

Assessing reserve-building pursuits and person characteristics: psychometric validation of the Reserve-Building Measure

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Abstract

Aims A growing body of research suggests that regularly engaging in stimulating activities across multiple domains—physical, cultural, intellectual, communal, and spiritual—builds resilience. This project investigated the psychometric characteristics of the DeltaQuest Reserve-Building Measure for use in prospective research.

Methods The study included Rare Patient Voice panel participants. The web-based survey included the Reserve-Building Measure with one-week re-test, measures of quality of life (QOL) and well-being (PROMIS General Health; NeuroQOL Cognitive Function and Positive Affect & Well-Being short-forms; Ryff Environmental Mastery subscale); and the Big Five Inventory-10 personality measure. Classical test theory and item response theory (IRT) analyses investigated psychometric characteristics of the Reserve-Building Measure.

Results This North American sample ($n = 592$) included both patients and caregivers [mean age = 44, SD 19)]. Psychometric analyses revealed distinct subscales

measuring current reserve-building activities (Active in the World, Games, Outdoors, Creative, Religious/Spiritual, Exercise, Inner Life, Shopping/Cooking, Passive Media Consumption,), past reserve-building activities (Childhood Activities, Achievement), and reserve-related person-factors (Perseverance, Current and Past Social Support, and Work Value). Test–retest stability ($n = 101$) was moderately high for 11 of 15 subscales (ICC range 0.78–0.99); four were below 0.59 indicating a need for further refinement. IRT analyses supported the item functioning of all subscales. Correlational analyses suggest the measure’s subscales tap distinct constructs (range $r = 0.11$ –0.46) which are not redundant with QOL, well-being, or personality (range $r = 0.11$ –0.48).

Conclusions The Reserve-Building Measure provides a measure of activities and person-factors related to reserve that may potentially be useful in prospective research.

Keywords Reserve · Measurement · Psychometrics · Activities · Person characteristics · Personality · Quality of life · Well-being

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Introduction

Characterizing how individuals can promote resilience to health challenges has been a long-standing focus of behavioral science [1, 2]. While each discipline focuses on different aspects of resilience, recent work by scientists across disciplines has focused on the unifying concept of reserve [3]. Reserve refers to a compensatory or protective capacity that limits the impact of assaults to the brain from disease or injury [4]. If an individual is functioning above and beyond what would be expected given the level of

impairment, then one infers that reserve is underlying this resilience.

Reserve theory posits that although inborn and environmental factors and disease burden influence expected performance, individuals can engage in activities and build character traits that buffer them from disability (Fig. 1). Reserve-building activities span one's lifetime, from childhood throughout adulthood, comprising physical, cultural, intellectual, communal, and spiritual pursuits [5]. Further, reserve-related person-characteristics refer to attitudes, values, and socio-emotional skills that emphasize perseverance, engagement, and social support [4]. Reserve is conceptualized as an epiphenomenon that is inferred when an individual's observed level of performance exceeds what would be expected based on presumed inborn and environmental factors, disease duration and severity. Direct measurement of reserve-building activities and person factors is thus needed to infer reserve.

Measurement of reserve has often focused on surrogate measures that are limited in scope, such as only educational attainment [6–8], intelligence [9], or a broad mix of stimulating leisure pursuits [10–12]. Research based on such measures has been suggestive that being more educated, having a larger brain, and/or having engaged in stimulating early-life leisure pursuits is associated with lower-than-

expected cognitive impairment [12–15]. While this body of research has been promising, it is limited by sampling relatively simplistic indicators that are ambiguous and do not have clear implications. For example, having a higher level of education may reflect being more book-smart, or having more opportunity or resources (i.e., socioeconomic status (SES)). Early-life or premorbid leisure pursuits may reflect past stimulating pursuits, but are confounded as well by early life SES.

To truly capture how an individual's modifiable behaviors can buffer against disease progression, a measure should assess those aspects of reserve-building that span a lifetime, thus including past and current activities. Moreover, given the finite amount of discretionary (i.e., leisure) time available to individuals, a measure should capture activities that are stimulating across a wide variety of domains (e.g., intellectual, physical, spiritual and creative), are passive (e.g., television) or active (e.g., games, working with their hands), and externally- or internally-focused (e.g., social club versus writing or meditating). To advance the understanding of reserve, it would be worthwhile to expand the timeframe and range of activities assessed.

Further, capturing person-level characteristics would be critical toward understanding what amplifies or attenuates the impact of reserve-building activities. For example, a

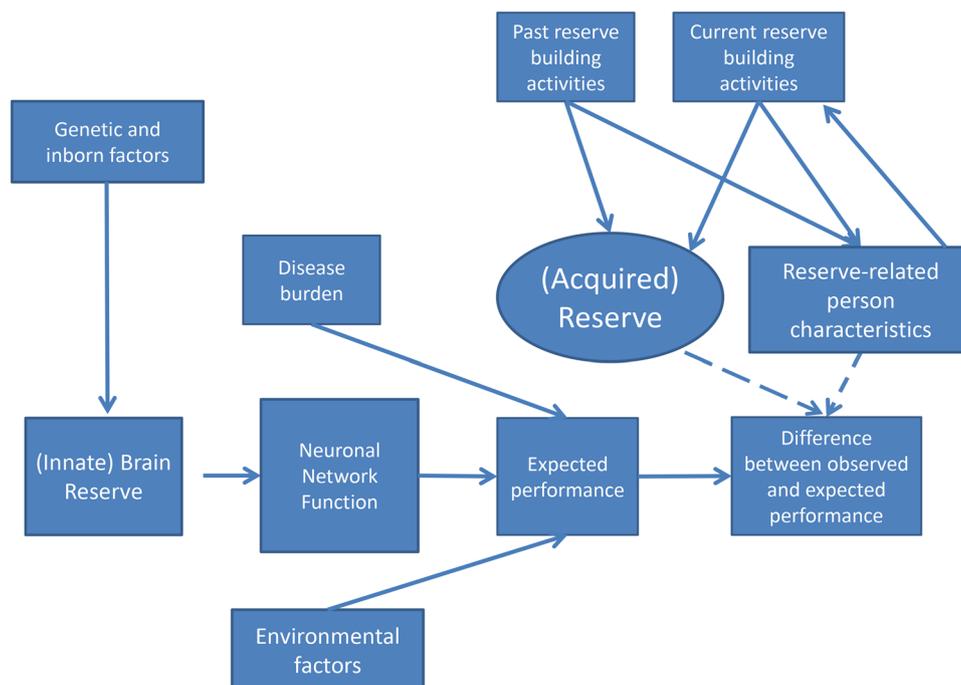


Fig. 1 Schwartz et al. [4] Reserve Model [4]. This model provides a roadmap for the nomenclature and expected relationships among reserve-related constructs at a specific point in time. The Reserve-Building Measure aims to provide a reliable and valid measure of key constructs influencing an individual's *reserve*. *Past- and current reserve-building activities* are hypothesized to include a

multidimensional array of activities that promote brain health, including cultural/intellectual pursuits, physical activity, social/community participation, spiritual/religious practices, and dietary/lifestyle habits. Reserve-related person characteristics refer to attitudes, values, or socio-emotional skills that are posited to enhance an individual's resilience in the face of adversity and/or disease

character trait such as perseverance may differentiate those who are able to figure out effective strategies for dealing with disease-related limitations, compared to those who surrender to them. Similarly, having better social skills [16] may enable navigating complex interpersonal situations that allow one to maintain a marriage and employment, or fundamentally to find social support as needed.

The present work sought to respond to these diverse needs in reserve research by developing and validating a measure of reserve-related activities and person factors. The new measure samples a broader set of past and current leisure domains, including those thought to enhance resilience as well as those thought to have no benefit. It also assesses relevant person factors, including perseverance, work value, and social support resources.

Methods

Initial measurement development

This measure was developed iteratively over seven years (2010–2017) and included several patient samples to hone response options and item content. The first iteration of the measure was implemented by using existing measures of “cognitive reserve” from Stern [3] and Sole-Padullés [17], and Godin’s leisure-time exercise questionnaire [18], with each author’s permission. This first version of the measure assessed past and current leisure activities, as well as educational and occupational attainment [5]. Occupational attainment was assessed with an open-ended question, and the data were then coded for Job Zone using the Occupational Information Network (O*NET) Online coding schema to reflect the complexity of the job [19]. Job Zones group occupations into one of five categories based on levels of education, experience, and training necessary to perform the occupation. Using data collected from multiple sclerosis participants ($n = 859$ – 1142), we published a number of articles documenting the relationship between educational/occupational achievement, past- and current-activities with cross-sectional indicators of QOL and well-being [5], and longitudinal disability trajectories [20]. We also described how indicators of reserve-building were associated with QOL appraisal [21], insight [22], personality [23], and altruism [24].

We then sought to expand the activity domains assessed by the measure so that all relevant leisure pursuits were tapped, and to include indicators of person-factors deemed relevant to reserve. This stage of development involved reviewing the literature to see if existing measures could be used in lieu of developing a new measure. In this version we also included one open-ended text item that asked respondents to list any leisure activities in which they

engaged that we might have missed. We wrote new items to assess Perseverance and Work Value. We modified items from existing measures of social support (e.g., [25, 26] to avoid plagiarism and to focus more specifically on what we thought were past and current indicators related to emotional intelligence. We then piloted interim versions (and translations) of the measure in the USA, Netherlands and Norway to assess whether the types of pursuits and/or the examples given worked well across respondents and cultures.

Data were then collected on this interim version from a sample of patients and caregivers ($n = 4173$; 101 with test–retest) from a heterogeneous group of panelists with chronic health conditions (Rare Patient Voice) or cancer (WhatNext) [27]. The open-ended leisure-item data were examined and coded to characterize whether they related to existing current-activity items or reflected distinct activities. Psychometric analysis of the interim-version data supported the item functioning of all subscales with the exception of the current reserve-building subscales, which had ceiling or floor effects on several items [27]. We thus realized a need to modify response options for the current-activity items. Further, the open-ended item suggested either adding items or modifying examples of queried activities. The present work represents the evaluation of this third iteration of our new measure.

Current study

Sample

Eligible participants were 18 years of age or older, and able to complete an online questionnaire. Participants were recruited from panels that include patients and caregiver panelists from a heterogeneous grouping of chronic health conditions (Rare Patient Voice) and cancer (WhatNext). The panel participants were recruited in-person at conferences and gatherings of disease-specific organizations, and thus have been screened to have the disease or be a caregiver of someone with the identified index condition. Because the present study is an unfunded academic study, we were not able to offer compensation.

Procedure and design

A web-based survey was administered using the HIPAA-compliant, secure SurveyGizmo engine (www.surveygizmo.com). Email invitations were sent to panel members using their standard protocol for notifying panel participants of study opportunities. We followed study procedures described by Dillman’s tailored design method [28]. The survey began with an informed consent form that participants signed prior to completing the questionnaires. To

minimize the occurrence of missing data, all questions on the online survey were required (i.e., respondent could not skip the question) but included an option “Not applicable/Prefer not to answer”. The study was reviewed and approved by the New England Review Board (NEIRB#15-254). A random sample of 50 participants per panel (Rare Patient Voice and WhatNext) was selected to provide one-week retest data on the new measure.

Measures

Reserve-Building was measured by the DeltaQuest Reserve-Building Measure, which is posited to have three broad components according to theory [4]: current reserve-building activities, past reserve-building activities, and person characteristics.

Current reserve-building was composed of items assessing a broad range of leisure activities, tapping physical, cultural, intellectual, communal, and spiritual pursuits. The time frame for the current activities varied depending on the nature of the activities, from the “past six months” to the “past 7 days” (see Table 1). Respondents endorsed a 5-point Likert scale ranging from “none of the time” to “all of the time”.

Past reserve-building was composed of items assessing childhood activities, educational, and occupational attainment (see Table 1). Childhood activities queried activities of the respondent and his/her family done as a child or adolescent (e.g., interest in the arts, physical activities). Educational attainment items queried the respondent’s, father’s and mother’s highest level of education. Occupational attainment was assessed using a close-ended brief series of skip-logic questions. The respondent first selected the best general occupational descriptor of their current or past job (if retired or disabled). S/he then selected the job that was closest to their current or most recent job. This selection generated an O*NET complexity score ranging from 1 to 5, with higher scores indicating more complexity. For example, an individual might choose “Architecture and Engineering Occupations” in the first step, and then would have to select one of up to five options ranging from least complex (i.e., architectural draftsman, Computer-Assisted Drawing technician) to most complex (i.e., principal architect, chief engineer, senior executive).

Person-factors related to reserve-building were composed of items assessing work value, perseverance, and past and current social support (see Table 1). Work value items queried how stimulating, challenging, etc. their work is, if employed. Perseverance items were statements related to not giving up despite challenges. Past and current social support queried how much the respondent’s past or current social network provided substantive support and help in dealing with problems. The items focused on emotional

processing of life’s challenges as well as the social network as a safety net.

Demographic characteristics collected included cohabitation/marital status, with whom the person lives, employment status, annual income categories, and difficulty paying bills [29]. Medical and mental health comorbidities were assessed using the Self-Administered Comorbidity Questionnaire [30]. ICD-10 codes [31] were used to characterize the diseases reflected by the panels.

Construct validity measures

Standardized and well-validated patient-reported measures of quality of life (QOL) and personality were used to test construct validity. Physical and mental health functioning were measured with the *PROMIS-10* [32]. The *PROMIS-10* global physical health scores have a possible range from 16.2 to 67.7; the global mental health scores ranged from 21.2 to 67.6, with higher scores indicating better health. Cognitive functioning was measured using the *NeuroQOL Applied Cognition* short-form [33], whose scores possible range is 36.4–76.8 with higher scores indicating worse reported cognitive function health. Well-being was measured using two questionnaires. The *NeuroQOL Positive Affect and Well-Being* [36] scores’ possible range is 9–45 with higher scores indicating better reported affect and well-being. The *Ryff Environmental Mastery* subscale (7-item version) [34] scores’ possible range is 7–42, with higher scores indicating a better sense of mastery or control. To assess relationships among the new measures’ subscales and stable characteristics of the individual, the *Brief NEO Personality Inventory* [35] was used to assess personality characteristics. The *Brief NEO* scores possible range is from 10 to 50 per personality domain, with higher scores indicating greater endorsement of the items reflecting that personality characteristic.

Statistical analysis

Psychometric analysis used classical test theory and item response theory (IRT) approaches. The sample was divided into test and validation subsamples, comprising 60 and 40% of the sample, respectively. Exploratory factor analysis (EFA) was done on the test sample followed by confirmatory factor analysis (CFA) in the validation sample. EFAs were implemented on items within their presumed domains to determine the factor structure of each domain. Factor analyses were conducted using Mplus [36]. Model fit focused on the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) using standard criteria (i.e., $CFI \geq 0.90$; $RMSEA < 0.08$) [37]. In cases when these two model fit indices did not agree, the CFI took precedence because the RMSEA can be overly

Table 1 Psychometric characteristics of the DeltaQuest Reserve-Building activities measure

Domain	Subscale	Item content summary	Time frame	No. items	No. non-missing responses	CFI	RMSEA	Factor loading ^f	Score range (min–max)	Alpha reliability	Test–retest stability
Current activities											
Expected to be reserve-promoting	Active in the World	Gone to lectures, concerts, theater, or museums?	Past 6 months	3	590	0.90	0.06	0.70	39.15–74.67	0.60	0.87
		Traveled?	Past 6 months	3	591			0.70			
		Volunteer work?	Past 6 months	3	591			0.65			
Games	Puzzles?	Puzzles?	Past 6 months	3	591			0.74	31.97–62.20	0.66	0.83
		Card games?	Past 6 months	3	589			0.80			
Outdoors	Video games?	Video games?	Past month	3	585			0.49			
		Time outdoors?	Past 6 months	3	591			0.71	36.09–67.02	0.66	0.81
		Working with your hands?	Past month	3	590			0.68			
Creative	Home improvement?	Home improvement?	Past month	4	591			0.68			
		Writing?	Past 6 months	4	591			0.57	39.87–69.54	0.66	0.89
		Working with your hands?	Past month	4	591			0.74			
Religious/Spiritual	Creative working with a device?	Creative working with a device?	Past month	3	591			0.63			
		Learning a new skill?	Past month	3	592			0.58			
		Musical instrument?	Past month	3	588			0.63	40.49–68.43	0.63	0.92
Exercise	Religious activities on your own?	Religious activities on your own?	Past month	3	589			0.77			
		Group religious activities?	Past month	3	589			0.81			
		Strenuous Exercise	Past 7 days	4	586			0.79	39.71–73.03	0.75	0.89
Inner Life	Moderate Exercise	Moderate Exercise	Past 7 days	4	588			0.83			
		Mild Exercise	Past 7 days	4	590			0.60			
		Taken part in sports?	Past month	3	591			0.81			
Shopping/Cooking	Took care of pet(s)?	Took care of pet(s)?	Past month	3	446			0.40	24.87–56.88	0.45	0.84
		Alone time?	Past month	3	591			0.45			
		Read?	Past month	2	591			0.82			
Expected not to influence reserve	Cooked as a hobby?	Cooked as a hobby?	Past month	2	590			0.55	38.08–70.89	0.45	0.85
		Shopped as a hobby?	Past month	2	590			0.64			
		Browsed the internet?	Past month	3	588			0.64	15.65–57.94	0.48	0.43
Consumption	Watched television?	Watched television?	Past month	3	588			0.80			
		Watched movies?	Past month	3	589			0.43			

Table 1 continued

Domain	Subscale	Item content summary	Time frame	No. items	No. non-missing responses	CFI	RMSEA	Factor loading	Score range (min–max)	Alpha reliability	Test–retest stability
Past activities											
Childhood Activities											
		Family interest in the arts?	NA		592	0.91	0.12	0.60	24.11–68.24	0.75	0.36
		Family engage in any physical activities?	NA		591			0.71			
		Read books for pleasure?	NA	6	585			0.47			
		Physical activities outside the school day?	NA		588			0.71			
		Hobby activities outside school?	NA		585			0.72			
		Musical activities?	NA		582			0.62			
		Education level	NA		590				24.41–70.85	0.62	0.99
		Occupational complexity (ONET zone code)	NA	2	532						
Person-characteristics											
Perseverance											
		Never give up	NA		591			0.79	31.60–63.21	0.69	0.78
		Relax	NA		592			0.66			
		If you fail, continue/persevere.	NA	5	589	0.95	0.11	0.87			
		Be grateful	NA		588			0.81			
		Don't take for granted	NA		589			0.81			
		Listen when you needed to talk?	NA		592			0.92	20.94–59.89	0.93	0.59
		Have a good time with?	NA		592	0.99	0.20	0.87			
		Turn to for suggestions?	NA	5	592			0.97			
		To understand your problems?	NA		591			0.94			
		To love?	NA		590			0.85			
		Listen when you needed to talk?	NA		591			0.93	28.83–61.90	0.95	0.37
		Have a good time with?	NA		591			0.86			
		Turn to for suggestions?	NA	5	590	0.99	0.18	0.99			
		To understand your problems?	NA		589			0.99			
		To love?	NA		588			0.89			
		Stimulating work	NA	2	238				21.49–60.80	0.82	0.95
		Rewarding work	NA		240						

Response options: 5 = All of the time; 4 = Most of the time; 3 = Some of the time; 2 = A little of the time; 1 = None of the time; –99 = Not applicable/prefer not to answer

†Factor loadings are not computed when subscales contain fewer than three items

sensitive to other issues in the data [38]. Graded IRT models [39] were then estimated for each unidimensional factor using data from the whole sample with the software package IRTPRO [40]. We examined item characteristics (item frequencies, item trace lines, item information function values) and other graded response model item output (parameter estimates and marginal fit indicators of local dependence) to identify poorly functioning items. Final selection of items was then made for each subscale prior to the whole-sample CFA. If items were markedly skewed but the item content seemed worthwhile to retain in the final measure, binary scoring was used (e.g., all and most of the time versus some, a little, and none of the time) [41]. CFA was re-computed for the final measurement model on the entire sample for reporting final model-fit statistics. Cronbach's alpha assessed internal consistency reliability; and intra-class correlations assessed test–retest stability. Missing data were handled with list-wise deletion.

Construct validity was assessed using Pearson correlations between the Reserve-Building Measure's subscales and the standardized measures of QOL, personality, and demographic characteristics, and for inter-correlations among the measure's subscales. Correlation coefficients were interpreted using Cohen's effect size guidelines [42]: small effect-size correlations being between 0.1 and 0.3, medium between 0.3 and 0.5, and large being greater than 0.5.

Construct validity hypotheses Based on past research [5], we hypothesized that past and current reserve-building activities would generally be associated but not overlap with indicators of QOL and well-being (i.e., small to medium rather than large effect-size correlations [42]). Reserve-building pursuits that are more physical in nature would be expected to correlate with physical and emotional functioning (QOL), whereas those that are more cognitive or intellectual would be expected to correlate with cognition. More spiritual or contemplative pursuits would be expected to correlate more with emotional functioning and well-being. We anticipated that leisure pursuits that are primarily passive in nature (i.e., passive media consumption) would not correlate with indicators of QOL and well-being. Based on past research [23], we hypothesized that reserve-building person-factors will generally be associated but not overlap with more adaptive personality characteristics. Specifically, Work Value and Perseverance would have small to moderate effect-size correlations with higher conscientiousness and lower neuroticism. We expect Past and Current Social Support to have small to moderate effect-size correlations with lower neuroticism levels.

Statistical analyses were done using Stata 14 [43], Mplus 7.4 [36], and IRTPRO3.1.21505.4001 [40].

Results

Sample

The study sample included 592 patients and caregivers. Table 2 provides the sociodemographic characteristics, and the ICD-10 categories of this heterogeneous sample. The sample had a mean age of 44, and 76% were female. Most respondents were married and living with spouse and/or family members. The most prevalent ICD-10 index health conditions were diseases of the nervous system followed by neoplasms, and endocrine diseases. The most prevalent comorbidities were back pain, depression, and insomnia.

Psychometric characteristics of the Reserve-Building Measure

Table 1 provides the psychometric characteristics of the Reserve-Building Measure, including model fit statistics, factor loadings, score ranges, alpha reliability, and intra-class correlation coefficients reflecting test–retest stability. The prevalence of missing data on the Reserve-Building Measure was very low overall (0.003–1.7%) (Table 1), with the exception of the two work-related items. The Work Value subscale was missing-by-design (i.e., a skip-logic ensured that the items were only presented to respondents if they were currently working, $n = 238$ –240). The Occupational Complexity score ($n = 532$) was missing if the respondent's job was not listed in the response options, and thus would not have a complexity code. After subscales were finalized based on factor analysis (see below), items within each subscale were evaluated further using IRT analysis. Subscales with fewer than 3 items were not subject to IRT calibration. For each subscale, the IRT analyses confirmed the absence of local dependence (excess residual item covariance) in each subscale, and informed item and sub-scale scoring. Specifically, we examined category trace lines for each item to identify the efficiency of the response options. For items with excess overlap in the category trace lines, we opted to collapse adjacent categories until every score assigned to an item reflected unique information. Accordingly, items related to watching television, browsing the internet, time alone, and reading books or magazines were collapsed to binary scoring (daily = 1, other = 0).

Current reserve-building activity subscales

The EFA of the 31 *Current Activity* items yielded a nine-factor solution on the test sample. After dropping three items (radio, spending time with friend, going to theme parks) because they did not load predominantly on any one

factor, the fit of this 9-factor solution was excellent (CFI = 0.98, RMSEA = 0.03), and was subsequently confirmed in CFAs run on the validation sample (CFI = 0.89, RMSEA = 0.06) and whole-sample final CFA (CFI = 0.90, RMSEA = 0.07). The nine current-activities subscales are Active in the World (e.g., attending lectures; 3 items), Games (e.g., puzzles; 3 items), Outdoors (e.g., spending time outdoors; 3 items), Creative (e.g., hobbies involving working with one's hands; 4 items), Religious/Spiritual (e.g., individual or group religious; 3 items), Exercise (e.g., mild, moderate and strenuous exercise; 4 items), Inner Life (e.g., reading; 3 items), Shopping/Cooking (e.g., cooking as a hobby; 2 items), and Passive Media Consumption (e.g., watching television; 3 items). These subscales tapped eight groupings of activities expected to enhance reserve, as well as one (i.e., Passive Media Consumption) expected not only not to enhance reserve-building but also to consume substantial amounts of time which could be devoted to more reserve-building activities.

This nine-factor solution reflects the domains posited by reserve theory [4]: physical (Exercise, Outdoors), cultural (Active in the World), intellectual (Games, Creative, Inner Life), communal (Religious/Spiritual), and spiritual pursuits (Religious/Spiritual, Inner Life) that are reserve-building while passive media consumption is posited to not be reserve-building. The Current Activities subscales (28 items) had moderate alpha reliability (i.e., >0.60), with the exception of Inner Life, Shopping/Cooking, and Passive Media Consumption (alpha range 0.45–0.48). Most had high test–retest stability (i.e., ICC = 0.81–0.92), with the exception of Passive Media Consumption (ICC = 0.43).

Past reserve-building activity subscales

The EFA of the 10 *Past Activities* yielded a two-factor solution on the test sample (CFI = 0.90, RMSEA = 0.12), and suggested dropping two variables related to mother's and father's education because they did not load on either factor. The two factor model was confirmed in CFAs run on the validation sample (CFI = 0.92, RMSEA = 0.15) and the whole-sample final CFA (CFI = 0.91, RMSEA = 0.12). The *Past Activities* subscales included Childhood Activities (6 items tapping family activities related to exercise, hobbies and the arts) and Achievement (respondent's education and profession). Both Childhood Activities and Achievement subscales had moderate alpha reliability (0.68 and 0.62, respectively), only Achievement had strong test–retest stability (ICC = 0.996).

Reserve-building person characteristics

The *Person Characteristics* subscales included Perseverance, Past and Current Social Support, and Work Value. The EFA of nine *Perseverance* items yielded multiple-factor solutions, but an examination of the item frequency distributions suggested that only five of the items had distributions that sampled all the response options. The EFA of the remaining five Perseverance items fit a one-factor solution on the test sample (CFI = 0.96, RMSEA = 0.08), which was confirmed in the CFA on the validation sample (CFI = 0.98, RMSEA = 0.13), and the whole-sample final CFA (CFI = 0.95, RMSEA = 0.11). This subscale demonstrated moderate alpha reliability ($\alpha = 0.69$) and high test–retest stability (ICC = 0.78). The EFA of 5 *Current Social Support* items yielded a one-factor solution on the test sample (CFI = 1.00, RMSEA = 0.14), which was confirmed in CFAs run on the validation sample (CFI = 0.99, RMSEA = 0.22) and whole-sample final CFA (CFI = 0.99, RMSEA = 0.20). This subscale demonstrated high alpha reliability ($\alpha = 0.93$) but only moderate test–retest stability (ICC = 0.59). No items were dropped in either the Past or Current Social Support subscales. The EFA of 5 *Past Social Support* items yielded a one-factor solution on the test sample (CFI = 1.00, RMSEA = 0.06), which was confirmed in CFAs run on the validation sample (CFI = 1.00, RMSEA = 0.17) and whole-sample final CFA (CFI = 0.99, RMSEA = 0.18). This subscale demonstrated high alpha reliability ($\alpha = 0.95$) but low test–retest stability (ICC = 0.37). The EFA of *Work Value* items yielded a one-factor solution on the test sample (CFI = 1.00, RMSEA = 0.00). Only two items were kept in the subscale (i.e., stimulating and rewarding; importance of work was dropped), which precluded further CFA. This subscale demonstrated high alpha reliability ($\alpha = 0.82$) and high test–retest stability (ICC = 0.95).

Reserve-Building Measure subscale inter-correlations

The Reserve-Building Measure subscales generally had small effect-size inter-correlations (Table 3), suggesting that they measure distinct constructs. Among the Current Activities component of the measure, several subscales had medium effect-size correlations, suggesting that they measure related but not overlapping constructs. Active in the World had medium effect-size correlations with Outdoor, Creative, Religious/Spiritual, and Exercise. Outdoor had medium effect-size correlations with Creative, Exercise, and Shopping/Cooking. Creative had medium effect-size correlations with Religious Spiritual and Shopping/Cooking. Among the past-activities components,

Table 2 Sample characteristics

Variable	
<i>n</i>	592
Age	
Mean (SD)	43.62 (18.72)
Gender (%)	
Male	21%
Female	76%
Status	
Patient	75.34%
Caregiver	17.40%
Patient and Caregiver	7.26%
Employment status	
Employed	40.44%
Unemployed	15.74%
Retired	11.00%
Disabled due to medical condition	31.81%
Prefer not to answer/do not know	1.02%
ICD-10 Diagnostic Category of Index Condition	
Diseases of the nervous system	39%
Neoplasms	19%
Endocrine, nutritional and metabolic diseases	9%
Diseases of the musculoskeletal system and connective tissue	6%
Diseases of the blood and blood-forming organs and immune mechanism disorders	5%
Diseases of the circulatory system	2%
Diseases of the digestive system	2%
Congenital malformations, deformations and chromosomal abnormalities	2%
Other	15%
Comorbidities (%) ^b	
Back pain	58%
Depression	51%
Insomnia	41%
Arthritis	37%
High Blood Pressure	29%
Cancer (now or in the past)	26%
Asthma	22%
Ulcer or stomach disease	14%
Diabetes	9%
Lung Disease	9%
Heart Disease	8%
Kidney Disease	4%
Liver Disease	3%
Stroke	2%
Marital Status (%)	
Never Married	14%
Married	61%
Cohabitation/Domestic Partnership	7%

Table 2 continued

Variable	
Separated	2%
Divorced	13%
Widowed	2%
Missing	1%
Income (%)	
Less than \$15,000	9%
\$15,001 to \$30,000	15%
\$30,001 to \$50,000	17%
\$50,001 to \$100,000	28%
\$100,001 to \$150,000	13%
\$150,001 to 200,000	3%
Over \$200,000	3%
Missing	12%
Living situation ^a (%)	
Spouse/Partner	70%
Other Relative (children, sibling, parent)	51%
Friend/Companion	4%
Pet(s)	47%
Alone	9%
Other	3%

^aMay add up to more than 100% because respondents were allowed to check all that apply

^bRespondents listed their comorbidities, which may overlap with the ICD-10 code for their index condition

Childhood Activities had a medium effect-size correlation with Past Social Support. Among the person-factors components, Perseverance was correlated with almost none of the subscales, with the exception of a small effect-size correlation with Inner Life. In contrast, Current Social Support had small effect-size correlations with almost all the subscales with the exception of Achievement. Past Social Support had medium effect-size correlations with Current Social Support and Childhood Activities.

Construct validity correlations

Table 4 shows the correlations among the new measure's subscales and established measures of QOL, well-being, and personality. As hypothesized, none of the Reserve-Building Measure subscales had large correlations with the standardized measures, suggesting that they all measure distinct constructs. Three current-activities subscales measured related but not overlapping constructs with standardized measures: Active in the World was moderately associated (i.e., medium effect-size correlations) with better emotional functioning. Outdoor and Exercise correlated moderately with physical functioning. All other Reserve-Building Measure current-activities and past-

Table 3 Reserve-Building Measure intercorrelations

	Current activities								
	Active in the world	Games	Outdoor	Creative	Religious/Spiritual	Exercise	Passive Media Consumption	Shopping/Cooking	Inner life
Current-reserve building									
Active in the world									
Games	0.19								
Outdoor	<i>0.33</i>	0.21							
Creative	<i>0.33</i>	0.27	<i>0.39</i>						
Religious/Spiritual	<i>0.31</i>	0.19	0.22	<i>0.32</i>					
Exercise	<i>0.31</i>	0.10	<i>0.46</i>	0.25	0.16				
Passive Media Consumption	0.16	<i>0.44</i>	0.18	0.23	0.11	0.16			
Shopping/Cooking	0.24	0.20	<i>0.33</i>	<i>0.34</i>	0.26	0.29	0.11		
Inner life	−0.01	0.20	0.03	0.10	0.00	−0.02	0.27	0.19	
Past Reserve-Building									
Childhood Activities	0.26	0.13	0.16	0.28	0.28	0.24	0.19	0.15	0.02
Achievement	0.26	0.02	0.12	0.07	0.02	0.13	0.15	−0.08	−0.08
Person Factors									
Perseverance	0.00	0.03	0.09	0.05	0.05	−0.01	0.08	0.09	0.12
Current Social Support	0.19	0.14	0.21	0.19	0.20	0.12	0.24	0.22	0.16
Past Social Support	0.19	0.04	0.10	0.10	0.17	0.13	0.08	0.13	0.05
Work Value	0.13	0.08	0.09	0.04	0.11	0.16	0.16	0.14	0.05
		Past activities			Person factors				
		Childhood activities	Achievement		Perseverance	Current social support	Past social support		
Current-reserve building									
Active in the world									
Games									
Outdoor									
Creative									
Religious/Spiritual									
Exercise									
Passive Media Consumption									
Shopping/Cooking									
Inner life									
Past Reserve-Building									
Childhood Activities									
Achievement	0.22								
Person Factors									
Perseverance	0.03		−0.06						
Current Social Support	0.19		0.04	0.11					
Past Social Support	<i>0.34</i>		0.07	0.16	<i>0.32</i>				
Work Value	0.27		0.30	0.11	0.23			0.17	

Bold Moderate effect-size correlation: related but not overlapping constructs ($0.30 < \text{Pearson's } r < 0.50$)

Italics Small effect-size correlation: unrelated constructs ($0.10 < \text{Pearson's } r < 0.30$)

Table 4 Construct validity correlations

	Current activities								
	Active in the world	Games	Outdoors	Creative	Religious/Spiritual	Exercise	Inner life	Passive Media Consumption	Shopping/Cooking
Quality of life									
PROMIS Physical Functioning	0.26	0.00	<i>0.36</i>	0.09	0.08	<i>0.43</i>	0.03	-0.12	0.18
PROMIS Emotional Functioning	<i>0.33</i>	0.08	0.29	0.18	0.25	0.22	0.15	0.02	0.20
NeuroQOL Applied Cognition	-0.11	0.02	-0.07	-0.06	-0.06	-0.05	-0.07	-0.05	-0.14
Well-Being									
Environmental Mastery	0.23	0.02	0.25	0.10	0.15	0.18	0.12	0.04	0.18
NeuroQOL Positive Affect and Well-Being	0.28	0.13	0.26	0.20	0.24	0.18	0.15	0.07	0.27
Personality									
Extraversion	0.02	-0.02	0.03	-0.01	0.02	0.02	-0.09	0.03	0.06
Agreeableness	0.11	-0.03	0.01	0.01	0.12	-0.03	0.08	-0.03	0.00
Conscientious	0.08	-0.09	0.18	0.05	0.09	0.12	0.04	-0.05	0.07
Neuroticism	-0.15	-0.04	-0.18	-0.09	-0.09	-0.08	-0.11	-0.05	-0.10
Openness	0.14	0.02	0.02	0.16	0.07	0.04	0.11	0.02	0.01
	Past activities			Person factors					
	Childhood Activities	Achievement		Perseverance	Current Social Support	Past Social Support	Work Value		
Quality of life									
PROMIS Physical Functioning	0.10	0.13		0.03	0.23	0.19	0.11		
PROMIS Emotional Functioning	0.18	0.19		0.09	<i>0.50</i>	<i>0.30</i>	<i>0.33</i>		
NeuroQOL Applied Cognition	-0.11	0.01		-0.13	-0.23	-0.15	-0.13		
Well-Being									
Environmental Mastery	0.11	0.15		0.11	<i>0.40</i>	0.23	<i>0.31</i>		
NeuroQOL Positive Affect and Well-Being	0.14	0.06		0.20	<i>0.48</i>	0.28	<i>0.31</i>		
Personality									
Extraversion	0.00	0.04		0.12	0.06	0.15	0.14		
Agreeableness	0.06	0.07		0.12	0.10	0.07	0.09		
Conscientious	0.16	0.14		0.10	0.14	0.05	0.27		
Neuroticism	-0.15	-0.09		-0.17	-0.21	-0.22	-0.21		
Openness	0.16	0.08		0.03	0.03	0.03	-0.09		

Bold Moderate correlation: related but not overlapping constructs

Italics Small correlation: unrelated constructs

activities subscales had minimal or no correlation with standardized measures. Among the Reserve-Building Measure person-factors subscales, Current and Past Social Support and Work Value had moderate correlations with emotional functioning, and Current Social Support and Work Value had moderate correlations with environmental mastery. As hypothesized, all other Reserve-Building Measure person-factor subscales had minimal or no correlation with standardized measures.

Discussion

The Reserve-Building Measure provides a potentially useful measure of activities and person-factors related to reserve which are distinct from QOL, well-being and personality. Whereas test-retest stability was within an acceptable range for most subscales, the internal consistency reliability was in the moderate-to-low range for most subscales. This may reflect the fact that the subscales had a

small number of items which were quite distinct, i.e., tapped relatively different types of activities within a domain. The measure's nine current activities subscales span a range of activities that reflect how people spend their leisure time, based on past research done by members of our group and others [6, 10, 11, 20, 44]. Some of these activities are hypothesized to enhance reserve (e.g., Active in the World, Games, Outdoor, Creative, Religious/Spiritual, Exercise, Inner Life, Shopping/Cooking) and one is expected not to have any salutogenic effect (i.e., Passive Media Consumption) [45]. Past Activities tap childhood activities that would have built reserve in the past. Person Factors assess characteristics expected to play a role in an individual's emotional and attitudinal resources that would influence one's ability to navigate challenging situations, which is considered an important aspect of adaptability [46] and possibly reserve. Future work will continue to hone items and evaluate the psychometric characteristics of the evolving tool.

The present study has a notable strength in its large and heterogeneous sample, which is useful for validating a general purpose scale such as the Reserve-Building measure. The limitations of this study should, however, be noted. While the sample is heterogeneous in its illness representation, it may over-represent patients who take an active role in their illness management, given their willingness to be a panel member for studies of rare diseases. Further, the new Reserve-Building Measure had several subscales with low test–retest stability (i.e., ICC's of 0.36–0.59), which warrants further examination. In past research done by members of our group, we have noted that low stability on a coping measure was associated with behavioral factors, such as neurocognitive problems, psychological morbidity, locus of control, and existential angst [47]. Future research might examine what factors are associated with low stability on the Passive Media Consumption, Childhood Activities, and Current and Past Social Support subscales on the Reserve-Building Measure. Further, several subscale's CFA had higher-than-preferable RMSEA statistics (i.e., >0.08 as seen in subscales for Past Activities and Person Characteristics), despite acceptable CFI fit indices. It is notable that these same subscales, which are important to retain because of reserve theory (Fig. 1; [3, 4, 48]), had low test–retest stability. Future research should focus on testing hypotheses related to recall bias or other response biases in these subscales. More advanced methods might be used in future research to assess discriminant validity and convergent validity, such as composite reliability; item reliabilities; and average variance extracted [49, 50]. Further attention might also address important aspects of the new measure's utility, such as cut-off points for clinical use, predictive validity in prospective research, and item development for

the above-mentioned subscales. For example, if future data sets yield similarly skewed items for the items related to watching television, browsing the internet, time alone, and reading books or magazines, we are considering changing the response options in future iterations of this measure.

The Reserve-Building Measure thus expands the measurement of reserve-related concepts by tapping a broader range of activity domains, by assessing domains that are posited to contribute to reserve as well as those that take up an individual's discretionary time and thus detract from reserve-building. Further, it assesses person-characteristics that are relevant to reserve and that may be amenable to behavioral-change interventions. This new measure can be used to study the longitudinal impact of activities and person-characteristics in buffering chronically ill patients from further disability progression. It could be used as a coaching tool, to identify the activities that might be pursued. It could be used for international comparisons and/or collaborations since international feedback from three countries was core to its development. It is hoped that the Reserve-Building Measure will provide a useful tool to researchers interested in understanding what individuals can do to influence their resilience to disease and disease progression over time.

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How to Obtain the Reserve-Building Measure The interested reader can obtain the DeltaQuest Reserve-Building Measure and further information about item parameters by contacting the first author (CES) and licensing the tool from DeltaQuest Foundation for a specified use and term. License fees vary, depending on the nature of the licensee organization (e.g., academic, not-for-profit, for-profit). Such fees are used to fund further measurement development by DeltaQuest Foundation for use in clinical research and practice.

Compliance with ethical standards

Conflict of interest All authors declare that they have no potential conflicts of interest.

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