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Malnutrition in the First Year of Life and Personality at Age 40

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Abstract

Background—Early childhood malnutrition is associated with cognitive and behavioral impairment during childhood and adolescence, but studies in adulthood are limited.

Methods—Using the NEO-PI-R personality inventory, we compared personality profiles at 37–43 years of age (mean 40.3 years, SD 1.9) of Barbadian adults who had experienced moderate to severe protein-energy malnutrition (PEM) in the first year of life (n=77) with healthy controls, who were former classmates of the index cases and were matched for age, sex and handedness in childhood (n=57). The previously malnourished participants had been rehabilitated, with good health and nutrition documented to 12 years of age, and study participants were followed longitudinally from childhood to 40 y. Group comparisons were adjusted for childhood and adolescent standard of living, with and without correcting for IQ.

Results—At the broad domain or factor level, previously malnourished participants had higher scores on Neuroticism and lower scores on Extraversion, Openness, Agreeableness and Conscientiousness than did the healthy controls. At the sub-domain or facet level, previously malnourished participants reported more anxiety, vulnerability, shyness and lowered sociability, less intellectual curiosity, greater suspiciousness of others, a more egocentric than altruistic orientation, and a lowered sense of efficacy or competence.

Conclusions—Malnutrition limited to the first year of life with good health and nutrition documented to 12 years of age, is associated with a significant overrepresentation of adult personality trait scores outside of the average range. This outcome has important implications for a variety of important life and mental health outcomes.

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Keywords

Malnutrition; protein-energy; kwashiorkor; longitudinal study; personality; adulthood

Introduction

Malnutrition in infancy is known to be associated with cognitive and behavioral impairment during childhood and adolescence (Walker, et al., 2007), but studies of adult outcomes are more limited, and follow-up studies of adult personality traits are virtually nonexistent. However, several studies do report associations between early nutritional status and adult personality pathology, however. Survivors of the Dutch Famine, who were exposed to famine *in utero* during World War II, were reported as having an increased prevalence of schizoid and antisocial personality, based on ICD-8, 9 criteria assessed as part of a standardized medical examination at the time of military induction (Hoek, et al., 1996; Neugebauer, Hoek, & Susser, 1999). The prevalence of these disorders was 4.4/1000 and 1.8/1000, respectively. A subsequent study however reported no association between gestational exposure to malnutrition and personality traits at 63 years of age (de Rooij, Veenendaal, Raikkonen, & Roseboom, 2012). A longitudinal study in Mauritius reported that children who were documented with malnutrition at three years of age (and likely chronically) and subsequently received a two-year enrichment intervention demonstrated fewer symptoms of conduct disorder at age 17 and fewer indicators of schizotypal personality at ages 17 and 23 relative to a control group (Raine, Liu, Venables, Mednick, & Dalais, 2009; Raine, Mellingen, Liu, Venables, & Mednick, 2003). These outcomes were mediated by cognitive functioning at 11 years of age (Venables & Raine, 2012). A recent study in a Finnish cohort has confirmed that slow growth in the first six months of life was associated with increased hospitalization for personality disorders, especially borderline and antisocial disorders, in adult males (Lahti, et al., 2011). To our knowledge, however, there are no published studies examining general personality traits in adulthood based on a comprehensive model, such as the well-established Five Factor Model (FFM) of personality, in postnatally malnourished infants.

The present report evaluates potential links between early childhood malnutrition and general personality trait levels in middle adulthood in the context of the Barbados Nutrition Study (BNS), a 40-year longitudinal study that has followed a cohort who experienced PEM at approximately seven months of age in tandem with a cohort of matched controls into midlife. These children were enrolled in an intervention program from infancy to 12 years of age. Personality trait levels are a potentially significant outcome in the life-span context of the study participants, not only because of potential links to psychopathology, but also because of the predictive associations which personality traits have with a wide range of important life outcomes (Ozer & Benet-Martinez, 2006).

As children, the previously malnourished cohort in the Barbados study exhibited impaired IQ and academic functioning (J. R. Galler, Ramsey, & Solimano, 1984; J. R. Galler, Ramsey, Solimano, Lowell, & Mason, 1983), an increase in attention problems (J. R. Galler, Ramsey, Solimano, & Lowell, 1983) and other adverse behavioral outcomes (J. R. Galler & Ramsey, 1989), even after controlling for socioeconomic and family background factors. Many of these outcomes persisted through adolescence, including cognitive deficits and low scores on a national high school entrance examination (J. R. Galler, Ramsey, Forde, Salt, & Archer, 1987; J. R. Galler, Ramsey, Morley, Archer, & Salt, 1990), as well as increased externalizing behaviors (J. R. Galler, et al., 2011) and depressive symptoms (J. R. Galler, et al., 2010; Waber, et al., 2011). As adults, the previously malnourished cohort exhibits

continuing attention deficits (J. R. Galler, Bryce, Zichlin, et al., 2012), as well as a downward trend in social status (J. R. Galler, Bryce, Waber, et al., 2012).

Personality traits in the Barbados cohort were evaluated using the NEO-PI-R (Costa & McCrae, 1992) which was developed to operationalize the FFM, a comprehensive model of the general dimensions of personality functioning. It comprises personality traits in the emotional, interpersonal, experiential, attitudinal and motivational domains. The NEO-PI-R has shown predictive validity over a host of consequential life outcomes, longitudinal stability, cross-cultural generalizability over 50 cultures (McCrae, et al., 2002; Terracciano, et al., 2005) and applicability to clinical populations including psychiatrically impaired individuals (Costa & Widiger, 2002). Specifically, the NEO-PI-R operationalizes the FFM as a hierarchical structure, with five broad domains at the highest level (Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness), each containing six sub-scales or facets. Neuroticism (N) contrasts adjustment or emotional adjustment with maladjustment. High N scores indicate susceptibility to psychological distress, proneness to irrational ideas and to coping poorly with stress. For Extraversion (E), high scores indicate pervasive sociability, assertiveness, activity, excitement seeking and cheerfulness. High Openness to Experience (O) scores indicates curiosity about the inner and outer worlds, an experiential richness, aesthetic sensitivity, preferences for variety and independence of judgment. The Agreeableness vs. Antagonism (A) scale primarily reflects interpersonal tendencies. High A scores indicate a person who is altruistic, sympathetic to and eager to help others and believes that others are equally helpful in return. Finally, Conscientiousness (C) refers to tendencies and active processes of planning, organizing and carrying out tasks. Individuals with high C scores are purposeful, strong-willed, disciplined, punctual and reliable.

We hypothesized that infant malnutrition would be associated with enduring personality differences on most if not all of the personality domains and related facets relative to local matched controls.

Methods

Study Sample and Design

The study was conducted in Barbados, an English-speaking Caribbean country with a population of approximately 260,000 persons. The majority of the Barbadian population is of African origin and socioeconomically lower middle class with a relatively high ranking (47 of 187 nations) on the UNDP Human Development Index (UNDP, 2011). School attendance is mandatory until 16 years of age and 99% of the population is literate.

In the current study, a group comparison design, based on the original case control design of the BNS (J. R. Galler, et al., 2010), was implemented, and included Barbadian adults, all born between 1967 and 1972, who participated in the study as children and adolescents and who completed personality assessments as part of the fifth wave of data collection at 40 years of age (J. R. Galler, Bryce, Waber, et al., 2012; J. R. Galler, Bryce, Zichlin, et al., 2012). The index group (MAL) included 77 adults who had been clinically diagnosed with Grade II-III PEM (marasmus or kwashiorkor) and subsequently admitted to the Queen Elizabeth Hospital in Bridgetown, Barbados at a median age of seven months. Inclusion criteria were normal birth weight (> 2500 g), absence of pre- or post-natal complications, good Apgar scores, the absence of encephalopathic events during childhood and no further malnutrition or serious medical illness after the initial episode. These children were subsequently enrolled in a government-supported intervention program at the Barbados Nutrition Centre that followed them from infancy to 12 years of age, providing health monitoring and home visits, nutrition education and subsidized foods (F. Ramsey, 1980; FC

Ramsey, 2006). Although they were growth-stunted after discharge from hospital, the participants were otherwise healthy and had complete catch-up growth by the end of puberty (Galler et al, 1987c). The comparison (CON) group included 57 adults, who were recruited in childhood and were classmates of the original index children. The controls were matched in childhood by age (within 3 months), sex and handedness to the MAL participants. They met the same inclusion criteria, but had no histories of malnutrition or other serious childhood diseases. All participants were assessed up to three time points during childhood and adolescence and again as adults.

To assure representativeness of the adult sample that was limited primarily due to funding constraints, the 134 adult participants (43% of the original sample) who completed the personality assessment as adults were compared with the 178 individuals who had participated only in earlier waves of data collection. There were no differences in the proportion of previously malnourished subjects versus controls, their ages, length of hospitalization, childhood IQ or childhood standard of living. Eleven of these 178 earlier participants were deceased. Thus, although matching was no longer possible in the adult follow-up sample due to attrition, there was no evidence of attrition bias in terms of the representativeness of the two groups.

Although measurement invariance has been demonstrated for the NEO-PI-R for individuals of differing levels of IQ within the normal range (Waiyavutti, Johnson, & Deary, 2011), such invariance is not assured for individuals with IQ's in the lower ranges of IQ distribution. Therefore, all analyses were performed for the full group of 77 MAL and 57 CON participants and also for a subgroup that excluded participants with adult IQ scores 70 (N=20 MAL; N=1 CON).

Written informed consent was obtained from all participants who were compensated for their time and travel to and from the research center. Approval for this study was granted by the Ministry of Health, Barbados and the Judge Baker Children's Center Human Research Review Committee (Assurance No. FWA 00001811).

Background variables

Perinatal measures were obtained from records at the BNS. Standard of living was assessed at three childhood and adolescent ages (5–11, 9–15 and 11–18 years of age) using the 50-item *Barbados Ecology Questionnaire* (J. R. Galler, Bryce, Waber, et al., 2012; J. R. Galler & Ramsey, 1985), which elicited information on ecological conditions in the home, the educational level and employment history of the parents. This questionnaire was administered to parents and guardians of the study participants and supplemented by home visits. Principal components analysis of all 50 items yielded a first factor that was presumed to represent the household standard of living (Armor $\theta = 0.86$). Despite being recruited from the same neighborhoods and classrooms, the groups did differ on this index during childhood (J. R. Galler, Bryce, Waber, et al., 2012). We therefore adjusted for childhood standard of living in all analyses. The Hollingshead Scale (Hollingshead & Redlich, 1953) was used to assess the educational level and employment of the adult participants. We did not adjust for adult socioeconomic status however since we reasoned that it could reflect in part the effects of the primary outcome being measured.

Personality assessment

The primary outcome for this study was personality as assessed by the NEO-PI-R (Costa & McCrae, 1992), a 240 item self-report questionnaire that operationalizes the five factor model (FFM). Each of the five major domains is composed of six lower order facets, each having eight items, roughly balanced as positive and negative items. Responses are based on

a five point Likert-type scale, ranging from *strongly disagree* to *strongly agree*. Internal consistencies (Cronbach's alpha) as reported in the Professional Manual for the NEO-PI-R range from 0.86 (A) to 0.92 (N) for the domain scales and from 0.56 (A6) to 0.81 (N3) for the facet scales. Additional information regarding test-retest reliabilities and construct and internal validity are available in the Professional Manual which also provides details of all scoring procedures used in this report. (Costa & McCrae, 1992). Although the NEO-PI-R has been used extensively in non-Western populations (Terracciano, et al., 2005), questions were read to the BNS participants by a single trained psychiatric nurse to ensure that all participants understood the questions. Three items in particular were modified to make them relevant to the local setting¹. To assess cross-cultural applicability in the Barbadian cohort, raw domain scores were converted to T-scores using United States normative means for adult males and females from the NEO-PI-R Professional Manual (Costa & McCrae, 1992). Domain T-score means in the BNS sample ranged from 44.7 (O) to 48.8 (A), and facet T-score means ranged from 40.9 (A1) to 56.3 (C6), close to the means based on samples of US adults. Internal consistencies for the Barbadian sample ranged from 0.65 (O) to 0.84 (C) for the domain scales.

Statistical analyses

Data were analyzed using SAS statistical software, version 9.2 (SAS, 2010). Group differences between participants and non-participants were evaluated by t-tests and chi-square tests. Multiple linear regressions were used to compare NEO-PI-R scores between the malnourished and control participants in analyses that adjusted for standard of living at all three childhood and adolescent ages. These analyses involved simultaneously fitting three separate multiple regression equations, thereby allowing the effect of household standard of living to potentially vary over the three childhood and adolescent ages. Finally, for inferences about the regression parameters, standard errors were based on the empirical (or so-called “sandwich”) variance estimator, thereby accounting for the correlation among the errors in the three regression equations (arising from the fact that the same outcome (NEO-PI-R score), albeit different covariate values for standard of living, appeared in the three regressions). The significance level was set at $p < 0.05$ and we did not control for experiment-wise error. Every analysis adjusted domain scores for gender by using within gender standardized T-scores.

Results

Background characteristics and personality

Table 1 summarizes background characteristics of the MAL and CON participants. There were no group differences in gender distribution, age at which subjects were tested (mean 40.3 years, SD 1.9) or birth weight (mean 3002 g, SD 383). However, standard of living (at all three childhood and adolescent ages) and social position in adulthood were significantly lower in the MAL than in the CON participants.

Difference in personality traits

Table 2a displays unadjusted group means for the T-scores for the five NEO-PI-R domains. When adjusted for standard of living at all three childhood and adolescent ages (see column

¹Three questions were not understood by the locals, and had to be modified, as follows:

52: I wouldn't enjoy vacationing in Las Vegas, [a place where you do a lot of gambling, casinos].

105: Sometimes I cheat when I play Solitaire, [which we call Patience].

119: I have no sympathy for panhandlers, [whom we call beggars].

of p -values in Table 2a), there were statistically significant differences between nutrition groups on four personality domains; previously malnourished adults scored higher on N, and lower on E, O, and C, with a trend for A. Correcting for childhood standard of living at three childhood and adolescent ages did not diminish the magnitude of the observed mean (data not presented) differences in personality between nutrition groups. When individuals with IQ ≤ 70 were excluded from the analyses, results were similar to those obtained in the full sample although A was no longer significant. Facet differences for the two groups are shown in Table 2b. Malnutrition effects were present for 17 of the 30 facets for the full group (and 12 out of 30 facets when limiting the sample to individuals with IQ > 70), with statistically significant group differences in the full sample for 5/6 facets in the N domain, 4/6 facets in E domain, 3/6 facets in the A and C domains and 2/6 in the O domain.

Percentage of scores outside the average range

The previous results evaluated central tendencies of the two nutrition groups. While the absolute differences were modest, they do not tell us about possible differences in individual scores. To that end, in addition to the group level analyses, we investigated individual T-scores for MAL and CON participants. T-scores are standardized to have a mean of 50 and SD of 10. The Professional Manual for the NEO-PI-R designates T-scores over 55 as High, and those below 45 as Low. Because the N domain is evaluated in the opposite direction from the other four (a high score is indicative of poor functioning), the significance of a high versus low classification varies by domain. We therefore refer to these categories in terms of "extreme" scores.

Table 3 displays the percentage of participants by nutrition group whose unadjusted domain T-scores fell below the mean cut-off (< 45 , classified as Low), were in the average range (45–55) or fell above the mean cut-off (> 55 , classified as High). For the N domain, the MAL participants were nearly 5 times as likely to have scores in the high ranges when compared with CON participants. Similarly, for E and C, the MAL participants were 3 times as likely to have low scores and, for O, 5.4 times less likely to have high scores, as were the CON participants. Group differences were least prominent for A. Limiting these analyses to participants with IQ scores > 70 did not appreciably change these findings, although group differences were no longer present for O. Thus, extreme scores or scores outside the average range were significantly overrepresented among the previously malnourished participants.

Discussion

Adults in mid-life with histories of infant malnutrition differed across multiple dimensions of personality, including four broad factors or domains of personality and 17 of the 30 narrower or lower-order traits when compared with healthy controls, suggesting that a single episode of malnutrition during the first year of life and associated conditions can have a long-term impact on personality. The previously malnourished adults reported higher neuroticism, and were also less extraverted, less open to experience and less conscientious than controls, effects that were not gender-specific. Excluding individuals with IQ ≤ 70 only slightly diminished the significance of these findings, likely a result of a smaller sample size.

At the more specific facet level, the previously malnourished participants reported more negative feelings (e.g., anxiety, angry hostility and depression) and more negative cognitions (e.g., self-consciousness and vulnerability to stress). Interpersonally MAL participants reported less warmth, gregariousness, assertiveness, trust, altruism, and tender-mindedness. In terms of the experiential domain of Openness to Experience, MAL participants were less sensitive to artistic concerns, and less flexible and less disposed to try new behaviors, less disposed to being analytic and non-dogmatic. In terms of motivation and self-regulation

reflected in the Conscientiousness domain, the MAL participants described themselves as being lower on planning, organizing and carrying out tasks, and less purposeful, strong-willed, punctual and reliable. These facet-level differences strongly suggest a less favorable personality profile in the malnourished group relative to controls.

Lowered socioeconomic status over the lifespan has been linked to increased Neuroticism, as well as to lower Extraversion and Conscientiousness (Jonassaint, Siegler, Barefoot, Edwards, & Williams, 2011), personality traits associated with early malnutrition in this cohort. These personality traits have also been advanced as one explanation for disparities in health outcomes and increased health-risk behaviors in low vs. high-income populations (Bogg & Roberts, 2004). In the current study, adjusting for childhood household standard of living did not attenuate the magnitude of the associations between early childhood malnutrition and adult personality. Because childhood malnutrition and household conditions are so closely associated, classifying individuals on the basis of childhood nutritional history may already have taken differences in household factors and standard of living into account (J. R. Galler, 1987; J. R. Galler & Ramsey, 1985).

As best we could ascertain, our study is the first and only study to use the NEO-PI-R measure of five-factor model (FFM) of personality to characterize the differences between previously malnourished and matched control participants. Our study, which is based on a dimensional measure, cannot identify individuals who would meet DSM-IV criteria for personality disorders, which have been reported as being increased in earlier studies of the Dutch Famine cohort (Hoek, et al., 1996; Neugebauer, et al., 1999), childhood malnutrition in Mauritius (Raine, et al., 2009; Raine, et al., 2003; Venables & Raine, 2012) and in Finnish adults with slow growth in the first year of life (Lahti, et al., 2011). The current findings, however, point to a higher prevalence of neuroticism, especially anxiety and vulnerability, and lower extraversion (less assertiveness, gregariousness, and excitement seeking) and openness, as well as less orderliness, trust and openness to new ideas, in previously malnourished Barbadian participants relative to healthy controls. Moreover, at the individual case level, the malnourished participants were more likely to be classified outside the average range of personality scores than the controls. Thus, the structure and format of the NEO-PI-R allowed us to identify important and subtle variations in personality, between the previously malnourished and control participants that may not be detected by threshold diagnoses of personality disorders.

The present study, which examined the effects of medically-confirmed postnatal malnutrition, contrasts with the recent report in a subgroup of the Dutch Famine cohort which did not find any effects of a famine history during gestation on personality traits at 63 years of age (de Rooij, et al., 2012). In the latter study, exposure was restricted to the prenatal period, and birth weights of the exposed subjects during the third trimester when maternal weight gain was lowest, were still in the average range (3179 g). This study made use of a Dutch translation of the Big Five, which measures only the five broad factors but not the lower order, narrower specific facets. Because of the timing of the exposure, the milder nutritional deficiency and measurement differences, results are not directly comparable with those obtained from the Barbados study using the NEO-PI-R.

These findings raise obvious questions about potential mechanisms. One possibility is that early childhood malnutrition affects personality development via direct impacts on the brain. Early protein malnutrition impacts both the prefrontal cortex and hippocampus (Lister, et al., 2011; Rosene, et al., 2004). A recent PET study suggested that increased neuroticism and extraversion on the NEO-PI-R were associated with changes in glucose metabolism specific to orbitofrontal cortex and the insular cortex (Deckersbach, et al., 2006), the former regions also known to be impacted by early malnutrition (J.R. Galler, Shumsky, & Morgane, 1996).

Early brain insults, including low birth weight (Schmidt, Miskovic, Boyle, & Saigal, 2008), have been associated with adult personality, including increased neuroticism and reduced extraversion. A conflicting report in a Finnish sample of very low birth weight children reported increased conscientiousness and agreeableness, and lower openness to experiences in young adulthood (Pesonen, et al., 2008).

A more developmental account is also plausible. Childhood temperament and traits appear to antedate the appearance of adult personality profile (Widiger, De Clercq, & De Fruyt, 2009). Accordingly, the proximal behavioral consequences of early childhood malnutrition (J. R. Galler, Ramsey, Solimano, & Lowell, 1983; Waber, et al., 2011), including changes in temperament (Baker-Henningham, Hamadani, Huda, & Grantham-McGregor, 2009; J. R. Galler, Cervera, & Harrison, 1998), could predispose to the personality traits observed in this study. Parenting styles may also impact personality profile in adulthood (Reti, et al., 2002). Hence the increase in maternal depressive symptoms in the previously malnourished group (J. R. Galler, et al., 2010; Salt, Galler, & Ramsey, 1988) may contribute to the observed personality outcomes. Maternal depression and an altered parent-child relationship are thus closely linked to a history of early childhood malnutrition and its consequences (Wachs, 2008).

The BNS has a number of methodological strengths. First, it is a cohort with a delimited history of medically confirmed malnutrition during the first year life without further nutritional deficits in childhood or adolescence. Second, because malnutrition was considered a reportable disease in Barbados, every child with malnutrition was identified and enrolled in the Nutrition Centre intervention program. Hence, there was little likelihood of selection bias, and all children were monitored and received health care, nutrition education and subsidies. Third, behavioral and health measures and socioeconomic measures were collected throughout childhood and adolescence, providing longitudinal data over the lifespan.

The present study also has limitations. First, the sample is relatively small compared with the other epidemiologically ascertained cohorts, such as the Finnish, Mauritius and Dutch Famine studies. However, the extensive documentation of the early health and nutrition status of both index cases and controls and continuing documentation of their status over the life span offsets this limitation. Second, given the low socioeconomic of the study population, it is important to consider the possibility of malnutrition during pregnancy in our sample. A primary inclusion criterion for the BNS sample however was normal birth weight. Consequently, the birth weights of the MAL and CON groups did not differ and it is therefore unlikely that prenatal malnutrition was a meaningful factor in this study. Third, the adult sample includes just under half of the participants identified in childhood, raising questions about attrition bias. We found no differences, however, between those who participated as adults and those who did not on key childhood measures. Finally, we chose not to correct for multiple comparisons because Bonferroni corrections, are well known to be overly conservative (Miller, 1981). With five domains and 30 facets, we would have expected approximately two significant results due to chance at the conventional $\alpha = 0.05$ level. Thus, the numerous statistically significant effects of malnutrition reported in Tables 2a and 2b are unlikely to be due to chance alone.

Conclusions

What are the implications of these findings? Early childhood malnutrition is a risk factor for the development of an adult personality trait profile that is maladaptive or less favorable than that of controls. The specific personality profile appears to involve heightened anxiety, depression and vulnerability to stress, lowered interpersonal orientation, lowered intellectual

curiosity, as well as withdrawal, distrust, and lowered sense of self-efficacy or competence. Future research should explore whether these trait levels are associated with other mental health and adaptive outcomes in this population.

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Abbreviations

BNS	Barbados Nutrition Study
PEM	protein energy malnutrition
MAL	malnourished group
CON	healthy comparison group

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Key points

- Childhood malnutrition is associated with impaired cognitive and behavioral outcomes.
- This study confirms that personality traits in adulthood differ significantly following a history of malnutrition in the first year of life relative to healthy classmates.
- Significant effects of early malnutrition include an increase in neuroticism and decreases in extraversion, conscientiousness and openness, even after adjusting for the effect of childhood standard of living and intellectual impairment.
- Malnutrition limited to the first year of life is associated with striking effects on adult personality, even when there is long-term nutritional rehabilitation, with implications for an increased risk of psychiatric and health problems

Table 1

Background characteristics of participants with histories of malnutrition (MAL) and healthy comparisons (CON) ¹.

	MAL	CON	F / χ^2	p
<i>n</i>	77	57		
Male, <i>n</i> (%)	41(53.3)	30 (52.6)	0.01	0.94
Age in 2010, <i>y</i>	40.4±1.9	40.2±1.9	0.38	0.54
Birth weight, g	2936 ±484	3044±387	1.73	0.19
Age at admission to hospital (mos.)	7.7±2.9	N/A		
Length of hospitalization (days)	43.8±18.6	N/A		
Childhood standard of living (5–11 y)	−0.91±0.93	−0.28±0.80	14.61	< 0.001
Hollingshead Index of Social Position (40 y)	4.34±0.72	3.44±1.05	34.44	< 0.001

¹Values are mean ± SD or *n* (%).

Tables 2

a and b: A comparison of domain and facet T-scores (means $\pm$ SE) in previously malnourished (MAL) and comparison (CON) groups².

Domains	Full Sample			Sample Excluding IQ 70		
	Malnourished	Comparison	Difference	Malnourished	Comparison	Difference
	N=77	N=57		N=57	N=56	
Neuroticism	52.5 $\pm$ 1.0	45.8 $\pm$ 1.2	6.7**	51.4 $\pm$ 1.1	45.8 $\pm$ 1.1	5.6*
Extraversion	43.2 $\pm$ 1.0	50.5 $\pm$ 1.1	-7.3***	44.5 $\pm$ 1.0	50.7 $\pm$ 1.0	-6.2***
Openness	42.1 $\pm$ 0.9	47.4 $\pm$ 1.0	-5.3***	43.5 $\pm$ 1.0	47.5 $\pm$ 1.0	-4.0*
Agreeableness	52.3 $\pm$ 1.5	57.1 $\pm$ 1.7	-4.8~	53.9 $\pm$ 1.7	56.9 $\pm$ 1.7	-3.0
Conscientiousness	46.5 $\pm$ 1.0	52.3 $\pm$ 1.1	-5.8**	47.4 $\pm$ 1.1	52.5 $\pm$ 1.1	-5.1*

Facets	Malnourished	Comparison	Difference	Malnourished	Comparison	Difference
N1: Anxiety	49.4 $\pm$ 0.8	44.8 $\pm$ 1.0	4.6**	49.6 $\pm$ 0.9	44.8 $\pm$ 1.0	4.8**
N2: Angry hostility	55.4 $\pm$ 1.3	50.5 $\pm$ 1.5	4.9*	53.4 $\pm$ 1.4	50.6 $\pm$ 1.4	2.8
N3: Depression	53.5 $\pm$ 1.0	48.0 $\pm$ 1.1	5.5**	52.8 $\pm$ 1.1	48.1 $\pm$ 1.1	4.7*
N4: Self-consciousness	50.5 $\pm$ 1.0	45.8 $\pm$ 1.1	4.7*	49.9 $\pm$ 1.1	45.6 $\pm$ 1.1	4.3~
N5: Impulsiveness	48.0 $\pm$ 0.9	45.8 $\pm$ 1.1	2.2	46.7 $\pm$ 1.0	45.7 $\pm$ 1.0	1.0
N6: Vulnerability	53.0 $\pm$ 1.0	46.1 $\pm$ 1.2	6.9***	51.9 $\pm$ 1.1	46.0 $\pm$ 1.1	5.9**
E1: Warmth	41.1 $\pm$ 1.3	48.4 $\pm$ 1.5	-7.3***	43.7 $\pm$ 1.3	48.5 $\pm$ 1.3	-4.8**
E2: Gregariousness	42.6 $\pm$ 1.2	48.8 $\pm$ 1.4	-6.2*	43.7 $\pm$ 1.3	48.6 $\pm$ 1.3	-4.9*
E3: Assertiveness	46.3 $\pm$ 0.9	52.4 $\pm$ 1.0	-6.1***	47.3 $\pm$ 1.0	52.7 $\pm$ 1.0	-5.4**
E4: Activity	46.4 $\pm$ 0.9	48.2 $\pm$ 1.0	-1.8	46.4 $\pm$ 1.0	48.4 $\pm$ 1.1	-2.0
E5: Excitement-Seeking	47.1 $\pm$ 1.0	50.6 $\pm$ 1.1	-3.5	46.3 $\pm$ 1.1	50.7 $\pm$ 1.1	-4.4*
E6: Positive Emotions	47.8 $\pm$ 0.9	53.3 $\pm$ 1.1	-5.5***	49.5 $\pm$ 1.0	53.4 $\pm$ 1.0	-3.9**
O1: Fantasy	45.4 $\pm$ 1.0	46.7 $\pm$ 1.1	-1.3	45.1 $\pm$ 1.2	46.6 $\pm$ 1.2	-1.5
O2: Aesthetics	47.9 $\pm$ 0.9	50.6 $\pm$ 1.1	-2.7~	48.7 $\pm$ 1.1	50.7 $\pm$ 1.1	-2.0
O3: Feelings	45.9 $\pm$ 0.7	47.7 $\pm$ 0.9	-1.8	46.1 $\pm$ 0.9	47.7 $\pm$ 0.9	-1.6
O4: Actions	47.0 $\pm$ 1.0	52.0 $\pm$ 1.2	-5.0***	48.2 $\pm$ 1.2	52.0 $\pm$ 1.2	-3.8*
O5: Ideas	41.1 $\pm$ 1.0	48.5 $\pm$ 1.2	-7.1***	43.1 $\pm$ 1.1	48.9 $\pm$ 1.1	-5.8**
O6: Values	42.2 $\pm$ 0.9	45.0 $\pm$ 1.0	-2.8	43.7 $\pm$ 1.1	45.0 $\pm$ 1.1	-1.3

Facets	Malnourished	Comparison	Difference	Malnourished	Comparison	Difference
A1: Trust	36.5±1.4	43.1±1.6	-6.6**	38.2±1.5	43.1±1.5	-4.9~
A2: Straightforwardness	50.2±0.9	49.6±1.1	0.6	50.2±1.1	49.5±1.1	0.7
A3: Altruism	46.6±1.0	51.7±1.2	-5.1**	48.4±1.2	51.7±1.2	-3.3
A4: Compliance	49.2±1.4	51.2±1.6	-2.0	50.5±1.6	51.1±1.6	-0.6
A5: Modesty	50.1±1.1	52.6±1.2	-2.5	49.9±1.3	52.6±1.3	-2.7
A6: Tender-Mindedness	54.1±0.9	58.8±1.1	-4.7**	55.8±1.0	58.6±1.1	-2.8~
C1: Competence	44.7±1.0	50.5±1.2	-5.8***	46.2±1.1	50.7±1.1	-4.5*
C2: Order	47.2±0.7	50.9±0.9	-3.7*	47.5±0.8	50.9±0.9	-3.4~
C3: Dutifulness	44.3±0.9	47.5±1.0	-3.2	44.3±1.0	47.6±1.0	-3.3
C4: Achievement	49.3±0.9	52.8±1.1	-3.5	49.8±1.1	53.1±1.1	-3.3
C5: Self-Discipline	47.0±0.9	51.3±1.1	-4.3**	47.9±1.0	51.6±1.0	-3.7*
C6: Deliberation	53.5±1.0	56.7±1.1	-3.3~	54.4±1.0	56.9±1.1	-2.5

² All analyses used gender-adjusted T-scores and controlled for childhood/adolescent standard of living.

Table 3

Chi-square tests comparing previously malnourished (MAL; N=77) and comparison (CON; N=57) participants with NEO-PI-R domain T-scores in the Low (<44), Average (45–55) or High (> 56) range.

	Low, N (%)		Average, N (%)		High, N (%)		χ^2
	Malnourished	Controls	Malnourished	Controls	Malnourished	Controls	
Neuroticism	15 (19.5)	25 (43.9)	36 (46.8)	28 (49.1)	26 (33.8)	4 (7.0)	17.0 ***
Extraversion	41 (53.3)	10 (17.5)	32 (41.6)	37 (64.9)	4 (5.2)	10 (17.5)	19.2 ***
Openness	49 (64.6)	26 (45.6)	26 (33.8)	23 (40.4)	2 (2.6)	8 (14.0)	8.0 *
Agreeableness	16 (20.8)	11 (19.3)	31 (40.3)	14 (24.6)	30 (39.0)	32 (56.1)	4.5
Conscientiousness	27 (35.1)	7 (12.3)	42 (54.6)	37 (64.9)	8 (10.4)	13 (22.8)	10.5 **

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$