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Somatic symptom reports in the general population: Application of a bi-factor model to the analysis of change

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ABSTRACT

Objective: To investigate the latent structure of somatic symptom reports in the general population with a bi-factor model and apply the structure to the analysis of change in reported symptoms after the emergence of an uncertain environmental health risk.

Methods: Somatic symptoms were assessed in two general population environmental health cohorts (AMIGO, n = 14,829 & POWER, n = 951) using the somatization scale of the four-dimensional symptom questionnaire (4DSQ-S). Exploratory bi-factor analysis was used to determine the factor structure in the AMIGO cohort. Multi-group and longitudinal models were applied to assess measurement invariance. For a subsample of residents living close to a newly introduced power line (n = 224), we compared a uni- and multidimensional method for the analysis of change in reported symptoms after the power line was put into operation.

Results: We found a good fit (RMSEA = 0.03, CFI = 0.98) for a bi-factor model with one general and three symptom specific factors (musculoskeletal, gastrointestinal, cardiopulmonary). The latent structure was found to be invariant between cohorts and over time. A significant increase ($p < .05$) was found only for musculoskeletal and gastrointestinal symptoms after the power line was put into operation.

Conclusions: In our study we found that a bi-factor structure of somatic symptoms reports was equivalent between cohorts and over time. Our findings suggest that taking this structure into account can lead to a more informative interpretation of a change in symptom reports compared to a unidimensional approach.

Introduction

The experience of non-specific somatic symptoms such as headaches or back pain has negative effects on daily functioning in a considerable proportion of the general population, and is a major cause of health care utilization [1–3]. These experiences are typically assessed with self-report questionnaires [4] and are frequently used in varying research disciplines such as psychosomatic medicine [e.g. 5] or environmental health [e.g. 6,7]. In most studies the total symptom score is analyzed and/or the individual symptoms separately. Neither approach reflects the multifactorial origin of reporting somatic symptoms [8,9].

Self-report symptom questionnaires such as the PHQ-15 [10] or the SCL-90 SOM [11] were designed to measure the experience of distressing somatic symptoms. A high score (clinical cut-off scores are generally provided) is interpreted as an indication of somatization. Although these questionnaires were designed to measure one underlying construct (i.e. somatization), there is evidence for the latent structure to be multi- rather than unidimensional [12–15]. This is due to the existence of specific symptom patterns, such as symptoms pertaining to musculoskeletal or gastrointestinal complaints. A wide range of influences can lead to higher scores on symptoms from a specific symptom group (e.g. infections, diseases, and psychosocial distress) while scores on other domains are less affected. It is therefore plausible that additional variance in reported symptoms is explained by symptom specific factors. The bi-factor model separates the general variance of scores on all symptoms (i.e. general factor, representing a general tendency to report symptoms), from the unique variance of scores relating to specific

Abbreviations: 4DSQ, Four-dimensional symptom questionnaire; 4DSQ-S, Somatization scale of the 4DSQ; RMSEA, Root mean square error of approximation; CFI, Comparative fit index; MI, Measurement invariance; WLSMV, Weighted least squares means and variance adjusted.

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symptom groups (i.e. specific factors). This model allows studying both components of somatic symptom reporting simultaneously.

So far, only a few studies [16–18] have applied a bi-factor model to data gathered with symptom questionnaires. These studies showed that specific factors explain unique variance over and above the common variance in symptom reporting explained by a general factor. In addition the bi-factor model has been shown to provide a better fit than alternative factor models. However, the evidence gathered so far is limited and mainly based on two cross-sectional clinical samples using two different symptom questionnaires. There may be differences in the underlying structure between populations and symptom questionnaires which could impact application to health effect studies.

In order to compare symptom scores on underlying constructs between different populations and over time, measurement invariance (MI) must be established [19]. MI refers to the underlying factor structure being equivalent across samples and over time. Changes in the underlying factor structure complicate the interpretation of differences in symptom scores. When the structure is not invariant a score difference could reflect a change in the score on the underlying latent construct, or reflect a change in the construct itself. If MI can be established, there may be useful practical applications of the bi-factor model to intervention studies using somatic symptom reports as an outcome. One could assess the effect of an intervention or exposure on general symptom reporting (i.e. over and above reporting symptoms from specific symptom groups), as well as on symptom specific factors (i.e. over and above general symptom reporting). A potential benefit of a bi-factor model is the greater conceptual clarity provided by a separation between general and specific variance [20].

The aim of the present study is threefold. First, we aim to test the structural validity of a bi-factor model for the somatization scale of the 4DSQ [4DSQ–S, 21] in a large general population sample. Structural validity of this subscale has not been investigated before. Second, we assess MI of the resulting latent structure by comparing the structure between two different general population samples, as well as across time in one sample. Third and last, we apply a bi-factor structure to analyze change in symptom reports after the emergence of an uncertain environmental health risk. In previous work we found a larger increase in overall reported somatic symptoms after a new power line was put into operation for residents living close by, compared to a control group of residents living farther away [22]. We extend those findings by evaluating the change in reported somatic symptoms in line with the underlying latent structure of the 4DSQ-S.

Methods

Participants

Participants were members of the adult general population in the Netherlands enrolled in two different cohorts. The first cohort (AMIGO) was set up to study environmental and occupational determinants of diseases and symptoms [see 23 for a full description]. The AMIGO cohort at baseline consisted of 14,829 subjects of which 50.2% men. The mean age of the AMIGO participants was 51 years (SD = 9). The second cohort (POWER) was set up to study health responses to the introduction of a new high-voltage power line [see 24 for a full description]. At baseline the POWER cohort consisted of 951 subjects of which 46% men. Mean age of the participants was 52 years (SD = 13). The longitudinal models to assess measurement invariance were based on a total of 1241 subjects. This number is higher than the number of participants at baseline, because new subjects were enrolled at T2 [22]. For the analysis of change we focused on the group of residents within 300 m of the new high voltage power line (n = 224), as we established in previous work that only this group experienced more symptoms after the line was put into operation [22]. The overall response rate to the baseline questionnaires was similar in both cohorts (AMIGO: 16%, POWER: 19%).

Procedures

In both cohorts invitations were sent through postal mail. Both studies were presented to participants as longitudinal environmental health studies, which consisted of filling out questionnaires by one adult per household about health and the environment. To reduce the chance of response bias, there was no mentioning of power lines in the POWER cohort invitation letter.

The AMIGO cohort subjects (31–65 years old) were recruited using a national information network of general practitioners established at the Netherlands Institute for Health Services Research (NIVEL), called NIVEL Primary Care Database. Participants were invited between April 2011 and July 2012. For the POWER cohort one member older than 18 of each household within 500 m of the planned construction of a new power line (n = 2379) was invited to participate, as well as a random stratified sample of households within 500–2000 m (n = 2382). Data was collected before the power line was put into operation, starting in June 2012 (T1), 5 months later (T2), and after the power line was put into operation, 12 months (T3) and 18 months (T4) after the baseline measurement (T1). The study protocols of both studies were approved by the Medical Ethics Committee of the research boards of the involved institutes, and all participants participated voluntarily with informed consent.

Measures

Somatic symptoms

In both cohorts the somatization scale of the 4DSQ [21] was used to measure self-reported somatic symptoms. The 4DSQ consists of 4 scales measuring distress, depression, anxiety and somatization, but only the somatization scale was administered in our study samples. The somatization scale (4DSQ-S) consists of 16 non-specific somatic symptoms (e.g. headaches, low back pain, and dizziness) commonly reported in general practices (see Fig. 1 for a list of all symptoms). For each symptom, participants indicated whether they were bothered by it during the previous week on a 5-point scale (ranging from no, through to constantly). The scores were trichotomized before analysis (no = 0; sometimes = 1, regularly/often/constantly = 2) [21].

Statistical analyses

To answer the first research question regarding the underlying latent structure of the 4DSQ-S we conducted a categorical exploratory bi-factor analysis on the AMIGO baseline data with Bi-Geomin rotation [25] and WLSMV estimation. Two (1 general, 1 specific factor) up to six (1 general, 5 specific factors) factor solutions were considered and one bi-factor specification was selected for a confirmatory analysis, based on the theoretical interpretation of the models as well as the statistical fit. We assigned items to a factor only if the factor loading for that item on that factor was greater than 0.30. The variances of the common factors were identified by fixing the loading of the first item to one. Root mean square error of approximation (RMSEA) and comparative fit index (CFI) were used to assess model fit. For RMSEA, models with values ≤0.06 had acceptable fit and for CFI values ≥0.95 had acceptable fit [26].

To answer the second research question regarding MI of the 4DSQ-S we fitted a multi-group model where we increasingly constrained more parameters to be equal across the baseline AMIGO and POWER cohort samples to assess invariance [19,27]. The following models were tested consecutively: configural invariance (factor loadings freely estimated and thresholds constrained), loading invariance (factor loadings and thresholds constrained), and residual invariance (factor loadings, thresholds and residual variance constrained). We compared the models using the criteria suggested by Chen et al. [28] to establish MI: a decrease in CFI of ≥0.01, and an increase in RMSEA of ≥0.015 were