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Unpacking the Socioeconomic Status and Resilience Connection: Reserve-Building Activities as Mediators

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Unpacking the Socioeconomic Status and Resilience Connection:

Reserve-Building Activities as Mediators

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Data collection: CES, JZ, WM

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Interpretation of findings: CES, JZ, BDS, BDR

Manuscript writing/editing: CES, JZ, WM, BDS, BDR

Abstract

Objectives: The purpose of this study is to test the hypothesis that the link between socioeconomic status (SES) and resilience is mediated by reserve-building activities.

Design: Cross-sectional observational study. Structural equation modeling (SEM) was used to test the mediation hypothesis.

Setting: Web-based survey

Participants: Participants with a chronic medical condition were recruited from Rare Patient Voice, LLC

Primary and Secondary Outcome Measures: DeltaQuest Reserve-Building Measure; demographic variables to capture SES; Centers for Disease Control Healthy Days Core Module; Self-Administered Comorbidity Questionnaire. Resilience was operationalized using residual modeling.

Results: The study sample included 442 patients (mean age 49, 85% female). SES was modeled as a bifactor model comprised of General SES and specific factors for Personal Finance and Parent's Education. A series of simple mediation models predicting Resilience led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise. The full SEM model supported the hypothesis that the relationships from both General SES and Personal Finance to Resilience were mediated by engaging in the three Reserve-Building activities. In addition, number of comorbidities partially mediated the relationship between Personal Finance and Reserve-Building. Those with more comorbidities generally had lower levels of Resilience.

Conclusions: This study provides a mechanism by which SES promotes resilience: people of higher SES are more likely to engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and include physical exercise. These reserve-building activities are not costly to

1 pursue. These findings may empower patients to introduce more such reserve-building activities into
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4 their lives.

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6 **Key Words:** cognitive reserve; socioeconomic status; social determinants of health; resilience,
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8 chronic illness
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Article Summary

Strengths and Limitations of this study

- Using a more comprehensive measure of reserve-building activities than previously used in past research, the present study of 442 people with chronic illness investigated whether reserve-building activities mediated the relationship between socioeconomic status and resilience.
- This study documents that people with higher SES tend to be more resilient in the face of chronic illness by dint of their regular practice of modifiable and not necessarily expensive activities that stimulate them intellectually, culturally, and physically.
- While the sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged white females who are married or living with family members.
- The data are also cross-sectional, limiting our ability to test causal effects.
- The present study provides a mechanism by which SES promotes resilience: people of higher SES are more likely to engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and include physical exercise.

Introduction

Substantial health disparities exist in the United States, despite 18% of the gross national product expenditures being on health care (1). A large literature has documented the relationship between socioeconomic status (SES) on morbidity and mortality (2, 3), and has shown that this relationship does not simply reflect the effects of poverty (4). This SES-morbidity relationship is similar across income groups, extending beyond poverty to explain relative differences in health among higher SES groups as well (2, 4). The SES-health connection may relate to patterns of social behavior and interpersonal experiences that either promote disease or protect against it (4, 5).

Recent work on the concept of reserve and reserve-building activities may provide a useful mechanism by which (high) SES buffers health. Building on observational work in patient populations with neurological disease, a substantial body of research has documented that past and current engagement in activities that stimulate the brain may buffer against disease progression in people with multiple sclerosis, Alzheimer's disease, or other neurological conditions(6-8), and may be protective against cognitive impairment after chemotherapy in cancer patients (9). The past and current "reserve-building activities" (10, 11) may reflect not only whole-brain stimulation (e.g., education, childhood enrichment activities) but also "multiple intelligences" (i.e., skills ranging across intellectual, artistic, and physical pursuits) (12). Thus, engaging in reserve-building activities may promote better health outcomes across the health-illness spectrum (i.e., resilience) by helping the individual to stimulate the brain; and to remain flexible and with higher plasticity (10, 13-16). This flexibility may translate to more adaptive ways of coping (17), as well as to appraisal processes that emphasize the positive and focus on aspects of their life that are more controllable (18).

To date, the fields of social determinants of health and reserve have remained distinct. Their inter-connection led to the present study involving a heterogeneous cohort of people with chronic illness. We seek to test the hypothesis that the SES-resilience link is mediated by reserve-building activities.

Methods

Sample

Eligible participants were patients with a chronic medical condition of age 18 years or older, and able to complete an online questionnaire. Participants were recruited from Rare Patient Voice, LLC and WhatNext panels, which include people with diagnoses of 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.

Patient and Public Involvement

The present study did not directly involve patients or the public in its design. It did, however, follow-up on a decade-long evolution. The concept of reserve-building evolved over a decade of research with chronically ill patients. The measure of reserve-building was developed over a period of seven years, involving patient feedback and input on item development, and cognitive interviews of earlier versions of the measure. Finally, the research question “Is reserve-building only available to patients with substantial financial and other socioeconomic resources?” was formulated by patients in open question-and-answer sessions directed at the first author at conference presentations. Results of this research path have been provided to study participants in the form of lay-language slide presentations supplied by the first author.

Procedure and Design

A web-based survey was administered in Spring 2016 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 (19). The survey began with an informed consent form that participants endorsed prior to completing the questionnaires. The study was reviewed and approved by the New England Review Board (NEIRB#15-254), and conforms to the principles embodied in the Declaration of Helsinki.

Measures

Reserve-Building was measured with subscales from the *DeltaQuest Reserve-Building Measure* (20) assessing current reserve-building activities, past reserve-building activities, and person characteristics (10). The present study included the nine Current-Reserve-Building Activities subscales: 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). Person Factors related to reserve-building included subscales for Perseverance (5 items), Work Value (2 items), and Current Social Support (5 items)(see (20) for psychometric details).

To capture SES-related variables, we included the following variables from the DeltaQuest Reserve-Building measure's past reserve-building subscales: self and parent education, income, and occupational complexity. Occupational complexity was assessed using a series of skip-logic questions querying the job that was closest to the respondent's current or past occupation, which were then scored for complexity using the O*NET system (21). Additionally, we included an item asking about the respondent's difficulty paying bills (22). This item was reverse-coded so that higher scores reflected *lower* difficulty paying bills.

Resilience was measured using a residual model approach described below in Statistical Analysis. Items from the *Centers for Disease Control (CDC) Healthy Days Core Module* (23) was used to create the Resilience score, consistent with prior work done by members of our group (24). Two items ask the respondent to indicate how many days of the past 30 days their physical (Physical Health Problems) or mental (Mental Health Problems) health, respectively, was not good. A third item (Activities of Daily Living Impaired (ADL Impaired)) asks how many days of the past 30 the

1 respondent's poor physical or mental health kept them from doing their usual activities, such as self-
2 care, work, or recreation.
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6 Respondent **demographic characteristics** included age, gender, ethnicity, race, cohabitation/marital
7 status, with whom the person lives, employment status, annual household income categories, and
8 number of comorbidities, as measured by the *Self-Administered Comorbidity Questionnaire* (25).
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12 **Statistical Analysis**

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14 To operationalize Resilience, we built on a precedent for using residual modeling to study
15 epiphenomena (26-28). We computed a regression model with the CDC Healthy Days ADL Impaired
16 as the dependent variable, and Physical Health Problems, Mental Health Problems, and their
17 interaction as predictors. The residuals from the regression model were saved and multiplied by
18 negative one (-1). Thus, a high Resilience score reflects fewer-than-expected days that the
19 respondent is unable to function due to physical or mental health problems or the synergistic effect of
20 physical and mental health problems (24).
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32 General SES was operationalized using a bifactor methodology (e.g., (29, 30)). In a bifactor model,
33 factor loadings on the single *general* factor reflect the magnitude of relationships between the
34 variables (e.g., self and parent education, income, and occupational complexity) and general SES. In
35 the bifactor context, shared content between subsets of variables is captured by a second loading on
36 a *content-specific* factor. For example, the residual correlation between mother's and father's
37 education may be captured by the specific factor Parent's Education. Similarly, the residual
38 correlation between income and difficulty paying bills is captured by the specific factor Personal
39 Finance. In this manner, the bifactor model accounts for dependencies between items when
40 establishing a total SES score.
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53 Mediation models were conducted within a structural equation modeling (SEM) framework. It was
54 hypothesized that Reserve-Building activities would mediate the relationship between SES and
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1 Resilience. In mediation analyses there are two types of relationships (*pathways*) to consider. There
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3 is the *direct effect* from SES to Resilience, and there is the *indirect effect* from SES to Resilience
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5 through both variables' relationship with Reserve-Building (the *mediator*; See Figure 1). In this
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7 instance, mediation occurs when some (partial) or all (full) of the direct effect between SES and
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9 Resilience is accounted for by the indirect effect through Reserve-Building.
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13 [FIGURE 1 NEAR HERE]
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16 SEM mediation analyses were conducted using Mplus version 7 software. Model fit was evaluated
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18 using the following indices: RMSEA \leq .08, TLI \geq .95, and CFI \geq .95;(31, 32). Analyses of observed
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20 variables were conducted using Stata 15 (33) and SPSS 24 (34). Pearson correlations were
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22 evaluated using Cohen's criteria for delineating small ($0.10 < r < 0.30$), medium ($0.30 < r < 0.50$), and
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24 large ($r > 0.50$) effect sizes, hereafter referred to as small, medium and large correlations (35). We
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26 examined distributions of all variables to be included in the analysis.
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32 Results

33 Sample

34 The study sample included 442 patients. Table 1 provides the sociodemographic characteristics, ICD-
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36 10 categories, and reported comorbidities of this heterogeneous sample. The sample had a mean
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38 age of 49, and 85% were female. Most respondents were married and living with spouse and/or
39
40 family members. The most prevalent ICD-10 index health conditions (i.e., for panel membership)
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42 were diseases of the nervous system followed by neoplasms, and endocrine diseases. The most
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44 prevalent co-morbidities were back pain, depression, and insomnia. Sixty-nine percent of the sample
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46 reported a family income of less than \$100,000 annually, and 69% of the sample reported that it was
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48 somewhat, very, or extremely difficult to pay their bills. The majority of the sample reported past or
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50 current occupations reflecting little to medium preparation needed.
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4 Table 2 shows descriptive statistics of the reserve-building, person factors and demographic scores
5 used to create the SES latent variable scores. Mother's education level was positively skewed,
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7 suggesting that most participants reported relatively low levels of maternal education. Two of the
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9 current Reserve-Building subscales were negatively skewed (Passive Media Consumption, Inner
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11 Life), suggested that most people spent substantial amounts of time in both of these types of
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13 activities. The other variables tested in the SEM model were normally distributed.
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18 [TABLE 2 NEAR HERE]
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21 Table 3 shows Pearson correlation coefficients among the variables considered in the current study.
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23 It revealed that the socioeconomic indices generally had small correlations, although mother's and
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25 father's education had moderate correlations, and difficulty paying bills had a moderate correlation
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27 with number of comorbidities. The Reserve-Building subscales generally had small or negligible
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29 correlations with socioeconomic indices, and small to moderate inter-correlations. The Reserve-
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31 Building measures generally had small or negligible correlations with the resilience score. Four
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33 Reserve-Building scores had small correlations with Resilience: Active in the World, Outdoors,
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35 Exercise, and Shopping/Cooking. The resilience score was most driven by (fewer) number of days
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37 with physical health problems. Resilience had a moderate negative correlation with number of
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39 comorbidities and difficulty paying bills, and small positive correlations with respondent's education
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41 and income tertile. Resilience was not correlated with mother's education, father's education, or job
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43 complexity. The correlation matrix providing a starting point for parsimonious SEM model building,
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45 suggesting that the socioeconomic indicators be modeled as a latent variable(s), and considering only
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47 four of the nine Reserve-Building scores in the model: Active in the World, Outdoor, Exercise, and
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49 Shopping/Cooking.
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Step 1: Bifactor model of SES

We first modeled SES as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills (Supplementary Figure 1). The specific (i.e., orthogonal) factors in the bifactor model account for residual covariance between Parent's Education (mother's and father's education) and Personal Finance (income and difficulty paying bills). Note that the magnitude of the general factor loadings is small for those items that also have factor loadings on Parent's Education and Personal Finance. This pattern is due to the strength of the covariance between these item subsets, and is reflected in the relatively high loadings on the specific factors. The bifactor SES model closely fit the data ($\chi^2=9.3$, $df=7$, $p=.23$; $RMSEA=.027$, $CFI=0.996$, $TLI=0.992$) and provided a starting point for subsequent mediation models.

Step 2: Simple mediation models for Reserve-Building activities

We next evaluated a series of simple mediation models where each of the nine Reserve-Building activities mediated the relationship between the general SES factor and Resilience (Supplementary Table 1). The results of these models led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise were significant mediators of the relationship between SES and Resilience. Of note, exercise was the strongest direct predictor for Resilience.

Step 3: Full mediation models tested

We then developed a mediation model where the relationship between SES (step 1) and Resilience was mediated by the three Reserve-Building activities identified in step 2. An addition, the number of comorbidities was modeled as a covariate of Resilience. The penultimate model accounted for 19% of variance in Resilience but poorly fit the data ($\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$; See Supplementary Table 2).

1 Review of modification indices and the correlation matrix in Table 3 suggested that the penultimate
2 mediation model was not accounting for relationships between Personal Finance, as defined in the
3 bifactor model, and Resilience. After adding the Personal Finance latent variable as a predictor of
4 Resilience, the final mediation model accounted for 25% of the variance in Resilience and closely fit
5 the data ($\chi^2=47.4$, $df=31$, $p=.03$; $RMSEA=.035$, $CFI=0.983$, $TLI=0.970$; See Table 4).
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12 [TABLE 4 NEAR HERE]
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16 As illustrated in Figure 2, the relationship between Resilience and both SES and Personal Finance is
17 mediated by three Reserve-Building activities (Active in the World, Outdoor, and Exercise). In other
18 words, the bivariate relationships (SES to Resilience) were significant until Reserve-Building activities
19 were included in the model, and then the significant relationships were *only* from SES to Reserve-
20 Building, but not the paths from Reserve-Building to Resilience. Further, the three specific Reserve-
21 Building to Resilience paths have p-values are .00, .12, and .17, two of which are *nearly* significant or
22 highly significant. The total mediation effect considers them as a whole collection, and taken together
23 they do account for enough of the variance to create a total mediation effect.
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35 In addition, the Personal Finance to Resilience path is also mediated by the participant's number of
36 comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both
37 General SES ($b = 0.06$, $p < 0.01$) and Personal Finance ($b = 0.13$, $p < 0.01$) to Resilience. This model
38 supports the hypothesis that the relationship between General SES and Resilience is fully mediated
39 by engaging in the three Reserve-Building activities. However, there is only partial mediation from
40 Personal Finance to Resilience because of the remaining significant direct effect ($b = 0.31$, $p < 0.01$).
41 Higher levels of Personal Finance were also negatively associated with number of comorbidities, and
42 those with more comorbidities generally had lower levels of Resilience.
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54 [FIGURE 2 NEAR HERE]
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Discussion

Our findings suggest that the SES-Resilience link is mediated by the individual's engagement in Reserve-Building activities. Thus, people with higher SES tend to be more resilient in the face of chronic illness by dint of their regular practice of activities that stimulate them intellectually, culturally, and physically. In other words, people with higher SES are more likely to spend their discretionary time engaging in reserve-building activities, and this practice makes them more resilient despite their chronic illness. This finding suggests that resilience is not determined by SES, but is modifiable if individuals can augment their practice of three types of reserve-building activities, such as attending lectures or concerts, participating in outdoor activities, and engaging in physical exercise. Choosing to engage in these three types of activities rather than other more passive, less stimulating activities appears to have a beneficial association with health.

A second finding of the present study is that Personal Finance had a direct effect on resilience: individuals with higher income and/or lower difficulty paying bills had higher resilience scores. Personal Finance also played a role in the relationship between number of comorbidities and resilience: people with more financial resources tended to have fewer comorbidities, these financial resources had a smaller protective effect in the context of multiple comorbidities. This finding may reflect the fact that people with fewer financial resources are less likely to treat their comorbidities (36). Untreated comorbidities would likely reduce one's ability to be resilient to health challenges.

There has been an increasing interest in improving healthcare outcomes. In this context, 'social determinants of health' are more often than not cast in terms of deficits or negative situations that people encounter (37, 38). What is missing is addressing positive social determinants of health (39, 40), or person factors that confer resilience, such as reserve-building activities. Our findings suggest that it would be worthwhile to recommend the three types of activities associated with enhanced resilience. Although exercise is standardly recommended to reduce mortality, our findings suggest that it is also beneficial for conferring day-to-day resilience in the face of physical or mental health

1 problems. Further, other types of activities may confer similar benefits. Thus, there may be more
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3 options that healthcare providers can offer to people that can help them achieve better resilience and
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5 that might fit their lifestyle more easily, if exercise is not a viable option.
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8 The present study has a notable strength in its large and heterogeneous sample, which is useful for
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10 testing a complex hypothesis via SEM techniques. It included both income and difficulty paying bills in
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12 the operationalization of General SES and Personal Finance, thus capturing complementary and
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14 distinct aspects of financial well-being that are often not considered in tandem. The sample had
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16 important variability in comorbidity burden, which allowed for evaluating the independent relationship
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18 between comorbidity and resilience. The limitations of this study should, however, be noted. While the
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20 sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged
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22 white females who are married or living with family members. Thus, additional work is needed to
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24 establish relationships with resilience across age and gender. Indeed, these variables were not
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26 strongly related as shown in bivariate correlations and thus were not kept in our SEM models. The
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28 data are also cross-sectional, limiting our ability to test causal effects. Replication of our findings in
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30 longitudinal data is needed. Future research might address how to increase the perceived availability
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32 and opportunities for engaging in reserve-building activities among people with fewer SES resources.
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34 For example, motivational interviewing techniques might be useful for addressing perceived barriers
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36 to different types of reserve-building activities (e.g., cultural activities, exercise, etc.), and helping
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38 patients to find inexpensive ways to get such activities into their lives.
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45 In summary, the present study provides a mechanism by which SES promotes resilience: people of
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47 higher SES are more likely to engage in reserve-building activities that are intellectually stimulating,
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49 involve outdoor pursuits, and include physical exercise. The implications of these findings may be
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51 useful for empowering patients to introduce more such reserve-building activities in their lives, and to
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53 replace more passive activities (e.g., television) with these active, salutogenic pursuits.
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1 Fundamentally, the reserve-building activities implicated in the present study are not costly to pursue
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3 (“the best things in life are free”). This critical accessibility and affordability has applications for public-
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5 health interventions to enhance resilience in healthy and chronically ill individuals.
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16 **Disclosures**

17 All authors declare that they have no potential conflicts of interest and report no disclosures.
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20 **Data sharing statement**

21 No additional data available.
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24 **Data deposition**

25 Not applicable.
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Figure Legends

Figure 1. Theoretical Model Being Tested. It was hypothesized that Reserve-Building activities would mediate the relationship between SES and Resilience. Thus, the direct effect from SES to Resilience would be partially or fully attenuated through both variables' relationship with Reserve-Building (the mediator).

Figure 2. The Full Mediation Model. Reserve-building activities mediate the relationships between Resilience and both SES and Personal Finance. The relevant Reserve-Building activities are Active in the World, Outdoor, and Exercise. The Personal Finance to Resilience path is also mediated by the participant's number of comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both General SES ($b = 0.06, p < 0.01$) and Personal Finance ($b = 0.13, p < 0.01$) to Resilience. This model supports the hypothesis that the relationship between General SES and Resilience is mediated by engaging in the three Reserve-Building activities. Bold values indicate significant paths ($p < .05$).

Figure 1. Theoretical model being tested

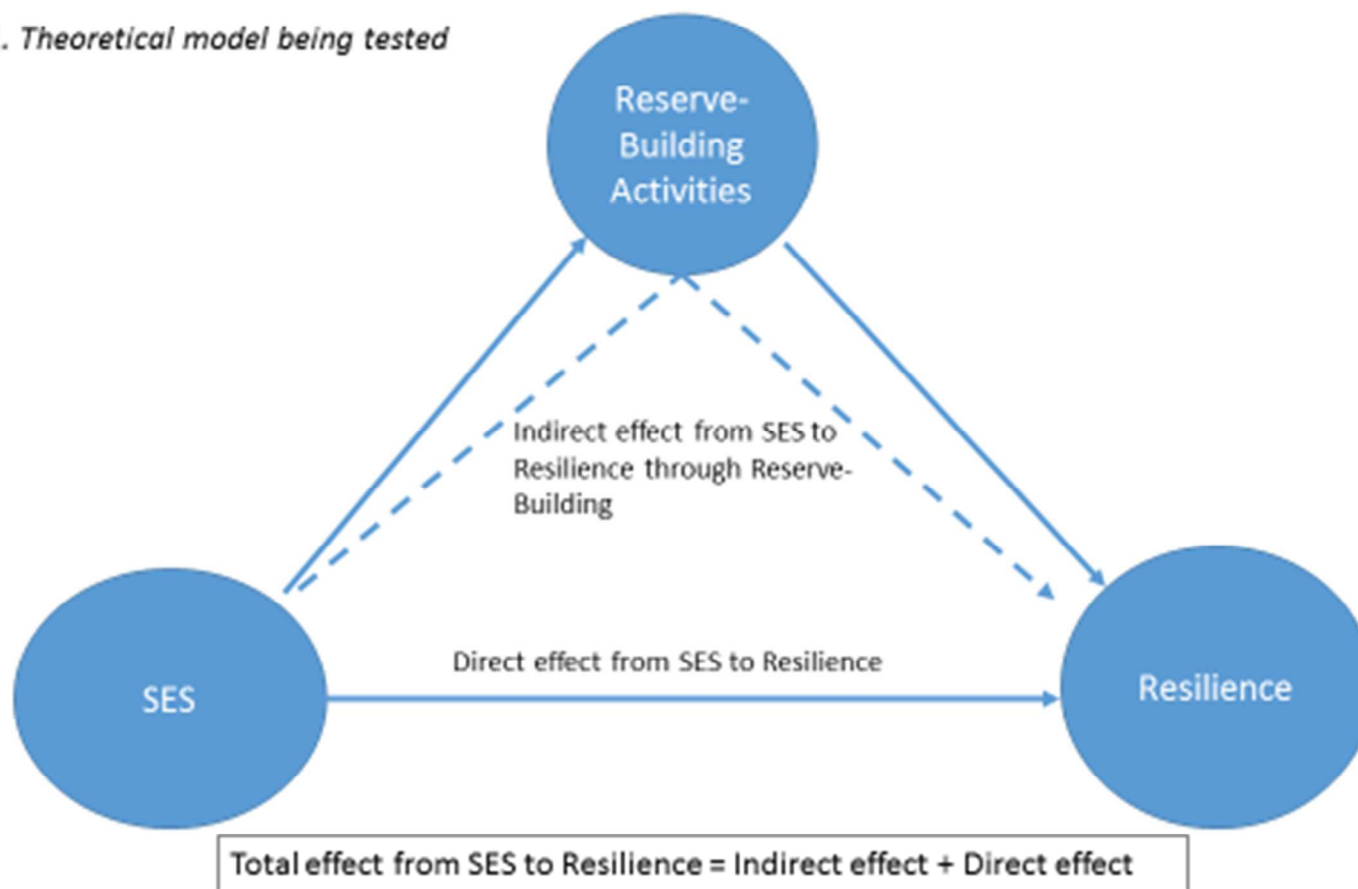
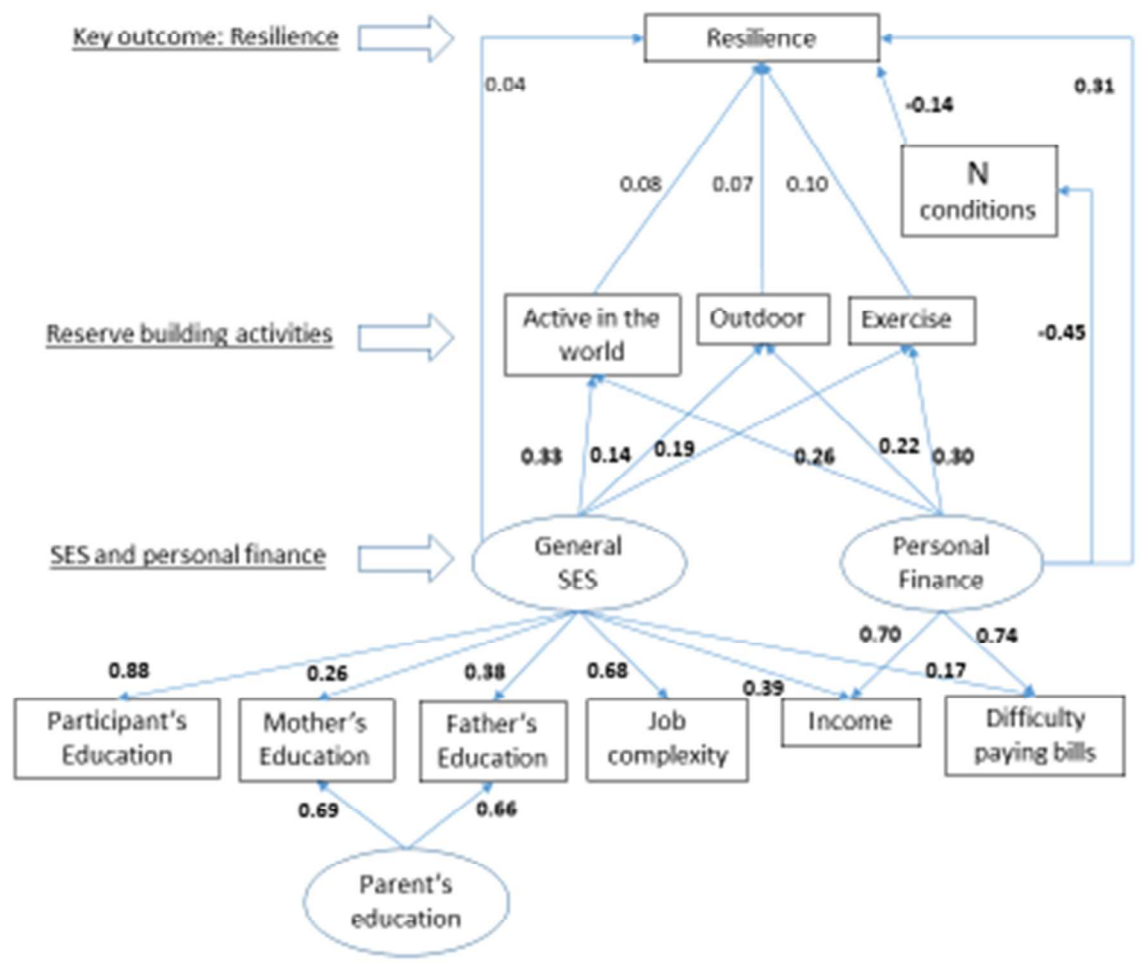


Figure 2. The Full Mediation Model.



Variable		
n		442
Age	Mean (sd)	48.97(12.96)
Gender (%)	Male	15%
	Female	85%
ICD-10 Diagnostic Category of Index Condition	Certain infectious and parasitic diseases	1%
	Neoplasms	25%
	Diseases of the blood and blood-forming organs and immune mechanism disorders	5%
	Endocrine, nutritional and metabolic diseases	6%
	Mental and behavioural disorders	3%
	Diseases of the nervous system	42%
	Diseases of the ear and mastoid process	0%
	Diseases of the circulatory system	3%
	Diseases of the respiratory system	3%
	Diseases of the digestive system	1%
	Diseases of the skin and subcutaneous tissue	1%
	Diseases of the musculoskeletal system and connective tissue	6%
	Diseases of the genitourinary system	0%
	Congenital malformations, deformations and chromosomal abnormalities	1%
Comorbidities (%)	Arthritis	38%
	Asthma	19%
	Back Pain	58%
	Cancer (now or in the past)	31%
	Depression	52%
	Diabetes	10%
	Heart Disease	10%
	High Blood Pressure	31%
	Insomnia	43%
	Kidney Disease	5%
	Liver Disease	3%
	Lung Disease	11%
	Stroke	2%
Ulcer or stomach disease	13%	
Education(%)	High school or less	14%
	Some college	38%
	College degree	27%
	Graduate degree	20%
	Missing	0%
Father's Education	High school or less	48%
	Some college	22%
	College degree	14%
	Graduate degree	11%

	Missing	5%
Mother's Education	High school or less	49%
	Some college	30%
	College degree	11%
	Graduate degree	8%
	Missing	2%
Marital Status (%)	Never Married	15%
	Married	60%
	Cohabitation/ Domestic Partnership	7%
	Separated	2%
	Divorced	13%
	Widowed	2%
	Missing	1%
Living Situation* (%)	Spouse/ Partner	69%
	Other Relative (children, sibling, parent)	44%
	Friend/ Companion	4%
	Pet(s)	48%
	Alone	11%
	Other	1%
Income (%)	Less than \$15,000	11%
	\$15,001 to \$30,000	14%
	\$30,001 to \$50,000	17%
	\$50,001 to \$100,000	27%
	\$100,001 to \$150,000	13%
	\$150,001 to 200,000	4%
	Over \$200,000	2%
	Missing	12%
Difficulty paying bills	Extremely difficult	28%
	Very difficult	16%
	Somewhat difficult	24%
	Slightly difficult	12%
	Not difficult at all	16%
	Missing	3%
Occupational Complexity (ONET Job Zone)	1: Little or No Preparation Needed	5%
	2: Some Preparation Needed	23%
	3: Medium Preparation Needed	24%
	4: Considerable Preparation Needed	22%
	5: Extensive Preparation Needed	7%
	Missing	19%
<i>*May add up to more than 100% because respondents were allowed to check all that apply.</i>		

Table 2. Descriptive Statistics of Variables Used In SEM Analysis				
	Obs	Median	Variable Label	Skewness
General SES				
Participant's Education	440	2	High School Diploma or GED	0.11
Mother's Education	431	1	Some High School or Less	1.05
Father's Education	418	1	Some High School or Less	0.85
Job Complexity	358	3	Medium Preparation Needed	0.03
Personal Finance				
Income	387	4	\$50,001 to \$100,000	0.12
Difficulty Paying Bills	428	3	Somewhat difficult	0.27
	Obs	Mean	Std. Dev.	Skewness
Current Reserve-Building Subscales				
Active in the World	439	49.91	7.65	0.65
Games	332	49.60	6.90	-0.10
Outdoor	438	49.40	7.63	0.35
Creative	440	50.03	7.03	0.47
Religious / Spiritual	437	49.97	7.68	0.45
Exercise	435	49.42	7.29	0.60
Passive Media Consumption	434	50.27	6.75	-1.25
Shopping / Cooking	438	49.86	8.01	0.36
Inner life	334	50.39	6.71	-1.17
Resilience	442	-0.11	1.02	-0.19
Covariate				
Number of Comorbidities	442	5.43	3.68	0.81

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Table 3. Correlation Matrix of Variables Included in SEM Modeling

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 Age																					
2 Gender	0.04																				
3 No. conditions	0.20	-0.09																			
4 Respondent's Education	0.13	0.03	-0.12																		
5 Mother's Education	-0.15	0.06	-0.05	0.19																	
6 Father's Education	-0.09	0.02	-0.05	0.26	0.46																
7 O*NET Occupational Complexity	0.23	0.04	0.04	0.55	0.10	0.24															
8 Income Tertile	0.17	-0.03	-0.25	0.29	0.07	0.07	0.25														
9 Difficulty Paying Bills	-0.29	-0.06	0.33	-0.13	0.02	0.02	-0.15	-0.48													
10 Active in the World	0.10	0.05	-0.08	0.26	0.11	0.14	0.22	0.24	-0.25												
11 Games	0.10	-0.12	0.08	-0.04	0.02	0.06	0.05	0.05	-0.12	0.19											
12 Outdoor	0.05	0.09	-0.09	0.12	0.02	0.07	0.08	0.16	-0.21	0.31	0.21										
13 Creative	0.02	0.02	0.06	0.05	0.08	0.06	0.06	0.05	-0.05	0.33	0.25	0.41									
14 Religious / Spiritual	0.08	-0.08	-0.04	0.00	0.04	-0.02	0.00	0.06	-0.11	0.29	0.20	0.23	0.34								
15 Exercise	-0.03	0.18	-0.15	0.18	0.16	0.07	0.06	0.22	-0.26	0.36	0.11	0.43	0.25	0.16							
16 Passive media consumption	-0.10	0.06	0.10	-0.11	-0.17	-0.08	-0.06	-0.13	0.01	-0.03	0.19	0.02	0.07	-0.02	-0.02						
17 Shopping / Cooking	-0.05	-0.02	-0.06	-0.07	-0.06	-0.01	-0.08	0.08	-0.11	0.24	0.25	0.30	0.34	0.27	0.23	0.18					
18 Inner Life	0.13	-0.02	0.03	0.14	0.03	0.09	0.11	0.12	-0.19	0.12	0.44	0.19	0.18	0.13	0.17	0.20	0.12				
19 Resilience	0.08	0.08	-0.31	0.12	0.09	0.04	-0.01	0.24	-0.39	0.25	-0.05	0.23	0.07	0.08	0.28	-0.09	0.13	0.04			
20 Healthy_days1	0.03	-0.06	0.29	-0.12	-0.09	-0.08	0.05	-0.18	0.26	-0.21	0.03	-0.22	-0.04	-0.05	-0.28	0.11	-0.11	-0.03	-0.91		
21 Healthy_days2	-0.23	-0.08	0.21	-0.08	-0.05	0.04	-0.06	-0.24	0.43	-0.22	0.06	-0.15	-0.10	-0.12	-0.16	0.04	-0.12	-0.04	-0.71	0.36	
22 Healthy_days3	-0.09	-0.05	0.29	-0.11	-0.10	-0.04	-0.04	-0.24	0.35	-0.19	0.02	-0.19	-0.03	-0.07	-0.27	0.09	-0.13	-0.02	-0.66	0.59	0.48
small correlation: unrelated constructs (0.10 < Pearson's R																					
moderate correlation: related but not overlapping																					
large correlation: overlapping constructs (Pearson's R>0.5)																					

Table 4. Final SEM Mediation Model Including Finance as a Predictor					
	Model	beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.33	0.05	6.48	0.000
	SES -> Outdoor activities	0.14	0.06	2.47	0.014
	SES -> Exercise	0.19	0.05	3.55	0.000
	Finance -> Active in the world	0.26	0.05	4.92	0.000
	Finance -> Outdoor activities	0.22	0.06	4.07	0.000
	Finance -> Exercise	0.30	0.05	6.03	0.000
Predicting resilience: Direct effects	SES -> Resilience	0.04	0.06	0.71	0.476
	Finance -> Resilience	0.31	0.07	4.72	0.000
	Active in the world -> Resilience	0.08	0.05	1.57	0.116
	Outdoor activities -> Resilience	0.07	0.05	1.37	0.170
	Exercise -> Resilience	0.10	0.05	1.88	0.060
	Comorbid Conditions -> Resilience	-0.14	0.05	-2.86	0.004
Predicting resilience: Total indirect effects	SES -> Resilience	0.06	0.02	2.65	0.008
	Finance -> Resilience	0.13	0.03	4.06	0.000
		R²	se	t	P value
R square	Education	0.78	0.11	6.87	0.000
	Father Education	0.59	0.04	13.71	0.000
	Mother Education	0.55	0.04	13.00	0.000
	ONET	0.46	0.08	6.14	0.000
	INCOME	0.63	0.04	15.11	0.000
	Difficulty paying bills	0.58	0.04	13.12	0.000
	Number of Conditions	0.20	0.05	3.79	0.000
	Active in the world	0.18	0.04	4.18	0.000
	Outdoor activities	0.07	0.03	2.39	0.017
	Exercise	0.13	0.04	3.64	0.000
Resilience	0.25	0.05	5.54	0.000	
Model Fit Statistics: $\chi^2=47.4$, $df=31$, $p=.03$; RMSEA=.035, CFI=0.983, TLI=0.970					
Path coefficients are reflected by " -> "					

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	Direct Effects
Model	Estimate
SES -> Active in the world	0.41 ***
SES -> Resilience	0.14 *
Active in the world -> Resilience	0.19 ***
Indirect effect	0.08 ***
SES -> Games	0.05
SES -> Resilience	0.20 ***
Games -> Resilience	-0.06
Indirect effect	0.00
SES -> Outdoor	0.20 ***
SES -> Resilience	0.16 ***
Outdoor -> Resilience	0.20 ***
Indirect effect	0.04 **
SES -> Creative	0.11
SES -> Resilience	0.19 ***
Creative -> Resilience	0.05
Indirect effect	0.01
SES -> Religious / Spiritual	0.04
SES -> Resilience	0.19 ***
Religious / Spiritual -> Resilience	0.07
Indirect effect	0.00
SES -> Exercise	0.29 ***
SES -> Resilience	0.15 **
Exercise -> Resilience	0.24 ***
Indirect effect	0.07 *
SES -> Passive Media Consumption	-0.17 ***
SES -> Resilience	0.18 ***
Passive Media Consumption -> Resilience	-0.06
Indirect effect	0.01
SES -> Shopping / Cooking	-0.06
SES -> Resilience	0.20 ***
Shopping / Cooking -> Resilience	0.14 ***
Indirect effect	-0.01
SES -> Inner life	0.23 ***
SES -> Resilience	0.20 ***
Inner life -> Resilience	-0.01
Indirect effect	0.00

† p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001

Supplementary Table 2. Penultimate SEM Mediation Model Without Including Finance as a Predictor					
Model		beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.40	0.05	7.66	0.000
	SES -> Outdoor activities	0.20	0.06	3.42	0.001
	SES -> Exercise	0.27	0.05	4.93	0.000
Predicting resilience: Direct effects	SES -> Resilience	0.05	0.06	0.86	0.389
	Active in the world -> Resilience	0.12	0.05	2.41	0.016
	Outdoor activities -> Resilience	0.10	0.05	2.25	0.024
	Exercise -> Resilience	0.13	0.05	2.77	0.006
	Comorbid Conditions -> Resilience	-0.31	0.04	-7.11	0.000
Predicting resilience: Total indirect effects	SES -> Resilience	0.11	0.03	3.79	0.000
	SES-> Active in the world-> Resilience	0.05	0.02	2.25	0.025
Predicting resilience: Specific Indirect effects	SES-> Outdoor activities-> Resilience	0.02	0.01	1.87	0.061
	SES-> Exercise-> Resilience	0.035	0.015	2.308	0.021
		R²	se	t	P value
R square	Education	0.60	0.08	7.81	0.000
	Father Education	0.58	0.04	13.92	0.000
	Mother Education	0.55	0.04	13.17	0.000
	ONET	0.50	0.07	7.05	0.000
	INCOME	0.59	0.05	12.57	0.000
	Difficulty paying bills	0.51	0.05	10.34	0.000
	Active in the world	0.16	0.04	3.83	0.000
	Outdoor activities	0.04	0.02	1.71	0.087
	Exercise	0.07	0.03	2.46	0.014
Resilience	0.19	0.04	5.29	0.000	

Model Fit Statistics: $\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$

Path coefficients are reflected by " -> "

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	11-12
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-10, Supp. Tables 1,2
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	NA

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	Tables 1,2
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13, Tables 3, 4, Supp. Tables 1, 2
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Tables 3, 4, Supp. Tables 1, 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	5, 15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

For peer review only

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**Is the link between socioeconomic status and resilience mediated by reserve-building activities?
Mediation analysis of web-based cross-sectional data from chronic medical illness patient panels**

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Conceptualize and designed study: CES, BDS, BDR

Access to sample: WM

Data collection: CES, JZ, WM

Data Analysis: CES, JZ, BDS, BDR

Interpretation of findings: CES, JZ, BDS, BDR

Manuscript writing/editing: CES, JZ, WM, BDS, BDR

Abstract

Objectives: The purpose of this study is to test the hypothesis that the link between socioeconomic status (SES) and resilience is mediated by reserve-building activities.

Design: Cross-sectional observational study. Structural equation modeling (SEM) was used to test the mediation hypothesis.

Setting: Web-based survey

Participants: Participants with a chronic medical condition were recruited from Rare Patient Voice, LLC

Primary and Secondary Outcome Measures: DeltaQuest Reserve-Building Measure; demographic variables to capture SES; Centers for Disease Control Healthy Days Core Module; Self-Administered Comorbidity Questionnaire. Resilience was operationalized using residual modeling.

Results: The study sample included 442 patients (mean age 49, 85% female). SES was modeled as a bifactor model comprised of General SES and specific factors for Personal Finance and Parent's Education. A series of simple mediation models predicting Resilience led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise. The full SEM model supported the hypothesis that the relationships from both General SES and Personal Finance to Resilience were mediated by engaging in the three Reserve-Building activities. In addition, number of comorbidities partially mediated the relationship between Personal Finance and Reserve-Building. Those with more comorbidities generally had lower levels of Resilience.

Conclusions: This study provides suggestive evidence that reserve-building activities may be one pathway by which SES is associated with resilience: people of higher SES are more likely to engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and include

1 physical exercise. These reserve-building activities are not costly to pursue. These findings may
2
3 empower patients to introduce more such reserve-building activities into their lives.
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6 **Key Words:** cognitive reserve; socioeconomic status; social determinants of health; resilience,
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8 chronic illness
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Article Summary

Strengths and Limitations of this study

- While the sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged white females who are married or living with family members.
- The data are also cross-sectional, limiting our ability to test mediation effects with certainty or causal effects.
- There are potential confounding factors, such as structural environmental factors, that were not addressed in the analysis. For example, while it may be true that many of the reserve-building activities are free or inexpensive, that does not mean that they are equally accessible across the SES continuum.

Introduction

Substantial health disparities exist in the United States, despite 18% of the gross national product expenditures being on health care¹. A large literature has documented the relationship between socioeconomic status (SES) on morbidity and mortality^{2,3}, and has shown that this relationship does not simply reflect the effects of poverty⁴. This SES-morbidity relationship is similar across income groups, extending beyond poverty to explain relative differences in health among higher SES groups as well^{2,4}. The SES-health connection may relate to patterns of social behavior and interpersonal experiences that either promote disease or protect against it^{4,5}.

Recent work on the concept of reserve and reserve-building activities may provide a useful mechanism by which (high) SES buffers health. Building on observational work in patient populations with neurological disease, a substantial body of research has documented that past and current engagement in activities that stimulate the brain may buffer against disease progression in people with multiple sclerosis, Alzheimer's disease, or other neurological conditions⁶⁻⁸, and may be protective against cognitive impairment after chemotherapy in cancer patients⁹. The past and current "reserve-building activities"^{10,11} may reflect not only whole-brain stimulation (e.g., education, childhood enrichment activities) but also "multiple intelligences" (i.e., skills ranging across intellectual, artistic, and physical pursuits)¹². Thus, engaging in reserve-building activities may promote better health outcomes across the health-illness spectrum (i.e., resilience) by helping the individual to stimulate the brain; and to remain flexible and with higher plasticity^{10,13-16}. This flexibility may translate to more adaptive ways of coping¹⁷, as well as to appraisal processes that emphasize the positive and focus on aspects of their life that are more controllable¹⁸.

To date, the fields of social determinants of health and reserve have remained distinct. Their inter-connection led to the present study involving a heterogeneous cohort of people with chronic illness. We seek to test the hypothesis that the SES-resilience link is mediated by reserve-building activities.

Methods

Sample

Eligible participants were patients with a chronic medical condition of age 18 years or older, and able to complete an online questionnaire. Participants were recruited from Rare Patient Voice, LLC and WhatNext panels, which include people with diagnoses of 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.

Patient and Public Involvement

The present study did not directly involve patients or the public in its design. It did, however, follow-up on a decade-long evolution. The concept of reserve-building evolved over a decade of research with chronically ill patients. The measure of reserve-building was developed over a period of seven years, involving patient feedback and input on item development, and cognitive interviews of earlier versions of the measure. Finally, the research question “Is reserve-building only available to patients with substantial financial and other socioeconomic resources?” was formulated by patients in open question-and-answer sessions directed at the first author at conference presentations. Results of this research path have been provided to study participants in the form of lay-language slide presentations supplied by the first author.

Procedure and Design

A web-based survey was administered in Spring 2016 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. No financial or other incentives were offered to participants. We followed study procedures described by Dillman’s Tailored Design Method¹⁹. The survey began with an informed consent form that participants endorsed prior to completing the questionnaires. The study was reviewed and approved by the New England Review Board (NEIRB#15-254), and conforms to the principles embodied in the Declaration of Helsinki.

Measures

Reserve-Building was measured with subscales from the validated *DeltaQuest Reserve-Building Measure*²⁰ assessing current reserve-building activities, past reserve-building activities, and person characteristics (see¹⁰ for full details of reliability and validity of the measure). The present study included the nine Current-Reserve-Building Activities subscales: 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). Person Factors related to reserve-building included subscales for Perseverance (5 items), Work Value (2 items), and Current Social Support (5 items)(see²⁰ for psychometric details).

To capture SES-related variables, we included the following variables from the DeltaQuest Reserve-Building measure's past reserve-building subscales: self and parent education, income, and occupational complexity. Occupational complexity was assessed using a series of skip-logic questions querying the job that was closest to the respondent's current or past occupation, which were then scored for complexity using the O*NET system²¹. Additionally, we included an item asking about the respondent's difficulty paying bills²². This item was reverse-coded so that higher scores reflected *lower* difficulty paying bills.

Resilience was measured using a residual model approach described below in Statistical Analysis. Items from the *Centers for Disease Control (CDC) Healthy Days Core Module*²³ was used to create the Resilience score, consistent with prior work done by members of our group²⁴. Two items ask the respondent to indicate how many days of the past 30 days their physical (Physical Health Problems) or mental (Mental Health Problems) health, respectively, was not good. A third item (Activities of Daily

1 Living Impaired (ADL Impaired)) asks how many days of the past 30 the respondent's poor physical
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3 or mental health kept them from doing their usual activities, such as self-care, work, or recreation.
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6 Respondent **demographic characteristics** included age, gender, cohabitation/marital status, with
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8 whom the person lives, employment status, annual household income categories, and number of
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10 comorbidities, as measured by the *Self-Administered Comorbidity Questionnaire* ²⁵.
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14 **Statistical Analysis**

15 To operationalize Resilience, we built on a precedent for using residual modeling to study
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17 epiphenomena ²⁶⁻²⁸. We computed a regression model with the CDC Healthy Days ADL Impaired as
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19 the dependent variable, and Physical Health Problems, Mental Health Problems, and their interaction
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21 as predictors. The residuals from the regression model were saved and multiplied by negative one (-
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23 1). Thus, a high Resilience score reflects fewer-than-expected days that the respondent is unable to
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25 function due to physical or mental health problems or the synergistic effect of physical and mental
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27 health problems ²⁴.
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32 General SES was operationalized using a bifactor methodology (e.g., ^{29 30}). In a bifactor model, factor
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34 loadings on the single *general* factor reflect the magnitude of relationships between the variables
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36 (e.g., self and parent education, income, and occupational complexity) and general SES. In the
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38 bifactor context, shared content between subsets of variables is captured by a second loading on a
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40 content-*specific* factor. For example, the residual correlation between mother's and father's education
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42 may be captured by the specific factor Parent's Education. Similarly, the residual correlation between
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44 income and difficulty paying bills is captured by the specific factor Personal Finance. In this manner,
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46 the bifactor model accounts for dependencies between items when establishing a total SES score.
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51 Mediation models were conducted within a structural equation modeling (SEM) framework. It was
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53 hypothesized that Reserve-Building activities would mediate the relationship between SES and
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55 Resilience. In mediation analyses there are two types of relationships (*pathways*) to consider. There
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1 is the *direct effect* from SES to Resilience, and there is the *indirect effect* from SES to Resilience
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3 through both variables' relationship with Reserve-Building (the *mediator*; See Figure 1). In this
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5 instance, mediation occurs when some (partial) or all (full) of the direct effect between SES and
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7 Resilience is accounted for by the indirect effect through Reserve-Building.
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10 [FIGURE 1 NEAR HERE]
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13 SEM mediation analyses were conducted using Mplus version 7 software. Model fit was evaluated
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15 using the following indices: $RMSEA \leq .08$, $TLI \geq .95$, and $CFI \geq .95$;^{31 32}. Analyses of observed variables
16
17 were conducted using Stata 15³³ and SPSS 24³⁴. Pearson correlations were evaluated using
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19 Cohen's criteria for delineating small ($0.10 < r < 0.30$), medium ($0.30 < r < 0.50$), and large ($r > 0.50$)
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21 effect sizes, hereafter referred to as small, medium and large correlations³⁵. We examined
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23 distributions of all variables to be included in the analysis.
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28 Results

29 Sample

30 The study sample included 442 patients. Table 1 provides the sociodemographic characteristics, ICD-
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32 10 categories, and reported comorbidities of this heterogeneous sample. The sample had a mean
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34 age of 49, and 85% were female. Most respondents were married and living with spouse and/or
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36 family members. The most prevalent ICD-10 index health conditions (i.e., for panel membership)
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38 were diseases of the nervous system followed by neoplasms, and endocrine diseases. The most
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40 prevalent co-morbidities were back pain, depression, and insomnia. Sixty-nine percent of the sample
41
42 reported a family income of less than \$100,000 annually, and 69% of the sample reported that it was
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44 somewhat, very, or extremely difficult to pay their bills. The majority of the sample reported past or
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46 current occupations reflecting little to medium preparation needed.
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Variable		
n		442
Age	Mean (sd)	48.97(12.96)
Gender (%)	Male	15%
	Female	85%
ICD-10 Diagnostic Category of Index Condition	Certain infectious and parasitic diseases	1%
	Neoplasms	25%
	Diseases of the blood and blood-forming organs and immune mechanism disorders	5%
	Endocrine, nutritional and metabolic diseases	6%
	Mental and behavioral disorders	3%
	Diseases of the nervous system	42%
	Diseases of the ear and mastoid process	0%
	Diseases of the circulatory system	3%
	Diseases of the respiratory system	3%
	Diseases of the digestive system	1%
	Diseases of the skin and subcutaneous tissue	1%
	Diseases of the musculoskeletal system and connective tissue	6%
	Diseases of the genitourinary system	0%
	Congenital malformations, deformations and chromosomal abnormalities	1%
Comorbidities (%)	Arthritis	38%
	Asthma	19%
	Back Pain	58%
	Cancer (now or in the past)	31%
	Depression	52%
	Diabetes	10%
	Heart Disease	10%
	High Blood Pressure	31%
	Insomnia	43%
	Kidney Disease	5%
	Liver Disease	3%
	Lung Disease	11%
Stroke	2%	
Ulcer or stomach disease	13%	
Education (%)	High school or less	14%
	Some college	38%
	College degree	27%
	Graduate degree	20%
	Missing	0%
Father's Education	High school or less	48%
	Some college	22%
	College degree	14%
	Graduate degree	11%

Reserve-Building and SES, page 12

	Missing	5%
Mother's Education	High school or less	49%
	Some college	30%
	College degree	11%
	Graduate degree	8%
	Missing	2%
Marital Status (%)	Never Married	15%
	Married	60%
	Cohabitation/ Domestic Partnership	7%
	Separated	2%
	Divorced	13%
	Widowed	2%
	Missing	1%
Living Situation* (%)	Spouse/ Partner	69%
	Other Relative (children, sibling, parent)	44%
	Friend/ Companion	4%
	Pet(s)	48%
	Alone	11%
	Other	1%
Income (%)	Less than \$15,000	11%
	\$15,001 to \$30,000	14%
	\$30,001 to \$50,000	17%
	\$50,001 to \$100,000	27%
	\$100,001 to \$150,000	13%
	\$150,001 to 200,000	4%
	Over \$200,000	2%
	Missing	12%
Difficulty paying bills	Extremely difficult	28%
	Very difficult	16%
	Somewhat difficult	24%
	Slightly difficult	12%
	Not difficult at all	16%
	Missing	3%
Occupational Complexity (ONET Job Zone)	1: Little or No Preparation Needed	5%
	2: Some Preparation Needed	23%
	3: Medium Preparation Needed	24%
	4: Considerable Preparation Needed	22%
	5: Extensive Preparation Needed	7%
	Missing	19%
<i>*May add up to more than 100% because respondents were allowed to check all that apply.</i>		

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4 Table 2 shows descriptive statistics of the reserve-building, person factors and demographic scores
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6 used to create the SES latent variable scores. Mother's education level was positively skewed,
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8 suggesting that most participants reported relatively low levels of maternal education. Two of the
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10 current Reserve-Building subscales were negatively skewed (Passive Media Consumption, Inner
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12 Life), suggested that most people spent substantial amounts of time in both of these types of
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14 activities. The other variables tested in the SEM model were normally distributed.
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Table 2. Descriptive Statistics of Variables Used In SEM Analysis				
	Obs	Median	Variable Label	Skewness
General SES				
Participant's Education	440	2	High School Diploma or GED	0.11
Mother's Education	431	1	Some High School or Less	1.05
Father's Education	418	1	Some High School or Less	0.85
Job Complexity	358	3	Medium Preparation Needed	0.03
Personal Finance				
Income	387	4	\$50,001 to \$100,000	0.12
Difficulty Paying Bills	428	3	Somewhat difficult	0.27
	Obs	Mean	Std. Dev.	Skewness
Current Reserve-Building Subscales				
Active in the World	439	49.91	7.65	0.65
Games	332	49.60	6.90	-0.10
Outdoor	438	49.40	7.63	0.35
Creative	440	50.03	7.03	0.47
Religious / Spiritual	437	49.97	7.68	0.45
Exercise	435	49.42	7.29	0.60
Passive Media Consumption	434	50.27	6.75	-1.25
Shopping / Cooking	438	49.86	8.01	0.36
Inner life	334	50.39	6.71	-1.17
Resilience	442	-0.11	1.02	-0.19
Covariate				
Number of Comorbidities	442	5.43	3.68	0.81

Table 3 shows Pearson correlation coefficients among the variables considered in the current study.

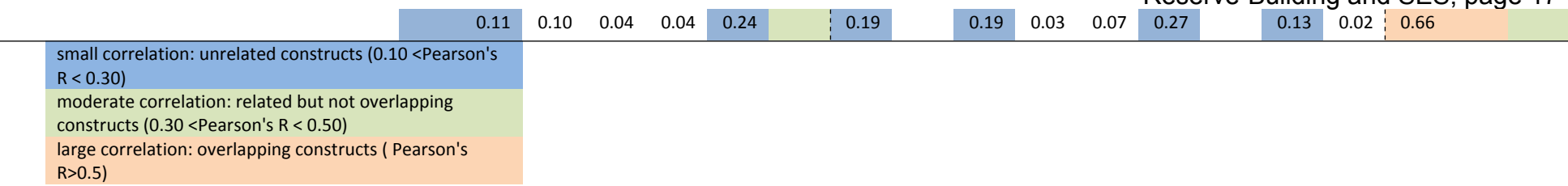
It revealed that the socioeconomic indices generally had small correlations, although mother's and father's education had moderate correlations, and difficulty paying bills had a moderate correlation with number of comorbidities. The Reserve-Building subscales generally had small or negligible correlations with socioeconomic indices, and small to moderate inter-correlations. The Reserve-Building measures generally had small or negligible correlations with the resilience score. Four Reserve-Building scores had small correlations with Resilience: Active in the World, Outdoors,

1 Exercise, and Shopping/Cooking. The resilience score was most driven by (fewer) number of days
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3 with physical health problems. Resilience had a moderate negative correlation with number of
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5 comorbidities and difficulty paying bills, and small positive correlations with respondent's education
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7 and income tertile. Resilience was not correlated with mother's education, father's education, or job
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9 complexity. The correlation matrix providing a starting point for parsimonious SEM model building,
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11 suggesting that the socioeconomic indicators be modeled as a latent variable(s), and considering only
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13 four of the nine Reserve-Building scores in the model: Active in the World, Outdoor, Exercise, and
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15 Shopping/Cooking.
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Table 3. Correlation Matrix of Variables Included in SEM Modeling

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1 Age																					
2 Gender	0.04																				
3 No. conditions	0.20	-0.09																			
4 Respondent's Education	0.13	0.03	0.12																		
5 Mother's Education	-0.15	0.06	0.05	0.19																	
6 Father's Education	-0.09	0.02	0.05	0.26	0.46																
7 O*NET Occupational Complexity	0.23	0.04	0.04	0.55	0.10	0.24															
8 Income Tertile	0.17	-0.03	0.25	0.29	0.07	0.07	0.25														
9 Difficulty Paying Bills	-0.29	-0.06	0.33	0.13	0.02	0.02	0.15	0.48													
10 Active in the World	0.10	0.05	0.08	0.26	0.11	0.14	0.22	0.24	0.25												
11 Games	0.10	-0.12	0.08	0.04	0.02	0.06	0.05	0.05	0.12	0.19											
12 Outdoor	0.05	0.09	0.09	0.12	0.02	0.07	0.08	0.16	0.21	0.31	0.21										
13 Creative	0.02	0.02	0.06	0.05	0.08	0.06	0.06	0.05	0.05	0.33	0.25	0.41									
14 Religious / Spiritual	0.08	-0.08	0.04	0.00	0.04	0.02	0.00	0.06	0.11	0.29	0.20	0.23	0.34								
15 Exercise	-0.03	0.18	0.15	0.18	0.16	0.07	0.06	0.22	0.26	0.36	0.11	0.43	0.25	0.16							
16 Passive media consumption	-0.10	0.06	0.10	0.11	0.17	0.08	0.06	0.13	0.01	0.03	0.19	0.02	0.07	0.02	0.02						
17 Shopping / Cooking	-0.05	-0.02	0.06	0.07	0.06	0.01	0.08	0.08	0.11	0.24	0.25	0.30	0.34	0.27	0.23	0.18					
18 Inner Life	0.13	-0.02	0.03	0.14	0.03	0.09	0.11	0.12	0.19	0.12	0.44	0.19	0.18	0.13	0.17	0.20	0.12				
19 Resilience	0.08	0.08	0.31	0.12	0.09	0.04	0.01	0.24	0.39	0.25	0.05	0.23	0.07	0.08	0.28	0.09	0.13	0.04			
20 Healthy_days1	0.03	-0.06	0.29	0.12	0.09	0.08	0.05	0.18	0.26	0.21	0.03	0.22	0.04	0.05	0.28	0.11	0.11	0.03	0.91		
21 Healthy_days2	-0.23	-0.08	0.21	0.08	0.05	0.04	0.06	0.24	0.43	0.22	0.06	0.15	0.10	0.12	0.16	0.04	0.12	0.04	0.71	0.36	
22 Healthy_days3	-0.09	-0.05	0.29	-	-	-	-	-	0.35	-	0.02	-	-	-	-	0.09	-	-	-	0.59	0.48

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small correlation: unrelated constructs (0.10 < Pearson's R < 0.30)

moderate correlation: related but not overlapping constructs (0.30 < Pearson's R < 0.50)

large correlation: overlapping constructs (Pearson's R > 0.5)

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Step 1: Bifactor model of SES

We first modeled SES as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills (Supplementary Figure 1). The specific (i.e., orthogonal) factors in the bifactor model account for residual covariance between Parent's Education (mother's and father's education) and Personal Finance (income and difficulty paying bills). Note that the magnitude of the general factor loadings is small for those items that also have factor loadings on Parent's Education and Personal Finance. This pattern is due to the strength of the covariance between these item subsets, and is reflected in the relatively high loadings on the specific factors. The bifactor SES model closely fit the data ($\chi^2=9.3$, $df=7$, $p=.23$; $RMSEA=.027$, $CFI=0.996$, $TLI=0.992$) and provided a starting point for subsequent mediation models.

Step 2: Simple mediation models for Reserve-Building activities

We next evaluated a series of simple mediation models where each of the nine Reserve-Building activities mediated the relationship between the general SES factor and Resilience (Supplementary Table 1). The results of these models led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise were significant mediators of the relationship between SES and Resilience. Of note, exercise was the strongest direct predictor for Resilience.

Step 3: Full mediation models tested

We then developed a mediation model where the relationship between SES (step 1) and Resilience was mediated by the three Reserve-Building activities identified in step 2. An addition, the number of comorbidities was modeled as a covariate of Resilience. The penultimate model accounted for 19% of variance in Resilience but poorly fit the data ($\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$; See Supplementary Table 2).

1 Review of modification indices and the correlation matrix in Table 3 suggested that the penultimate
2 mediation model was not accounting for relationships between Personal Finance, as defined in the
3 bifactor model, and Resilience. After adding the Personal Finance latent variable as a predictor of
4 Resilience, the final mediation model accounted for 25% of the variance in Resilience and closely fit
5 the data ($\chi^2=47.4$, $df=31$, $p=.03$; $RMSEA=.035$, $CFI=0.983$, $TLI=0.970$; See Table 4).
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Table 4. Final SEM Mediation Model Including Finance as a Predictor					
	Model	beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.33	0.05	6.48	<0.001
	SES -> Outdoor activities	0.14	0.06	2.47	0.014
	SES -> Exercise	0.19	0.05	3.55	<0.001
	Finance -> Active in the world	0.26	0.05	4.92	<0.001
	Finance -> Outdoor activities	0.22	0.06	4.07	<0.001
	Finance -> Exercise	0.30	0.05	6.03	<0.001
Predicting resilience: Direct effects	SES -> Resilience	0.04	0.06	0.71	0.476
	Finance -> Resilience	0.31	0.07	4.72	<0.001
	Active in the world -> Resilience	0.08	0.05	1.57	0.116
	Outdoor activities -> Resilience	0.07	0.05	1.37	0.170
	Exercise -> Resilience	0.10	0.05	1.88	0.060
	Comorbid Conditions -> Resilience	-0.14	0.05	-2.86	0.004
Predicting resilience: Total indirect effects	SES -> Resilience	0.06	0.02	2.65	0.008
	Finance -> Resilience	0.13	0.03	4.06	<0.001
		R²	se	t	P value
R square	Education	0.78	0.11	6.87	<0.001
	Father Education	0.59	0.04	13.71	<0.001
	Mother Education	0.55	0.04	13.00	<0.001
	ONET	0.46	0.08	6.14	<0.001
	INCOME	0.63	0.04	15.11	<0.001
	Difficulty paying bills	0.58	0.04	13.12	<0.001
	Number of Conditions	0.20	0.05	3.79	<0.001
	Active in the world	0.18	0.04	4.18	<0.001
	Outdoor activities	0.07	0.03	2.39	0.017
	Exercise	0.13	0.04	3.64	<0.001
	Resilience	0.25	0.05	5.54	<0.001
Model Fit Statistics: $\chi^2=47.4$, $df=31$, $p=.03$; $RMSEA=.035$, $CFI=0.983$, $TLI=0.970$					
Path coefficients are reflected by " -> "					

1 As illustrated in Figure 2, the relationship between Resilience and both SES and Personal Finance is
2 mediated by three Reserve-Building activities (Active in the World, Outdoor, and Exercise). In other
3 words, the bivariate relationships (SES to Resilience) were significant until Reserve-Building activities
4 were included in the model, and then the significant relationships were *only* from SES to Reserve-
5 Building, but not the paths from Reserve-Building to Resilience. Further, the three specific Reserve-
6 Building to Resilience paths have p-values are .00, .12, and .17, two of which are *nearly* significant or
7 highly significant. The total mediation effect considers them as a whole collection, and taken together
8 they do account for enough of the variance to create a total mediation effect.
9

10 In addition, the Personal Finance to Resilience path is also mediated by the participant's number of
11 comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both
12 General SES ($b = 0.06, p < 0.01$) and Personal Finance ($b = 0.13, p < 0.01$) to Resilience. This model
13 supports the hypothesis that the relationship between General SES and Resilience is fully mediated
14 by engaging in the three Reserve-Building activities. However, there is only partial mediation from
15 Personal Finance to Resilience because of the remaining significant direct effect ($b = 0.31, p < 0.01$).
16 Higher levels of Personal Finance were also negatively associated with number of comorbidities, and
17 those with more comorbidities generally had lower levels of Resilience.
18

19 [FIGURE 2 NEAR HERE]

20 **Post-hoc Analyses**

21 Figures 3a-3c juxtapose the relationship between reserve-building and resilience and the mean level
22 of each reserve-building activity, by SES-tertile group. Z-score transformations were used to compare
23 the correlation coefficients, and analysis of variance was used to compare means by group (Type I
24 error rate of 0.05). Figure 3a illustrates that the relationship between Active in the World and
25 resilience is similar across SES groups ($z=0.28, p=0.39$), but the mean level of these activities varied
26 by SES group ($F=7.20, df=2, p=0.001$). For Outdoor activities, the associations with resilience were
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not statistically significant ($z=1.65$, $p<0.10$), and the group means were not different from each other ($F=1.30$, $df=2$, $p=0.27$). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience ($z=2.10$, $p<0.05$), and the group means were not different from each other ($F=2.57$, $df=2$, $p=0.08$).

[FIGURES 3a-c NEAR HERE]

Discussion

Our findings are consistent with the idea that the SES-Resilience link is mediated by the individual's engagement in Reserve-Building activities. Thus, people with higher SES tend to be more resilient in the face of chronic illness by dint of their regular practice of activities that stimulate them intellectually, culturally, and physically. In other words, people with higher SES may be more likely to spend their discretionary time engaging in reserve-building activities, and this practice makes them more resilient despite their chronic illness. The post-hoc analyses revealed that the association between reserve-building and resilience was similar across SES-tertile groups for Active in the World and Outdoor activities, but not for Exercise. For Exercise, medium-SES people who engaged in more exercise had more resilience, but this was not as strongly associated in the high-SES group. The high-SES group engaged in more Active in the World activities but similar levels of Outdoor and Exercise activities compared to the other SES-tertile groups. Our findings suggest that resilience is not determined by SES, but is modifiable if individuals can augment their practice of three types of reserve-building activities, such as attending lectures or concerts, participating in outdoor activities, and engaging in physical exercise. Choosing to engage in these three types of activities rather than other more passive, less stimulating activities appears to have a beneficial association with health.

A second finding of the present study is that Personal Finance had a direct effect on resilience: individuals with higher income and/or lower difficulty paying bills had higher resilience scores. Personal Finance also played a role in the relationship between number of comorbidities and

1 resilience: people with more financial resources tended to have fewer comorbidities, these financial
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3 resources had a smaller protective effect in the context of multiple comorbidities. This finding may
4
5 reflect the fact that people with fewer financial resources are less likely to treat their comorbidities ³⁶.
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8 Untreated comorbidities would likely reduce one's ability to be resilient to health challenges.
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11 There has been an increasing interest in improving healthcare outcomes. In this context, 'social
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13 determinants of health' are more often than not cast in terms of deficits or negative situations that
14
15 people encounter^{37 38}. What is missing is addressing positive social determinants of health ^{39 40}, or
16
17 person factors that confer resilience, such as reserve-building activities. Our findings suggest that it
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19 would be worthwhile to recommend the three types of activities associated with enhanced resilience.
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22 Although exercise is standardly recommended to reduce mortality, our findings suggest that it is also
23
24 beneficial for conferring day-to-day resilience in the face of physical or mental health problems.
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27 Further, other types of activities may confer similar benefits. Thus, there may be more options that
28
29 healthcare providers can offer to people that can help them achieve better resilience and that might fit
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31 their lifestyle more easily, if exercise is not a viable option.
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34 The present study has a notable strength in its large and heterogeneous sample, which is useful for
35
36 testing a complex hypothesis via SEM techniques. It included both income and difficulty paying bills in
37
38 the operationalization of General SES and Personal Finance, thus capturing complementary and
39
40 distinct aspects of financial well-being that are often not considered in tandem. The sample had
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42 important variability in comorbidity burden, which allowed for evaluating the independent relationship
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44 between comorbidity and resilience. The limitations of this study should, however, be noted. While the
45
46 sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged
47
48 white females who are married or living with family members. Thus, additional work is needed to
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50 establish relationships with resilience across age, gender, race, and ethnicity groups. Indeed, age
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52 and gender were not strongly related as shown in bivariate correlations and thus were not kept in our
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1 SEM models. We are unable to quantify the response rate and thus to further identify the selection
2 bias because we do not have access to information about who was invited to participate in the study
3 and opted not to participate. The data are also cross-sectional, limiting our ability to test mediation
4 effects with certainty or causal effects. Replication of our findings in longitudinal data is needed.
5
6 Finally, there are potential confounding factors, such as structural environmental factors, that were
7 not addressed in the analysis. While it may be true that many of the reserve-building activities are
8 free or inexpensive, that does not mean that they are equally accessible across SES groups. For
9 example, people from lower SES backgrounds are often limited in their available free time (especially
10 those who work more than one job) and in structural opportunities for activities like exercise (limited
11 availability of green space, safe places to walk/run, access to gyms or sports facilities) and outdoor
12 recreation. Cooking, shopping, and many cultural events also have associated costs. Even if
13 cultural/intellectual events are free, they are often difficult to get to and people from low-SES
14 backgrounds often have transportation barriers. Future research might address how to increase the
15 perceived and real availability and opportunities for engaging in reserve-building activities among
16 people with fewer SES resources and/or with more severe illness. For example, motivational
17 interviewing techniques might be useful for addressing perceived barriers to different types of
18 reserve-building activities (e.g., cultural activities, exercise, etc.), and helping patients to find
19 inexpensive ways to get such activities into their lives.
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45 In summary, the present study provides suggestive evidence that reserve-building activities may be
46 one pathway by which SES is associated with resilience: people of higher SES may be more likely to
47 engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and
48 include physical exercise. The implications of these findings may be useful for empowering patients to
49 introduce more such reserve-building activities in their lives, and to replace more passive activities
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(e.g., television) with these active, salutogenic pursuits. Fundamentally, the reserve-building activities implicated in the present study are not costly to pursue (“the best things in life are free”). This critical accessibility and affordability has applications for public-health interventions to enhance resilience in healthy and chronically ill individuals. It is important to ensure that individuals from low SES backgrounds have opportunities for reserve-building activities.

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Data sharing statement

No additional data available.

Data deposition

Not applicable.

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Figure Legends

Figure 1. Theoretical Model Being Tested. It was hypothesized that Reserve-Building activities would mediate the relationship between SES and Resilience. Thus, the direct effect from SES to Resilience would be partially or fully attenuated through both variables' relationship with Reserve-Building (the mediator).

Figure 2. The Full Mediation Model. Reserve-building activities mediate the relationships between Resilience and both SES and Personal Finance. The relevant Reserve-Building activities are Active in the World, Outdoor, and Exercise. The Personal Finance to Resilience path is also mediated by the participant's number of comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both General SES ($b = 0.06, p < 0.01$) and Personal Finance ($b = 0.13, p < 0.01$) to Resilience. This model supports the hypothesis that the relationship between General SES and Resilience is mediated by engaging in the three Reserve-Building activities. Bold values indicate significant paths ($p < .05$).

Figures 3a-3c. The Relationship Between Reserve-Building and Resilience. Correlation coefficients between the reserve-building activity and resilience are displayed as bar charts, with the left axis showing units. The mean values by SES tertile are displayed as line graphs, with the right axis showing units. The relationship between Active in the World and resilience is similar across SES groups, but the mean level of these activities varied by SES group (Figure 3a). For Outdoor activities, the associations with resilience and the group means were not different from each other (Figure 3b). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience, and the group means were not different from each other (Figure 3c).

Supplementary Figure 1. The Bifactor Model of SES. SES was modeled as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills.

Figure 1. Theoretical model being tested

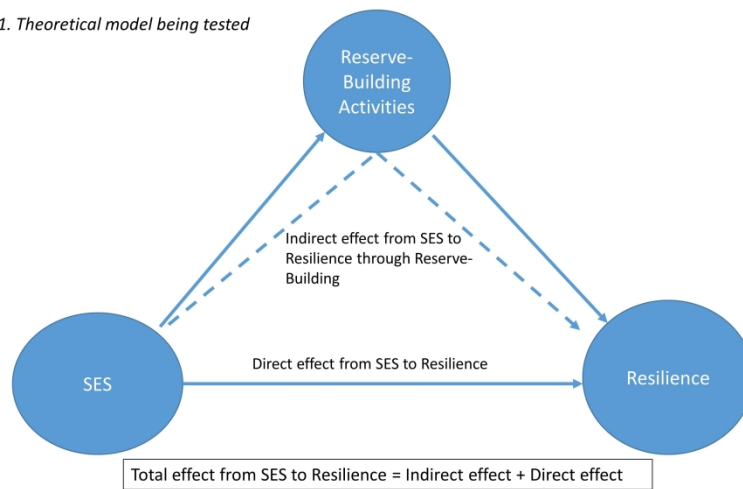


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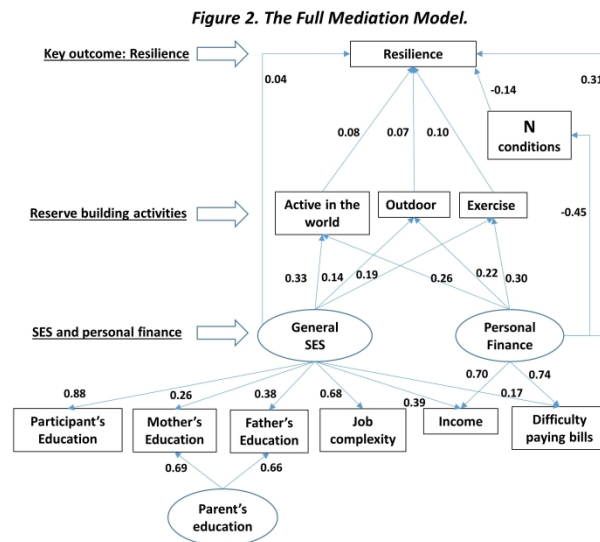
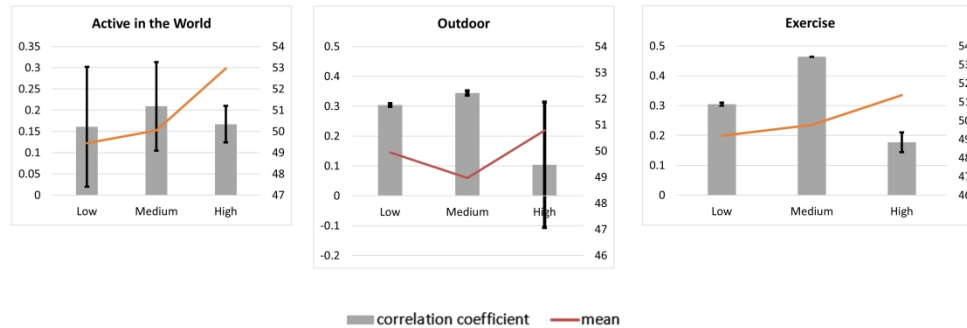


Figure 2. The Full Mediation Model. Reserve-building activities mediate the relationships between Resilience and both SES and Personal Finance. The relevant Reserve-Building activities are Active in the World, Outdoor, and Exercise. The Personal Finance to Resilience path is also mediated by the participant's number of comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both General SES ($b = 0.06$, $p < 0.01$) and Personal Finance ($b = 0.13$, $p < 0.01$) to Resilience. This model supports the hypothesis that the relationship between General SES and Resilience is mediated by engaging in the three Reserve-Building activities. Bold values indicate significant paths ($p < .05$).

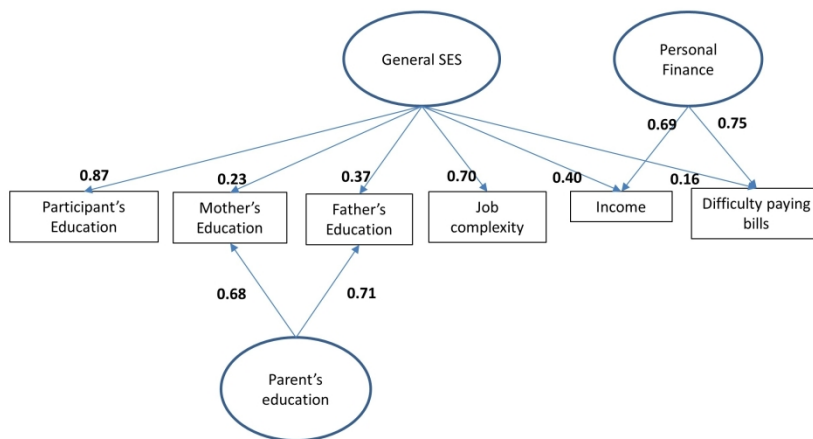
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Figures 3a-3c. The Relationship Between Reserve-Building and Resilience. Correlation coefficients between the reserve-building activity and resilience are displayed as bar charts, with the left axis showing units. The mean values by SES tertile are displayed as line graphs, with the right axis showing units. The relationship between Active in the World and resilience is similar across SES groups, but the mean level of these activities varied by SES group (Figure 3a). For Outdoor activities, the associations with resilience and the group means were not different from each other (Figure 3b). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience, and the group means were not different from each other (Figure 3c).

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Supplementary Figure 1. The Bifactor Model of SES



Supplementary Figure 1. The Bifactor Model of SES. SES was modeled as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills.

254x190mm (300 x 300 DPI)

Supplementary Table 1. Results of Simple Mediation Models	
	Direct Effects
Model	Estimate
SES -> Active in the world	0.41 ***
SES -> Resilience	0.14 *
Active in the world -> Resilience	0.19 ***
Indirect effect	0.08 ***
SES -> Games	0.05
SES -> Resilience	0.20 ***
Games -> Resilience	-0.06
Indirect effect	0.00
SES -> Outdoor	0.20 ***
SES -> Resilience	0.16 ***
Outdoor -> Resilience	0.20 ***
Indirect effect	0.04 **
SES -> Creative	0.11
SES -> Resilience	0.19 ***
Creative -> Resilience	0.05
Indirect effect	0.01
SES -> Religious / Spiritual	0.04
SES -> Resilience	0.19 ***
Religious / Spiritual -> Resilience	0.07
Indirect effect	0.00
SES -> Exercise	0.29 ***
SES -> Resilience	0.15 **
Exercise -> Resilience	0.24 ***
Indirect effect	0.07 *
SES -> Passive Media Consumption	-0.17 ***
SES -> Resilience	0.18 ***
Passive Media Consumption -> Resilience	-0.06
Indirect effect	0.01
SES -> Shopping / Cooking	-0.06
SES -> Resilience	0.20 ***
Shopping / Cooking -> Resilience	0.14 ***
Indirect effect	-0.01
SES -> Inner life	0.23 ***
SES -> Resilience	0.20 ***
Inner life -> Resilience	-0.01
Indirect effect	0.00

† p<0.10; * p<0.05; ** p<0.01; *** p<0.001

Supplementary Table 2. Penultimate SEM Mediation Model Without Including Finance as a Predictor					
Model		beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.40	0.05	7.66	<0.001
	SES -> Outdoor activities	0.20	0.06	3.42	0.001
	SES -> Exercise	0.27	0.05	4.93	<0.001
Predicting resilience: Direct effects	SES -> Resilience	0.05	0.06	0.86	0.389
	Active in the world -> Resilience	0.12	0.05	2.41	0.016
	Outdoor activities -> Resilience	0.10	0.05	2.25	0.024
	Exercise -> Resilience	0.13	0.05	2.77	0.006
	Comorbid Conditions -> Resilience	-0.31	0.04	-7.11	<0.001
Predicting resilience: Total indirect effects	SES -> Resilience	0.11	0.03	3.79	<0.001
	SES-> Active in the world-> Resilience	0.05	0.02	2.25	0.025
Predicting resilience: Specific Indirect effects	SES-> Outdoor activities-> Resilience	0.02	0.01	1.87	0.061
	SES-> Exercise-> Resilience	0.035	0.015	2.308	0.021
		R²	se	t	P value
R square	Education	0.60	0.08	7.81	<0.001
	Father Education	0.58	0.04	13.92	<0.001
	Mother Education	0.55	0.04	13.17	<0.001
	ONET	0.50	0.07	7.05	<0.001
	INCOME	0.59	0.05	12.57	<0.001
	Difficulty paying bills	0.51	0.05	10.34	<0.001
	Active in the world	0.16	0.04	3.83	<0.001
	Outdoor activities	0.04	0.02	1.71	0.087
	Exercise	0.07	0.03	2.46	0.014
Resilience	0.19	0.04	5.29	<0.001	

Model Fit Statistics: $\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$

Path coefficients are reflected by " -> "

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	11-12
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-10, Supp. Tables 1,2
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	NA

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	Tables 1,2
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13, Tables 3, 4, Supp. Tables 1, 2
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Tables 3, 4, Supp. Tables 1, 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	5, 15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

**Is the link between socioeconomic status and resilience mediated by reserve-building activities?
Mediation analysis of web-based cross-sectional data from chronic medical illness patient panels**

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025602.R2
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Date Submitted by the Author:	06-Feb-2019
Complete List of Authors:	Schwartz, Carolyn; DeltaQuest Foundation, Inc., ; Tufts University School of Medicine, Medicine & Orthopaedic Surgery Zhang, Jie; DeltaQuest Foundation, Inc. Stucky, Brian; Los Alamos National Laboratory Michael, Wesley; Rare Patient Voice, LLC Rapkin, Bruce; Albert Einstein College of Medicine, Epidemiology & Population Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Patient-centred medicine
Keywords:	cognitive reserve, socioeconomic status, social determinants of health, resilience, chronic illness

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4 Is the link between socioeconomic status and resilience mediated by reserve-building activities?

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6 Mediation analysis of web-based cross-sectional data from chronic medical illness patient panels
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Author Contributorship Statement:

Conceptualize and designed study: CES, BDS, BDR

Access to sample: WM

Data collection: CES, JZ, WM

Data Analysis: CES, JZ, BDS, BDR

Interpretation of findings: CES, JZ, BDS, BDR

Manuscript writing/editing: CES, JZ, WM, BDS, BDR

Abstract

Objectives: The purpose of this study is to test the hypothesis that the link between socioeconomic status (SES) and resilience is mediated by reserve-building activities.

Design: Cross-sectional observational study. Structural equation modeling (SEM) was used to test the mediation hypothesis.

Setting: Web-based survey

Participants: Participants with a chronic medical condition were recruited from Rare Patient Voice, LLC

Primary and Secondary Outcome Measures: DeltaQuest Reserve-Building Measure; demographic variables to capture SES; Centers for Disease Control Healthy Days Core Module; Self-Administered Comorbidity Questionnaire. Resilience was operationalized using residual modeling.

Results: The study sample included 442 patients (mean age 49, 85% female). SES was modeled as a bifactor model comprised of General SES and specific factors for Personal Finance and Parent's Education. A series of simple mediation models predicting Resilience led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise. The full SEM model supported the hypothesis that the relationships from both General SES and Personal Finance to Resilience were mediated by engaging in the three Reserve-Building activities. In addition, number of comorbidities partially mediated the relationship between Personal Finance and Reserve-Building. Those with more comorbidities generally had lower levels of Resilience.

Conclusions: This study provides suggestive evidence that reserve-building activities may be one pathway by which SES is associated with resilience: people of higher SES are more likely to engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and include

1 physical exercise. These reserve-building activities are not costly to pursue. These findings may
2
3 empower patients to introduce more such reserve-building activities into their lives.
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6 **Key Words:** cognitive reserve; socioeconomic status; social determinants of health; resilience,
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8 chronic illness
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Article Summary

Strengths of this study

- The study uses a more comprehensive measure of reserve-building activities than previously used in past research.
- The study sample is robust (n=442 people with chronic illness), enabling the use of structural equation modeling to test the following mediation hypothesis: Reserve-building activities mediate the relationship between socioeconomic status and resilience.

Limitations of this study

- While the sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged white females who are married or living with family members.
- The data are also cross-sectional, limiting our ability to test mediation effects with certainty or causal effects.
- There are potential confounding factors, such as structural environmental factors, that were not addressed in the analysis. For example, while it may be true that many of the reserve-building activities are free or inexpensive, that does not mean that they are equally accessible across the SES continuum.

Introduction

Substantial health disparities exist in the United States, despite 18% of the gross national product expenditures being on health care¹. A large literature has documented the relationship between socioeconomic status (SES) on morbidity and mortality^{2,3}, and has shown that this relationship does not simply reflect the effects of poverty⁴. This SES-morbidity relationship is similar across income groups, extending beyond poverty to explain relative differences in health among higher SES groups as well^{2,4}. The SES-health connection may relate to patterns of social behavior and interpersonal experiences that either promote disease or protect against it^{4,5}.

Recent work on the concept of reserve and reserve-building activities may provide a useful mechanism by which (high) SES buffers health. Building on observational work in patient populations with neurological disease, a substantial body of research has documented that past and current engagement in activities that stimulate the brain may buffer against disease progression in people with multiple sclerosis, Alzheimer's disease, or other neurological conditions⁶⁻⁸, and may be protective against cognitive impairment after chemotherapy in cancer patients⁹. The past and current "reserve-building activities"^{10,11} may reflect not only whole-brain stimulation (e.g., education, childhood enrichment activities) but also "multiple intelligences" (i.e., skills ranging across intellectual, artistic, and physical pursuits)¹². Thus, engaging in reserve-building activities may promote better health outcomes across the health-illness spectrum (i.e., resilience) by helping the individual to stimulate the brain; and to remain flexible and with higher plasticity^{10,13-16}. This flexibility may translate to more adaptive ways of coping¹⁷, as well as to appraisal processes that emphasize the positive and focus on aspects of their life that are more controllable¹⁸.

To date, the fields of social determinants of health and reserve have remained distinct. Their inter-connection led to the present study involving a heterogeneous cohort of people with chronic illness. We seek to test the hypothesis that the SES-resilience link is mediated by reserve-building activities.

Methods

Sample

Eligible participants were patients with a chronic medical condition of age 18 years or older, and able to complete an online questionnaire. Participants were recruited from Rare Patient Voice, LLC and WhatNext panels, which include people with diagnoses of 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.

Patient and Public Involvement

The present study did not directly involve patients or the public in its design. It did, however, follow-up on a decade-long evolution. The concept of reserve-building evolved over a decade of research with chronically ill patients. The measure of reserve-building was developed over a period of seven years, involving patient feedback and input on item development, and cognitive interviews of earlier versions of the measure. Finally, the research question “Is reserve-building only available to patients with substantial financial and other socioeconomic resources?” was formulated by patients in open question-and-answer sessions directed at the first author at conference presentations. Results of this research path have been provided to study participants in the form of lay-language slide presentations supplied by the first author.

Procedure and Design

A web-based survey was administered in Spring 2016 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. No financial or other incentives were offered to participants. We followed study procedures described by Dillman’s Tailored Design Method¹⁹. The survey began with an informed consent form that participants endorsed prior to completing the questionnaires. The study was reviewed and approved by the New England Review Board (NEIRB#15-254), and conforms to the principles embodied in the Declaration of Helsinki.

Measures

Reserve-Building was measured with subscales from the validated *DeltaQuest Reserve-Building Measure*²⁰ assessing current reserve-building activities, past reserve-building activities, and person characteristics (see¹⁰ for full details of reliability and validity of the measure). The present study included the nine Current-Reserve-Building Activities subscales: 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). Person Factors related to reserve-building included subscales for Perseverance (5 items), Work Value (2 items), and Current Social Support (5 items)(see²⁰ for psychometric details).

To capture SES-related variables, we included the following variables from the DeltaQuest Reserve-Building measure's past reserve-building subscales: self and parent education, income, and occupational complexity. Occupational complexity was assessed using a series of skip-logic questions querying the job that was closest to the respondent's current or past occupation, which were then scored for complexity using the O*NET system²¹. Additionally, we included an item asking about the respondent's difficulty paying bills²². This item was reverse-coded so that higher scores reflected *lower* difficulty paying bills.

Resilience was measured using a residual model approach described below in Statistical Analysis. Items from the *Centers for Disease Control (CDC) Healthy Days Core Module*²³ was used to create the Resilience score, consistent with prior work done by members of our group²⁴. Two items ask the respondent to indicate how many days of the past 30 days their physical (Physical Health Problems) or mental (Mental Health Problems) health, respectively, was not good. A third item (Activities of Daily

1 Living Impaired (ADL Impaired)) asks how many days of the past 30 the respondent's poor physical
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3 or mental health kept them from doing their usual activities, such as self-care, work, or recreation.
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6 Respondent **demographic characteristics** included age, gender, cohabitation/marital status, with
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8 whom the person lives, employment status, annual household income categories, and number of
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10 comorbidities, as measured by the *Self-Administered Comorbidity Questionnaire* ²⁵.
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13 14 **Statistical Analysis**

15 To operationalize Resilience, we built on a precedent for using residual modeling to study
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17 epiphenomena ²⁶⁻²⁸. We computed a regression model with the CDC Healthy Days ADL Impaired as
18
19 the dependent variable, and Physical Health Problems, Mental Health Problems, and their interaction
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21 as predictors. The residuals from the regression model were saved and multiplied by negative one (-
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23 1). Thus, a high Resilience score reflects fewer-than-expected days that the respondent is unable to
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25 function due to physical or mental health problems or the synergistic effect of physical and mental
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27 health problems ²⁴.
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32 General SES was operationalized using a bifactor methodology (e.g., ^{29 30}). In a bifactor model, factor
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34 loadings on the single *general* factor reflect the magnitude of relationships between the variables
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36 (e.g., self and parent education, income, and occupational complexity) and general SES. In the
37
38 bifactor context, shared content between subsets of variables is captured by a second loading on a
39
40 content-*specific* factor. For example, the residual correlation between mother's and father's education
41
42 may be captured by the specific factor Parent's Education. Similarly, the residual correlation between
43
44 income and difficulty paying bills is captured by the specific factor Personal Finance. In this manner,
45
46 the bifactor model accounts for dependencies between items when establishing a total SES score.
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50
51 Mediation models were conducted within a structural equation modeling (SEM) framework. It was
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53 hypothesized that Reserve-Building activities would mediate the relationship between SES and
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55 Resilience. In mediation analyses there are two types of relationships (*pathways*) to consider. There
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1 is the *direct effect* from SES to Resilience, and there is the *indirect effect* from SES to Resilience
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3 through both variables' relationship with Reserve-Building (the *mediator*; See Figure 1). In this
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5 instance, mediation occurs when some (partial) or all (full) of the direct effect between SES and
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7 Resilience is accounted for by the indirect effect through Reserve-Building.
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10 [FIGURE 1 NEAR HERE]
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13 SEM mediation analyses were conducted using Mplus version 7 software. Model fit was evaluated
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15 using the following indices: $RMSEA \leq .08$, $TLI \geq .95$, and $CFI \geq .95$;^{31 32}. Analyses of observed variables
16
17 were conducted using Stata 15³³ and SPSS 24³⁴. Pearson correlations were evaluated using
18
19 Cohen's criteria for delineating small ($0.10 < r < 0.30$), medium ($0.30 < r < 0.50$), and large ($r > 0.50$)
20
21 effect sizes, hereafter referred to as small, medium and large correlations³⁵. We examined
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23 distributions of all variables to be included in the analysis.
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28 Results

29 Sample

30 The study sample included 442 patients. Table 1 provides the sociodemographic characteristics, ICD-
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32 10 categories, and reported comorbidities of this heterogeneous sample. The sample had a mean
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34 age of 49, and 85% were female. Most respondents were married and living with spouse and/or
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36 family members. The sample was predominantly white (91%), non-Hispanic ethnicity (92%), with 5%
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38 of respondents endorsing black race and 3% endorsing Asian, Middle-Eastern or Other. The most
39
40 prevalent ICD-10 index health conditions (i.e., for panel membership) were diseases of the nervous
41
42 system followed by neoplasms, and endocrine diseases. The most prevalent co-morbidities were
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44 back pain, depression, and insomnia. Sixty-nine percent of the sample reported a family income of
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46 less than \$100,000 annually, and 69% of the sample reported that it was somewhat, very, or
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48 extremely difficult to pay their bills. The majority of the sample reported past or current occupations
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50 reflecting little to medium preparation needed.
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Variable		
n		442
Age	Mean (sd)	48.97(12.96)
Gender (%)	Male	15%
	Female	85%
ICD-10 Diagnostic Category of Index Condition	Certain infectious and parasitic diseases	1%
	Neoplasms	25%
	Diseases of the blood and blood-forming organs and immune mechanism disorders	5%
	Endocrine, nutritional and metabolic diseases	6%
	Mental and behavioral disorders	3%
	Diseases of the nervous system	42%
	Diseases of the ear and mastoid process	0%
	Diseases of the circulatory system	3%
	Diseases of the respiratory system	3%
	Diseases of the digestive system	1%
	Diseases of the skin and subcutaneous tissue	1%
	Diseases of the musculoskeletal system and connective tissue	6%
	Diseases of the genitourinary system	0%
	Congenital malformations, deformations and chromosomal abnormalities	1%
Comorbidities (%)	Arthritis	38%
	Asthma	19%
	Back Pain	58%
	Cancer (now or in the past)	31%
	Depression	52%
	Diabetes	10%
	Heart Disease	10%
	High Blood Pressure	31%
	Insomnia	43%
	Kidney Disease	5%
	Liver Disease	3%
	Lung Disease	11%
	Stroke	2%
Ulcer or stomach disease	13%	
Education (%)	High school or less	14%
	Some college	38%
	College degree	27%
	Graduate degree	20%
	Missing	0%
Father's Education	High school or less	48%
	Some college	22%
	College degree	14%
	Graduate degree	11%

Reserve-Building and SES, page 12

	Missing	5%
Mother's Education	High school or less	49%
	Some college	30%
	College degree	11%
	Graduate degree	8%
	Missing	2%
Marital Status (%)	Never Married	15%
	Married	60%
	Cohabitation/ Domestic Partnership	7%
	Separated	2%
	Divorced	13%
	Widowed	2%
	Missing	1%
Living Situation* (%)	Spouse/ Partner	69%
	Other Relative (children, sibling, parent)	44%
	Friend/ Companion	4%
	Pet(s)	48%
	Alone	11%
	Other	1%
Income (%)	Less than \$15,000	11%
	\$15,001 to \$30,000	14%
	\$30,001 to \$50,000	17%
	\$50,001 to \$100,000	27%
	\$100,001 to \$150,000	13%
	\$150,001 to 200,000	4%
	Over \$200,000	2%
	Missing	12%
Difficulty paying bills	Extremely difficult	28%
	Very difficult	16%
	Somewhat difficult	24%
	Slightly difficult	12%
	Not difficult at all	16%
	Missing	3%
Occupational Complexity (ONET Job Zone)	1: Little or No Preparation Needed	5%
	2: Some Preparation Needed	23%
	3: Medium Preparation Needed	24%
	4: Considerable Preparation Needed	22%
	5: Extensive Preparation Needed	7%
	Missing	19%
<i>*May add up to more than 100% because respondents were allowed to check all that apply.</i>		

1
2
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4 Table 2 shows descriptive statistics of the reserve-building, person factors and demographic scores
5
6 used to create the SES latent variable scores. Mother's education level was positively skewed,
7
8 suggesting that most participants reported relatively low levels of maternal education. Two of the
9
10 current Reserve-Building subscales were negatively skewed (Passive Media Consumption, Inner
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12 Life), suggested that most people spent substantial amounts of time in both of these types of
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14 activities. The other variables tested in the SEM model were normally distributed.
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Table 2. Descriptive Statistics of Variables Used In SEM Analysis				
	Obs	Median	Variable Label	Skewness
General SES				
Participant's Education	440	2	High School Diploma or GED	0.11
Mother's Education	431	1	Some High School or Less	1.05
Father's Education	418	1	Some High School or Less	0.85
Job Complexity	358	3	Medium Preparation Needed	0.03
Personal Finance				
Income	387	4	\$50,001 to \$100,000	0.12
Difficulty Paying Bills	428	3	Somewhat difficult	0.27
	Obs	Mean	Std. Dev.	Skewness
Current Reserve-Building Subscales				
Active in the World	439	49.91	7.65	0.65
Games	332	49.60	6.90	-0.10
Outdoor	438	49.40	7.63	0.35
Creative	440	50.03	7.03	0.47
Religious / Spiritual	437	49.97	7.68	0.45
Exercise	435	49.42	7.29	0.60
Passive Media Consumption	434	50.27	6.75	-1.25
Shopping / Cooking	438	49.86	8.01	0.36
Inner life	334	50.39	6.71	-1.17
Resilience	442	-0.11	1.02	-0.19
Covariate				
Number of Comorbidities	442	5.43	3.68	0.81

Table 3 shows Pearson correlation coefficients among the variables considered in the current study.

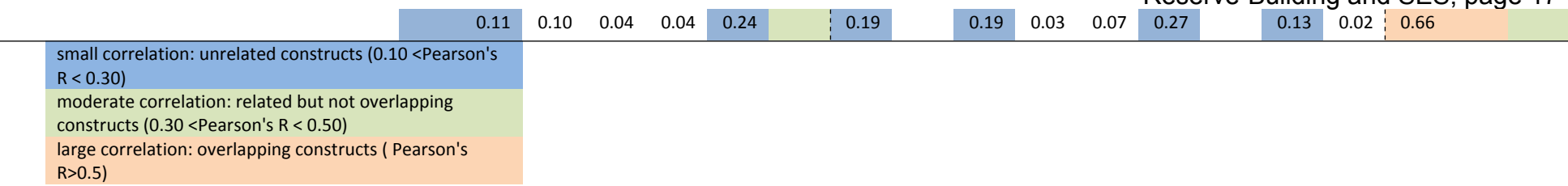
It revealed that the socioeconomic indices generally had small correlations, although mother's and father's education had moderate correlations, and difficulty paying bills had a moderate correlation with number of comorbidities. The Reserve-Building subscales generally had small or negligible correlations with socioeconomic indices, and small to moderate inter-correlations. The Reserve-Building measures generally had small or negligible correlations with the resilience score. Four Reserve-Building scores had small correlations with Resilience: Active in the World, Outdoors,

1 Exercise, and Shopping/Cooking. The resilience score was most driven by (fewer) number of days
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3 with physical health problems. Resilience had a moderate negative correlation with number of
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5 comorbidities and difficulty paying bills, and small positive correlations with respondent's education
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7 and income tertile. Resilience was not correlated with mother's education, father's education, or job
8
9 complexity. The correlation matrix providing a starting point for parsimonious SEM model building,
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11 suggesting that the socioeconomic indicators be modeled as a latent variable(s), and considering only
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13 four of the nine Reserve-Building scores in the model: Active in the World, Outdoor, Exercise, and
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15 Shopping/Cooking.
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Table 3. Correlation Matrix of Variables Included in SEM Modeling

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 Age																					
2 Gender	0.04																				
3 No. conditions	0.20	-0.09																			
4 Respondent's Education	0.13	0.03	-																		
5 Mother's Education	-0.15	0.06	0.05	0.19																	
6 Father's Education	-0.09	0.02	0.05	0.26	0.46																
7 O*NET Occupational Complexity	0.23	0.04	0.04	0.55	0.10	0.24															
8 Income Tertile	0.17	-0.03	0.25	0.29	0.07	0.07	0.25														
9 Difficulty Paying Bills	-0.29	-0.06	0.33	0.13	0.02	0.02	0.15	0.48													
10 Active in the World	0.10	0.05	0.08	0.26	0.11	0.14	0.22	0.24	0.25												
11 Games	0.10	-0.12	0.08	0.04	0.02	0.06	0.05	0.05	0.12	0.19											
12 Outdoor	0.05	0.09	0.09	0.12	0.02	0.07	0.08	0.16	0.21	0.31	0.21										
13 Creative	0.02	0.02	0.06	0.05	0.08	0.06	0.06	0.05	0.05	0.33	0.25	0.41									
14 Religious / Spiritual	0.08	-0.08	0.04	0.00	0.04	0.02	0.00	0.06	0.11	0.29	0.20	0.23	0.34								
15 Exercise	-0.03	0.18	0.15	0.18	0.16	0.07	0.06	0.22	0.26	0.36	0.11	0.43	0.25	0.16							
16 Passive media consumption	-0.10	0.06	0.10	0.11	0.17	0.08	0.06	0.13	0.01	0.03	0.19	0.02	0.07	0.02	0.02						
17 Shopping / Cooking	-0.05	-0.02	0.06	0.07	0.06	0.01	0.08	0.08	0.11	0.24	0.25	0.30	0.34	0.27	0.23	0.18					
18 Inner Life	0.13	-0.02	0.03	0.14	0.03	0.09	0.11	0.12	0.19	0.12	0.44	0.19	0.18	0.13	0.17	0.20	0.12				
19 Resilience	0.08	0.08	0.31	0.12	0.09	0.04	0.01	0.24	0.39	0.25	0.05	0.23	0.07	0.08	0.28	0.09	0.13	0.04			
20 Healthy_days1	0.03	-0.06	0.29	0.12	0.09	0.08	0.05	0.18	0.26	0.21	0.03	0.22	0.04	0.05	0.28	0.11	0.11	0.03	0.91		
21 Healthy_days2	-0.23	-0.08	0.21	0.08	0.05	0.04	0.06	0.24	0.43	0.22	0.06	0.15	0.10	0.12	0.16	0.04	0.12	0.04	0.71	0.36	
22 Healthy_days3	-0.09	-0.05	0.29	-	-	-	-	-	0.35	-	0.02	-	-	-	-	0.09	-	-	-	0.59	0.48

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small correlation: unrelated constructs (0.10 < Pearson's R < 0.30)

moderate correlation: related but not overlapping constructs (0.30 < Pearson's R < 0.50)

large correlation: overlapping constructs (Pearson's R > 0.5)

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Step 1: Bifactor model of SES

We first modeled SES as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills (Supplementary Figure 1). The specific (i.e., orthogonal) factors in the bifactor model account for residual covariance between Parent's Education (mother's and father's education) and Personal Finance (income and difficulty paying bills). Note that the magnitude of the general factor loadings is small for those items that also have factor loadings on Parent's Education and Personal Finance. This pattern is due to the strength of the covariance between these item subsets, and is reflected in the relatively high loadings on the specific factors. The bifactor SES model closely fit the data ($\chi^2=9.3$, $df=7$, $p=.23$; $RMSEA=.027$, $CFI=0.996$, $TLI=0.992$) and provided a starting point for subsequent mediation models.

Step 2: Simple mediation models for Reserve-Building activities

We next evaluated a series of simple mediation models where each of the nine Reserve-Building activities mediated the relationship between the general SES factor and Resilience (Supplementary Table 1). The results of these models led to the selection of three Reserve-Building activities for subsequent SEM-based mediation models: Active in the World, Outdoor, and Exercise were significant mediators of the relationship between SES and Resilience. Of note, exercise was the strongest direct predictor for Resilience.

Step 3: Full mediation models tested

We then developed a mediation model where the relationship between SES (step 1) and Resilience was mediated by the three Reserve-Building activities identified in step 2. An addition, the number of comorbidities was modeled as a covariate of Resilience. The penultimate model accounted for 19% of variance in Resilience but poorly fit the data ($\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$; See Supplementary Table 2).

1 Review of modification indices and the correlation matrix in Table 3 suggested that the penultimate
2 mediation model was not accounting for relationships between Personal Finance, as defined in the
3 bifactor model, and Resilience. After adding the Personal Finance latent variable as a predictor of
4 Resilience, the final mediation model accounted for 25% of the variance in Resilience and closely fit
5 the data ($\chi^2=47.4$, $df=31$, $p=.03$; $RMSEA=.035$, $CFI=0.983$, $TLI=0.970$; See Table 4).
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Table 4. Final SEM Mediation Model Including Finance as a Predictor					
	Model	beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.33	0.05	6.48	<0.001
	SES -> Outdoor activities	0.14	0.06	2.47	0.014
	SES -> Exercise	0.19	0.05	3.55	<0.001
	Finance -> Active in the world	0.26	0.05	4.92	<0.001
	Finance -> Outdoor activities	0.22	0.06	4.07	<0.001
	Finance -> Exercise	0.30	0.05	6.03	<0.001
Predicting resilience: Direct effects	SES -> Resilience	0.04	0.06	0.71	0.476
	Finance -> Resilience	0.31	0.07	4.72	<0.001
	Active in the world -> Resilience	0.08	0.05	1.57	0.116
	Outdoor activities -> Resilience	0.07	0.05	1.37	0.170
	Exercise -> Resilience	0.10	0.05	1.88	0.060
	Comorbid Conditions -> Resilience	- 0.14	0.05	-2.86	0.004
Predicting resilience: Total indirect effects	SES -> Resilience	0.06	0.02	2.65	0.008
	Finance -> Resilience	0.13	0.03	4.06	<0.001
		R²	se	t	P value
R square	Education	0.78	0.11	6.87	<0.001
	Father Education	0.59	0.04	13.71	<0.001
	Mother Education	0.55	0.04	13.00	<0.001
	ONET	0.46	0.08	6.14	<0.001
	INCOME	0.63	0.04	15.11	<0.001
	Difficulty paying bills	0.58	0.04	13.12	<0.001
	Number of Conditions	0.20	0.05	3.79	<0.001
	Active in the world	0.18	0.04	4.18	<0.001
	Outdoor activities	0.07	0.03	2.39	0.017
	Exercise	0.13	0.04	3.64	<0.001
	Resilience	0.25	0.05	5.54	<0.001
Model Fit Statistics: $\chi^2=47.4$, $df=31$, $p=.03$; $RMSEA=.035$, $CFI=0.983$, $TLI=0.970$					
Path coefficients are reflected by " -> "					

1 As illustrated in Figure 2, the relationship between Resilience and both SES and Personal Finance is
2 mediated by three Reserve-Building activities (Active in the World, Outdoor, and Exercise). In other
3 words, the bivariate relationships (SES to Resilience) were significant until Reserve-Building activities
4 were included in the model, and then the significant relationships were *only* from SES to Reserve-
5 Building, but not the paths from Reserve-Building to Resilience. Further, the three specific Reserve-
6 Building to Resilience paths have p-values are .00, .12, and .17, two of which are *nearly* significant or
7 highly significant. The total mediation effect considers them as a whole collection, and taken together
8 they do account for enough of the variance to create a total mediation effect.
9

10 In addition, the Personal Finance to Resilience path is also mediated by the participant's number of
11 comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both
12 General SES ($b = 0.06, p < 0.01$) and Personal Finance ($b = 0.13, p < 0.01$) to Resilience. This model
13 supports the hypothesis that the relationship between General SES and Resilience is fully mediated
14 by engaging in the three Reserve-Building activities. However, there is only partial mediation from
15 Personal Finance to Resilience because of the remaining significant direct effect ($b = 0.31, p < 0.01$).
16 Higher levels of Personal Finance were also negatively associated with number of comorbidities, and
17 those with more comorbidities generally had lower levels of Resilience.
18

19 [FIGURE 2 NEAR HERE]

20 **Post-hoc Analyses**

21 Figures 3a-3c juxtapose the relationship between reserve-building and resilience and the mean level
22 of each reserve-building activity, by SES-tertile group. Z-score transformations were used to compare
23 the correlation coefficients, and analysis of variance was used to compare means by group (Type I
24 error rate of 0.05). Figure 3a illustrates that the relationship between Active in the World and
25 resilience is similar across SES groups ($z=0.28, p=0.39$), but the mean level of these activities varied
26 by SES group ($F=7.20, df=2, p=0.001$). For Outdoor activities, the associations with resilience were
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not statistically significant ($z=1.65$, $p<0.10$), and the group means were not different from each other ($F=1.30$, $df=2$, $p=0.27$). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience ($z=2.10$, $p<0.05$), and the group means were not different from each other ($F=2.57$, $df=2$, $p=0.08$).

[FIGURES 3a-c NEAR HERE]

Discussion

Our findings are consistent with the idea that the SES-Resilience link is mediated by the individual's engagement in Reserve-Building activities. Thus, people with higher SES tend to be more resilient in the face of chronic illness by dint of their regular practice of activities that stimulate them intellectually, culturally, and physically. In other words, people with higher SES may be more likely to spend their discretionary time engaging in reserve-building activities, and this practice makes them more resilient despite their chronic illness. The post-hoc analyses revealed that the association between reserve-building and resilience was similar across SES-tertile groups for Active in the World and Outdoor activities, but not for Exercise. For Exercise, medium-SES people who engaged in more exercise had more resilience, but this was not as strongly associated in the high-SES group. The high-SES group engaged in more Active in the World activities but similar levels of Outdoor and Exercise activities compared to the other SES-tertile groups. Our findings suggest that resilience is not determined by SES, but is modifiable if individuals can augment their practice of three types of reserve-building activities, such as attending lectures or concerts, participating in outdoor activities, and engaging in physical exercise. Choosing to engage in these three types of activities rather than other more passive, less stimulating activities appears to have a beneficial association with health.

A second finding of the present study is that Personal Finance had a direct effect on resilience: individuals with higher income and/or lower difficulty paying bills had higher resilience scores. Personal Finance also played a role in the relationship between number of comorbidities and

1 resilience: people with more financial resources tended to have fewer comorbidities, these financial
2
3 resources had a smaller protective effect in the context of multiple comorbidities. This finding may
4
5 reflect the fact that people with fewer financial resources are less likely to treat their comorbidities ³⁶.
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8 Untreated comorbidities would likely reduce one's ability to be resilient to health challenges.
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11 There has been an increasing interest in improving healthcare outcomes. In this context, 'social
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13 determinants of health' are more often than not cast in terms of deficits or negative situations that
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15 people encounter^{37 38}. What is missing is addressing positive social determinants of health ^{39 40}, or
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17 person factors that confer resilience, such as reserve-building activities. Our findings suggest that it
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19 would be worthwhile to recommend the three types of activities associated with enhanced resilience.
20
21 Although exercise is standardly recommended to reduce mortality, our findings suggest that it is also
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23 beneficial for conferring day-to-day resilience in the face of physical or mental health problems.
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25 Further, other types of activities may confer similar benefits. Thus, there may be more options that
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27 healthcare providers can offer to people that can help them achieve better resilience and that might fit
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29 their lifestyle more easily, if exercise is not a viable option.
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34 The present study has a notable strength in its large and heterogeneous sample, which is useful for
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36 testing a complex hypothesis via SEM techniques. It included both income and difficulty paying bills in
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38 the operationalization of General SES and Personal Finance, thus capturing complementary and
39
40 distinct aspects of financial well-being that are often not considered in tandem. The sample had
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42 important variability in comorbidity burden, which allowed for evaluating the independent relationship
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44 between comorbidity and resilience. The limitations of this study should, however, be noted. While the
45
46 sample is heterogeneous in its illness representation, it is predominantly comprised of middle-aged
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48 white females who are married or living with family members. Accordingly, there was too little
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50 variation in race or ethnicity to permit inclusion of these variables in the SEM models. Thus, additional
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52 work is needed to establish relationships with resilience across age, gender, race, and ethnicity
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1 groups. Indeed, age and gender were not strongly related as shown in bivariate correlations and thus
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3 were not kept in our SEM models. We are unable to quantify the response rate and thus to further
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5 identify the selection bias because we do not have access to information about who was invited to
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7 participate in the study and opted not to participate. The data are also cross-sectional, limiting our
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9 ability to test mediation effects with certainty or causal effects. There is, however, some debate about
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11 cross-sectional mediation when the presumed mediator logically precedes the outcome, even if both
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13 are measured in the same survey. In our case, the data were collected at one time-point, but the
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15 reserve-building activities logically precede the resilience score. The reserve-building items query
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17 activities done over the past one to six months, depending on the type of activity, and these activities
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19 are generally long-standing hobbies or practices. The SES variables are either far in the past (e.g.,
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21 parental education, participant education) or relatively long-standing (i.e., over the past year or two,
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23 such as income or difficulty paying bills). In contrast, the resilience questions query physical and
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25 mental health sick-days of only *the past 30 days*. Thus, there is a logical precedence to the activities
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27 included as predictors or mediators. Nonetheless, replication of our findings in longitudinal data is
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29 needed to dispute possible “reverse causality” (i.e., the presumed mediator causes the presumed
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31 outcome or vice versa) . Finally, there are potential confounding factors, such as structural
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33 environmental factors, that were not addressed in the analysis. While it may be true that many of the
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35 reserve-building activities are free or inexpensive, that does not mean that they are equally
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37 accessible across SES groups. For example, people from lower SES backgrounds are often limited in
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39 their available free time (especially those who work more than one job) and in structural opportunities
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41 for activities like exercise (limited availability of green space, safe places to walk/run, access to gyms
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43 or sports facilities) and outdoor recreation. Cooking, shopping, and many cultural events also have
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45 associated costs. Even if cultural/intellectual events are free, they are often difficult to get to and
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47 people from low-SES backgrounds often have transportation barriers. Future research might address
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49 how to increase the perceived and real availability and opportunities for engaging in reserve-building
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1 activities among people with fewer SES resources and/or with more severe illness. For example,
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3 motivational interviewing techniques might be useful for addressing perceived barriers to different
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5 types of reserve-building activities (e.g., cultural activities, exercise, etc.), and helping patients to find
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7 inexpensive ways to get such activities into their lives.
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13 In summary, the present study provides suggestive evidence that reserve-building activities may be
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15 one pathway by which SES is associated with resilience: people of higher SES may be more likely to
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17 engage in reserve-building activities that are intellectually stimulating, involve outdoor pursuits, and
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19 include physical exercise. The implications of these findings may be useful for empowering patients to
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21 introduce more such reserve-building activities in their lives, and to replace more passive activities
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23 (e.g., television) with these active, salutogenic pursuits. Fundamentally, the reserve-building activities
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25 implicated in the present study are not costly to pursue (“the best things in life are free”). This critical
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27 accessibility and affordability has applications for public-health interventions to enhance resilience in
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29 healthy and chronically ill individuals. It is important to ensure that individuals from low SES
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31 backgrounds have opportunities for reserve-building activities.
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38
39

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42
43

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45 All authors declare that they have no potential conflicts of interest and report no disclosures.
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47

48 **Data sharing statement**

49 Participants did not consent to having their data shared with anyone other than DeltaQuest
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51 Foundation research staff.
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Data deposition

Not applicable.

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Figure Legends

Figure 1. Theoretical Model Being Tested. It was hypothesized that Reserve-Building activities would mediate the relationship between SES and Resilience. Thus, the direct effect from SES to Resilience would be partially or fully attenuated through both variables' relationship with Reserve-Building (the mediator).

Figure 2. The Full Mediation Model. Reserve-building activities mediate the relationships between Resilience and both SES and Personal Finance. The relevant Reserve-Building activities are Active in the World, Outdoor, and Exercise. The Personal Finance to Resilience path is also mediated by the participant's number of comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both General SES ($b = 0.06, p < 0.01$) and Personal Finance ($b = 0.13, p < 0.01$) to Resilience. This model supports the hypothesis that the relationship between General SES and Resilience is mediated by engaging in the three Reserve-Building activities. Bold values indicate significant paths ($p < .05$).

Figures 3a-3c. The Relationship Between Reserve-Building and Resilience. Correlation coefficients between the reserve-building activity and resilience are displayed as bar charts, with the left axis showing units. The mean values by SES tertile are displayed as line graphs, with the right axis showing units. The relationship between Active in the World and resilience is similar across SES groups, but the mean level of these activities varied by SES group (Figure 3a). For Outdoor activities, the associations with resilience and the group means were not different from each other (Figure 3b). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience, and the group means were not different from each other (Figure 3c).

Supplementary Figure 1. The Bifactor Model of SES. SES was modeled as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills.

Figure 1. Theoretical model being tested

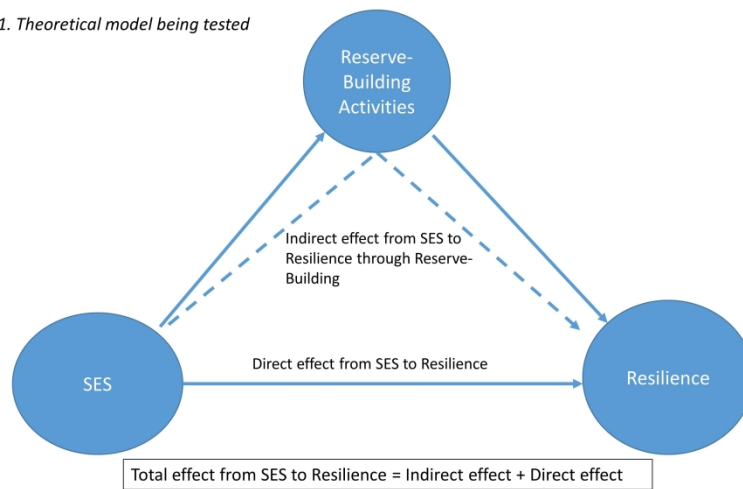


Figure 1. Theoretical Model Being Tested. It was hypothesized that Reserve-Building activities would mediate the relationship between SES and Resilience. Thus, the direct effect from SES to Resilience would be partially or fully attenuated through both variables' relationship with Reserve-Building (the mediator).

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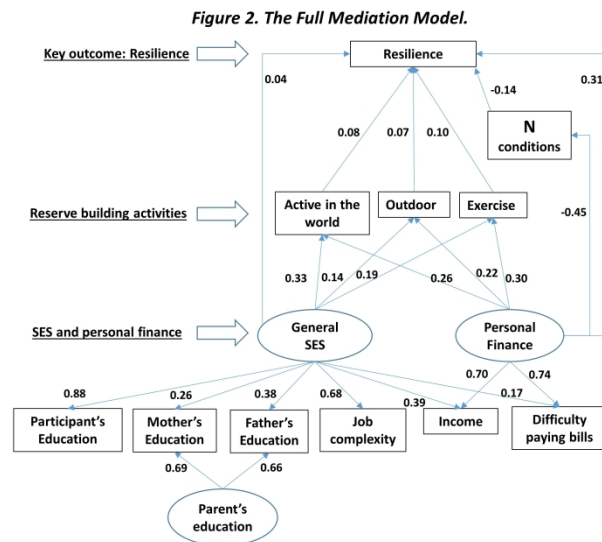
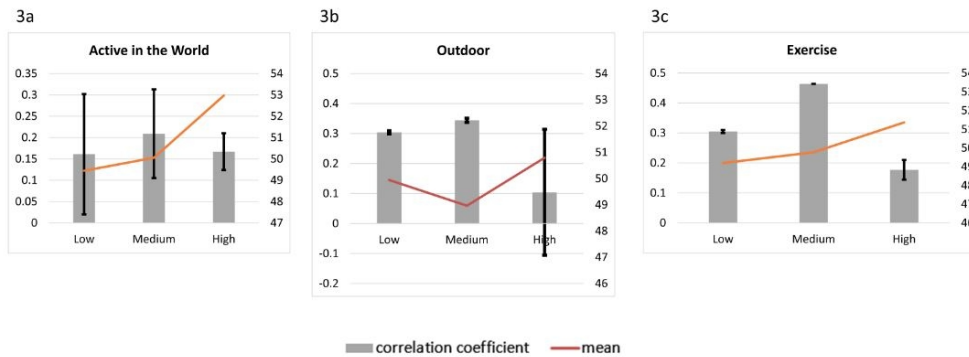


Figure 2. The Full Mediation Model. Reserve-building activities mediate the relationships between Resilience and both SES and Personal Finance. The relevant Reserve-Building activities are Active in the World, Outdoor, and Exercise. The Personal Finance to Resilience path is also mediated by the participant's number of comorbid conditions. As indicated in Table 4, there are significant total indirect effects from both General SES ($b = 0.06$, $p < 0.01$) and Personal Finance ($b = 0.13$, $p < 0.01$) to Resilience. This model supports the hypothesis that the relationship between General SES and Resilience is mediated by engaging in the three Reserve-Building activities. Bold values indicate significant paths ($p < .05$).

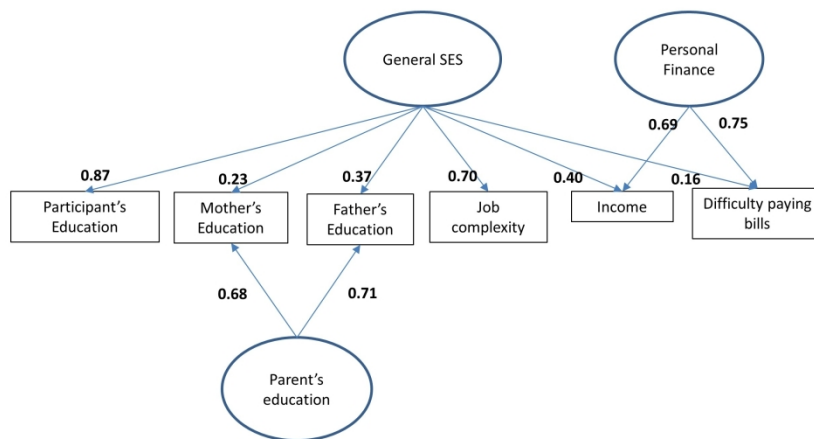
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Figures 3a-3c. The Relationship Between Reserve-Building and Resilience. Correlation coefficients between the reserve-building activity and resilience are displayed as bar charts, with the left axis showing units. The mean values by SES tertile are displayed as line graphs, with the right axis showing units. The relationship between Active in the World and resilience is similar across SES groups, but the mean level of these activities varied by SES group (Figure 3a). For Outdoor activities, the associations with resilience and the group means were not different from each other (Figure 3b). For Exercise, however, the medium and high SES groups showed a statistically significant difference in associations with resilience, and the group means were not different from each other (Figure 3c).

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Supplementary Figure 1. The Bifactor Model of SES



Supplementary Figure 1. The Bifactor Model of SES. SES was modeled as a bifactor model with the general factor comprised of respondent's education, father's education, mother's education, occupational complexity, income tertile, and endorsed difficulty paying bills.

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Supplementary Table 1. Results of Simple Mediation Models	
	Direct Effects
Model	Estimate
SES -> Active in the world	0.41 ***
SES -> Resilience	0.14 *
Active in the world -> Resilience	0.19 ***
Indirect effect	0.08 ***
SES -> Games	0.05
SES -> Resilience	0.20 ***
Games -> Resilience	-0.06
Indirect effect	0.00
SES -> Outdoor	0.20 ***
SES -> Resilience	0.16 ***
Outdoor -> Resilience	0.20 ***
Indirect effect	0.04 **
SES -> Creative	0.11
SES -> Resilience	0.19 ***
Creative -> Resilience	0.05
Indirect effect	0.01
SES -> Religious / Spiritual	0.04
SES -> Resilience	0.19 ***
Religious / Spiritual -> Resilience	0.07
Indirect effect	0.00
SES -> Exercise	0.29 ***
SES -> Resilience	0.15 **
Exercise -> Resilience	0.24 ***
Indirect effect	0.07 *
SES -> Passive Media Consumption	-0.17 ***
SES -> Resilience	0.18 ***
Passive Media Consumption -> Resilience	-0.06
Indirect effect	0.01
SES -> Shopping / Cooking	-0.06
SES -> Resilience	0.20 ***
Shopping / Cooking -> Resilience	0.14 ***
Indirect effect	-0.01
SES -> Inner life	0.23 ***
SES -> Resilience	0.20 ***
Inner life -> Resilience	-0.01
Indirect effect	0.00

† p<0.10; * p<0.05; ** p<0.01; *** p<0.001

Supplementary Table 2. Penultimate SEM Mediation Model Without Including Finance as a Predictor					
Model		beta	se	t	P value
Predicting reserve building	SES -> Active in the world	0.40	0.05	7.66	<0.001
	SES -> Outdoor activities	0.20	0.06	3.42	0.001
	SES -> Exercise	0.27	0.05	4.93	<0.001
Predicting resilience: Direct effects	SES -> Resilience	0.05	0.06	0.86	0.389
	Active in the world -> Resilience	0.12	0.05	2.41	0.016
	Outdoor activities -> Resilience	0.10	0.05	2.25	0.024
	Exercise -> Resilience	0.13	0.05	2.77	0.006
	Comorbid Conditions -> Resilience	-0.31	0.04	-7.11	<0.001
Predicting resilience: Total indirect effects	SES -> Resilience	0.11	0.03	3.79	<0.001
	SES-> Active in the world-> Resilience	0.05	0.02	2.25	0.025
Predicting resilience: Specific Indirect effects	SES-> Outdoor activities-> Resilience	0.02	0.01	1.87	0.061
	SES-> Exercise-> Resilience	0.035	0.015	2.308	0.021
		R²	se	t	P value
R square	Education	0.60	0.08	7.81	<0.001
	Father Education	0.58	0.04	13.92	<0.001
	Mother Education	0.55	0.04	13.17	<0.001
	ONET	0.50	0.07	7.05	<0.001
	INCOME	0.59	0.05	12.57	<0.001
	Difficulty paying bills	0.51	0.05	10.34	<0.001
	Active in the world	0.16	0.04	3.83	<0.001
	Outdoor activities	0.04	0.02	1.71	0.087
	Exercise	0.07	0.03	2.46	0.014
Resilience	0.19	0.04	5.29	<0.001	

Model Fit Statistics: $\chi^2=229.1$, $df=36$, $p<.01$; $RMSEA=.110$, $CFI=0.796$, $TLI=0.689$

Path coefficients are reflected by " -> "

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	11-12
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-10, Supp. Tables 1,2
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	NA

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	Tables 1,2
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13, Tables 3, 4, Supp. Tables 1, 2
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Tables 3, 4, Supp. Tables 1, 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	5, 15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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