncertainty experiences [12].

However, there is a lack of reliable and valid instruments to assess uncertainty among those who manage terminal illnesses with paramount care demands, such as patients with advanced cancer and their caregivers. From a clinical perspective, the existing MUIS tools (33 items for patients and 31 items for caregivers) are burdensome for patients with advanced cancer and their caregivers, who often feel overwhelmed by the patient's health condition and care demands. A 5-item MUIS Spanish version was recently used to assess the uncertainty among patients with metastatic cancer [4]. Yet, this questionnaire was initially adopted for patients in the emergency department and their relatives [14]. Testing the psychometric properties of a brief English version of the MUIS is urgently needed to clinically assess uncertainty and ensure its reliability and validity without increasing the burden on advanced cancer patients and their caregivers. Although the current scales attempt to capture the multidimensionality of illness uncertainty (i.e., ambiguity, complexity, inconsistency, and unpredictability), the results of the psychometric evaluation have shown varied factor structures, ranging from 1–4 factors among different study populations [11, 14]. To the best of our knowledge, no research has conducted comprehensive psychometric testing, including factor analysis, on the illness uncertainty scales among patients with advanced cancer and their caregivers who face intensified challenges, such as physical symptoms and mental distress associated with choosing between active treatment or comfort, the timing for advance care planning, and the prognosis. In addition, advanced cancer patients frequently transition between professional hospital care and home self-management, and even hospice care. Therefore, these patients and caregivers may experience pressing illness uncertainty that differs from those associated with acute and chronic illnesses and related treatment with curative intent [15].

Development of the Brief MUIS for patients with advanced cancer (MUIS-P) and their caregivers (MUIS-Cg)

The MUIS-P and MUIS-Cg were developed based on the MUIS-A which is the original version with the most comprehensive assessment items. Based on the interviews of hospitalized patients about their experiences with illness and hospitalization with input from a group of nurses, doctors, and patients [10], Dr. Mishel developed the MUIS-A as a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). MUIS-A sums all items to provide a total score; higher scores indicate a higher level of illness uncertainty.

To measure illness uncertainty among advanced cancer patients and caregivers, the team worked with Dr. Mishel and three content experts to shorten the MUIS-A to a brief format (MUIS-P) based on extensive expert discussions, considering reducing participants' burden when they manage significant symptoms and distress. The team then adjusted the scale for caregivers to self-report their illness uncertainty while managing advanced cancer. They evaluated the content validity of both the patient and caregiver versions of the scales through six focus groups that consisted of 22 men with prostate cancer, including those with advanced cancer, and 20 spousal caregivers [16, 17]. During the focus group, the team debriefed participants

to ensure that the questionnaire was clear, easy to understand, relevant to patients with advanced cancer and their caregivers, and that the wording was appropriate and acceptable. The team also assessed the difficulty of these scales, participants' understanding of items, and time for completion (unpublished). According to Mishel's original work, the questionnaire was designed to be understood by individuals with a 7th-grade reading level. The questionnaire responses were changed from a 5-item to a 4-point Likert scale ranging from 1 to 4 (not at all, a little, some, a lot) to capture the level of illness uncertainty while reducing respondents' cognitive burden. Dr. Mishel, the original developer of the Mishel Uncertainty in Illness scale, approved the final versions of the MUIS-P and MUIS-Cg (Table 1).

In the present study, we comprehensively evaluated the psychometric properties of the MUIS-P and MUIS-Cg, including acceptability, floor and ceiling effects, factor structure, and reliability, among patients with advanced cancer and their caregivers. We also examined their validity based on Mishel's Uncertainty in Illness Theory [2], Han's taxonomy of uncertainty in health care [18], and illness uncertainty literature [15, 19]. We hypothesized that, among patients with advanced cancer and their caregivers, 1) illness uncertainty would positively correlate with negative appraisals of illness/caregiving, hopelessness, and avoidant coping (i.e., convergent validity), 2) illness uncertainty would negatively correlate with active coping and self-efficacy (i.e., discriminant validity), and 3) illness uncertainty at baseline would have a negative association with quality of life. We also hypothesized that uncertainty at baseline would positively correlate with hopelessness, depression, distress, and avoidant coping at the 3-month follow-up (i.e., predictive validity).

Table 1 MUIS-P and MUIS-Cg: Acceptability, Floor/Ceiling Effects, and Item-correlation for Patients with Advanced Cancer and Their Family Caregivers

	MUIS-P					
Items	N	Mean	SD	% at floor	% at ceiling	Item-total Correlation
1. I have a lot of questions about my illness	484	2.63	0.89	12.40	15.50	0.52
2. I am unsure if the treatment I am getting for my cancer is helping	484	2.30	1.11	32.85	18.18	0.59
#3. I know what side effects to expect from my treatment	484	1.82	0.86	41.94	5.58	0.31
4. I feel uncertain about the future because of my illness	484	2.90	1.01	12.19	34.71	0.70
5. Because of my illness, I am unsure what activities I will be able to do from day-to-day	484	2.56	1.02	19.01	20.66	0.70
6. I am bothered by the uncertainty caused by my illness	484	2.74	1.02	14.26	27.89	0.73
#7. The plan for treating my cancer is clear to me	484	1.81	0.88	43.80	5.99	0.51
#8. I can manage the uncertainty that my illness creates	484	2.01	0.77	25.83	3.10	0.57
#9. I understand all of the information I have received about my illness	484	1.65	0.75	48.76	2.48	0.47
Scale total	484	20.42	4.78	0.83	0.21	-
	MUIS-Cg					
Items	N	Mean	SD	% at floor	% at ceiling	Item-total Correlation
1. I have a lot of questions about his/her illness	484	2.61	0.95	13.64	19.63	0.51
2. I am unsure if the treatment he/she is getting for cancer is helping	484	2.27	1.06	30.79	15.70	0.57
#3. I know what side effects to expect from his/her treatment	484	1.91	0.88	36.98	6.40	0.45
4. I feel uncertain about the future because of his/her illness	484	2.80	0.99	11.78	28.72	0.58
5. Because of his/her illness, I am unsure what activities I will be able to do from day-to-day	484	2.26	1.02	29.13	13.22	0.59
6. I am bothered by the uncertainty caused by his/her illness	484	2.63	0.97	13.43	22.11	0.63
#7. The plan for treating his/her cancer is clear to me	484	1.88	0.92	42.36	6.82	0.56
#8. I can manage the uncertainty that his/her illness creates	484	1.99	0.77	25.83	3.72	0.50
#9. I understand all of the information I have received about his/her illness	484	1.73	0.77	43.39	2.89	0.59
Scale total	484	20.07	4.63	1.03	0.41	-

1) The results were reported after data imputation

2) Item with # needs to be reverse scored

3) MUIS-P: Brief Mishel Uncertainty in Illness Scale for patients with advanced cancer

4) MUIS-Cg: Brief Mishel Uncertainty in Illness Scale for family caregivers

Methods

We conducted a secondary data analysis from a randomized controlled trial (RCT) that tested the effects of a dyadic-based psychoeducational intervention on psychological outcomes for patients with advanced cancer and their family caregivers (R01CA107383, PI: Northouse; Clinicaltrial.gov registration number: NCT00709176, registration date: 2008–07-03). The study was conducted in accordance with the Declaration of Helsinki. The study design and procedure were previously published [20]. The original study received Institutional Review Board (IRB) approval from the cancer center recruitment sites and the University of Michigan (coordinating site) (IRBMED No. 2004–0129). The University of North Carolina at Chapel Hill IRB exempted this secondary analysis of the extant deidentified data involving no direct contact with participants. All participants provided written informed consent before data collection. To eliminate the intervention effects on illness uncertainty, we used the baseline data ($N=484$ patients and $N=484$ caregivers) before randomization to assess the acceptability, factor structure, reliability, and convergent and discriminant validity. We used the control group data at the baseline and 3-month follow-up ($n=118$ patients and $n=118$ caregivers) to assess the predictive validity.

Participants

The original RCT deemed patients eligible if they had advanced (stage III or IV) lung, colorectal, breast, or prostate cancer diagnosis, a life expectancy of ≥ 6 months (as indicated by their oncologist), were ≥ 21 years of age, lived within 75 miles of one of the four participating cancer centers, and had a family caregiver willing to participate in the study. The original research excluded patients diagnosed with multiple primary cancer sites. The RCT included family caregivers who were ≥ 18 years old and identified by patients as the primary person who provided emotional and/or physical care and excluded caregivers diagnosed with cancer within the past year or receiving active cancer treatment.

Instruments

Brief Mishel Uncertainty in Illness Scale for patients with advanced cancer (MUIS-P) and caregivers (MUIS-Cg)

Patients with advanced cancer and their caregivers completed the MUIS-P and MUIS-Cg separately to assess their own illness uncertainty [20]. The MUIS-P and MUIS-Cg each consist of nine items, each scored on a 4-point Likert scale from 1 (not at all) to 4 (a lot). The total possible scores range from 9 to 36; higher scores indicate higher illness uncertainty.

Instruments for validity testing

As suggested by Henrica de Vet et al. [21], we used hypothesis testing to explore the validity of MUIS-P and MUIS-Cg. We used the Mishel Uncertainty in Illness Theory [2] and Han's taxonomy of uncertainty in health care [18] to guide the selection of the variables for testing the MUIS-P and MUIS-Cg construct validity (convergent and discriminant) and predictive validity in the following hypotheses. Each measurement scale of the selected variables has prior evidence of reliability and validity.

Convergent validity We hypothesized that in patients with advanced cancer and their caregivers, higher illness uncertainty would positively correlate with more negative appraisals of illness/caregiving, hopelessness, and avoidant coping.

Appraisals of illness/caregiving. The 32-item Appraisals of Illness Scale assessed patient and caregiver perceptions of the degree of threat associated with illness and caregiving [22, 23]. Hopelessness. The 20-item Beck Hopelessness Scale measured the three major aspects of hopelessness: feelings about the future, loss of motivation, and expectations among patients and caregivers [24]. Avoidant Coping. Carver's Brief Cope (COPE) scale assessed avoidant coping through denial, self-distraction, behavioral disengagement, venting, and self-blame among patients and caregivers [25].

Discriminant validity We hypothesized that illness uncertainty would negatively correlate with active coping and self-efficacy.

Active coping. The COPE scale assessed active coping through emotional support, positive reframing, planning, acceptance, and instrumental support [25]. Self-efficacy. The 17-item Lewis Cancer Self-efficacy Scale assessed patient and caregiver confidence in managing advanced cancer [26].

Predictive validity We hypothesized that illness uncertainty at baseline would negatively correlate with quality of life and positively correlate with hopelessness, avoidant coping, depression, and distress at the 3-month follow-up.

Quality of life. We used the Functional Assessment of Cancer Therapy-General (version 4) (FACT-G) and Caregiver FACT-G to assess patient and caregiver cancer-specific overall quality of life and well-being in four domains (social, emotional, functional, and physical) [9, 27]. *Depression*. The 20-item Center for Epidemiological Studies-Depression Scale assessed patient and caregiver depressive symptomatology [28]. *Distress*. Using a 0–10 rating scale, the Distress Thermometer assessed patient and caregiver distress levels [29].

Data analysis

We used R software (R 4.1.2, Vienne, Austria) for the data analysis. To maintain consistency in item wording, we reverse-coded items 3, 7, 8, and 9 during data analysis. We calculated the percentage of missing data, and the floor and ceiling effects (the lowest and highest responses from participants, which can influence a questionnaire's responsiveness to change) at the item level [30], and item-total correlations. The overall level of missingness in the sample was 0.20%, with individual item missingness ranging from 0%–0.83%. The highest rates of missing data were observed for item 2, "I am unsure if the treatment I am getting for my cancer is helping" (0.83%), and item 8, "I can manage the uncertainty that my illness creates" (0.62%). We imputed missing items using the mean of observed items for each participant. We randomly split the sample into two subsamples of equal size ($n=242$) and used one subsample for exploratory factor analysis (EFA) and the other for confirmatory factor analysis (CFA) [31]. To ensure the EFA data's appropriateness, we examined the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlett's Test of Sphericity; we required a KMO ≥ 0.60 and a significant chi-square value of Bartlett's test to continue with the factor analysis [32]. We conducted an EFA using the principal component method with oblique (Promax) rotation to evaluate pattern matrices. We based the decision for the number of factors on how many eigenvalues of the correlation matrix are greater than 1.0 and the scree plot [33]. For CFA, we used the maximum likelihood estimation method to assess model fit. We used the comparative fit index (CFI) (>0.95 indicating an excellent fit), the Tucker-Lewis index (TLI) (>0.95 indicating an excellent fit), standardized root mean square residual (SRMR) (≤ 0.08 indicating a good fit), and root mean square error of approximation (RMSEA) (<0.06 indicating a good fit) to examine model fit [34]. We examined Cronbach's alpha and McDonald's omega (to account for the possibility that items may contribute unequally to the total variance) coefficients and correlations between the subscales and the total scale for internal consistency testing. Finally, we conducted Pearson correlation analyses to examine the MUIS-P and MUIS-Cg's convergent, discriminant, and predictive validity with the abovementioned instruments.

Results

Patient and caregiver characteristics

Among the 484 participating dyads, the mean age was 60.5 years ($SD=11.5$; range 26–95) and 56.5 years ($SD=13.4$; range 18–88) for patients and caregivers, respectively. The mean education level for patients and caregivers was 15 years. Most patients (62%) and caregivers (56.8%) were female. Most patients (78.9%) and caregivers (79.6%) were White. Patients had advanced breast (32.4%), lung (29.1%), colorectal (25.4%), and prostate cancer (13.0%). Approximately 41% of patients had their diagnosis for less than one year. Most caregivers were spouses (70%).

MUIS-P and MUIS-Cg acceptability and floor/ceiling effects

MUIS-P

The mean total score was 20.42 ($SD=4.78$) (Table 2). The floor effects (lowest scores) varied from 12.19%–48.76%, with the highest percentage occurring in the item "I understand all of the information I have received about my illness." The ceiling effect (highest scores) varied from 2.48%–34.71%, with the highest percentage occurring in the item "I feel uncertain about the future because of my illness." Item-total correlations—relationships between individual items and the total scale score—ranged from 0.31–0.73.

MUIS-Cg

The mean total score was 20.07 ($SD=4.63$) (Table 2). The floor effects varied from 11.78%–43.39%, with the highest percentage occurring in the item "I understand all of the information I have received about his/her illness." The ceiling effect varied from 2.89%–28.72%, with the highest percentage occurring in the item "I feel uncertain about the future because of his/her illness." Item-total correlations—relationships between individual items and the total scale score—ranged from 0.45–0.63.

MUIS-P and MUIS-Cg factor structure: EFA and CFA

MUIS-P

The EFA results from the first split patient sample ($n=242$) suggested a correlated two-factor structure as the preferred choice, determined by the number of eigenvalues of the correlation matrix greater than 1.0. The largest eigenvalue was 2.944, and the second largest was 1.982. All items loaded above 0.4 with excellent KMO and Bartlett's Test of Sphericity values for patients [KMO = 0.77; Bartlett's Test = 590.009(36), $p<0.0001$]. The correlated two-factor model explained 54.7% of the variance of illness uncertainty. The two factors were named unpredictability and ambiguity, respectively (Table 2). Table 3 displays the factor loadings. The CFA assessed the fit of the two-factor model using the second split patient sample ($n=242$). The two-factor model showed an excellent fit: $\chi 2\ (26)=44.722$, $p=0.013$; CFI = 0.968; TLI = 0.955; RMSEA = 0.055 (90% CI [0.025, 0.081]); SRMR = 0.063 (Table 3).

MUIS-Cg

The EFA results from the first spit caregiver sample ($n=242$) suggested a correlated two-factor structure

Table 2 Exploratory factor analysis for MUIS-P and MUIS-Cg

	MUIS-P (*n* = 242)	
Items	**Factor 1 (Unpredictability)**	**Factor 2 (Ambiguity)**
1. I have a lot of questions about my illness	**0.43**	0.13
2. I am unsure if the treatment I am getting for my cancer is helping	**0.60**	0.14
#3. I know what side effects to expect from my treatment	−0.21	**0.69**
4. I feel uncertain about the future because of my illness	**0.87**	−0.13
5. Because of my illness, I am unsure what activities I will be able to do from day-to-day	**0.79**	0.02
6. I am bothered by the uncertainty caused by my illness	**0.88**	−0.09
#7. The plan for treating my cancer is clear to me	−0.11	**0.79**
#8. I can manage the uncertainty that my illness creates	0.22	**0.65**
#9. I understand all of the information I have received about my illness	−0.05	**0.78**
	MUIS-Cg (*n* = 242)	
	Factor 1 (Unpredictability)	**Factor 2 (Ambiguity)**
1. I have a lot of questions about his/her illness	**0.39**	0.23
2. I am unsure if the treatment he/she is getting for cancer is helping	**0.45**	0.21
#3. I know what side effects to expect from his/her treatment	−0.20	**0.76**
4. I feel uncertain about the future because of his/her illness	**0.85**	−0.16
5. Because of his/her illness, I am unsure what activities I will be able to do from day-to-day	**0.82**	−0.08
6. I am bothered by the uncertainty caused by his/her illness	**0.80**	−0.01
#7. The plan for treating his/her cancer is clear to me	−0.09	**0.81**
#8. I can manage the uncertainty that his/her illness creates	0.14	**0.60**
#9. I understand all of the information I have received about his/her illness	−0.02	**0.84**

1) We randomly split the sample into two subsamples of equal size and used first-split subsample for exploratory factor analysis

2) Item with # needs to be reverse scored

3)The important factor loadings are in bold font

Table 3 Confirmatory factor analysis for MUIS-P and MUIS-Cg

Global model fit	**MUIS-P (*n* = 242)**	**MUIS-Cg (*n* = 242)**
χ2-test for discrepancy between sample and fitted covariance matrices	$\chi^2 = 44.722, df = 26, p = 0.013$	$\chi^2 = 55.113, df = 26, p = 0.001$
Comparative fit index (CFI)	0.968	0.928
Tucker Lewis index (TLI)	0.955	0.900
Root mean square error of approximation (RMSEA)	0.055 (90% CI (0.025,0.081))	0.068 (90% CI (0.043,0.093))
Weighted standardized root mean square residual index	0.063	0.066

We randomly split the sample into two subsamples of equal size and used a second-split subsample for confirmatory factor analysis

as the preferred choice, determined by the number of eigenvalues of the correlation matrix greater than 1.0. The largest eigenvalue was 3.020, and the second largest eigenvalue was 1.743. All items loaded above 0.4 with excellent KMO and Bartlett's Test of Sphericity values for caregivers [KMO = 0.77; Bartlett's Test = 518.849(36), $p < 0.0001$]. The two-factor model explained 52.9% of the variance of illness uncertainty. The correlated two factors were named unpredictability and ambiguity, respectively (Table 2). Table 3 presents the factor loadings. The CFA assessed the fit of the two-factor model using the second split caregiver sample ($n = 242$). The two-factor model showed an acceptable fit: χ^2 (26) = 55.113, $p = 0.001$; CFI = 0.928; TLI = 0.900; RMSEA = 0.068 (90% CI [0.043, 0.093]); SRMR = 0.066 (Table 3).

MUIS-P and MUIS-Cg internal consistency testing

MUIS-P

Cronbach's alpha ranged from 0.66–0.78 for the total scale and the subscales, indicating adequate internal consistency [35]. McDonald's omega ranged from 0.72–0.84 for the total scale and the subscales, indicating acceptable to good reliability [36, 37]. The correlation between the two subscales (0.22, $p < 0.001$) indicated a small

relationship. The correlations between the total scale and the two subscales were 0.88 ($p < 0.0001$) and 0.65 ($p < 0.0001$), indicating significant relationships (Table 4).

MUIS-Cg

Cronbach's alpha ranged from 0.70–0.72 for the total scale and the subscales, indicating acceptable internal consistency. McDonald's omega ranged from 0.76–0.79 for the total scale and the subscales, indicating acceptable reliability [36, 37]. The correlation between the two subscales was 0.24 ($p < 0.0001$), indicating a small relationship. The correlations between the total scale and the two subscales were 0.86 ($p < 0.0001$) and 0.71 ($p < 0.0001$), indicating significant relationships (Table 4).

MUIS-P and MUIS-Cg validity testing (Table 5)

Convergent validity

The patients' illness uncertainty subscale (unpredictability and ambiguity) and total scores positively correlated with negative appraisals of illness, hopelessness, and avoidant coping ($p < 0.0001$), indicating satisfactory convergent validity of the MUIS-P. Similarly, the caregivers' illness uncertainty subscale (unpredictability and ambiguity) and total scores positively correlated with appraisals of caregiving, hopelessness, and avoidant coping ($p < 0.0001$), indicating satisfactory convergent validity of the MUIS-Cg.

Discriminant validity

The patients' illness uncertainty subscale (unpredictability and ambiguity) and total scores negatively correlated with self-efficacy ($p < 0.0001$). The ambiguity subscale score was negatively related to active coping ($p < 0.0001$). The unpredictability score was positively associated with active coping ($p < 0.001$). Similarly, the caregivers' illness uncertainty subscale (unpredictability and ambiguity) and total scores negatively correlated with self-efficacy ($p < 0.0001$); the ambiguity subscale score was negatively related to active coping ($p < 0.001$), and the unpredictability score was positively associated with active coping ($p < 0.0001$). These results indicated satisfactory discriminant validity of the MUIS-P and MUIS-Cg.

Predictive validity

The patients' illness uncertainty unpredictability subscale and total score at baseline had a negative association with quality of life ($p < 0.0001$) and a positive association with hopelessness (unpredictability subscale, $p < 0.0001$; total score, $p < 0.001$), depression ($p < 0.001$), distress ($p < 0.05$), and avoidant coping ($p < 0.001$) at the 3-month follow-up. These results indicated satisfactory predictive validity of the MUIS-P. The caregivers' illness uncertainty subscale (unpredictability and ambiguity) and total scores at baseline had a negative association with their quality of life (unpredictability subscale and total score, $p < 0.0001$; ambiguity subscale, $p < 0.001$) and a positive association with their hopelessness (unpredictability subscale and total score, $p < 0.0001$; ambiguity subscale: $p < 0.05$), depression (unpredictability subscale and total score, $p < 0.0001$; ambiguity subscale: $p < 0.05$), and distress (unpredictability subscale and total score, $p < 0.0001$; ambiguity subscale: $p < 0.001$) at the 3-month follow-up. The caregivers' illness uncertainty unpredictability subscale and total scores at baseline positively correlated with avoidant coping at the 3-month follow-up ($p < 0.0001$). These results indicated satisfactory predictive validity of the MUIS-Cg.

Discussion

Our study is the first to comprehensively evaluate the English version of Brief Mishel Uncertainty in Illness Scale's psychometric properties in patients with advanced cancer and their caregivers, making a significant contribution to the research literature and clinical practice. The 9-item MUIS-P and MUIS-Cg show a goodness of fit for a two-factor structure, good internal consistency, and

Table 4 Internal reliability and inter-factor correlation for MUIS-P and MUIS-Cg

	MUIS-P ($N = 484$)				MUIS-Cg ($N = 484$)			
	Cronbach's alpha	McDonald's Omega	Inter-factor correlation		Cronbach's alpha	McDonald's Omega	Inter-factor correlation	
			Factor 1 (Unpredictability)	Factor 2 (Ambiguity)			Factor 1 (Unpredictability)	Factor 2 (Ambiguity)
Factor 1 (Unpredictability)	0.78	0.84	1	0.22***	0.70	0.76	1	0.24***
Factor 2 (Ambiguity)	0.66	0.72	0.22***	1	0.72	0.78	0.24***	1
Total score	0.74	0.83	0.88***	0.65***	0.72	0.79	0.86***	0.71***

** $p < .001$; *** $p < .0001$

Table 5 MUIS-P and MUIS-Cg Validity testing

MUIS-P						
	Cronbach's Alpha	**McDonald's Omega**	**N**	**Factor 1 (Unpredictability)**	**Factor 2 (Ambiguity)**	**Total Score**
Convergent (Baseline)						
Appraisal of illness/caregiving	0.94	0.95	484	.72*** (.68, .76)	.28*** (.19, .36)	.69*** (.64, .74)
Hopelessness	0.87	0.89	484	.52*** (.45,.58)	.29*** (.21,.37)	.55*** (.48,.61)
Avoidant coping	0.78	0.84	484	.42*** (.34, .49)	.24*** (.15,.32)	.44*** (.37,.51)
Discriminant (Baseline)						
Self-efficacy	0.97	0.98	484	-.44*** (-.51, -.37)	-.40*** (-.48, -.33)	-.54*** (-.60, -.47)
Active coping	0.87	0.90	484	.16** (.07,.24)	-.19*** (-.27, -.10)	.03 (-.05,.12)
Predictive (3-month follow up)						
Quality of life	0.91	0.94	117	-.42*** (-.56, -.26)	-.17 (-.34,.01)	-.43*** (-.56, -.27)
Hopelessness	0.89	0.91	118	.39*** (.23,.54)	.05 (-.13,.23)	.35** (.18,.50)
Depression	0.90	0.92	117	.34** (.17,.49)	.12 (-.06,.30)	.34** (.17,.49)
Distress	-	-	118	.23* (.06,.40)	.14 (-.04,.31)	.26* (.08,.42)
Avoidant coping	0.79	0.85	117	.34** (.17,.49)	.09 (-.09,.27)	.32** (.15,.48)
MUIS-Cg						
	Cronbach's Alpha	**McDonald's Omega**	**N**	**Factor 1 (Unpredictability)**	**Factor 2 (Ambiguity)**	**Total Score**
Convergent (Baseline)						
Appraisal of illness/caregiving	0.87	0.89	484	.53*** (.46,.59)	.31*** (.23,.39)	.55*** (.48,.61)
Hopelessness	0.85	0.88	483	.47*** (.40,.54)	.22*** (.13,.30)	.46*** (.38,.53)
Avoidant coping	0.74	0.80	484	.49*** (.42,.55)	.24*** (.15,.32)	.48*** (.41,.55)
Discriminant (Baseline)						
Self-efficacy	0.97	0.97	482	-.38*** (-.45, -.30)	-.40*** (-.48, -.33)	-.49*** (-.55, -.42)
Active coping	0.87	0.89	484	.23*** (.15,.31)	-.15** (-.24, -.06)	.09 (-.00,.18)
Predictive (3-month follow up)						
Quality of life	0.93	0.95	118	-.48*** (-.61, -.33)	-.34** (-.49, -.17)	-.54*** (-.65, -.39)
Hopelessness	0.88	0.91	118	.46*** (.30,.59)	.29* (.11,.44)	.49*** (.34,.61)
Depression	0.93	0.94	118	.50*** (.35,.62)	.29* (.12,.45)	.52*** (.38,.64)
Distress	-	-	118	.36*** (.19,.51)	.34** (.17,.49)	.45*** (.29,.58)
Avoidant coping	0.80	0.85	118	.44*** (.29,.58)	.17 (-.01,.34)	.42*** (.25,.55)

* $p < .05$; ** $p < .001$; *** $p < .0001$

sound convergent, discriminant, and predictive validity for measuring illness uncertainty among patients with advanced cancer and family caregivers.

Psychometric properties of the scales

The analysis supported the two-factor structure of the MUIS-P and MUIS-Cg, which consists of unpredictability and ambiguity. This two-factor structure showed stability for patients and caregivers managing advanced cancer. The MUIS-P and MUIS-Cg and two subscales had adequate to acceptable internal consistency (Cronbach's alpha ranging from 0.66–0.78 for patients and 0.70–0.72 for caregivers; McDonald's omega ranged from 0.72–0.84 for patients and 0.76–0.79 for caregivers). The two-factor structure of the MUIS-P and MUIS-Cg scales aligns with the domains identified in the original MUIS-A (Adult version) [10], but differs from the MUIS-C (Community version), which included only a single factor [11]. Additionaly, four of the five items in the ambiguity factor of the MUIS-P and MUIS-Cg (except Item #5: Because of my illness, I am unsure what activities I will be able to do from day-to-day) correspond to the ambiguity factor in Mishel's original MUIS-A [10]. The findings also provide empirical support for Han's taxonomy of uncertainty, highlighting that the indeterminacy of future outcomes and the lack of reliability, credibility, or adequacy of information are significant parts of the uncertainty [18]. Although the literature commonly reports that illness uncertainty includes Mishel's four domains, it is essential to note that Mishel's Uncertainty in Illness Theory predetermined the four-factor structure rather than based on empirical evidence [10]. The literature has put forth several alternative factor structures

among different populations, including one, two, and four factors [11]. The variability in factor structures across studies may suggest that the construct of illness uncertainty can differ in patients with different types and stages of illnesses and caregivers.

Our findings also indicated that the MUIS-P and MUIS-Cg have strong convergent, discriminant, and predictive validity. We confirmed the hypotheses concerning the convergent validity of the MUIS-P and MUIS-Cg. The patients' and caregivers' illness uncertainty total and subscale (unpredictability and ambiguity) scores positively correlated with negative appraisals of illness, hopelessness, and avoidant coping. These relationships, consistent with findings from other research [1, 2], have confirmed the Mishel Uncertainty in Illness Theory. We partially confirmed the hypotheses concerning the discriminant validity of the MUIS-P and MUIS-Cg. The patients' and caregivers' illness uncertainty subscale (unpredictability and ambiguity) and total scores negatively correlated with self-efficacy; the ambiguity subscale scores had a negative relationship with active coping, and the unpredictability subscale score was positively related to active coping. Interestingly, in the presence of more ambiguity, patients and caregivers were less likely to engage in active coping strategies, whereas greater unpredictability increased patients' and caregivers' likelihood to use active coping strategies; this phenomenon requires further research to understand how and why patient and caregiver respond differently to the various domains of illness uncertainty.

Another significant finding of this study's was the strong evidence for the MUIS-P and MUIS-Cg's predictive validity. The MUIS-P and MUIS-Cg baseline total scores were significantly associated with the patients' and caregivers' quality of life, hopelessness, depression, distress, and avoidant coping at the three-month follow-up. Our findings confirmed Han's taxonomy of uncertainty in healthcare, which emphasized the issues of uncertainty encompassing substantive outcomes, including personal psychosocial outcomes [18]. Notably, among family caregivers, the ambiguity subscale emerged as a significant predictor of poorer quality of life, hopelessness, depression, and distress. However, the ambiguity subscale did not demonstrate an influence on these outcomes among patients with advanced cancer. One potential explanation could be that patients confronting life-limiting conditions or experiencing declining health might not be attuned to the absence or vagueness of cues related to their illness (ambiguity). Consequently, they demonstrate tolerance of ambiguity [38] with their primary concern being the future. One qualitative study also demonstrated that uncertainty for the future was a predominant theme for patients with advanced cancer [39].

Notably, the floor effects of four items of the MUIS-P and MUIS-Cg exceed 30%, indicating that many patients and caregivers reported uncertainty scores at or near the lowest possible value. Some patients and caregivers likely reported low uncertainty scores because they accepted the diagnosis, perceived a clear prognosis, and focused on the present. It is also possible that some patients and caregivers mitigated the feelings of uncertainty using coping mechanisms such as seeking information, emotional support, and engaging in activities that gave them a sense of control and, thus, developed tolerance of uncertainty [40]. While there is a need to understand further this finding, such high percentages of floor effects can impede the differentiation of uncertainty levels among participants. This suggests that these measurements may lack sensitivity in capturing variations at the lower end of uncertainty. Research is needed to decide on the cut-off point for illness uncertainty so that supportive care interventions can target those experiencing high uncertainty.

Conversely, the results regarding ceiling effects demonstrate that the MUIS-P and MUIS-Cg can effectively distinguish individuals with high uncertainty levels and detect differences among participants. This suggests that the briefed uncertainty scales possess the necessary sensitivity to capture variations at the upper end of the uncertainty measurements. Consequently, MUIS-P and MUIS-Cg may serve as sensitive tools for assessing the effects of interventions aimed at reducing uncertainty among advanced cancer patients and their caregivers.

Limitations and future direction

This study possesses several limitations that underscore the need for further investigation. First, we shortened the MUIS-A based on the focus group discussion with patients with prostate cancer (including advanced cancer patients) and caregivers and expert feedback due to the challenges (personnel, costs, and time) in accessing large numbers of patients with advanced cancer and their caregivers. Future assessment development would benefit from using techniques such as cognitive interviews conducted among patients with different types of cancer and field pre-testing under realistic conditions [41]. Modern psychometric methods (e.g., Rasch analysis or item response theory) would also be beneficial for examining the measurement properties of the MUIS-P and MUIS-Cg. Second, it is noteworthy that the unpredictability factor included all of the negatively worded items while the ambiguity factor includes all of the positively worded items, possibly suggesting that the factors may be influenced by the wording of the items included in them. Additionally, the questionnaire included reverse-scored items which could have

impacted factor loadings by influencing how respondents interpret and answer. Next, the brief MUIS-P and MUIS-Cg responses were changed from a 5-point to a 4-point Likert scale to reduce the burden of patients with advanced cancer and their caregivers who often experience tremendous cognitive and mental distress and fatigue. However, such a change increased the difficulty of cross-study comparison. The original questionnaire developed by Dr. Mishel used "he/she" to refer to patients. Future research should consider updating this to "they/their" to ensure inclusivity for individuals who do not identify within the gender binary. Finally, most participants in the original RCT were White, well-educated, and English-speaking, warranting future psychometric testing in a heterogeneous sample of diverse sociocultural backgrounds.

Implications of findings

The MUIS-P and MUIS-Cg demonstrated promising psychometric properties in measuring illness uncertainty for patients with advanced cancer and family caregivers. The 9-item brief scales reduce the burden and increase user-friendliness, making widespread use in assessing illness uncertainty among patients and caregivers with significant symptoms and care burdens in clinical and research settings more suitable than the original MUIS-A and MUIS-C. The identified subdomains of illness uncertainty can help to measure ambiguity and unpredictability and facilitate the targeted interventions, such as providing caregivers with information to reduce ambiguity and assist in coping with the unpredictable nature of illness. Future research could further investigate the minimal clinically important difference for illness uncertainty and the subdomains. However, Different versions of the MUIS feature varying numbers of items and factor structures, as observed in psychometric evaluations across diverse study populations [11]. Researchers need to identify the most appropriate version of the MUIS for their study population and consider using the relevant full scale along with its subscales to ensure a more comprehensive assessment of illness uncertainty.

Conclusions

Our study comprehensively evaluated the psychometric properties of the Brief Mishel Uncertainty in Illness Scale for patients with advanced cancer and their caregivers. A shortened, psychometrically sound measure can help rapidly assess illness uncertainty among patients and caregivers who manage high symptoms and care demands and facilitate the delivery of targeted psychosocial supportive care.

Abbreviations

CFA	Confirmatory factor analysis
CFI	Comparative fit index
EFA	Exploratory factor analysis
FACT-G	Functional Assessment of Cancer Therapy-General
IRB	Institutional Review Board
KMO	Kaiser–Meyer–Olkin
MUIS	Mishel Uncertainty in Illness Scale
MUIS-A	Mishel Uncertainty in Illness Scale for Adults
MUIS-C	Mishel Uncertainty in Illness Scale-Community form
MUIS-P	Brief Mishel Uncertainty in Illness Scale for patients with advanced cancer
MUIS-Cg	Brief Mishel Uncertainty in Illness Scale for family caregivers of patients with advanced cancer
PPUS	Parent Perception of Uncertainty Scale
PPUS-FM	Family member version of the Parent Perception of Uncertainty Scale
RCT	Randomized controlled trial
RMSEA	Root mean square error of approximation
SRMR	Standardized root mean squared residual
TLI	Tucker-Lewis index

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Authors' contributions

Data collection: LN; Conceptualization: LS, TG; Methodology: LS, TG, YZ, LN; Data analyses: YZ, LS; Manuscript writing: TG, LS, YZ; Review and editing: LS, TG, YZ, LN.

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Data availability

The data are currently used for other studies and manuscript development. The data that support the study may be available upon request with permission from the researchers who collected the data.

Declarations

Ethics approval and consent to participate

Institutional Review Board approval was obtained from the cancer centers where study participants were recruited and the University of Michigan (coordinating site) (IRBMED No. 2004–0129). The University of North Carolina at Chapel Hill Institutional Review Board exempted secondary analysis of the extant deidentified data and involved no direct contact with participants. All participants provided written informed consent before data collection.

Consent for publication

Not appliable.

Competing interests

The authors declare no competing interests.

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