

# The Psychometric Properties of the Psoriasis Disability Index in United States Patients

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Although it has had only limited psychometric assessment in one country (the UK), the Psoriasis Disability Index (PDI) is a commonly used measure of the impact of psoriasis on patients. This study's objective was to analyze the psychometric properties of the PDI in 1196 US patients. High Cronbach's  $\alpha$  coefficients suggested that the PDI's internal consistency is good. The validity of the PDI was tested using a global question on disease burden and self-assessed extent of disease and both appeared to be good predictors of the PDI. Large floor effects and the suboptimal response distribution of most items, however, suggested that the PDI is insensitive to mild functional limitation. Factor analyses indicated that the current PDI subscales are suboptimal. In the Rasch analysis, the PDI and its subscales appeared to measure multiple constructs, making the validity of deriving a single overall score questionable. The frequent presence of differential item functioning related to several patient characteristics confirmed the instrument's multidimensionality. These findings suggest that the PDI is not an optimal measure for use in US study populations. The psychometric properties of instruments designed to measure the impact of psoriasis should be tested in populations in which the instrument is to be applied.

Key words: clinical trial/cross-cultural differences/health-related quality of life/patient-based outcome/Rasch model  
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Psoriasis is an incurable skin condition that affects about 2% of the population (Stern *et al*, 2004). Measures of clinical severity of psoriasis may not reflect patients' perceptions of the impact of the disease on their lives (De Korte *et al*, 2004; Sampogna *et al*, 2004). Health-Related Quality of Life (HRQOL) impairment is important in assessing psoriasis severity (Krueger *et al*, 2000). The impact of psoriasis on HRQOL may be comparable with that of other common chronic conditions (Finlay and Coles, 1995; Rapp *et al*, 2000).

The measurement of HRQOL provides valuable information about disease burden to various decision makers, including clinicians and researchers, third-party payers, technology assessment groups, and government regulatory bodies. These measures are also often utilized in psoriasis clinical trials providing the patients' perspective on the effectiveness of therapies. Although several instruments have been available to assess the impact of psoriasis (Naldi *et al*, 2003; De Korte *et al*, 2004), the psychometric properties of these instruments are not fully known (Ashcroft *et al*, 1998). Psychometrics is the science of measurement of abstract concepts or ideas such as intelligence, well-being or quality

of life (QOL) and its properties reflect different aspects of the instrument's performance in a study population (Streiner, 1994; Chren *et al*, 1999). Moreover, the utility of these measures and cross-cultural differences in patient populations with varying disease severity or demographic characteristics are generally unknown (Bullinger *et al*, 1993; Koo, 1996; Chren, 1999; Guyatt *et al*, 2002; Choi and Koo, 2003; Tennant *et al*, 2004a). Understanding the characteristics of tools used to measure patients' perceptions (Testa and Simonson, 1996; Chren, 1999) is important for interpreting studies accurately and applying them to clinical care and decision making (Williams, 2003; Chren and Weinstock, 2004).

The Psoriasis Disability Index (PDI) was one of the attempts to quantify the impact of psoriasis on patients' lives (Finlay and Kelly, 1987) and is the most commonly used disease-specific instrument for this purpose (De Korte *et al*, 2002; Naldi *et al*, 2003). Its psychometric properties have been partially tested in the UK using different patient populations and different versions of the instrument, (Finlay and Kelly, 1987; Finlay *et al*, 1990; Kent and Al-Abadie, 1993; Finlay and Coles, 1995; O'Neill and Kelly, 1996). With the exception of a factor analysis conducted on a reduced version of the PDI (Kent and Al-Abadie, 1993), assessments of its scaling structure in relation to internal consistency, factor analysis, Rasch analysis, and differential item functioning (DIF) have not been reported.

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Abbreviations: DIF, differential item functioning; HRQOL, Health-Related Quality of Life; PDI, Psoriasis Disability Index; QOL, quality of life

Although the PDI has been used in surveys and clinical trials in several countries (O'Neill and Kelly, 1996; Finlay, 1997; van de Kerkhof *et al*, 2000; Zachariae *et al*, 2002), including the US (Gelfand *et al*, 2005), the psychometric properties of this instrument in US patients are unknown (Choi and Koo, 2003). Such an assessment is crucial, as concepts, assessments, and relevance statements about constructs such as HRQOL may vary dramatically by culture or national context (Bullinger *et al*, 1993; Tennant *et al*, 2004a).

In response to this, this study examined the psychometric properties of the PDI, including its consistency, validity, and dimensional structure, using data from a recent survey of approximately 1200 US psoriasis patients.

## Results

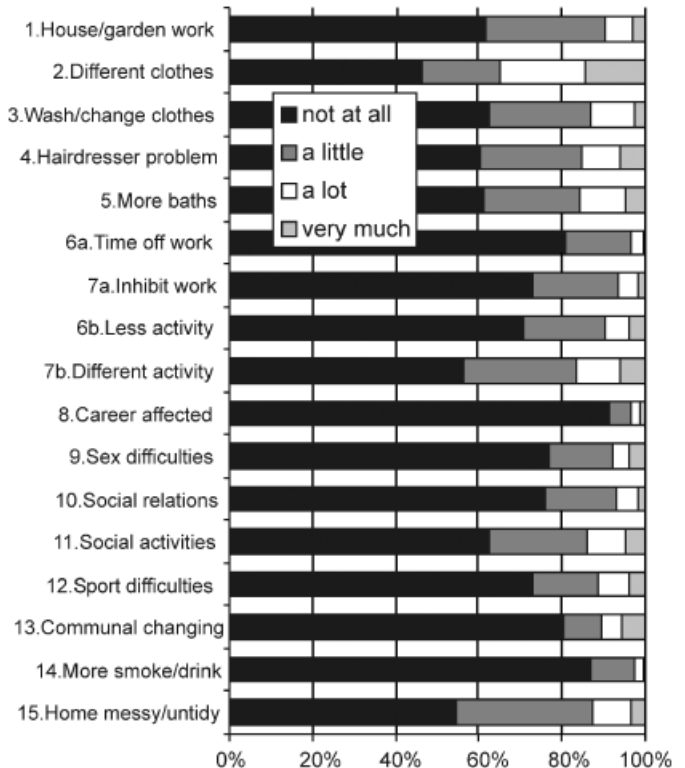
**Study participants** Of a total of 1861 respondents, 1196 (64.3%), who were 18 or older and reported having been diagnosed with cutaneous psoriasis without psoriatic arthritis by a physician, completed the PDI questionnaire. Of these, 19.4% were from the general population, 30.6% were members of the Psoriasis Foundation, and 50.1% were individuals who had contacted the Foundation but were not members. The three samples differed in age, annual income, extent, and global burden of disease (Nijsten *et al*, 2005a). Most study participants were middle-aged whites with longstanding psoriasis (Table S1). Almost half reported needing three palms or more to cover their psoriasis. Participants who were working (full- or part-time) were significantly ( $p < 0.001$ ) more likely to be older and male than those not working. Otherwise, patient characteristics did not differ substantially with employment status.

**Response distribution of PDI** The percentage of questionnaires with one or with more than one item missing were 10.5% and 2.5%, respectively. Items were answered by at least 96.5% of subjects.

Of the 1196 persons, 85.4% responded "not at all" to at least half (eight of 15) of the PDI items (Fig 1). Nine items demonstrated a suboptimal response distribution, with  $\geq 70\%$  of participants choosing the same response category (Fig 1). All PDI subscales had small ceiling effects ( $\leq 5\%$ ) but substantial floor effects ( $\geq 49\%$ ), except daily activities (Table I).

An analysis of mixtures demonstrated that the PDI's distribution was a mixture of five independent distributions (maximized log-likelihood =  $-1553.69$ ) (Table II). This resulted in five categories of disability: none (PDI score 0), little (PDI score 1–4), moderate (PDI score 5–9), large (PDI score 10–18), and very large (PDI score  $> 18$ ). The validity of this categorization, which includes the validity of the PDI, was confirmed by comparing the PDI categories (I–V) with degree of global disease burden in everyday life and extent of disease ( $p$ -values for trend  $< 0.01$ ).

**Validity of the PDI** Total PDI score increased significantly ( $p < 0.001$ ) with increasing problems in everyday life score (Fig 2). The correlation between the total PDI score and the global question was moderately high ( $r = 0.65$ ). In contrast with the global item, the range of the PDI and its subscales



**Figure 1** Distribution of response to each of the items of the Psoriasis Disability Index.

scores were not fully used (Table S2). For example, the 6.9% of the patients who scored 10 of 10 on the global item reported a median score on the total PDI of 19.0 (25th percentile = 9.0 and 75th percentile = 26.25) suggesting that the upper third range of the PDI score is not optimally used. The PDI was significantly ( $p < 0.001$ ) related to extent of disease (Fig 2) ( $r = 0.50$  for PDI score and extent of disease).

**Consistency of the PDI** The  $\alpha$  values and the item-rest score correlations suggest that the internal consistency of the PDI subscales was adequate (Table I). The correlation coefficients between items in a subscale and other subscales (range  $r$ : 0.21–0.56) were comparable with the item-rest coefficients (Table I) suggesting low discriminant validity; however, no PDI item correlated more strongly with another subscale than with its own subscale (data not shown). Of the 17 items, only three (items 4, 8, and 14) failed to demonstrate a correlation of 0.40 or above with any of the other items (Table S3). The correlation coefficients between the subscales ranged from 0.39 to 0.61.

**Dimensionality of the PDI** Both parallel analyses and minimum average partial tests identified two factors for working and one for nonworking respondents (Table III), which accounted for 45.3% and 41.6% of the total PDI variance, respectively. For working people, the first factor may reflect work-related disabilities and the second factor may reflect hygiene and embarrassment. One factor was retained that loaded 0.40 or more for all but items 4 and 14, which indicated item complexity, among those not working. For working people the, uniqueness of items 4, 8, and 14 was

Table 1. Distribution of scores of the Psoriasis Disability Index (PDI) and its subscales

PDI and its scales	No. of items (range of score)	Mean (SD, 25th, and 75th percentiles)	% floor	% ceiling	Item-rest correlation <sup>b</sup>	Cronbach's $\alpha$
PDI	15 (0–45)	7.3 (7.2, 2.0, 11.0)	14.7	0.0	—	—
Daily activities	5 (0–15)	3.5 (3.2, 1.0, 5.8)	20.5	0.2	0.35–0.59	0.78
Work	3 (0–9)	0.8 (1.5, 0.0, 1.0)	63.8	0.3	0.45–0.56	0.81
Personal	2 (0–6)	0.7 (1.2, 0.0, 1.0)	67.6	1.0	0.52–0.53	0.80
Leisure	4 (0–12)	1.9 (2.6, 0.0, 3.0)	49.3	0.2	0.33–0.56	0.77
Treatment	1 (0–3)	0.7 (0.8, 0.0, 1.0)	52.9	4.5	— <sup>a</sup>	— <sup>a</sup>

<sup>a</sup>Scale consists of one item.

<sup>b</sup>Correlation of an item with all other items within a subscale.

very high ( $\geq 0.70$ ) suggesting that these items' variances were not well captured by the retained factors.

The Rasch analysis of the total PDI scale yielded poor overall fit of the data to the model (item-trait interaction

$\chi^2 = 429.9$  (df = 153;  $p < 0.001$ )). Examination of individual item fit highlighted six items with a  $\chi^2$  statistic  $< 0.05$  and a standardized residual above 2.5 or less than  $-2.5$  (Table S4). An additional four items showed misfit according to one of these two criteria. Problems were particularly evident with the items of the daily activities and, to a lesser extent, the leisure subscales. When the daily activities, work, and leisure subscales were analyzed separately, misfit remained for many of the daily activities items, suggesting problems with the items themselves (within-subscale item fit in Table S5). Individual item misfit was also evident in the work and leisure subscales. These findings indicate violations of the assumption of unidimensionality for the individual subscales and the overall PDI.

DIF was examined in relation to sex, age, employment status, extent of disease, and level of disease burden (Table S5). Several items were found to exhibit some degree of DIF within each of the patient characteristics examined, with the exception of employment status. DIF was most evident in relation to age, with 11 of 17 items showing variations by this factor. Eight items were found to function differently by more than one factor. Items 4 and 15 were particularly problematic in this regard, with variations in responses at the same level of disability by four of the five patient characteristics.

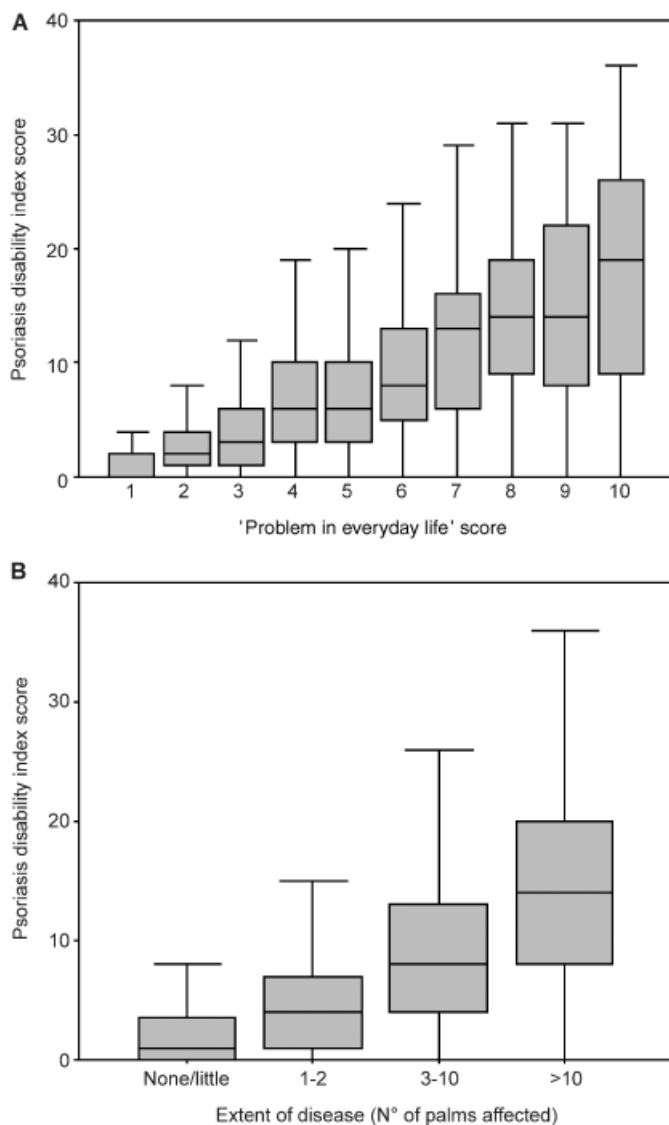


Figure 2  
Box plots of the Psoriasis Disability Index score stratified to (A) problem in everyday life score and (B) extent of disease.

## Discussion

**Response distribution** In contrast to a British study that observed substantially greater variance in the distribution of responses of items (Finlay and Coles, 1995), a broad sample of US psoriasis patients were likely to indicate that they were "not at all" affected by their psoriasis for most of the items. The large floor effect associated with many items suggests that the PDI provides limited information about how disability among US patients varies, particularly for those reporting low levels of disability because of their psoriasis. This discrepancy between British and US patients may reflect the heterogeneous and probably more generally representative nature of our sample, which was not limited to patients seen in a hospital setting or undergoing a specific therapy. But restricting the sample to the 156 individuals with 10 palms or more of psoriasis did not overcome the problem; floor effects remained high (25.0%–75.6%). These persistent floor effects suggest that other issues may

play a role in the distribution of item responses. Social anthropological studies have demonstrated that concepts, assessments, and relevance statements about constructs such as QOL may vary dramatically by culture or national context (Bullinger *et al*, 1993). The interpretation of scoring systems may also differ between cultures (Bullinger *et al*, 1993; Stern, 2003; Tennant *et al*, 2004a).

Although the PDI may be useful in evaluating therapies for moderate-to-severe psoriasis, our results suggest a relative lack of sensitivity, which implies that it is an inappropriate instrument to be used in clinical trials for those with limited disease (Wall *et al*, 1998; Gupta *et al*, 1999; Hutchinson *et al*, 2000; Andreassi *et al*, 2003; Woo *et al*, 2003). Both our respondents and those in a Scandinavian survey (Zachariae *et al*, 2002) with limited disease reported lower PDI scores with high floor effects (data not shown) suggesting it is also an insensitive measurement tool in general population surveys (O'Neill and Kelly, 1996; van de Kerkhof *et al*, 2000; Zachariae *et al*, 2002; Gelfand *et al*, 2005). This study demonstrated that the PDI should be used cautiously in international collaborations (Tennant *et al*, 2004a) and modifications are needed to improve its sensitivity for US studies.

**Validity and consistency of PDI** There is no gold standard for HRQOL measurements. Therefore, assessing their validity is a multifaceted, iterative process (Guyatt *et al*, 1992; Chren, 1999). Although clinically assessed disease severity may not always correlate well with the degree of HRQOL impairment (De Korte *et al*, 2004; Sampogna *et al*, 2004), this study confirmed previous findings that the PDI appears to be able to discriminate between individuals with different severities of disease in British (Finlay and Kelly, 1987; Finlay *et al*, 1990; Finlay and Coles, 1995) and US (Gelfand *et al*, 2005) samples. Furthermore, comparison with a global score of disease burden supported the PDI's validity. In contrast to the global question, the higher half to a third of the range of the PDI and its subscales is unused, which confirms its poor sensitivity and discriminant ability.

**Dimensionality of the PDI** The PDI items were originally grouped into five subscales on a "common-sense" basis and may have some degree of face validity (Finlay *et al*, 1990); however, this structure could not be confirmed by factor analysis (Kent and Al-Abadie, 1993) and may reflect the limited number of items in some of the PDI subscales. Nevertheless, the lack of fit to the Rasch model indicates that the PDI is not unidimensional. Multidimensionality of a psychometric tool compromises its additivity and thus the validity of creating an overall score (Tesio, 2003; Conrad and Smith, 2004; Tennant *et al*, 2004b). Moreover, the presence of DIF, indicates that persons with the same degree of psoriasis-related disability but who differ with respect to different gender or age are not likely to score in a similar way on these items. This implies that the PDI is not intrinsically generalizable in heterogenous populations, which suggest that comparison of the PDI scores of these different patient groups may not be appropriate. Although self-assessed global disease burden and extent of disease were associated with PDI scores, the lack of unidimensionality raises questions about the validity of the measure (Tesio, 2003; Conrad and Smith, 2004; Tennant *et al*, 2004b). Attempting

**Table II. Analysis of mixtures of the Psoriasis Disability Index score and its categorization**

Category of disability	Weight	Mean	Range	% of patients (n = 1196)
I. None	0.17	0.26	0	14.7
II. Little	0.29	2.95	1–4	31.4
III. Moderate	0.26	6.48	5–9	23.8
IV. Large	0.20	12.58	10–18	21.0
V. Very large	0.09	23.71	19–45	9.1

to identify a valid dimensional structure for the PDI is, however, beyond the scope of this study.

**HRQOL instruments in clinical trials** In psoriasis trials, instruments commonly used to assess patients' perspectives of the efficacy of therapy include the PDI, Short Form-36, and the Dermatology Life Quality Index (Naldi *et al*, 2003; De Korte *et al*, 2004). At present, the lack of a well-tested and widely accepted psoriasis-specific HRQOL instrument has led to the use of multiple health status endpoints to assess patients' perception of the effectiveness of a therapy in a single study (Gordon *et al*, 2003). Although generic or dermatology-specific HRQOL instruments may be useful in assessing the impact of psoriasis on patients' lives, adding a psoriasis-specific HRQOL instrument is preferred because it should be more clinically sensitive, provide a higher correlation with disease severity and be more responsive to changes in effect of the disease over time (Patrick and Deyo, 1989; Chren, 1999; Choi and Koo, 2003; De Korte *et al*, 2004). Although the PDI appears to be reasonably valid and reliable in the assessment of psoriasis-associated disabilities in patients with moderate-to-severe disease, its psychometric properties appear to be suboptimal. Moreover, the PDI falls short of providing an overall assessment of the impact of the condition and its treatment on the patient (Finlay and Kelly, 1987; Koo, 1996; De Korte *et al*, 2002; McKenna *et al*, 2003). High-quality, disease-specific, patient-based outcome measures are needed for robust assessments of psoriasis therapies. These instruments should be validated across cultures and for a broad range of psoriasis severities. Because of the impact of intercultural differences (Bullinger *et al*, 1993; Tennant *et al*, 2004a), the development of an optimal HRQOL instrument may be even more challenging than choosing a measure of clinical disease severity. New psoriasis-specific measures such as the Psoriasis Index of Quality of Life (PSORIQL; McKenna *et al*, 2003) and the Psoriasis Quality of Life Questionnaire (Choi and Koo, 2003) have been developed, but they have not yet been widely tested across cultures or in diverse patient populations.

**Strengths and limitations** A strength of this study is its large, heterogenous sample including patients with varying disease severity. Although the results of this study may not be fully representative of the general population, subanalyses of the three patient groups suggested that the PDI is likely to do worse in patients from the general population (data not shown). This is an attempt to test fully the psy-

Table III. Factor analyses of Psoriasis Disability Index<sup>a,b</sup>

Scales	Items	Persons who were working (n = 985)			Persons who were not working (n = 211)	
		Factor I (eigenvalue = 5.46)	Factor II (eigenvalue = 1.33)	Uniqueness <sup>c</sup>	Factor I (eigenvalue = 6.24)	Uniqueness <sup>c</sup>
Daily activities	1. House/garden work	<b>0.56</b>	0.25	0.60	<b>0.62</b>	0.42
	2. Different clothes	0.17	<b>0.56</b>	0.59	<b>0.53</b>	0.62
	3. Wash/change clothes	0.33	<b>0.53</b>	0.50	<b>0.65</b>	0.44
	4. Hairdresser problem	0.11	<b>0.47</b>	0.73	0.35	0.65
	5. More baths	0.26	<b>0.48</b>	0.63	<b>0.64</b>	0.44
Work	6a. Time off work	<b>0.70</b>	0.12	0.49	—	—
	7a. Inhibit work	<b>0.77</b>	0.23	0.35	—	—
	6b. Less activity	—	—	—	<b>0.77</b>	0.29
	7b. Different activity	—	—	—	<b>0.79</b>	0.28
	8. Career affected	0.21	0.27	0.76	<b>0.52</b>	0.60
Personal relations	9. Sex difficulties	0.24	<b>0.59</b>	0.55	<b>0.63</b>	0.43
	10. Social relations	0.38	<b>0.58</b>	0.53	<b>0.63</b>	0.44
	11. Social activities	0.45 <sup>d</sup>	<b>0.62</b>	0.43	<b>0.80</b>	0.30
	12. Sport difficult	0.21	<b>0.51</b>	0.45	<b>0.69</b>	0.35
Leisure	13. Communal changing	0.21	<b>0.51</b>	0.61	<b>0.58</b>	0.47
	14. More smoke/drink	0.21	0.37	0.78	0.32	0.78
Treatment	15. Home messy/untidy	0.30	<b>0.51</b>	0.64	<b>0.57</b>	0.52

<sup>a</sup>Principal axis method followed by oblique rotation (promax) of factors that were selected using parallel analysis and minimum average partial tests.

<sup>b</sup>In bold, the items that are best represented (factor loading > 0.40) by each factor.

<sup>c</sup>For each item, uniqueness represents the proportion of variance that is not explained by the retained factors.

<sup>d</sup>Although a factor loading greater than 0.40, it is not in bold because the loading is higher for the second factor.

chometric properties of the PDI, including internal consistency, factor analysis, and Rasch modelling and DIF in a heterogenous sample of US patients. Previous studies have tested its validity (Finlay and Kelly, 1987; Finlay *et al*, 1990; Finlay and Coles, 1995) and determined its underlying structure (Kent and Al-Abadie, 1993) in UK patient populations.

As a convenience sample, this study is subject to possible biases and other limitations including diagnostic bias and imprecision in the assessment of extent of disease and global burden (Stern *et al*, 2004; Nijsten *et al*, 2005a,b; Gelfand *et al*, 2005). To enhance diagnosis accuracy and to reduce confounding because of disability from arthritis (Kay *et al*, 2003), the analysis was restricted to individuals reporting only cutaneous disease. Because the PDI was administered once to the participants, we were unable to determine test-retest reliability, instrument's responsiveness, or its minimal important difference.

## Conclusion

The PDI was one of the disease-specific HRQOL instruments to be developed in dermatology and has contributed greatly to our understanding of the patient's perspective of psoriasis. Nevertheless, this study suggests that it is not well targeted to measuring disease impact among patients with low levels of disability. Also, the unidimensionality and the generalizability of the total scale and the underlying

structure of the subscales could not be confirmed. The psychometric properties of instruments designed to assess the overall impact of a disease and its treatments on patients' lives should be thoroughly tested in populations that vary culturally, demographically, and in disease severity before they are recognized as valid HRQOL assessment tools.

## Methods

**Design and participants** The survey design, setting, and study participants are described in detail elsewhere (Stern *et al*, 2004; Gelfand *et al*, 2005; Nijsten *et al*, 2005a,b). Briefly, in 2001, the National Psoriasis Foundation commissioned two survey research companies to interview patients with psoriasis. The subjects included came from two random samples: one drawn from the general population using random digit dialing, one drawn from the database of the National Psoriasis Foundation that registered members and people who had contacted the Foundation but did not join it. The study sample is a convenience sample. Eligibility required that interviewees reported having been diagnosed with psoriasis by a physician. Individuals were contacted independently of extent of disease, type of psoriasis, level of disability, use of therapies, or treating physician. This analysis was restricted to respondents who were aged 18 or older with psoriasis without psoriatic arthritis.

To estimate functional lifestyle disabilities caused by psoriasis, the second version of the PDI (Finlay and Coles, 1995) was used. The PDI uses a categorical rating scale, with responses of "not at all," "a little," "a lot," and "very much" scored 0, 1, 2, and 3, respectively. In line with the instrument guidelines, missing items

Table IV. Definitions of some of the test characteristics and statistical methods used in this study<sup>a</sup>

Statistical methods and test characteristics	Definition <sup>a</sup>
Differential item functioning (DIF)	This test assesses the impact of patient characteristics (also referred to as personal factors) such as gender and age on individual items of the measurement tool. For example, do patients with the same degree of disability respond differently to an item because they differ by gender or age? If the p-value of the analysis of variance of standardized residuals across a factor was less than 0.05, an item was defined as having significant DIF, which suggests that an item lacks generalizability in populations that span different patient groups
Exploratory factor analysis	This statistical approach is used to test whether the proposed subscale of an existing instrument is appropriate. The number of factors derived from the analysis reflects the number of different constructs being measured by the instrument. The cluster of items that load on the same factor forms a subscale. An item belongs to a factor (i.e., subscale) if its loading is greater than 0.40 (see also item complexity)
"Floor-and-ceiling" effect	If more than 20% of the patients reported lowest or highest possible score of an instrument's (sub)scale, respectively, the (sub)scale is likely to be insensitive
Item complexity	If an item "loads heavily on" (i.e., is strongly correlated with) a factor (i.e., a subscale) in an exploratory factor analysis (see above) it should belong to that factor and not to any other. If it loads on none or two or more factors then it is likely that it may be tapping something other than what the developer intended. Suboptimal complexity was said to exist if the highest loading of an item was less than 0.40 or if the difference between the loadings on different factors was less than 0.10
Internal consistency	Assesses the degree of correlation of a patient's responses to items enquiring about similar constructs. For each subscale (i.e., a construct), Cronbach's $\alpha$ , which is based on average inter-item correlation and number of items, was calculated. If the $\alpha$ was less than 0.70, the internal consistency was considered suboptimal for each subscale's items
Item-rest correlation	Spearman's correlation coefficients ( $r$ ) of each item with the sum of the other items in that subscale were calculated to check the homogeneity of the (sub)scales. <sup>b</sup> Suboptimal item-rest correlation was defined as $r < 0.20$ .
Item-discriminant validity	We compared the item-rest correlation coefficients with the correlation coefficients of an item with the other subscales. If the former equalled or was smaller than the latter, an item was defined as having poor discriminant validity
Item-trait interaction	An overall summary fit statistic, which is a formal test of invariance to the scale. It evaluates whether or not the data fit the Rasch model for the discrete groups (class intervals) along the scale. If the $\chi^2$ p-value is $> 0.05$ , it suggests that the data fit the Rasch model
Mixture analysis	This statistical method is used to determine whether multiple, distinct subdistributions are present in the overall distribution of the scores of all the individuals. Subsequently, it can be used to categorize each observation in one of the distinct subdistributions and thus creates categories
Parallel analysis and minimum average partial test	Statistical methods used in factor analysis to determine which limited number of factors should be retained to contain the maximum amount of information
The Rasch model	The Rasch model is a unidimensional model that has two main assertions: that the milder the health problem is, the more likely it will be affirmed, and the more impaired the patient, the more likely they will be to affirm a health problem compared with a less impaired patient. Where data fit the Rasch model unidimensionality is confirmed and order, additivity and specific objectivity (i.e., sample-free measurement) result
Item fit of the Rasch model	Two statistical approaches are used to test whether the individual items fit the Rasch model:  Residual A function of the difference between respondents' observed item responses and the ones predicted by the model, expressed in "logits" (log-odds units). If located between $-2.5$ and $+2.5$ , it suggests that an item fits the Rasch model  p-value A goodness-of-fit $\chi^2$ statistic that assesses the discrepancy between the expected and actual response pattern across respondents. $p > 0.05$ suggests that an item fits the Rasch model
Response distribution	An item was described as having a poor distribution if more than 70% of patients chose the same response, indicating that the item is not sensitive

<sup>a</sup>For references, see Methods section.<sup>b</sup>Based on the factor analysis.

were scored "0." The higher the summed score (range: 0–45), the greater the limitations experienced because of psoriasis. In addition to the total score, the PDI has five subscales: daily activities, work, personal relations, leisure, and treatment. All items were identical for all respondents except that out of a possible five work items, respondents completed only 3; those who were working (either full- or part-time) responded to items 6a, 7a, and 8, whereas those who were not working responded to items 6b, 7b, and 8.

Participants were also asked to rate psoriasis as a "problem in everyday life" using a 10-point Likert scale (1 = no problem to 10 = a very large problem) (Likert, 1932). Although not shown, a mixture model (Haughton, 1997; Boehning and Schlattmann, 2004) was used to group responses as follows: 1–4 = "little burden" and 5–10 = "substantial burden." In addition to questions about demographic and disease characteristics, respondents were asked to estimate the number of palms needed to cover all their psoriasis at the time of the interview (little or none, 1–2, 3–10 or > 10 palms).

The survey was granted exempt status by an independent IRB.

### Statistical methods

**Response distribution** For each item, the response distribution (Streiner, 1994; Chren *et al*, 1997) and for each subscale, the "floor" and "ceiling" effects were assessed (Anderson *et al*, 1997) (Table IV). To categorize the PDI score, a mixture analysis was used (Table IV) (Haughton, 1997; Boehning and Schlattmann, 2004). First, we estimated the weights, which reflect the proportion of the total variance of a scale, for the maximum number of grid points assuming Poisson distributions. In this case, we entered the minimum and maximum PDI scores to calculate the number of grid points which are used as a first estimate for the support points. All grid points with positive weight together with the corresponding weights were used as starting values for the expectation–maximization algorithm. So, in this phase, weights as well as support points, which are parameters of the distinct subdistributions, were estimated. Then a much smaller number of weights and support points were computed with a nonparametric maximum likelihood estimator. Because some support points were extremely close to each other, we combined identical parameters with an accuracy of 0.01. This procedure resulted in a number of support points and weights that were then entered into a *fixed* mixture analysis to classify each observation in one of the different mixture components using posterior probabilities.

**Consistency of the PDI** For each subscale, several item performance features such as Cronbach's  $\alpha$  (Cronbach, 1951), item–rest correlations (Chren *et al*, 1997), and item–discriminant validity were determined (Haley *et al*, 2004) (Table IV).

**Validity of the PDI** *Construct validity*, which hypothesizes logical relations that should exist between patients' characteristics and their responses to an instrument, was assessed through convergent validity and known groups validity (Streiner, 1994; Chren *et al*, 1999). *Convergent validity* was established by assessing the degree to which PDI scores were associated with the global "problem in everyday life" item. Spearman's correlation coefficient was used to assess the correlation between the global item and the total PDI and its subscales. *Known groups validity* assessed the ability of the PDI to distinguish between groups that differed according to the extent of their disease (none or little, 1–2, 3–10, and > 10 palms), which we expected would be correlated with PDI scores. The Kruskal–Wallis test was used to test for statistical differences between the groups.

**Dimensionality of the PDI** To identify constructs accounting for variability in responses to the items of the PDI, an *exploratory factor analysis* (Table IV) was conducted for persons who were working and for those who were not working, separately (Gorusch, 1974). The principal axis method was used for the initial extraction of factors. We hypothesized that the subscales were correlated and, therefore, performed an oblique rotation (promax). Rotation

modifies the result of the initial factor analysis to create a set of loadings that are often more interpretable than those produced by the factor analysis. We used parallel analyses and minimum average partial tests (Zwick and Velicer, 1986; O'Connor, 2000) to limit the number of factors (Table IV).

*Rasch analysis* also examined the subscale structure of the PDI because data fit to the model suggests unidimensionality (Table IV) (Rasch, 1960; Tesio, 2003; Conrad and Smith, 2004; Tennant *et al*, 2004b). The overall fit of the data was assessed estimating the item–trait interaction and the individual item fit by calculating a  $\chi^2$  statistic and a standardized residual (Table IV). Such analyses were conducted for the total PDI scale and its subscales, except for the personal relations and treatment subscales which have too few items. In addition, *differential item functioning* (Table IV) (Angoff, 1993; Tesio, 2003; Tennant *et al*, 2004b), which may also be a potential source of violation of unidimensionality, was evaluated in relation to various factors including: sex, age, employment status, extent of disease, and disease burden.

All statistical tests were two sided. Significance was assessed at an  $\alpha$  level < 0.05. Stata version 7.0 (Stata, College Station, Texas) was used to estimate Cronbach's  $\alpha$ , the correlation coefficients and the principal axis analyses. SPSS version 10.0 for Windows (SPSS, Chicago, Illinois) was used to determine the number of retained components (O'Connor, 2000). Assessments of unidimensionality and DIF through the Rasch analysis were performed using RUMM2010 (RUMM Laboratory, Perth, Australia). To categorize the PDI, computer-assisted analysis of mixtures 2.0 (Haughton, 1997; Boehning and Schlattmann, 2004) was used.

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### Supplementary Material

The following material is available online for this article

**Table S1**  
**Table S2**  
**Table S3**  
**Table S4**  
**Table S5**

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