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SYMPTOMS, SUPPORTIVE CARE NEEDS, AND FUNCTION IN CANCER PATIENTS: HOW ARE THEY RELATED?

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Abstract

AIMS—To explore the associations among symptoms, supportive care needs, and function.

METHODS—117 cancer patients completed the Supportive Care Needs Survey and EORTC-QLQ-C30 in a cross-sectional study. Associations among functions (physical, role, emotional, cognitive, social), symptoms (fatigue, nausea/vomiting, pain, dyspnea, insomnia, appetite loss, constipation, diarrhea), and supportive care needs (physical and daily living, psychological, patient care and support, health system and information, sexual) were tested using multivariate item regression (MIR). We tested (1) functions as the dependent variable with symptoms and supportive care needs as independent variables and (2) supportive care needs as the dependent variable with symptoms and functions as independent variables.

RESULTS—Worse fatigue, pain, and appetite loss were associated with worse function. Greater unmet physical and daily living needs were associated with worse physical, role, and cognitive function. Greater unmet psychological needs were associated with worse emotional and cognitive function. Worse sleep problems were associated with greater unmet needs. Better physical function was associated with fewer unmet physical and daily living needs, and better emotional function was associated with fewer unmet psychological, patient care and support, and health system and information needs.

CONCLUSIONS—These models suggested several consistent relationships among symptoms, supportive care needs, and functions.

Keywords

health-related quality of life; supportive care needs; symptoms; functional status

BACKGROUND

Interest in using patient-reported measures (PRMs) in clinical practice for individual patient management is increasing [1-6]. Acquadro et al list a variety of patient-reported outcomes including functional status, health-related quality-of-life (HRQOL), and symptoms [7], although they do not go into detail regarding how these various outcomes differ, and there is likely some overlap. Supportive care needs are a different kind of patient-reported measure that assess whether a need exists and how well it is being met [8]. However, little empiric work has been conducted to date to explore the associations among these different types of

measures [8,9]. This study was undertaken to begin investigating the relationship among three different PRMs: symptoms, supportive care needs, and function.

Understanding the relationship among different PRMs can facilitate their application in clinical practice by helping to (1) select the appropriate measures, (2) interpret the results, and (3) understand how to address identified problems. For example, imagine a patient who reports poor physical function, high levels of nausea and vomiting, and the need for more information on how to manage symptoms and side effects. How should the clinician respond? Is prescribing a medication to treat the nausea and vomiting sufficient, or is educating the patient regarding nausea and vomiting management also important? Improving our understanding of the relationship among function, symptoms, and supportive care needs may shed light on questions like these.

To our knowledge, no conceptual model explicitly includes symptoms, functional status, and supportive care needs (referred to as “needs”). While some of the complex models of HRQOL include symptoms and functional status, the role of needs is less clear. Both the Wilson and Cleary and Patrick and Chiang models of HRQOL position symptoms adjacent to functional status [9], and researchers have explored the relationship between symptoms and HRQOL [10,11]. While not addressing the relationship between symptoms, needs, and function specifically, Gustafson [8] does discuss how needs, satisfaction, and HRQOL might be distinguished. He suggests that HRQOL is a measure of how well the patient is doing and that needs assessments provide “raw material” for HRQOL and satisfaction measures.

In this study, we conducted initial exploratory analyses of the associations among symptoms, supportive care needs, and function. Using data from a cross-sectional sample of cancer patients undergoing treatment who completed a cancer HRQOL measure (that included both symptom and function measures) and a supportive care needs assessment, we explored the relationship among these three different types of PRMs.

Because this initial exploratory analysis used cross-sectional data, we could not explore the longitudinal relationships among these outcomes and how they might change over time. Thus, it is somewhat unclear whether function is an outcome of symptoms and needs or whether need is the outcome of symptoms and functions (we did not think it was conceptually defensible to have symptoms as the outcome of functions and needs). Thus, we undertook two separate sets of analyses: (1) function as described by symptoms and needs and (2) need as described by symptoms and function (Figure 1). In all of these analyses, we explored which independent variables had the strongest relationship to the outcome and whether the different categories of variables (i.e., symptoms, needs, and functions) contributed unique information.

METHODS

Study Population and Procedures

This was a descriptive, cross-sectional study exploring symptoms, supportive care needs, and function among a convenience sample of breast, prostate, and lung cancer patients. Between January and May 2006, the patients of seven oncologists in the Sidney Kimmel Comprehensive Cancer Center at Johns Hopkins were recruited for the study using flyers handed out by clinic personnel. Interested patients were referred to a research coordinator stationed in the clinic for more information and eligibility evaluation.

Patients were eligible for this study if they were diagnosed with breast, lung, or prostate cancer at any stage; aged 18 years or older; currently undergoing treatment; able to complete the questionnaire in English; and able and willing to provide oral informed consent. Target

enrollment was 35 to 50 patients per cancer type, for a total sample size of 105 to 150 patients. This number of patients was estimated to be adequate for initial exploratory analysis based on consultations with a statistician. This study was approved by the Johns Hopkins School of Medicine Institutional Review Board (NA_00001797).

Subjects completed the study questionnaire in paper-and-pen format during their clinic visit. Oncologists provided Eastern Cooperative Oncology Group (ECOG) performance status, cancer type, extent of disease, and current and previous treatments for enrolled patients. There were no other interventions or departures from standard care.

Questionnaire

Patients completed the EORTC-QLQ-C30 and the Supportive Care Needs Survey-Short Form (SCNS). These instruments were selected because they were rated as having the most relevant content for clinical practice applications in a previous study [12].

EORTC-QLQ-C30—The European Organization for Research and Treatment of Cancer Quality-of-Life-Questionnaire-Core 30 is a 30-item cancer HRQOL measure that assesses five functions (physical, role, emotional, social, cognitive), eight symptoms (fatigue, pain, nausea and vomiting, dyspnea, insomnia, appetite loss, constipation, diarrhea), plus financial impact and a global health/quality of life rating [13] (see Table 1 for example questions). Patients respond on a four-point scale (1=not at all, 2=a little, 3=quite a bit, 4=very much). All domains are transformed to a 0 to 100 score, with higher scores on the function domains representing better function and higher scores on the symptom domains representing greater symptom burden.

SCNS—The 34-item Supportive Care Needs Survey-Short Form identifies the level of unmet need patients have as a result of their cancer in five domains: physical and daily living, psychological, patient care and support, health system and information, and sexual [14,15] (see Table 1 for example questions). Patients respond on a five-point scale (1=not applicable, 2=satisfied, 3=low need, 4=moderate need, 5=high need). To compute the domain scores, the average score of the items in the domain was calculated. Higher scores indicate greater level of unmet need.

Finally, patients reported their age, gender, race, and education.

Statistical Methods

Patient Characteristics—We performed descriptive analyses of the patients' age, gender, race, education, type of cancer, performance status, extent of disease, and current and previous treatments.

Factor Analysis—After scoring the EORTC-QLQ-C30 and SCNS using the procedures described above, we calculated the correlations among the domains and performed exploratory factor analysis. We performed four factor analyses: (1) including only the EORTC symptoms (fatigue, nausea/vomiting, pain, dyspnea, insomnia, appetite loss, constipation, diarrhea), (2) including only the EORTC functions (physical, role, emotional, cognitive, social), (3) including only the supportive care needs (physical and daily living, psychological, patient care and support, health system and information, sexual), and (4) including all symptoms, functions, and needs together. The first three factor analyses examined the unidimensionality of the symptom, function, and need domains, and the fourth factor analysis examined the groupings of symptoms, functions, and needs when included together. We used varimax rotation for the first three factor analyses because we

hypothesized that each would be strongly unidimensional, but promax rotation for the fourth since we hypothesized that there would be three correlated factors.

We also performed confirmatory factor analysis (CFA) with the three factors (function, needs, and symptoms). In the first CFA, we allowed the factors to be correlated with one another but forced independence of the error (i.e., uniqueness) terms. To identify the model, we set the distribution of the factors to be normal, with mean 0 and variance 1 (instead of forcing a loading to be 1 for each factor). We then fit a more flexible model allowing for correlation between error terms within factors. That is, we abandoned the conditional independence assumption.

Multivariate Item Regression (MIR)—We conducted MIR analysis to explore how symptoms, needs, and functions relate. MIR involves simultaneous regression across multiple outcomes per person, allowing for correlations among outcomes [16]. It is particularly appropriate when multiple related outcomes are of interest and are known to be moderately to highly correlated. We conducted two sets of MIRs: (1) function as the outcome described by symptoms and needs and (2) need as the outcome described by symptoms and functions. Note that while this type of analysis is termed “multivariate item regression,” in this case both the multivariate outcomes and the explanatory variables are domain scores rather than individual items.

MIR requires testing whether each covariate in the model has the same association with each of the outcomes. For example, when the five functions are the outcomes and the symptoms are the predictors, does fatigue have the same association with each of the five function outcomes (e.g., physical, emotional)? Interaction terms are included in the model to test for differential associations, and if the interactions are significant, they are retained. If two or more of the interactions are similar in size, they can be combined to achieve a more parsimonious model and still retain approximately the same model fit.

An alternative to MIR would be a latent variable approach where we assume there is an underlying unobservable (i.e., latent) variable which is responsible for the correlation structure among outcomes of interest. However, a latent variable approach has stringent statistical and theoretical assumptions. One assumption is conditional independence (e.g., conditional on the latent variable, function items are independent). Based on prior knowledge of items, exploration of the data, and our factor analysis, this seems unlikely to be reasonable. Another assumption is non-differential measurement (also known as differential item functioning), which asserts that the measurement model is the same across subgroups of the data. The non-differential measurement assumption would imply that, for example, the factor structure for needs is the same for high functioning patients and low functioning patients, which does not appear consistent with our data. Given that the relationship between needs, functions, and symptoms is the primary goal of this study and that the non-differential measurement assumption is unrealistic in this case, MIR is a more appropriate approach. The MIR approach is more flexible by allowing interactions and adjustment for covariates such as ECOG status.

Below, we describe the MIR models we used to investigate the relationship among symptoms, needs, and functions. Table 2 summarizes all the models. We labeled the models Function 1-6 when Function is the outcome described by symptoms and needs and Need 1-6 when Need is the outcome described by symptoms and functions.

Function as the Outcome: First, the multiple outcomes that were regressed simultaneously were the five EORTC function domains (physical, role, emotional, cognitive, social). The outcomes were standardized by dividing the scores for each outcome by the observed

sample standard deviation. A linear mixed effects model accounted for the correlation among the five function scores within patients. Statistical significance was defined as $p < 0.05$.

Identifying Relevant Patient Characteristics (Function 1): First, we included age, race, ethnicity, education, performance status, type of cancer, and extent of disease as covariates with the multivariate function domains as outcomes. We removed the variables one at a time starting with the highest p-value until only statistically significant variables remained. This initial model assumed that the association between a covariate and each outcome was the same. We then tested for differences in associations between each covariate and the different outcomes using interaction terms and retained interactions that were statistically significant.

Developing the Base Symptom Model (Function 2): After identifying the appropriate patient characteristic model (Function 1), we added the eight symptoms to the model simultaneously. We then tested to see if symptoms were differentially related to the multivariate function outcome using interaction terms. Interactions were retained if they were statistically significant and interaction terms with similar coefficients were combined to create a more parsimonious model. This Base Symptom Model (Function 2) represents the relationship between symptoms and function, without including needs.

Developing the Base Need Model (Function 3): We then added the five supportive care needs simultaneously to the relevant patient characteristics model (Function 1). For each need, we included interaction terms to test for differential associations with functions. Again, we retained statistically significant interactions and combined those with similar magnitude. The Base Need Model (Function 3) represents the relationship between needs and function, without including symptoms.

Adding Symptoms to Base Need Model (Function 4a- 4h): We then added each symptom (along with its interactions) to the Base Need Model (Function 3). A separate model was fit for each symptom. These models identified which symptoms added significant information to describing function beyond needs.

Adding Needs to Base Symptom Model (Function 5a-5e): We then added each need domain (along with its interactions) to the Base Symptom Model (Function 2). A separate model was fit for each need domain. These models identified which needs added significant information to describing function beyond symptoms.

Including All Significant Symptoms and Needs Together (Function 6): Finally, we included all the symptoms that were significant in Function 4a-4h and all the needs that were significant in Function 5a-5e and the patient characteristics from Function 1 in one final model. Insignificant effects were removed one at a time, based on the magnitude of the p-value, until only significant predictors remained. The only exception to this approach was that main effects were retained regardless of significance if an interaction including that main effect was retained. This model identified which symptoms and needs were most strongly related to the function outcomes when included together.

Need as the Outcome: We repeated the above six steps with the five need domains as the multivariate outcome as described by symptoms and functions. Models with need as the outcome are referred to as Need 1, Need 2, Need 3, Need 4a-4h, Need 5a-5e, and Need 6 (Table 2).

RESULTS

Patients

There were 129 patients referred to the research coordinator, of whom 117 (91%) enrolled. Reasons for not enrolling were not currently undergoing treatment (n=2), too ill (n=2), or not interested (n=8). Our sample included 50 breast, 18 lung, and 49 prostate cancer patients with a mean age of 61.2 years, 49% female, 77% White, and 95% with a performance status rating of 0 or 1 (Table 3).

Factor Analysis

The domain score correlations demonstrated the expected patterns with, for example, physical domains more highly correlated with one another and emotional domains more highly correlated with one another than with domains of other types (data not shown).

The three exploratory factor analyses that examined symptom, function, and need domains separately confirmed that each is strongly unidimensional. For symptoms, the first two eigenvalues were 3.2 and 0.4; for functions, the first two eigenvalues were 2.7 and 0.4, and for needs, the first two eigenvalues were 2.7 and 0.4. When symptom, function, and need domains were included together, three factors were identified (eigenvalues of 7.5, 1.8, and 1.2). The three factors did not perfectly differentiate between symptoms, needs, and functions, which is not surprising because the correlations suggest relationships both within and across the different PRMs, as we had hypothesized. The first factor included physical function, role function, social function, fatigue, pain, constipation, and physical and daily living needs. The second factor included psychological needs, patient care and support needs, health system and information needs, and sexual needs, and the third factor included emotional function, cognitive function, nausea/vomiting, dyspnea, sleep, appetite loss, and diarrhea.

The first CFA model (assuming conditional independence) gave expected results: loadings for needs ranged from -0.20 to -0.12, loadings for function ranged from 0.19 to 0.22, and loadings for symptoms ranged from 0.12 to 0.23. The factors all had high correlations with each other (correlation >0.40 in absolute value for each pairwise comparison of factors). The second CFA model (abandoning conditional independence assumption) encountered some model identification problems, depending on how many errors we allowed to be correlated. But, in general, we found strong evidence that within the CFA model, allowing for correlation of factors, residual correlation still exists between error terms. This result is consistent with our hypothesis that the factor structure imposed by a standard structural equation modeling approach is not rich enough to describe the associations between variables in our analysis.

Multivariate Item Regression Models

Function as the Outcome-Summary of Findings—The key finding from our models with function as the outcome described by symptoms and needs is that both symptoms and needs contributed significant information in describing function, but symptoms added more information to needs than needs added to symptoms. Specifically, 7 of 8 symptoms were statistically significant when added to the Base Need Model (Function 4a-4h), but only 2 of 5 needs were significant when added to the Base Symptom Model (Function 5a-5e). Fatigue, pain, and appetite loss were the symptoms most consistently associated with function. Physical and daily living needs were consistently associated with physical, role, and cognitive function; psychological needs were consistently associated with emotional and cognitive function.

Function as the Outcome—Details of Models—Figures 2a and 2b summarize the results from all of the models examining the relationship between symptoms and needs with the multivariate function outcome. Some symptoms (e.g., appetite loss) and needs (e.g., physical and daily living) had different associations with the various function outcomes, which required estimating separate coefficients and standard errors. However, in viewing the Figures, the key thing to look for is which symptoms and needs had consistently statistically significant relationships with the multivariate function outcome (i.e., error bars that do not cross 0). For example, greater fatigue is associated with worse function in all models, and greater unmet psychological need is associated with worse emotional and cognitive function in all models.

In models with function as the outcome, we determined that it was necessary to control for cancer type, extent of disease, and performance status interacted with function (Function 1). In the final Base Symptom Model (Function 2), worse fatigue, pain, and diarrhea were associated with worse function, and worse appetite loss was associated with worse function, except for physical function. In the Base Need Model (Function 3), we found that greater unmet physical and daily living needs were associated with worse physical, role, and cognitive function. It was also associated with worse emotional and social function, but less so. Greater unmet psychological needs were associated with worse emotional and cognitive function (but not the other functions). Greater unmet patient care and support needs were associated with better physical function, and greater unmet health system and information needs were associated with worse function for all function domains. When each symptom was added to the Base Need Model, all symptoms (except constipation) were associated with worse function (Function 4a-4h). When each need was added to the Base Symptom Model, greater unmet physical and daily living needs were associated with worse physical, role, and cognitive function. Additionally, greater unmet psychological needs were associated with worse emotional and cognitive function (Function 5a-5e). When all significant symptoms from Function 4a-4h were added to all significant needs from Function 5a-5e, we found that worse fatigue, pain, and appetite loss were all significantly associated with worse function. Greater unmet physical and daily living needs were associated with worse physical, role, and cognitive function, and greater unmet psychological needs were associated with worse emotional and cognitive function (Function 6).

In summary, greater levels of fatigue, pain, and appetite loss were associated with statistically significantly worse function in all of the models (Function 2, Function 4a-4h, and Function 6). Greater unmet physical and daily living needs were associated with worse physical, role, and cognitive function, and greater unmet psychological needs were associated with worse emotional and cognitive function (Function 3, Function 5a-5e, and Function 6). For the interested reader, Technical Appendix A presents the coefficients, standard errors, and p-values of models Function 1-Function 6.

Need as the Outcome—Summary of Findings—The key finding from our models with need as the outcome described by symptoms and function is that both symptoms and function contributed significant information, but function added more information to symptoms than symptoms added to function. Specifically, only 1 of 8 symptoms was significant when added to the Base Function Model (Need 4a-4h), but 3 of 5 functions were significant when added to the Base Symptom Model (Need 5a-5e). Sleep was the symptom most consistently associated with need. Physical function was consistently associated with physical and daily living needs, and emotional function with psychological, patient care and support, and health system and information needs. Adjustment for symptoms did not tend to affect the association between functions and need.

Need as the Outcome—Details of Models—Figures 3a and 3b summarize the results from all of the models examining the relationship between symptoms and functions with the multivariate need outcome. Again, some symptoms (e.g., appetite loss) and functions (e.g., physical), had different associations with the various need outcomes, which required estimating separate coefficients and standard errors. And, again, in viewing the Figures, the key thing to look for is which symptoms and functions had consistently statistically significant relationships with the multivariate need outcome (i.e., error bars that do not cross 0). For example, greater sleep problems is associated with greater unmet needs in all models, and better physical function is associated with fewer physical and daily living needs in all models.

In models with need as the outcome, performance status interacted with the multivariate need outcome was the only statistically significant patient characteristic and was included in all models (Need 1). In the final Base Symptom Model (Need 2), worse fatigue was associated with greater unmet physical and daily living and health system and information needs; worse pain was associated with greater unmet physical and daily living and psychological needs; and greater appetite loss was associated with greater unmet needs in all areas, but a larger effect size on psychological and patient care and support than the other needs. Sleep was associated with greater unmet needs across all needs. In the final Base Function Model (Need 3), better physical function was associated fewer unmet physical and daily living needs, and better emotional function was associated with fewer unmet psychological, patient care and support, and health system and information needs. When each symptom was added to the Base Function Model, only worse sleep was significantly associated with greater unmet needs (Need 4a-4h). When each function was added to the Base Symptom Model, we found essentially the same patterns of associations as in the Base Function Model, suggesting that adjustment for symptoms does not affect the association between functions and need (Need 5a-5e). Our final model which included all the relevant symptoms and functions to assess their associations with need after adjustment showed several significant results (Need 6). Better physical function was associated with fewer unmet physical and daily living needs; better emotional function was associated with fewer unmet psychological, patient care and support, and health system and information needs; and better social function was associated with fewer unmet needs in all areas. Worse sleep problems was the only statistically significant symptom, and it was associated with greater unmet needs.

In summary, greater sleep problems were associated with greater unmet needs in all models (Need 2, Need 4a-4h, and Need 6). Better physical function was associated with fewer unmet physical and daily living needs, and better emotional function was associated with fewer unmet psychological, patient care and support, and health system and information needs (Need 3, Need 5a-5e, and Need 6). For the interested reader, Technical Appendix B presents the coefficients, standard errors, and p-values of models Need 1-Need 6.

DISCUSSION

Improved understanding of how PRMs relate to one another can facilitate more effective use of PRMs in clinical practice, including informing measure selection, result interpretation, and problem resolution. However, little research has been done to explore how symptoms, supportive care needs, and function relate to one another. This study was conducted to begin exploring these issues and to develop hypotheses for further testing.

Before discussing the implications of the study, it is important to consider its limitations. First, because this study uses cross-sectional data it was unclear whether need or function should be the outcome, so we performed the analyses both with function as the outcome and

with need as the outcome. In addition, it is also important to note that the measures used for symptoms, needs, and function may not be comprehensive and also do not complement each other perfectly. For example, the symptoms included in the EORTC-QLQ-C30 may not assess some relevant symptoms. Also, while the needs assessment measures need for help with certain symptoms specifically (e.g., pain), for most symptoms, need for help is measured in a non-specific manner (e.g., being given information... about aspects of managing your illness and side effects at home). Ideally, the EORTC-QLQ-C30 would include all relevant symptoms, and the needs assessment would ask whether the patient perceives a need for help with each of the symptoms listed in the EORTC. This ideal situation would allow for clear interpretation of whether and how to act on problems that are identified.

While the limitations of this study preclude making definitive conclusions on the relationships among symptoms, needs, and function, the results from these analyses inform hypothesis generation for future studies. Our hypothesis based on these initial analyses is that symptoms affect function which affects needs. Specifically, we found that symptoms tended to add more to needs than needs added to symptoms in describing function. Thus, from a clinical perspective, if the goal is to improve function, it may be more important to address symptom issues than to address supportive care needs. The symptoms we found to be most consistently associated with function were fatigue, pain, and appetite loss.

On the other hand, we found that function tended to add more to symptoms than symptoms added to function in describing need. Therefore, for patients who present with significant unmet needs, attention to functional deficits may be warranted (although as noted above, addressing symptoms may be needed to address function). We found that physical function was consistently associated with physical and daily living needs, and emotional function with psychological, patient care and support, and health system and information needs.

Thus, these analyses were instructive in generating the hypothesis that symptoms affect function which affects needs. This hypothesis requires additional testing in larger, more diverse samples through longitudinal studies. The longitudinal studies will be important both to assess how the relationship among symptoms, needs, and function may change over time and to evaluate the causal assumptions. If this hypothesis is confirmed, the resulting knowledge can inform clinicians' decision on which PRM to use (depending on whether they are most concerned with the symptom-function or function-need relationship) and how to address problems that are identified through the PRM.

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Technical Appendix A

RELATIONSHIP BETWEEN SYMPTOMS AND NEEDS TO MULTIVARIATE FUNCTION OUTCOME ^a

	Coefficient	SE	P-Value	Coefficient	SE	P-Value	Coefficient	SE	P-Value
	Table 5a: Results for Model with All 8 Symptoms and Relevant Interactions (Function 2)			Table 5c: Results for Each Symptom Added to Base Need Model (Function 4a-4h)			Table 5e: Results for All Significant Symptoms and Needs Together (Function 6)		
Fatigue	-0.017	0.002	<0.001	-0.022	0.003	<0.001	-0.017	0.002	<0.001
Nausea/Vomiting: physical, role, and social function	0.001	0.003	0.686						
Nausea/Vomiting: emotional and cognitive function	-0.005	0.004	0.15	-0.017 ^b	0.003	<0.0001	-0.001	-0.003	0.732
Pain	-0.008	0.002	<0.001	-0.016	0.003	<0.001	-0.008	0.002	<0.001
Dyspnea	0.001	0.002	0.620	-0.008	0.002	<0.001	0.001	0.002	0.460
Sleep	<0.001	0.001	0.986	-0.006	0.003	0.028	0.001	0.002	0.668
Appetite Loss: physical function	<0.001	0.003	0.904						
Appetite Loss: role, emotional, cognitive, and social function	-0.007	0.002	0.001	-0.013 ^b	0.003	<0.001	-0.005	0.002	0.029
Constipation	0.001	0.002	0.601	-0.001	0.004	0.890			
Diarrhea	-0.004	0.002	0.047	-0.015	0.003	<0.001	-0.004	0.002	0.110

	Table 5b: Results for Model with All 5 Needs with Relevant Interactions (Function 3)			Table 5d: Results for Each Need Added to Base Symptom Model (Function 5a-5e)					
Physical & Daily Living: physical, role, and cognitive function	-0.477	0.087	<0.001	-0.173	0.067	0.010	-0.146	0.073	0.045
Physical & Daily Living: emotional and social function	-0.200	0.093	0.032	0.076	0.073	0.292	0.110	0.079	0.163
Psychological: physical, role, and social function	-0.056	0.119	0.636	-0.045	0.055	0.413	-0.004	0.060	0.950
Psychological: emotional and cognitive function	-0.288	0.123	0.020	-0.191	0.063	0.002	-0.258	0.066	<0.001
Patient Care & Support: physical function	0.491	0.187	0.009						
Patient Care & Support: role, emotional, cognitive, and social function	0.205	0.169	0.225	-0.041 ^b	0.062	0.508			
Health System & Information	-0.435	0.176	0.013	-0.106	0.069	0.124			

	Table 5b: Results for Model with All 5 Needs with Relevant Interactions (Function 3)			Table 5d: Results for Each Need Added to Base Symptom Model (Function 5a-5e)		
Sexual	0.017	0.066	0.797	-0.053	0.035	0.127

^a Cancer type, performance status (interacted with the functional outcome), and extent of disease (early stage/loco-regional vs. metastatic) were included as covariates in all models

^b Interaction no longer significant in adjusted model. Result shown is for model refit removing interaction.

Technical Appendix B

RELATIONSHIP BETWEEN SYMPTOMS AND FUNCTION TO MULTIVARIATE NEED OUTCOME ^a

	Coefficient	SE	P-Value	Coefficient	SE	P-Value	Coefficient	SE	P-Value
	Table 6a: Results for Model with All 8 Symptoms and Relevant Interactions (Need 2)			Table 6c: Results for Each Symptom Added to Base Function Model (Need 4a-4h)			Table 6e: Results for All Significant Symptoms and Functions Together (Need 6)		
Fatigue: physical and daily living and health system and information needs	0.012	0.004	0.003						
Fatigue: psychological, patient care and support, and sexual needs	0.002	0.004	0.563	0.004 ^b	0.004	0.399			
Nausea/Vomiting	-0.005	0.004	0.290	-0.003	0.004	0.439			
Pain: physical and daily living and psychological needs	0.011	0.003	0.001						
Pain: patient care and support, health system and information, and sexual needs	0.005	0.003	0.130	0.005 ^b	0.003	0.118			
Dyspnea	-0.002	0.003	0.479	-0.002	0.002	0.376			
Sleep	0.006	0.002	0.005	0.006	0.002	0.006	0.006	0.002	0.004
Appetite Loss: physical and daily living, health system and information, and sexual needs	0.007	0.003	0.030	0.004 ^b	0.003	0.179			
Appetite Loss: psychological and patient care and support needs	0.015	0.004	<0.001						
Constipation	0.001	0.003	0.662	0.002	0.003	0.409			
Diarrhea	-0.002	0.003	0.609	-0.001	0.003	0.690			

	Table 6b: Results for Model with All 5 Functions with Relevant Interactions (Need 3)			Table 6d: Results for Each Function Added to Base Symptom Model (Need 5a-5e)					
Physical: physical and daily living needs	-0.018	0.005	0.001	-0.014	0.005	0.012	-0.019	0.005	<0.001
Physical: psychological, patient care and support, health system and information, and sexual needs	0.005	0.005	0.300	0.005	0.004	0.281	0.003	0.004	0.327
Emotional: physical and daily living and sexual needs	-0.003	0.004	0.357	-0.004	0.004	0.320	-0.003	0.003	0.430
Emotional: psychological, patient care and support, and health system and information needs	-0.015	0.003	<0.001	-0.010	0.004	0.004	-0.014	0.003	<0.001
Role	-0.001	0.004	0.748	0.001	0.004	0.766			
Cognitive	-0.005	0.004	0.185	-0.005	0.003	0.168			
Social	-0.007	0.004	0.053	-0.007	0.003	0.037	-0.008	0.003	0.009

^a Performance status (interacted with the need outcome) was included in all models

^b Interaction no longer significant in adjusted model. Result shown is for model refit removing interaction.

ABBREVIATIONS

CFA	confirmatory factor analysis
ECOG	Eastern Cooperative Oncology Group
EORTC-QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30
HRQOL	health-related quality of life
MIR	multivariate item regression
PRM	patient-reported measure
SCNS	Supportive Care Needs Survey-Short Form
Phys	physical function
Soc	social function
Emot	emotional function
Cog	cognitive function
PDL	physical and daily living needs
Psyc	psychological needs
PCS	patient care and support needs
HSI	health system and information needs

SEX	sexual needs
Constip	constipation

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Figure 1. Summary of relationships explored in multivariate item regression analyses. Solid lines illustrate relationships tested with Function as the outcome, and dashed lines illustrate relationships tested with Need as the outcome.

Figure 2a.

Results of Function 2, Function 4a-4h, and Function 6 for the association between symptoms and functions. Triangles, circles, and Xs represent regression coefficients from linear regression models and vertical lines spanning them represent their 95% confidence intervals. Triangles indicate coefficients from Function 2, circles from Function 4a-4h, and Xs from Function 6. When there are two coefficients from one model within one symptom this indicates that an interaction was present and the appropriate functions to which the coefficient refers is noted above the plotting symbol.

Figure 2b.

Results of Function 3, Function 5a-5e, and Function 6 for the association between needs and functions. Triangles, circles, and Xs represent regression coefficients from linear regression models and vertical lines spanning them represent their 95% confidence intervals. Triangles indicate coefficients from Function 3, circles from Function 5a-5e, and Xs from Function 6. When there are two coefficients from one model within one need this indicates that an interaction was present and the appropriate functions to which the coefficient refers is noted above the plotting symbol.

Figure 3a.

Results of Need 2, Need 4a-4h, and Need 6 for the association between symptoms and needs. Triangles, circles, and Xs represent regression coefficients from linear regression models and vertical lines spanning them represent their 95% confidence intervals. Triangles indicate coefficients from Need 2, circles from Need 4a-4h, and Xs from Need 6. When there are two coefficients from one model within one symptom this indicates that an interaction was present and the appropriate needs to which the coefficient refers is noted above the plotting symbol.

Figure 3b.

Results of Need 3, Need 5a-5e, and Need 6 for the association between functions and needs. Triangles, circles, and Xs represent regression coefficients from linear regression models and vertical lines spanning them represent their 95% confidence intervals. Triangles indicate coefficients from Function 3, circles from Need 5a-5e, and Xs from Need 6. When there are two coefficients from one model within one function this indicates that an interaction was present and the appropriate needs to which the coefficient refers is noted above the plotting symbol.

Table 1

Example Questions from EORTC QLQ-C30 and Supportive Care Needs Survey-Short Form

EORTC QLQ-C30	SUPPORTIVE CARE NEEDS SURVEY-SHORT FORM
<p>1. Do you have any trouble doing strenuous activities like carrying a heavy shopping bag or a suitcase? <i>(not at all, a little, quite a bit, very much)</i></p> <p>During the past week:</p> <p>9. Have you had pain? <i>(not at all, a little, quite a bit, very much)</i></p> <p>22. Did you worry? <i>(not at all, a little, quite a bit, very much)</i></p>	<p>In the last month, what was your level of need for help with:</p> <p>1. pain <i>(not applicable, satisfied, low need, moderate need, high need)</i></p> <p>6. anxiety <i>(not applicable, satisfied, low need, moderate need, high need)</i></p> <p>24. being given information (written, diagrams, drawings) about aspects of managing your illness and side effects at home <i>(not applicable, satisfied, low need, moderate need, high need)</i></p>
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Table 2

Summary of Multivariate Item Regression Models

MODEL	INDEPENDENT VARIABLES	PURPOSE
FUNCTION AS OUTCOME		
Function 1	patient characteristics	identifies patient characteristics (and interactions) significantly associated with function outcomes
Function 2 Base Symptom Model	8 symptoms (and their interactions) + patient characteristics from Function 1	represents the relationship between symptoms and functions, without including needs
Function 3 Base Need Model	5 needs (and their interactions) + patient characteristics from Function 1	represents the relationship between needs and functions, without including symptoms
Function 4a-4h	8 symptoms (and interactions) added individually to Function 3 (Base Need Model); 8 separate models	identifies which symptoms add significant information to describing functions beyond needs
Function 5a-5e	5 needs (and interactions) added individually to Function 2 (Base Symptom Model); 5 separate models	identifies which needs add significant information to describing functions beyond symptoms
Function 6	patient characteristics (Function 1) + significant symptoms from Function 4a-4h + significant needs from Function 5a-5e	identifies which symptoms and needs were most strongly related to the function outcomes when included together
NEED AS OUTCOME		
Need 1	patient characteristics	identifies patient characteristics (and interactions) significantly associated with need outcomes
Need 2 Base Symptom Model	8 symptoms (and their interactions) + patient characteristics from Need 1	represents the relationship between symptoms and needs, without including functions
Need 3 Base Function Model	5 functions (and their interactions) + patient characteristics from Need 1	represents the relationship between functions and needs, without including symptoms
Need 4a-4h	8 symptoms (and interactions) added individually to Need 3 (Base Function Model); 8 separate models	identifies which symptoms add significant information to describing needs beyond functions
Need 5a-5e	5 functions (and interactions) added individually to Need 2 (Base Symptom Model); 5 separate models	identifies which functions add significant information to describing needs beyond symptoms
Need 6	patient characteristics (Need 1) + significant symptoms from Need 4a-4h + significant functions from Need 5a-5e	identifies which symptoms and functions were most strongly related to the need outcomes when included together

Table 3

Patient Characteristics

CHARACTERISTIC	
Age (mean, sd)	61.23 (11.61)
Sex (% male)	51.3
Race (%)	
Black	19.0
White	76.7
Other	4.3
Hispanic (%)	4.5
Education (%)	
Less than high school graduate	8.7
High school graduate	11.3
Some college	15.7
College graduate	20.0
Any post-graduate work	44.4
Type of Cancer (%)	
Breast	43.1
Prostate	41.4
Lung	15.5
ECOG Performance Status (%)	
0	58.1
1	36.8
2	5.1
Extent of Disease (%)	
Early stage	35.3
Loco-regional	14.7
Metastatic	50.0
Current Treatment (%)	
Chemotherapy	28.2
Radiation therapy	4.3
Biologic therapy	16.2
Hormonal therapy	65.8
Therapy as part of a clinical trial	11.1
Other therapy	1.7
Previous Treatment (%)	
Surgery	70.9
Chemotherapy	37.6
Radiation therapy	41.9
Biologic therapy	6.8
Hormonal therapy	23.9
Therapy as part of a clinical trial	7.7

CHARACTERISTIC	
Other therapy	0.9