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Personality, disability-free life years, and life expectancy: Individual-participant meta-analysis of 131,195 individuals from 10 cohort studies

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Abstract

Objective: We examined how personality traits of the Five Factor Model were related to years of healthy life years lost (mortality and disability) for individuals and the population.

Method: Participants were 131,195 individuals from 10 cohort studies from Australia, Germany, the United Kingdom, and the United States (n=43,935 from 7 cohort studies for the longitudinal analysis of disability, assessed using scales of Activities of Daily Living, ADL).

Results: Lower conscientiousness was associated with higher mortality and disability risk, but only when conscientiousness was below its median level. If the excess risk associated with low conscientiousness had been absent, population life expectancy would have been 1.3 years longer and disability-free life 1.0 years longer. Lower emotional stability was related to shorter life expectancy, but only among those in the lowest 15% of the distribution, and disability throughout the distribution: if the excess risk associated with low emotional stability had been absent, population life expectancy would have been 0.4 years longer and disability-free life 2.4 years longer.

Conclusions: Personality traits of low conscientiousness and low emotional stability are associated with reduced healthy life expectancy of individuals and population.

Keywords: Personality; Mortality; Disability; Longevity; Meta-analysis

Personality traits are related to individual differences in longevity (Graham et al., 2017; Jokela, Batty, et al., 2013). The most consistent evidence has supported low *conscientiousness* as the main personality trait associated with elevated risk of premature death: one standard deviation decrease in conscientiousness has been associated with a 14% higher mortality rate (Jokela, Batty, et al., 2013). Individuals with low conscientiousness tend to have low self-control, act spontaneously without planning, show little persistence in pursuing long-term goals, and not be driven by obligations of duty and responsibility (Roberts, Lejuez, Krueger, Richards, & Hill, 2014)—all characteristics that may lead to unhealthy life choices and risk taking (Hakulinen et al., 2015; Hakulinen, Elovainio, et al., 2015; Jokela et al., 2013; Sutin et al., 2016).

Higher mortality rate has also been associated with lower emotional stability (e.g., low liability to negative emotions and psychopathology), lower openness to experience (e.g., cognitive flexibility and preference for variety; Ferguson & Bibby, 2012), lower extraversion (e.g., sociability and positive emotionality), and lower agreeableness (e.g., empathy and trust in others; Graham et al., 2017). These traits have been weaker predictors of mortality compared to conscientiousness, with around 5% mortality-rate difference associated with one standard deviation of the trait (Graham et al., 2017), and their associations have been less consistent across studies than those reported for low conscientiousness (Jokela, Batty, et al., 2013).

The relative mortality risks associated with personality traits have now been fairly well documented. However, these associations have not been quantified using absolute population metrics, such as life expectancy. Absolute metrics are crucial because they provide a better basis for evaluating the public health significance of risk associations (Stringhini et al., 2017) and are easier to communicate with non-researchers. Moreover, there seems to be no previous studies on personality and disability-free life years. The concept of disability-free life years extends the measurement of life expectancy by considering the years people can live without having any disabling conditions or morbidity that limits their ability to carry out daily activities (Stringhini et al., 2018). A long life is valuable, but a healthy and fully functional long life is even more valuable. The overall burden of different diseases in epidemiology is often assessed as lost disability-adjusted life years (Kyu et al., 2018), that is, the combined effects of how many life years are lost due to premature mortality and the disabling effects of the disease. Disabling conditions naturally increase the risk of premature mortality, so disability and mortality are not independent measures, but two individuals with the same lifespan can still differ in the number of healthy life years they have. Personality traits, low conscientiousness in particular, have been associated with frailty (Stephan, Sutin, Canada, & Terracciano, 2017) and many disabling chronic diseases, such as obesity (Jokela et al., 2013), type-2 diabetes (Jokela et al., 2014) and cardiovascular diseases (Jokela, Pulkki-Råback, Elovainio, & Kivimäki, 2014), so associations between personality traits and disability are to be expected.

We examined the associations of the five major personality traits (i.e., conscientiousness, emotional stability, extraversion, agreeableness, and openness to experience) with life expectancy and the loss of disability-free life years, as measured by limitations in daily activities. The longitudinal association with disability risk was assessed among those who did not report disabilities at baseline. To translate these associations into population-level metrics, we estimated how much longer the average population life expectancy would have been and how many disability-free life years would have been added if personality differences were not related to mortality and disability, that is, if all individuals had personality scores that were not associated with elevated mortality or disability. We also examined whether the personality associations were accounted for by educational level, smoking, alcohol consumption, physical inactivity, and body mass index.

Methods

We utilized individual-level data from 10 prospective cohort studies from Australia, Germany, UK, and USA with a total of 130,000 participants: the British Household Panel Survey (BHPS); the English Longitudinal Study of Aging (ELSA); the Health and Retirement Study (HRS; USA); the Household, Income, and Labour Dynamics of Australia (HILDA); the Midlife in the United States (MIDUS) study; the National Child Development Study (NCDS; UK); the German Socioeconomic Panel Study (SOEP); the UK Household Longitudinal Survey (UKHLS); and the Wisconsin Longitudinal Study graduate (WLSG) and sibling (WLSS) samples (USA).

The study-specific descriptions of the assessments are reported in **Supplementary Material**. Briefly, personality was assessed at baseline using questionnaires of the Big Five personality traits. Disability was measured using Activities of Daily Living (ADL) scales at baseline and again at a follow-up (range: 3-19 years). ADL data were collected for the survival analysis from multiple follow-ups, except for WLSG and WLSS in which there was only one follow-up for ADL. Mortality data were derived from national mortality registers, except for BHPS, HILDA, and UKHLS for which mortality information were collected at annual follow-ups.

We estimated associations of personality traits with mortality and disability using flexible parametric survival analysis with age as the timescale. The pooled hazard ratios were estimated using two-stage meta-analysis in which the survival models were first fitted in each cohort study separately, and then random-effect meta-analysis was used to pool the associations across studies. In order to test potential non-linear associations, we used one-stage meta-analysis (with study as a stratifying variable) in which we pooled the results across studies. Personality traits were first standardized (mean=0, standard deviation=1) within each cohort study and then, in the pooled data, percentile scores were created and classified into groups (0-5, 5-15, 15-25, 25-40, 40-60, 60-75, 75-85, 85-95, and 95-100%).

Healthy life years lost associated with personality traits were determined from differences between survivor curves: To calculate years of life expectancy and disability-free life years, we first determined the model-predicted survivor curves for the different personality percentile groups, with confidence intervals calculated using bootstrapping with 500 repetitions. Life expectancy and disability-free life years were determined with the integrals of the area under the survivor curves. The years of life (and disability-free years) lost by individuals in a specific personality percentile group were then calculated as the difference between this group's integral compared to the integral of the reference group (e.g., life expectancy of individuals in the lowest 5 percentile compared to life expectancy of individuals in the highest 15 percentile). To determine how many life years and disability-free life years the overall population would gain, on average, if the personality traits were not associated with mortality and disability, we calculated the sum of lost life years and disability-free years across the personality percentile groups by weighting the sum by the relative proportions of the percentile groups in the population. Thus, the scenario in which personality trait is not associated with mortality or disability risk refers to calculations in which everybody is assumed to have personality scores of the reference group that are not associated with elevated mortality or disability risk. Participants with disability at baseline were excluded from the analysis of disability-free life years but were included in the analysis of mortality. Three studies (NCDS, SOEP, and UKHLS) were included only in analyses of life expectancy because these studies did not have repeated measurements of disability.

We also calculated the population attributable fractions using the formula for multi-category exposure assuming confounding (Rockhill, Newman, & Weinberg, 1998). Population attributable fraction indicates the proportional decrease in the prevalence or rate of the outcome if the exposure variable was not associated with the outcome. For example, a population attributable risk of 10% for conscientiousness in predicting disability would indicate that the incidence of disability in the population would be 10% lower if low conscientiousness was not associated with higher risk of disability. For an exposure variable with multiple categories, the equation is: $1 - \sum_{i=0}^{k} \frac{pd_i}{RR_i}$, where pd_i is the proportion of cases (e.g., deaths) in category i of the exposure variable (e.g., personality percentile group), RR_i is the relative risk for the ith exposure level compared to the reference group, and k is the number of exposure variable levels.

We used linear regression to impute missing values for smoking (2.9% missing observations), heavy alcohol consumption (10.7%), physical inactivity (0.4%), body mass index (8.1%), and education (3.5%) using all the predictor variables and the outcome variable. The BHPS and UKHLS cohorts were not included in the multivariable-adjusted analysis owing to an absence of data for physical inactivity and alcohol consumption.

Results

The analysis of mortality was based on 10 cohort studies comprising 131,195 participants followed up on average of 7.2 years (range: 2 to 22 years) during which period there were 8,405 deaths. For the analysis of disability, there were 7 cohort studies with a total of 43,935 participants (after excluding 17,480 participants with disability at baseline) with an average follow-up of 5.5 years (range: 3 to 19 years) giving rise to 5,099 incident cases of disability. Detailed descriptive statistics are shown in **Supplementary Table 2**. The numbers of participants, deaths, and incident disability cases in each personality percentile categories are reported in **Figures 1** and **2**.

Associations with mortality and disability. Lower conscientiousness was associated with higher mortality risk in a dose-response manner below the median whereas no association was observed for conscientiousness levels above the median (**Figure 1**). Lower emotional stability was also related to higher mortality risk but only in the lowest 15% of the distribution and not across the full distribution. Lower emotional stability was linearly related to higher risk of disability, with a dose-response association seen across the entire distribution, whereas the association of lower conscientiousness was again only observed below the median; the association of conscientiousness was weaker compared to the association of emotional stability (**Figure 2**). People in in top 25% for the openness to experience trait appeared to be have a higher disability risk but this association was induced by the mutual adjustment of all the personality trait percentiles in a single model, as openness to experience was unrelated to disability when examined alone (linear trend HR=0.99, CI=0.98, 1.00 when excluding other personality traits). No consistent associations were observed for extraversion or agreeableness in relation to disability risk.

We conducted supplementary analysis of personality traits as continuous predictors, where models were first fitted in each cohort study separately and then pooled together using random-effect meta-analysis. One standard deviation increase in conscientiousness was related to a lower risk of mortality (HR=0.88, 95% CI=0.84, 0.91) and disability (HR=0.89, 95% CI=0.85, 0.94), and one standard deviation increase in emotional stability was related to lower mortality (HR=0.96, 95% CI=0.93, 0.99) and disability (HR=0.76, 95% CI=0.74, 0.79). Other continuously coded traits showed no associations with death (**Supplementary Figures 1** and **2**).

Years of life lost and years of disability-free life lost. With there being no difference in life expectancy between the highest 4 groups of conscientiousness (i.e., top 60%) these categories were collapsed (**Figure 1**). For disability-free life years, we used the highest 15% of conscientiousness as the reference group. We applied the same recodings for emotional stability. We then refitted the above survival models with these categorizations and calculated the population-level indicators based on differences between survivor curves. Years of life lost and years of disability-free life lost associated with low conscientiousness and low emotional stability are shown in **Figures 3** and **4 (**see **Supplementary Table 3** for the confidence intervals). Compared to those in the highest 60% of conscientiousness, people in the lowest 5% had 6.2 (95% CI = 5.1, 7.1) years shorter life expectancy and 2.5 (1.5, 3.5) fewer disability-free life years. The corresponding figures for low emotional stability were 3.0 (1.8, 4.0) and 8.3 (7.3, 9.5).

Average healthy years lost in the population. We then estimated the average years of life lost and years of disability-free years lost in the population as the sum of years weighted by the population proportions of the personality percentile groups (**Figures 3** and **4**). Average population life expectancy was 1.3 (1.1, 1.4) years lower and disability-free life years 1.0 (0.4, 1.7) fewer due to the risks associated with low conscientiousness. With emotional stability, the corresponding numbers were 0.4 years (0.2, 0.6) for life expectancy and 2.4 (1.9, 3.0) for disability years. The population attributable fractions of conscientiousness were 12.0% (10.1, 13.7) for mortality and 11.4% (4.2, 18.1) for disability. For emotional stability, these were 3.3% (1.5, 5.0) and 27.9% (21.4, 31.9).

Multivariable-adjusted associations. In the cohort studies that had data on covariates, adjusting for education and health-related factors attenuated the average years of life lost associated with low conscientiousness from 1.23 to 0.91 years (25% reduction), and years with low emotional stability from 0.38 to 0.14 years (75% reduction). The average disability-free years lost was attenuated from 0.96 to 0.50 years (48% reduction) for low conscientiousness, and from 2.41 to 2.31 years (4% reduction) for low emotional stability (**Supplementary Table 4**). The reductions in the strength of these associations was mostly due to health-related factors, such as high body mass index, smoking and low physical activity, rather than educational attainment (**Supplementary Tables 5** and **6**). We also examined whether baseline disability explained the personality associations with mortality in the cohorts that had data on baseline disability (n=60,831; 5,660 deaths). Adjusting for disability attenuated the average years of life lost associated with low conscientiousness by 10.5% (from 1.20 years to 1.07 years) and associated with low emotionality by 47.6% (from 0.41 to 0.22 years).

Sensitivity analyses. As the associations might have been confounded by reverse causality (i.e., poor health influencing conscientiousness and emotional stability), we carried out a sensitivity analysis in which the 3 or 5 first years were excluded from the analysis. The associations of conscientiousness and emotional stability remained largely the same as in the main analysis, except that the association between conscientiousness and mortality attenuated somewhat (**Supplementary Figures 3** and **4**).

Discussion

In this analysis of individual-level meta-analysis of 130,000 adults, individuals with low conscientiousness had up to 6 years shorter life expectancy and 2 years fewer disability-free life years compared to those with conscientiousness score above the median. If the excess risks associated with low conscientiousness had been absent, the average population life expectancy would have been 1.3 years longer, with an additional 1.0 disability-free life years. Lower emotional stability was related to shorter life expectancy, but only among those in the lowest 15% of the distribution, and especially to higher disability risk: the population life expectancy would have been 0.4 years longer, with an additional 2.4 disability-free life years, if the excess risk associated with low emotional stability had been absent. We observed no consistent associations with life expectancy or disability-free life years for extraversion, agreeableness, or openness to experience.

Our study benefits from a large multi-cohort sample and the measurement of personality using the Five Factor Model, which is the most widely used and validated models of personality (Widiger, 2017). We were also able to account for potential issue of reverse causality, that is, personality changes that might anticipate death and declining health; the associations did not change substantially when the first 3 or 5 follow-up years were excluded from the analysis.

Different cohort studies assessed the five personality traits with different instruments, which may have introduced heterogeneity in the analysis. This may not be a major methodological problem, however, because (1) some of the cohorts did use the same measures (five cohorts using the BFI and three cohorts the MIDUS inventory), and (2) different measures of the five personality traits show at least moderately high correlations: Previous studies have reported average correlations of 0.77 between corresponding traits assessed by the 44-item BFI and the 60-item NEO Five-Factor Inventory, and correlations of 0.80 between BFI and the 100-item Character Trait Descriptive Adjectives inventory (John, Naumann, & Soto, 2008). Two different IPIP measures (IPIP-NEO and IPIP-FFM) had average correlations of 0.63 between corresponding traits (Donnellan, Oswald, Baird, & Lucas, 2006), the BFI and IPIP had average correlations of 0.67 with Chinese translations of the questionnaires (Zheng et al., 2008), and the correlations between corresponding traits of BFI and MIDUS inventories was also 0.67 (Pozzebon et al., 2013). More detailed analyses with multiple cohorts are needed to test whether specific facets or items are particularly important for health outcomes (e.g., Vainik, Mõttus, Allik, Esko, & Realo, 2015). Moreover, our analysis did not consider the mean age differences between the cohorts when standardizing the personality scores (except for including age and study as covariates), so the same standardized score may not have had the same meaning in cohorts that differ in average age. However, except for ELSA and HRS, the average baseline ages of the cohorts were quite similar (45 to 54 years), which probably did not confound the analysis substantially.

Major health risk factors, such as high blood pressure, dyslipidaemia, and diabetes, reduce life expectancy by 5 to 10 years (Bardenheier et al., 2016; Clarke et al., 2009). Thus, the 6-year shortening of life expectancy in individuals with very low conscientiousness is substantial—bearing in mind, of course, that the 6-year loss was observed only for those in the lowest 5% of the population; the 5%-15% percentile had 4 years and the 15%-25% percentile 2 years shorter life expectancy than those with average or high conscientiousness. Low conscientiousness has been associated with poorer health behaviors and higher risk of several chronic diseases, and these behaviors and diseases increase mortality risk (Hakulinen, Elovainio, et al., 2015; Hakulinen, Hintsanen, et al., 2015; Jokela, Hintsanen, et al., 2013). In this study, adjusting for education and baseline health variables (smoking, physical inactivity, heavy alcohol consumption, and body mass index) accounted for one-fourth of the years life lost associated with lower conscientiousness. Other mechanisms such as social relationships, physical changes or reactions to environmental circumstances might be important explanatory factors (Murray & Booth, 2015).

The mortality and disability risks associated with conscientiousness were observed only among those below the median level of conscientiousness, suggesting a threshold effect in which average level of conscientiousness is sufficient to avoid the mortality risk associated with low conscientiousness. Most previous studies have not examined potential non-linear health associations of conscientiousness, so there is not yet enough data to suggest possible mechanisms that would follow a similar non-linear association with conscientiousness. We hypothesize that multiple health risks and risky behaviors are more likely to accumulate at the low end of conscientiousness distribution, which might help to explain the shape of the association.

Low emotional stability was more strongly related to the loss of disability-free life years than with lost life years. Emotional stability is associated with poor health behaviors, and very low emotional stability is also a strong indicator of diagnosable mental disorders (Jeronimus, Kotov, Riese, & Ormel, 2016) that are associated with elevated mortality risk (Liu et al., 2017). In the present study, the mortality risk of low emotional stability was only observed for those in the lowest 15% of the distribution, suggesting that severe mental disorders might be one of the mediating mechanisms. In multivariable adjusted analyses, educational level, unhealthy life choices and lifestyle-related factors explained more than half of the association between emotional stability and mortality.

Education and health behaviors explained less than 10% of the association between low emotional stability and loss of disability-free life years. People with low emotional stability tend to be more sensitive to physical symptoms than those with high emotional stability (Vassend, Røysamb, & Nielsen, 2012). They may therefore be more likely to report limitations in daily activities even if they were physically capable of doing those activities. This might be considered as a source of reporting bias. On the other hand, even subjectively perceived limitations may have adverse consequences if these perceived limitations influence the person's behaviors, for example, if the person tends to avoid certain daily activities.

It is yet unclear whether personality traits are causal health risk factors or whether they are only non-causal risk markers for mortality and morbidity (Jokela, Airaksinen, Kivimäki, & Hakulinen, 2018). There might be common genetic or environmental factors that contribute to personality and health (Kim, 2016), in which case the associations might not be causal. The associations might also reflect reverse causality, as poor health behaviors, such as heavy alcohol consumption (Hakulinen & Jokela, 2019) and physical inactivity (Stephan, Sutin, & Terracciano, 2014), and the incidence of chronic diseases (Jokela, Hakulinen, Singh-Manoux, & Kivimäki, 2014) have been associated with decreasing levels of conscientiousness and emotional stability over time (Allen, Vella, & Laborde, 2015). However, reverse causality did not seem to account for much of the associations with mortality and disability.

In conclusion, this multi-cohort study provides individual-level and population-level estimates for the years of life lost and years of disability-free years lost associated with individual differences in personality traits. Further data are needed to identify the mechanisms that account for these associations, as common health behaviors do not seem to explain them completely.

Figure captions

Figure 1. Mortality risk associated with percentile groups of personality traits in the pooled dataset of 131,195 individuals from 10 cohort studies.

Figure 2. Disability risk (assessed with Activities of Daily Living scales) associated with percentile groups of personality traits in a pooled dataset of 43,935 individuals from 7 cohort studies.

Figure 3. Estimated difference in life expectancy and disability-free life years associated with lower conscientiousness compared to the highest 15% (for disability) and highest 60% (for mortality) end of conscientiousness. Hazard ratios are reported in Supplementary Tables 5 and 6.

Figure 4. Estimated difference in life expectancy and disability-free life years associated with lower emotional stability compared to the highest 15% (for disability) and highest 60% (for mortality) end of emotional disability. Hazard ratios are reported in Supplementary Tables 5 and 6.

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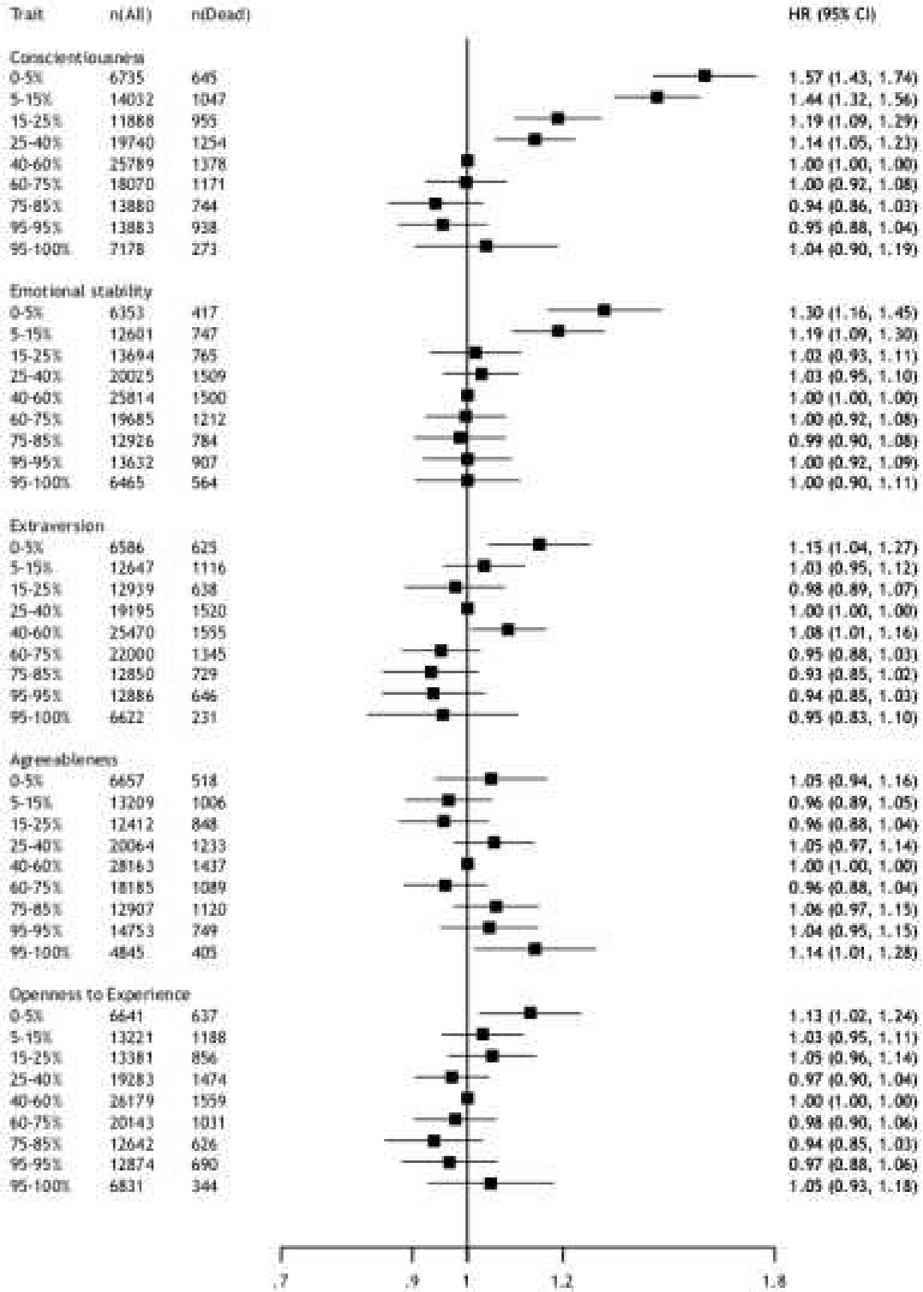

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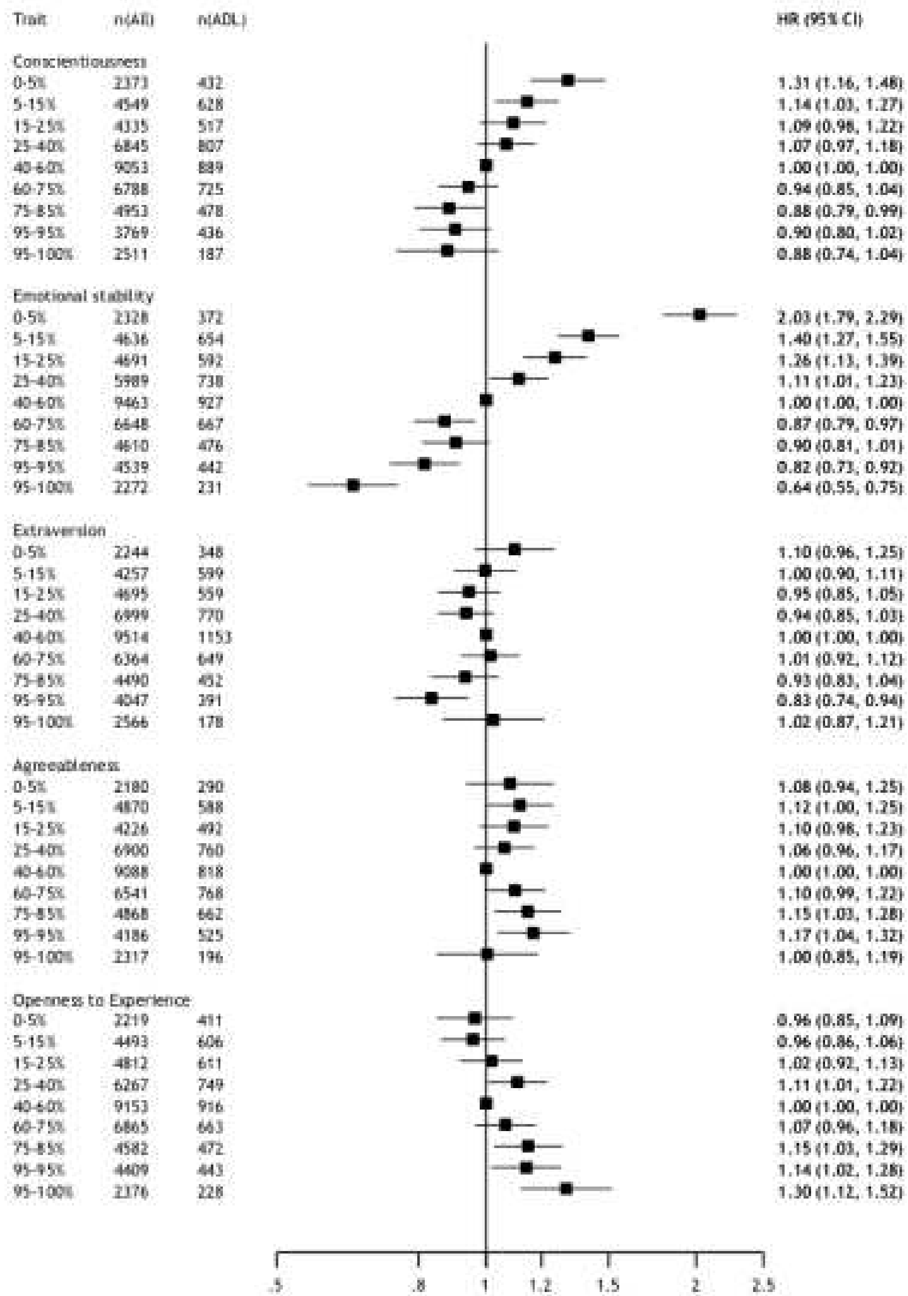

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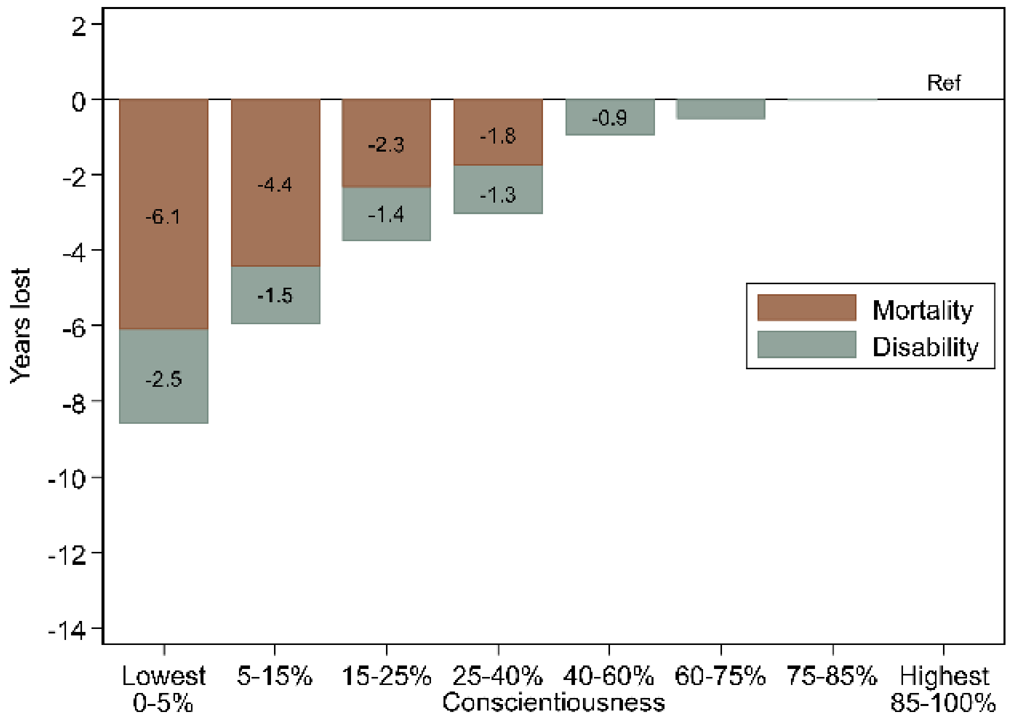

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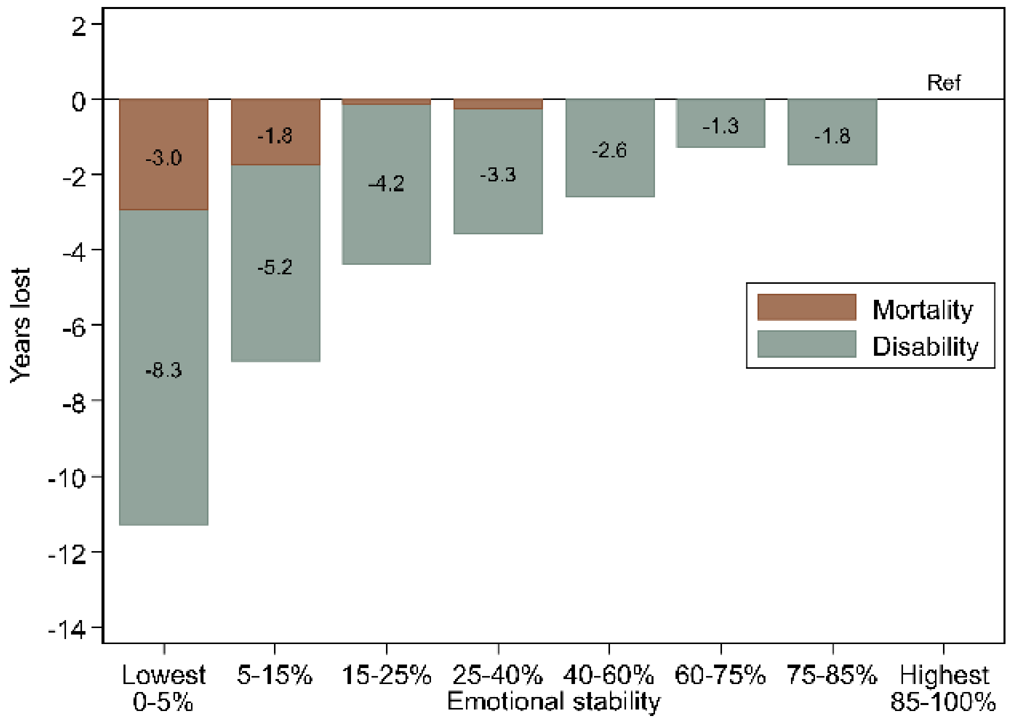

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