The vital personality and healthy aging:

Replicated life-course evidence about measurement, correlates, and familial transmission

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ABSTRACT (Word count: 196)

Personality traits are linked with healthy aging, but it is unclear how these associations come to manifest across the life-course. To study this question, we developed and validated a measure that aggregates the contributions of Big 5 personality traits to mortality: a "vital personality" score. We used the vital personality score to test a series of hypotheses about life-course associations between personality and healthy aging. Our data come from two population-based cohort studies, comprising over 6,000 participants across two generations, and spanning an age range from childhood to late life. Our analyses revealed three main findings: First, the vital personality score predicted lifespan and healthspan. Individuals with more vital personalities lived longer, aged slower, and had healthier lifestyles. Second, the vital personality score showed both stability and change across the lifespan. Individuals' vital personalities could be predicted from early-life temperament and were relatively stable across adulthood, but also increased across time. Third, vital personalities clustered within families. Individuals with more vital personalities had children with similarly vital partners, and these children grew up to have more vital personalities themselves. Our study shows how the health benefits associated with personality accrue throughout the life-course and across generations.

Keywords: personality, aging, health, life-course, Big 5

Life expectancy has been increasing around the world, fuelling research efforts to understand determinants of healthy aging. There is growing recognition of the role of psychological factors in healthy aging, particularly of people's personalities. A wealth of research now documents links between personality traits, (un)healthy aging and mortality.[1–3 4,5] In order to translate these findings into interventions, more work is needed to understand how associations between personality traits and healthy aging unfold across the life-course. Here we address this question.

Our study has two novel elements. First, we developed and validated a measure of personality that quantifies the cumulative contribution of an individual's personality traits to healthy aging. Personality traits can be organized along five dimensions, labeled the "Big Five": Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism.[6–9] Prior research has often investigated each trait in isolation.[4,5,10] However, individuals do not vary along a single trait only; it is the combination of traits that constitutes a personality. To develop a measure that captures aging-related variation across Big 5 personality traits, we borrowed methods from algorithm-based scoring systems such as those summarizing cardiovascular disease risk (e.g., Framingham Risk Score[11]) or genetic propensity (e.g., polygenic scores[12]). These algorithms construct individual risk scores by weighting multiple factors (e.g., health-risk factors or genetic variants) by the strength of association with an outcome, as estimated in independent training samples (e.g., health survey or genome-wide association study). Such scores have several attractive properties. First, summarizing across multiple factors (e.g. millions of genetic variants) produces a more thorough description of a person's profile than does a single factor (e.g. single genetic variant). Second, using scoring weights estimated in an independent training sample minimizes the risk of overfitting a predictive model to a dataset, increasing generalizability and replicability. Third, weighing each contributing factor by its association with

an outcome of interest maximizes criterion validity of the resulting score. The approach of computing personality profiles using meta-analytic results has recently been used in research on obesity[13] and attainment.[14] Here we apply this method to studying associations between personality traits and healthy aging. Specifically, we used the published regression weights from a meta-analysis of associations between Big 5 traits and mortality[5] to develop a poly-trait measure for mortality: a "vital personality" score. The score aggregates the contributions of the Big 5 personality traits to mortality. In the meta-analysis, all Big 5 traits apart from Openness were significantly associated with mortality, with effect sizes ranging from HR=.87 (for Conscientiousness) to HR=1.08 (for Neuroticism) (Jokela et al., 2013; Web Table 3). For our vital personality score we included all Big 5 traits, and opted against modeling nonlinearities and intercorrelations, in keeping with practices of polygenic score construction[12,15] (however, we report additional analyses in the supplementary materials).

The second novel element of our study is that in order to capture the unfolding of personality-aging associations across life-course and across generations, we combined data collected from individuals and their parents. Participants are members of two population-based longitudinal cohort studies, one based in New Zealand and the other in the UK, together totalling a sample size of over 6,000 and covering an age range from childhood to late life. We used these data to test three sets of hypotheses; (1) about the validity of the vital personality score to predict indicators of health and aging (including mortality); (2) about the development of the vital personality across the life-course; and (3) about its intergenerational transmission.

METHODS

Samples

This study uses data from two population-based longitudinal cohort studies; the Dunedin Longitudinal Study in New Zealand, and the Environmental Risk (E-Risk) Longitudinal Twin Study in the UK. In both studies, we collected data from participants and their parents.

Dunedin participants (N=1,037; 91% of eligible births; 52% male) were all individuals born between April 1972 and March 1973 in Dunedin (NZ), who were eligible based on residence and participated in the first assessment at age 3.[16] The cohort represented the full range of SES in the general population of New Zealand's South Island. On adult health, it matches the NZ National Health & Nutrition Survey.[16] The cohort is primarily white (93%). Assessments were carried out at birth and ages 3, 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, and 38 years, when 95% (n=961) of the 1,007 participants still alive took part. At assessments, each study member is brought to the research unit for a day of interviews and examinations. The Otago Ethics Committee approved each phase of the study. Data on Dunedin participants' parents were collected during home visits carried out from 2003-2006 when participants were 30 to 33 years old.[17] 93% (n=945) of living Dunedin participants had at least one parent participate; 71% (n=724) had two. The total number of individual parents for whom information was available was n=1,717 (n= 1,625 biological-parents).

The E-Risk sample was constructed in 1999-2000, when N=1,116 families (93% of those eligible) with same-sex 5-year-old twins (56% monozygotic, 44% dizygotic; sex was evenly distributed within zygosity; 49% male) participated in home-visit assessments. The cohort represents the full range of socioeconomic conditions in Great Britain [18,19]. The cohort is primarily white (90%). Home visits were conducted with children and mothers at ages 7, 10, 12,

and with children only at 18 years, when 93% (n=2,066) of participants took part. The Joint South London and Maudsley and the Institute of Psychiatry Research Ethics Committee approved each phase of the study. Data on E-Risk participants' parents were collected during the childhood home visits. Interviews were conducted with mothers, and mothers reported on children's fathers. 99% of participants had a mother participate in the study; 80% (n=1,796) had information about both parents. The total number of individual parents for whom information was available was n=1,986. All mothers and most fathers (89%; n=801) were biological-parents.

Personality measures

We measured the personalities of Dunedin and E-Risk participants through reports by co-informants (mostly best friends, partners, or other family members) as previously described[2,20]. Reports were made on a brief, 25-item version of the Big 5 Inventory[21] measuring the personality traits of openness to experience ("Original, comes up with new ideas"), conscientiousness ("Works until a thing is done"), extraversion ("Outgoing, likes people"), agreeableness ("Kind and considerate"), and neuroticism ("Gets nervous easily"). We measured the personalities of participants' parents through reports by trained research workers who interviewed the parents, or, for E-Risk fathers, through reports by E-Risk mothers, using the same 25-item Big 5 inventory as for participants[21]. Internal-consistency reliabilities ranged from .58 to .91 (mean=.76; **Table S1**). Big 5 traits were correlated with each other (**Table S2**), replicating prior research [5,22].

Health and aging outcomes

Mortality. We measured mortality of Dunedin participants' biological parents through participants' reports about their parents' death, up to 2019. Among the 1,506 biological parents for whom personality and mortality data was available, there were 182 parental deaths (12%).

Pace of Aging. We measured the pace of biological aging of Dunedin participants as changes in 18 biomarkers of cohort members' cardiovascular, metabolic, endocrine, pulmonary, hepatic, renal, immune, and periodontal systems across ages 26, 32, and 38 years, as previously described.[23] The measure quantifies participants' rate of aging in year-equivalent units of physiological decline per chronological year. The average study member experienced 1 year of physiological decline per year, a Pace of Aging of 1. The fastest-aging participants experienced more than twice this rate of change, while the slowest-aging participants experienced almost no change.[23]

Health habits. We measured health habits (smoking, drinking, physical activity; and stress-coping strategies) in Dunedin and E-Risk participants through structured interviews. In both cohorts, smoking was measured as number of cigarettes smoked per day; drinking was measured as average number of alcoholic drinks per week; leisure physical activity was assessed as time spent on physically demanding activities per week and stress-coping strategies were assessed by asking participants how often they used each of a list of strategies to cope with stress (e.g., "Talk with other people"; "Give up"; **Table S3**). We created measures of 'active', 'avoidant' and 'distressed' coping based on factor analysis (**Tables S3**).

Life-course predictors and correlates of the vital personality

Childhood temperament. We measured Dunedin and E-Risk participants' temperament during childhood, through reports by trained research workers as previously described.[24]. Research workers rated each child-participant on 22 items which loaded on three replicable factors: "lack of control" indexing emotional lability and short attention span; "sluggishness" indexing shyness and fear; "approach" indexing self-confidence, and self-reliance.[24]

Health parenting. We measured E-Risk mothers' promotion of a healthy lifestyle for their children at the age-10 home visit. Mothers responded to items about children's health-related behaviors , such as how many hours they watched television per day or how often they ate takeaway food per week (**Table S7**).

Construction of the vital personality score

For each participant, a vital personality score was calculated as O*o + C*c + E*e + A*a + N*n where O, C, E, A, and N are the natural log of the hazard ratios for mortality risk associated with a 1 SD difference in each of the Big 5 (Openness to Experience [HR 0.94], Conscientiousness [HR 0.87], Extraversion [HR 0.91], Agreeableness [HR 0.94], and Neuroticism [HR 1.08]) as estimated in a previous, independent meta-analysis in 76,150 individuals (Jokela et al., 2013; Web Table 3), and o, c, e, a, and n are Big 5 personality factor z-scores for the individual study member. Vital personality scores were standardized to M=0 and SD=1 and reverse scored so that a higher score would be expected to predict better health and aging outcomes (**Figure S1**).

Statistical Analyses

To test associations between Dunedin parents' vital personality scores and mortality, we used Cox proportional hazards models adjusted for sex and age at baseline with standard errors adjusted for the clustering of parents within participants. To test associations between vital personality scores and other variables (e.g. Pace of Aging) we used linear regression or Poisson regression models depending on the scale of the outcome variable. When analyzing E-Risk twin data, standard errors were adjusted for clustering of twins within families. To test associations between the vital personality and health-risk behaviors within twins, we used sibling fixed-effects regression models to account for family-wide factors shared between siblings growing up

in the same family. To test rank-order stability of the vital personality over time, we used regression models. To test mean-level change over time, we used longitudinal growth models. All models were adjusted for sex. To test the heritability of the vital personality, we used biometric twin models that decompose variance in an outcome into additive genetic influences (A), shared-environmental influences (C) that make members of a family similar, and non-shared environmental influences (E) that make members of a family different, including measurement error. We used Stata version 14.1,[25] and OpenMx.[26] Analyses were checked for reproducibility by an independent data-analyst using SAS version 9.4[27] and MPlus version 8.3.[28]

RESULTS

The vital personality predicts lifespan and healthspan

Hypothesis 1: Vital personalities have a lower mortality risk. Dunedin parents' vital personality scores forecast their mortality risk. A parent with a vital personality score 1 SD above the mean was 25% less likely to die during follow-up (HR= .75, 95% CI [.67, .84], p<.01) **Figure 1a**). The difference in mortality among individuals in the bottom versus top quintiles of the vital personality score amounted to 9 percentage points (17.1% versus 7.9%; **Figure 1b**). The vital personality score was not dependent on any single personality dimension for predicting mortality (**Table S4a)**. Notably, vital personality scores predicted mortality after removing Conscientiousness (HR=.82 [95% CI .73 - .93], p<.01), the Big 5 dimension carrying the largest weight in our score.

Hypothesis 2: Vital personalities age more slowly. Dunedin participants' vital personality scores at age 26 years predicted a slower Pace of Aging during their 30s (β =-.16 [95%CI -.22; -

.09], p<.01). This amounted to approximately 2 fewer years of biological aging between ages 26 to 38 for participants in the bottom versus top quintiles on vital personality.

Hypothesis 3: Vital personalities led healthier lives. Individuals with more vital personalities had healthier lifestyles, as indicated by healthier habits. Dunedin participants with more vital personalities at age 26 years smoked fewer cigarettes, drank less alcohol and were more physically active, and used more active and less distressed coping strategies at age 38 (**Figure 2**). These findings replicated among 18-year old E-Risk participants (**Figure 2**) and even within E-Risk families: compared to their less vital co-twins, E-Risk participants with more vital personalities smoked fewer cigarettes, were more active, used more active stress-coping strategies, but did not differ in other stress-coping strategies or alcohol consumption (**Table S5**).

Additional analysis: How does the vital personality score compare to using each Big 5 trait separately as a predictor of healthy aging? For our main healthy aging outcomes (mortality, pace of aging, health-lifestyle) we compared estimates when using the vital personality score versus each Big 5 trait separately (**Tables S4b and S8**). We note three findings. First, the vital personality score showed consistent associations with most outcomes, whereas individual-trait associations were less consistent. Second, associations tended to be larger when the vital personality was used as a predictor, compared to using one Big 5 trait at a time. Third, whereas order and magnitude of individual-trait associations differed across cohorts, those between the vital personality score and most outcomes were remarkably similar.

The vital personality across the life-course

Hypothesis 4: Vital personalities are predicted by childhood temperament. In both cohorts, participants' behavioral styles in childhood forecast their vital personality scores in

adulthood. Those who showed greater control, less sluggishness and (in E-Risk) greater approach as children, grew up to have more vital personalities (**Table 1**).

Hypothesis 5: Individual differences in vital personality are stable. Vital personality scores showed considerable rank-order stability from age 26 to age 38 years, implying that Dunedin participants with relatively more vital personalities at one age tended to have more vital personalities at later ages (correlations ranged from r=.54 to r=.61 across ages).

Hypothesis 6: Personalities become more vital with age. There was a small mean-level increase in participants' vital personalities over the adult years, as indicated by the linear slope estimate of a longitudinal growth model fitted to repeated measures of Dunedin participants' personality traits at ages 26, 32, and 38 years (β=.008 [95%CI .003, .013], p<.05). This amounted to approximately a one tenth of a standard deviation increase in the vital personality score from age 26 to age 38.

The vital personality in the family

Hypothesis 7: Partners resemble each other in their vital personalities. The personalities of romantic partners resembled each other in vitality, as indicated by positive correlations in vital personality scores between the mothers and fathers of Dunedin and E-Risk participants (**Figure 3**).

Hypothesis 8: Vital personalities have vital children. Parents with more vital personalities had children who grew up to have more vital personalities, as indicated by positive correlations in vital personality scores between parents and (adult) children in both cohorts (**Figure 3).**

Hypothesis 9: Vital personalities are heritable. Individual differences in vital personality were partly attributable to genetic influences, as indicated by E-Risk identical (MZ) twin

correlations more than twice as high as non-identical (DZ) correlations (**Figure 3**). Formal twin modeling indicated that 53% of variance in vital personality at age 18 was explained by additive genetic influences (A=.53 [95%CI .46, .59]). Environmental influences shared between twins did not account for any variance (C=.00 [95%CI .00, .06]). The remaining variance was accounted for by environmental influences not shared between twins, including measurement error (E=.47 [95%CI .41, .52]).

Hypothesis 10: Parents with vital personalities promote children's healthier living. E-Risk mothers with higher vital personality scores had children who spent fewer hours watching television and playing videogames; ate fruits and vegetables more often and takeaway food less often; and brushed their teeth more often (**Figure 4, Table S7**). There were no differences in how often children ate crisps and sweets. Re-analyzing all associations controlling for offspring's own vital personality did not change these results (**Table S7**).

DISCUSSION

We developed a vital personality score that summarizes associations between Big 5 personality traits and all-cause mortality based on a meta–analysis of over 75,000 people.[5] Our initial validation analysis confirmed that the score predicted mortality in a new sample, independent from the meta-analysis providing the scoring weights. Our in-depth investigation across the life-course and across generations revealed three main findings. First, individuals with more vital personalities led healthier lives. As children, they spent less time in front of screens, ate healthier, and brushed their teeth more often. As young adults, they smoked and drank less; were more physically active; and used healthier stress-coping strategies. By mid-life, they had aged at a slower pace than less vital peers. Second, individuals' vital personality showed both stability and change across development. The developmental origins of a more vital personality were evident as early as age 3, in measurements of childhood temperament. Across the adult years, individuals tended to retain the placement of their vital personality score within the population. There was also evidence for small population-wide increases in vital personality over time. Third, individuals with more vital personalities made decisions that impacted not only on their own health, but also that of future generations. Vital personalities tended to select partners with vital personalities, and their children went on to have more vital personalities themselves. As parents, vital personalities promoted healthier habits of their children, building a foundation for the health of the next generation.

Our findings should be interpreted in light of limitations. First, not all outcomes (e.g. mortality) were measured in the same sample. Second, the vital personality score is simple and atheoretical in its computation, ignoring patterns of interactions or correlations between traits. This is in keeping with practices in computing the algorithm-based scores that inspired our

approach, such as polygenic scores.[29] Third, we used short measures to assess Big 5 traits, and informants varied across samples (co-informants for participants; research workers for parents). The convergent results across informants support the validity of our findings and the replicability of personality-outcome associations[30] and suggest that findings carry over to contexts (e.g., the clinic) in which extensive Big 5 measurement is difficult. Fourth, the vital personality score is an aggregate score and does not provide inferences about which traits mediate health-associations. In fact, these may vary for different people, so that individuals may differ in Big 5 traits, but have a similar vital personality score. Fifth, our observed associations are modest. The vital personality score by itself cannot predict an individual's health or mortality with precision. However, many of our observed effect sizes are on par with those of more established predictors of healthy aging, including SES; smoking; self-reported health and family medical history.[2,31,32]

Why is the vital personality associated with healthy aging? Our findings suggest several explanations. First, individuals with more vital personalities led healthier lives. They smoked and drank less, exercised more, and used more active stress-coping strategies. Such behaviors are predictors of age-related disease and mortality and mediators of personality-health associations.[5,33–35] Second, associations between the vital personality and aging may partly reflect genetic influences.[36] Third, individuals with more vital personalities were surrounded by vital parents, partners, and children. Although we found no evidence for familial social transmission in the form of shared-environmental influences, individuals with vital personalities might still affect each others' health.[37–39]

Our findings have implications for research. The vital personality score could be used by aging researchers across disciplines who are looking to incorporate personality measures into

their studies. The Big 5 are cheap and easy to collect,[2,40] and the vital personality score is a straightforward way to represent personality contributions to healthy aging.

Our findings have implications for healthcare. The vital personality score could be used to support the move towards a more personalized medicine. Greater integration of social, psychological, and behavioral data with conventional clinical data could help clinicians better understand the needs of their patients, facilitate coordinated action, and increase patient-centredness.[41–44] For this promise to be realized, there is a need for standardized measures of psychosocial determinants of health. The vital personality score responds to this demand.

Our findings have implications for understanding associations between personality and aging. They reveal that the personality processes that contribute to healthy aging are set in motion from before birth and early in life onwards. This underscores the need to start early with interventions to extend healthy lives[45,46] and suggests that such efforts have pay-offs across generations.[47] The findings also point to the many possible mediators of personality-aging associations across the life-course.[5,34,35,48] To identify these mediators, it is critical to study individuals while they are still free from age-related disease and follow them as they develop and change.[46,49,50] Taken together, these findings emphasize the importance of a life-course approach to studying aging, to elucidate pathways toward healthy long lives.

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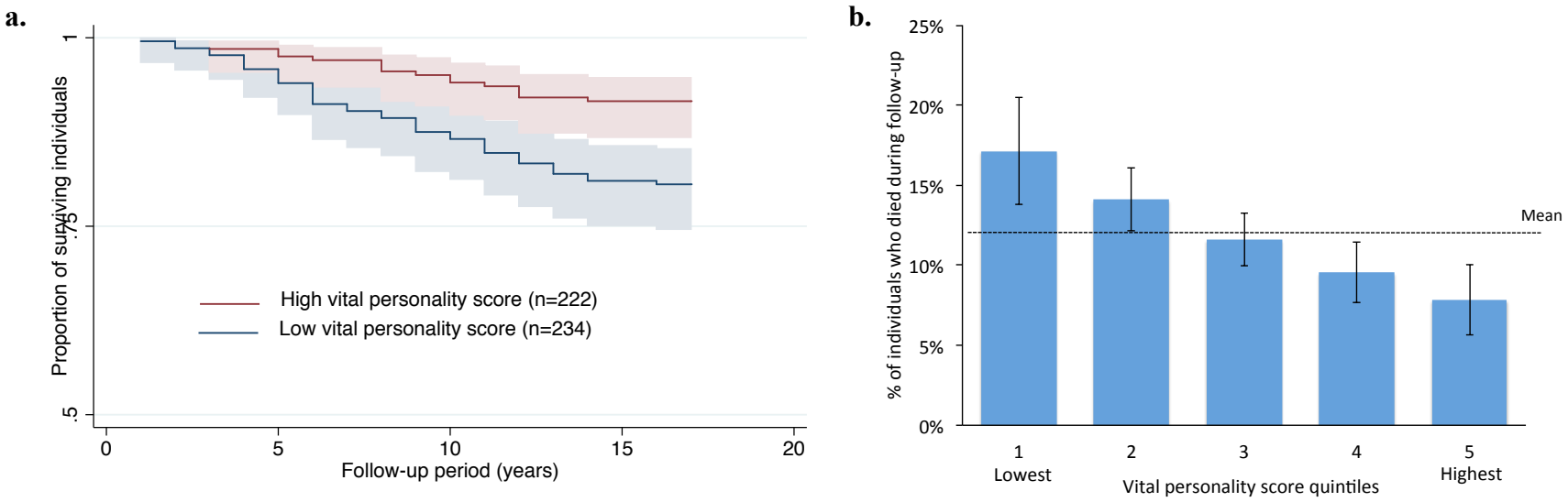
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Table 1. Childhood temperament predicts adult vital personality.

	Dunedin cohort		E-Risk cohort	
Predictors	β	(95% CI)	β	95% CI
Lack of control	**-.21**	**(-.27, -.14)**	**-.10**	**(-.15, -.04)**
Sluggishness	**-.12**	**(-.18, -.06)**	**-.06**	**(-.11, -.02)**
Approach	.06	(.00, .13)	**.09**	**(.04, .14)**

Note: The table shows standardized regression coefficients (β) estimated in separate models predicting vital personality (measured at age 26 years in Dunedin and at age 18 in E-Risk) from childhood temperament (measured at ages 3 and 5 years in Dunedin and at age 5 years in E-Risk). All analyses are adjusted for participants' sex. Bolded estimates are statistically significant ($p<.01$).

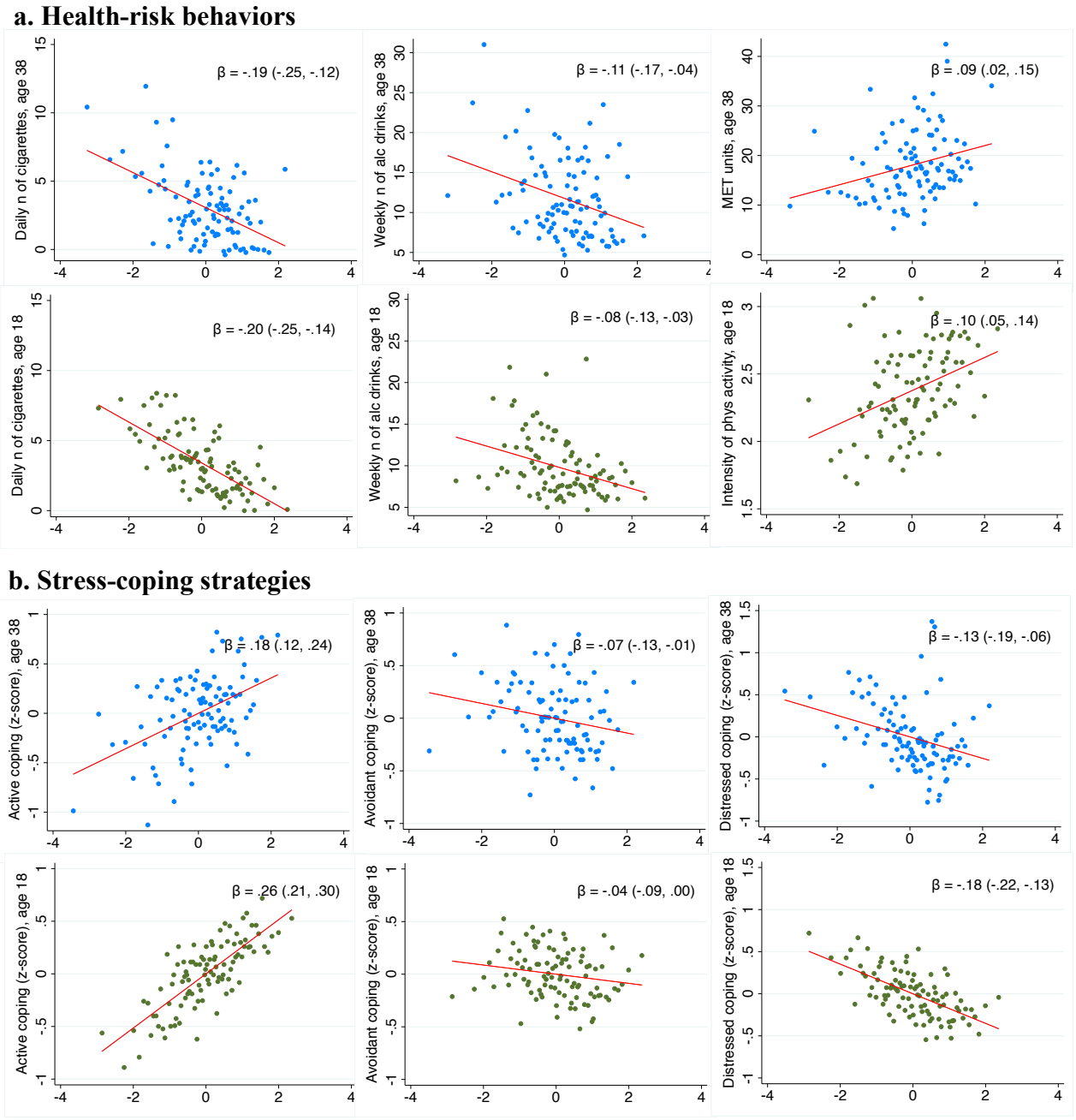
Figure 1. Vital personalities live longer.



Note: Associations between vital personality score and mortality in Dunedin participants' parents. **Panel a.** shows Kaplan Meier survival functions of the proportion of surviving individuals by follow-up year, separately for parents with more vital personalities (vital personality score ≥ 1 SD above the mean; n=222) versus parents with less vital personalities (vital personality score ≤ 1 SD below the mean; n=234). The plots show that individuals with higher vital personality scores stayed alive for longer. **Panel b.** shows the per cent of individuals who died during follow-up by vital personality score quintile. All estimates are adjusted for parents' sex and age at baseline. Shaded areas and error bars indicate 95% confidence intervals. Supplementary data shows associations between

the vital personality score and mortality when removing one Big 5 trait at a time (**Table S4a**) and between each Big 5 trait and mortality separately (**Table S4b**).

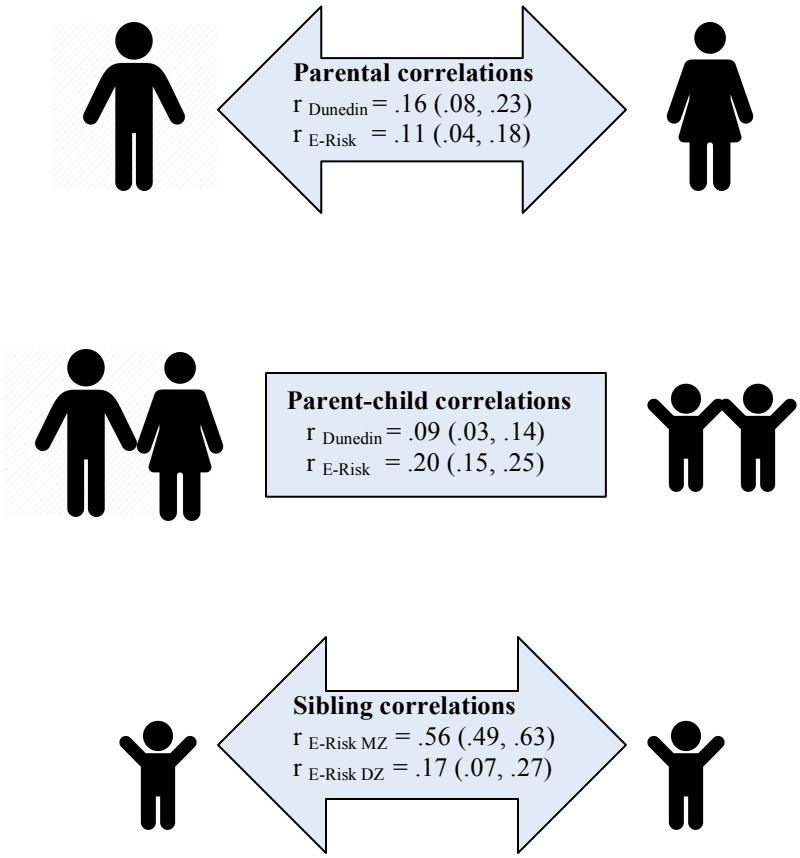
Figure 2. Vital personalities engaged in fewer health-risk behaviors (Panel a) and used better stress-coping strategies (Panel b), in both the Dunedin (in blue) and E-Risk cohorts (in green).



Note: The figures show sex-adjusted associations between vital personality scores and health-risk behaviors (smoking; drinking; exercise; **Panel a**) and stress-coping strategies (active, avoidant, distressed, **Panel b**) in the Dunedin (blue) and E-Risk (green) cohorts. Each plotted

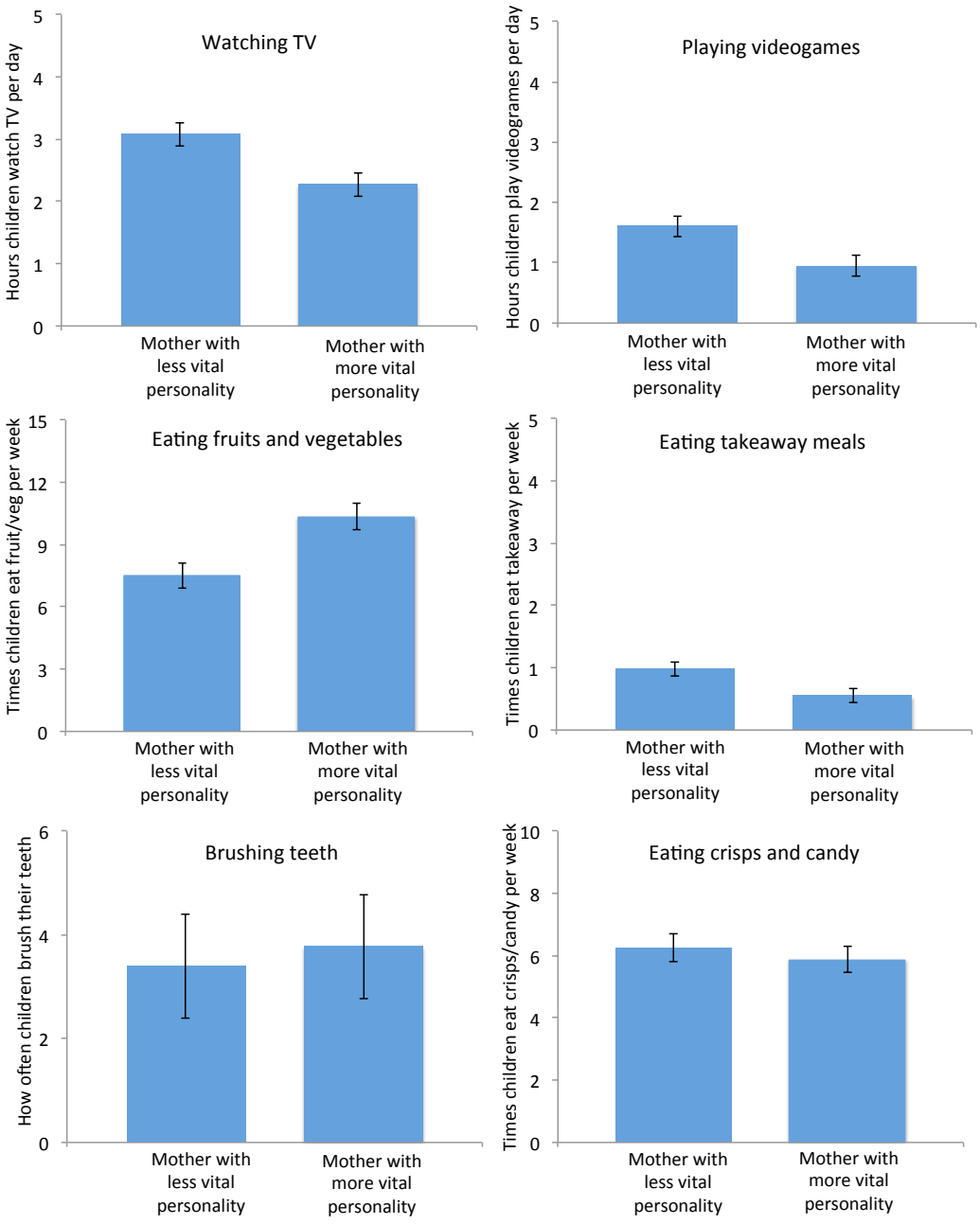
point represents mean x and y coordinates for a bin of about 10 Dunedin and 20 E-Risk participants. Regression lines and effect size estimates were estimated from unbinned data. Because all measures apart from exercise were assessed in the same way in both cohorts, associations can be directly compared across cohorts. **Table S5** additionally reports within-twin-pair estimates based on twins in the E-Risk cohort.

Figure 3. The vital personality runs in families.



Note: The figure shows correlations in vital personality scores between Dunedin and E-Risk participants' parents (top arrow); participants' parents and participants (i.e. parent and child; middle arrow); and between identical (MZ) and nonidentical (DZ) twin participants in the E-Risk cohort (bottom arrow). 95% Confidence intervals are reported in parentheses. Estimates from analyses in only-biological parents were very similar (**Table S6**).

Figure 4. Mothers with more vital personalities promote healthier habits in their children.



Note: The figure shows the means for each health-parenting measure for E-Risk study member mothers with less vital personalities (as indicated by a vital personality score ≤ 1 SD below the mean; n=180) versus study member mothers with more vital personalities (≥ 1 SD above the mean; n=171). Error bars indicate 95% confidence intervals. For all outcomes apart from brushing teeth, the scales are in units of x per day or week. For brushing teeth, the scale ranged from 0 (Never) to 5 (Three times per day). Standardized estimates of associations between E-

Risk mothers' vital personality and health-parenting before and after controlling for participants' own vital personality scores at age 18 years are reported in **Table S7**.