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RESEARCH ARTICLE

Does personality predict health? Non-cognitive skills, health behaviours, and longevity in Russia

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Abstract

Non-cognitive skills have recently gained much attention as an explanation for various social outcomes, including health inequalities. This paper explores the relationship between non-cognitive skills measured as the Big Five and locus of control, health behaviours such as physical activity, smoking, and drinking, and the resulting measures of health. A set of binary and multinomial logit models, as well as Cox proportional hazard models for longevity, are estimated on rich panel RLMS-HSE data for the years 2011-2021. Conscientiousness from the Big Five and internal locus of control show a significant and consistent positive association with self-assessed health and objective longevity in both genders, which is only partly mediated through health behaviours. Gender-specific differences are also present, with neuroticism increasing the risks of mortality for males, and openness decreasing them for females. Openness, conscientiousness, extraversion, neuroticism, and internal locus of control all show a statistically significant link with self-assessed health. Policies, aimed at the formation of positive non-cognitive skills during early stages of socialisation, may be a promising instrument for improving individual health.

Keywords

Big Five, health behaviours, locus of control, longevity, non-cognitive skills, personality, survival analysis

JEL codes: I12, J24

Introduction

The World Health Organization defines health as a state of total physical, psychological, and social well-being, implying an objective lack of illnesses, but not necessarily limited to it (WHO 1946). From a microeconomic perspective, health is a core part of human capital

which affects individual productivity, acquisition of skills, and, consequently, determines individuals' earning potential (Grossman 1972). At the same time, population health shapes a country's economic capabilities, which are significantly limited by the burden of disease. The reduction of the global burden of disease is a major topic in public policy which encourages the search for the factors of individual health and health inequalities.

Why do some people live longer and healthier lives than others? First, apart from genetically inherited diseases, the health risks are heavily dependent on health behaviours which individuals pursue. Heavy smoking and drinking, lack of physical exercise, unhealthy diet, and other actions all contribute to morbidity and mortality. Second, lack of access to quality medical care limits individual involvement in preventive and curative measures, which may significantly reduce longevity. Both reasons, at least partly, can be explained by socioeconomic status (SES) and education, which serve as the primary focus of health economics research. Individuals with lower SES are, on average, more inclined to bad health (Mackenbach et al. 1997), while more educated individuals tend to be healthier and to live longer (e.g., Conti and Hansman 2013).

Another possible explanation for health inequalities might lie in individual psychological differences, which in economic research are usually referred to as non-cognitive skills. Non-cognitive skills are defined as a stable pattern of thoughts, feelings, and behaviours, which determine individual responses to certain circumstances (Roberts 2009). Non-cognitive skills are also called personality in psychology or socio-emotional skills in social sciences in general. By referring to these characteristics as "skills", economic literature emphasises the ability to nurture them, especially at the stage of early education, and their policy relevance (see Kautz et al. 2014). In this paper, terms "non-cognitive skills" and "personality" are used interchangeably. Over the past decade, non-cognitive skills have turned into a prominent research field at the intersection of economics, education, and psychology. Previous literature suggests that these characteristics affect a variety of socioeconomic outcomes from employment and wages to educational decisions, migration, and health (see (Almlund et al. 2011) for a review). Including non-cognitive skills into the analysis is important for several reasons. First, they are closely related to education and may, at least partially, mediate the observed "education-health" gradient in the literature. Second, to a great extent, the formation of non-cognitive skills depends on early socialisation and family, transmitting initial socioeconomic inequalities. However, these skills remain responsive to external influences until late adolescence. Shaping positive and productive non-cognitive skills, especially during childhood and early adolescence, may be considered as a promising target for interventions in education and public health.

Psychologists have long been exploring personality as a determinant of individual health. Personality serves as a cause of various illnesses, including cardio-vascular and inflammatory diseases (Hemingway and Marmot 1999). However, most of the evidence, presented in psychology research, is based on small samples and correlation analysis. Therefore, one should be cautious trying to interpret these findings in a causal way (see (Roberts et al. 2007) for a review). Although economists remained rather slow in incorporating personality into health research, economic literature takes steps to prove the likely causal mechanisms. For instance, Conti et al. (2010) and Conti and Hansman (2013) establish the positive effect of childhood non-cognitive skills on adult health behaviours and health outcomes, suggesting that not accounting for personality overestimates the effect of cognitive abilities and education on health. Recently the field of health economics has experienced a sharp increase in research, covering the effect of non-cognitive skills on health-related behaviours and outcomes (Bellmann and Hübler 2022; Savelyev 2022; Attanasio et al. 2020).

This study is one of the first papers analysing the relationship between non-cognitive skills, health behaviours and the resulting longevity for Russia on rich longitudinal data. Using duration analysis design, as well as binary and multinomial logit models, this study establishes a statistically significant association between non-cognitive skills, measured as the Big Five or internal locus of control, and self-assessed health, health behaviours, and longevity. The results suggest that there exists a direct effect of non-cognitive skills on health, not mediated through individual health behaviours or acquired education.

Literature review

a. Theoretical background

The theoretical framework of this research is given by Grossman's demand for health model (1972). Health is an important part of human capital, with higher levels of health implying higher individual productivity. Everyone is born with a certain innate stock of health, which suffers from amortisation, but can be enhanced with health investments. Health investment is a set of actions, including regular doctor visits, following medical prescriptions, conducting a healthy lifestyle with regular physical activities, healthy nutrition, and avoiding harmful addictions like smoking and drinking alcohol. Although health investments require financial resources and time, they also extend the time horizon, during which an individual receives benefits from other components of human capital. This makes health complementary to other forms of human capital and determines one's ability to acquire other skills (Currie 2005; Currie and Stabile 2006). Moreover, better health translates into the ability to consume more and brings greater earnings potential due to increased individual productivity. Finally, the duration of one's life is endogenous: when the health stock falls below a critical threshold, life is over. In this framework, non-cognitive skills can affect individual health investments, eventually increasing the health stock and extending the time horizon. Moreover, health is a self-reproducing system where the state of health at each consequent step depends on the previous health investments. The larger the past investments, the more productive it becomes to invest in health in the forthcoming periods (Hai and Heckman 2017).

From the psychological perspective, there are several theories explaining the link between personality and health inequalities. One of them is the Health belief model (Rosenstock 1974), suggesting that if individuals rate themselves as susceptible to a health condition that, in their view, can bring serious consequences, they are more likely to take actions to reduce their risks if these actions are believed to be beneficial. Personality can shape individual beliefs about the potential susceptibility to health risks and benefits from interventions.

b. Measures of non-cognitive skills

Empirical literature investigating the relationship between non-cognitive skills and health generally relies on the well-known psychological concepts. The first concept is the Big Five, suggesting that everyone can be described from the viewpoint of five personality categories: openness to experience (defined as being imaginative and inventive), conscientiousness (comprised of diligence and hard work), extraversion (defined as being sociable and assertive), agreeableness (includes altruism, cooperation, and friendliness), and neuroticism (or the reverse of emotional stability). An alternative measure, frequently used in literature, is locus of control, which reflects the individual tendency to explain various life events with

external forces (external locus of control) or with one's own actions and behaviours (internal locus of control).

The particular attention to the Big Five and locus of control as proxies for non-cognitive skills is motivated by their stability over time. Psychological literature reports a trend increase in neuroticism and a decrease in conscientiousness in older cohorts due to ageing, as well as a decrease in neuroticism, extraversion, openness and an increase in agreeableness and conscientiousness in younger cohorts due to their maturing (Terracciano et al. 2005). Nevertheless, there is a large body of evidence of the predictive power of childhood, along with adolescent measures of personality, on adult outcomes (Conti and Hansman 2013). Personality measured at the age of 30 can be considered as fixed (Terracciano et al. 2006). In economic research, it has been shown that the Big Five and locus of control, measured with short survey instruments, remain stable across one's working life. Cobb-Clark and Schurer (2012, 2013), using Australian longitudinal household data, showed that the Big Five and locus of control are consistent, at least in the short- and medium-term, and remain unresponsive to major life events. Health shocks have also been shown to have a relatively small and mostly insignificant effect on non-cognitive skills measured by locus of control; more pronounced reverse effects may only appear in older cohorts. (Marsaudon 2022; Cobb-Clark and Schurer 2012).

Although economic research has been mostly relying on the Big Five and locus of control as the core measures of non-cognitive skills, the choice of measure is usually motivated by data availability. For instance, Chiteji (2010) explores the association between future orientation and self-efficacy as measures of non-cognitive skills and health behaviours. Apart from locus of control, Mendolia and Walker (2014) used self-esteem and work ethic to proxy non-cognitive skills. However, such concepts as locus of control, self-efficacy, neuroticism, and self-esteem are closely related and may be measuring the same higher order concept (Judge et al. 2002).

c. Non-cognitive skills and health outcomes

Psychological literature consistently reports conscientiousness to be the most predictive personality trait for health-related outcomes (Friedman et al. 1995; Jokela et al. 2013; Kern and Friedman 2008). Being at the lowest 25% of conscientiousness distribution is associated with a 30 percent increase in preliminary mortality risk compared to the upper 25%, which is equal to a 2 year longer life expectancy (Friedman et al. 1995). However, the effect of traits, particularly conscientiousness, on health behaviours may be stronger for younger adults than for older ones (Bogg and Roberts 2004).

In contrast to the health benefits of conscientiousness, neuroticism is generally associated with the reduced health and higher mortality risks (Savelyev and Tan 2019). Neuroticism is correlated with worse health, especially when it is measured as a construct of psychosocial and subjective aspects (Friedman 2019). High neuroticism combined with high conscientiousness may create a phenomenon of healthy neuroticism, predicting lower mortality risks (Friedman 2000). However, recent empirical findings did not support the existence of this link (Turiano et al. 2020). Evidence concerning the remaining Big Five constructs (i.e., extraversion, openness, agreeableness) is less pronounced.

Conscientiousness, agreeableness, and emotional stability are positively correlated with the overall good self-assessed health, although only neuroticism is significantly associated with an objective measure of the number of sick days (Bellman and Hübler 2022). On PIAAC data (Programme for the International Assessment of Adult Competencies) from

Poland, The Big Five categories explain a larger portion of additional variance in self-assessed health (2.6%) than cognitive abilities (0.3%). While conscientiousness and extraversion are positively related to health, neuroticism implies a negative effect (Palczyńska and Świst 2018).

Locus of control is also consistently associated with health outcomes. Externality implies a significantly higher hazard rate ratio for mortality, although for women the effect is either small or insignificant after the adjustment for health behaviours (Lindström and Rosvall 2020; Lindström et al. 2022). Externality is associated with higher chances of dropping out of the labour force after a health shock among men, unrelated to early retirement, and fewer working hours per week, especially among men with lower socioeconomic status (Schurer 2017).

d. Mechanisms

An open question is why non-cognitive skills predict health-related outcomes and whether fostering positive skills will help the improvement of health. The main channels linking personality with longevity and other health outcomes are health behaviours such as nutrition, sleep, smoking, and drinking alcohol. Heckman et al. (2006) showed that locus of control and self-esteem causally affect the probability of smoking and risky behaviours. Physical activity is correlated with extraversion, neuroticism, conscientiousness, and openness (Wilson and Dishman 2015), as well as internal locus of control (Cobb-Clark et al. 2014). External locus of control is associated with higher chances of risky health behaviours (Mendolia and Walker 2014). A positive effect of traits related to emotional stability is observed for the reduction of alcohol consumption and an increase in physical activity (Chiteji 2010). Childhood skills predict adolescent health with external locus of control being negatively associated with smoking (Attanasio et al. 2020). When it comes to unhealthy habits, personality determines individual susceptibility to peer pressure, making less emotionally stable adolescents more likely to start smoking (Hsieh and van Kippersluis 2018). The positive effect of higher conscientiousness on longevity is by 42% mediated by risky habits such as drinking patterns and smoking (Turiano et al. 2015). In a recent context, personality is often associated with COVID-19 precautionary behaviours (higher openness, conscientiousness, neuroticism) (Airaksinen et al. 2021), including vaccination (Roshchina et al. 2022).

Gender differences in the effects also exist. While for men openness is associated with health-harming behaviours, for women the relationship is reversed (Savelyev and Tan 2019). Different explanations can be applied. For instance, while men with internal locus of control expect to have higher rewards from a healthy diet and exercise, internal women get more satisfaction from healthy activities compared to their external counterparts (Cobb-Clark et al. 2014). Programs promoting positive non-cognitive skills in childhood and adolescence may have gender-specific effects, with more pronounced results for boys rather than girls (Conti et al. 2016). Due to gender differences in the effects for various skills, some caution should be taken when choosing the skills to foster (Savelyev 2022).

An alternative pathway from non-cognitive skills to health is education. Conti and Hansman (2013) suggest that non-cognitive skills contribute to the education-health gradient almost as much as cognitive abilities. Non-cognitive skills are a stronger predictor of mortality than cognition (Öhman 2015). On a longitudinal sample of high-ability individuals, Savelyev (2022) shows a strong effect of conscientiousness and extraversion on longevity for men and no effect for women, although little of this relationship can be attributed to education. Approximately one third of the education-health gradient can be explained by non-cog-

nitive skills (Carter et al. 2019). Recent literature suggests that in most health outcomes, non-cognitive skills reduce the education-health gradient by 20-30%, even after taking into consideration sibling-fixed effects (Gørtz and Gensowski 2023).

Part of the relationship also runs through socioeconomic status and income (Öhman, 2015). Stronger associations between non-cognitive skills (both the Big Five and LOC) and health outcomes are observed for low-income earners (Öhman 2015; Musich et al. 2020). Locus of control may as well have a modest but significant effect on the formation of socioeconomic inequality in adult health (Pedron et al. 2021). Policies improving non-cognitive skills may be more important for those with the poorest health (Atkins et al. 2020). However, even after controlling for health behaviours, education, and socioeconomic characteristics, research reports the existence of a direct effect of non-cognitive skills (Hampson et al. 2007; Lodi-Smith et al. 2010).

e. Evidence from Russia

For Russia, there exists only limited economic research on the determinants of health and longevity. Roshchina (2009), on RLMS-HSE data for years 2000-2005, shows positive returns on private health investment, such as physical activity, avoiding smoking and abstinence, although the analysis does not cover any psychological factors. Denisova (2010), conducting a survival analysis on the same dataset but during a different time period (1994-2007), suggests that excessive alcohol consumption and smoking were prominent health behaviours reducing longevity in the Russian population during the economic transition and early 2000's. A recent study, using survival modelling on the same data for years 2004-2019, showed a non-existent effect of marriage for men's health, a singlehood health penalty for younger women, and a premium for older cohorts (Akhtemzyanov 2023).

The link between non-cognitive skills, health behaviours and health outcomes, including longevity for Russia, remains largely unexplored. The probability of alcohol consumption and the amount of alcohol consumed are significantly affected by the Big Five. While only conscientiousness (a negative relationship) and extraversion (a positive relationship) are related to the probability of alcohol consumption, agreeableness and neuroticism are only related to the volume of consumption. Moreover, non-cognitive skills may mediate the relationship between education and alcohol consumption (Rozhkova et al. 2023). Finally, the Big Five and risk attitudes are demonstrated to significantly affect vaccination hesitancy and refusal during the COVID-19 pandemic (Roshchina et al. 2022). Conscientiousness, openness to experience, internal locus of control, and emotional stability are positively correlated with individual intentions to pursue higher education and the probability to graduate with a university degree (Rozhkova and Roshchin 2021). In the labour market context, a highly significant positive correlation is observed between conscientiousness, openness, emotional stability, and wages (Rozhkova 2019; Gimpelson et al. 2020).

Data and method

a. Data

For this study, data from the Russian Longitudinal Monitoring Survey (RLMS-HSE) is used. The survey is conducted annually since 1994 on a large nationally representative sample of approximately 14,000 respondents from 5,000 households, and comprises a wide array

of socioeconomic, psychological, and health-related questions. The data are retrieved from rounds 20-30 of the survey which were conducted in 2011-2021. The analysis is performed on a sample for all individuals aged 17-100 years. Additional models calculated on a limited sample aged 18-65 provide similar results. As health behaviours and the effect of non-cognitive skills on longevity might have gender specifics, analysis is performed for men and women separately.

The RLMS-HSE dataset contains several measures of non-cognitive skills. Wave 20, for 2011, provides questions related to individual locus of control. To construct a measure of internal locus of control, an average of 7 behavioural questions, assessed on a scale from 1 to 4, is used. Given the personality stability assumption, the 2011 measure is extrapolated to future rounds if the respondent participated in them. The final measure is standardised with a mean of zero and a standard deviation of one. The full list of questions and a basic distribution of responses are available in Table 1A in the Supplementary materials.

In 2016 (round 24), a new block of 24 behavioural questions was introduced to the survey. These questions can be mapped into 5 categories: 3 questions are related to openness to experience, 7 to conscientiousness, 3 to extraversion, 4 to agreeableness, and 7 to neuroticism. The questions are assessed on a scale from 1 to 4. Each category is constructed as an average of the attributed questions and standardised with a mean of 0 and a standard deviation of 1. The Big Five is used separately from locus of control due to the time mismatch and loss of observations. Also, the longevity analysis with the Big Five only covers 5 years (from 2016 to 2021), while that with locus of control covers 10 years. Although this can be considered as a limitation, the results provide some interesting insights about the relationship between health and personality.

b. Method

Three different approaches are used to assess the association between non-cognitive skills and health, given the benefits of longitudinal data. We describe them below separately.

Model 1

First, a multinomial logit model with standard errors clustered on the individual level is run to look at the non-cognitive predictors of self-assessed health. The model uses self-assessed health as the dependent variable. Self-assessed health is widely used in the research context as a valid predictor of the actual mortality (Idler and Benyamini 1997). Health is measured on a 5-point scale where 1 signifies "very bad health" while 5 translates into "very good health". The estimated model can be written as:

$$\Pr\left(Y_i = k|X_i;\beta\right) = \frac{\exp\left(X_i'\beta_k\right)}{\sum_{j=1}^{5}\exp\left(X_i'\beta_j\right)} \quad \text{for} \quad k = 1\ldots5 \tag{1}$$

where Y is the dependent variable taking value k from 1 to 5, which reflects five possible health states, X is the vector of explanatory variables, and β are the estimated coefficients, i refers to an individual. The model is estimated in two specifications. Specification one controls only for non-cognitive measures (either the Big Five or locus of control) and socio-demographic factors. Specification 2 also includes health behaviors (a set of binary variables for smoking, drinking, and physical activity). Socio-demographic factors include gender (a binary variable which equals to 1 for male and 0 for female), age, education

(higher education, vocational degree, or lower as a reference category), marital status (a binary variable which equals to 1 if the respondent is officially married and 0, otherwise), presence of children (a binary variable), number of family members (a continuous variable), type of settlement (a binary variable which equals to 1 for urban area, and 0, otherwise), employment status (a binary variable which equals to 1 for being currently employed, and 0, otherwise). We additionally control for the year of observation (2016-2021 for the Big Five models, 2011-2021 for locus of control models)[1]. Since coefficients in multinomial regressions reflect the sign and significance, but can be hardly interpreted quantitively, marginal effects at means are presented instead.

Model 2

Second, a block of logit models with standard errors clustered on the individual level is used to measure the link between non-cognitive skills and health behaviours such as smoking, alcohol consumption, and physical activity. These health behaviours are reportedly named among the most important determinants of individual health (Chiteji 2010; Schurer 2017). The estimated model in general terms can be written as:

$$\Pr\left(Y_i = 1 | X_i; \beta\right) = \frac{1}{1 + \exp^{-X_i'\beta}} \tag{2}$$

where Y is the dependent variable (smoking, alcohol consumption, or physical activity) taking value 1 or 0, X is the vector of explanatory variables, and β are the estimated coefficients, i refers to an individual. Smoking is a binary variable which is assessed with the following question: "Are you a smoker?". Drinking is a binary variable which measures any alcohol consumption, including moderate, and is assessed with the following question: "Do you consume alcoholic beverages, including beer?". Physical activity is a binary variable which is assessed with the following question: "During the past 12 months did you take part, at least 12 times, in some type of physical activities?", with the list of activities including running, swimming, exercising in a gym, walking, cycling, aerobics, shaping, yoga, playing basketball, volleyball, badminton, tennis, boxing, martial arts, or others. Similar to Model 1, independent variables include gender, age, education, marital status, presence of children, number of family members, type of settlement, employment status, year of observation.

Health behaviours may serve as channels of non-cognitive skills, eventually linking them to health. Therefore, these variables are used as dependent for logit models and as independent variables for other health and survival models.

Model 3

When it comes to the association between personality and health, reversed causality may arise. First, worse health may affect certain measures of personality traits, given that data are collected via self-assessment. For instance, bad health may increase neuroticism and lead to the externalisation of locus of control. Second, reversed causality may arise when considering health behaviours. Although excessive drinking and physical activity may shift personality, less evidence exists for smoking (Allen et al. 2015). As an ultimate solution for the issue of reversed causality, we use mortality data and duration analysis design. For this, we estimate a proportional hazard survival model, namely a non-parametric Cox model with standard errors clustered on the regional level. This approach is used to overcome the

1 Descriptive statistics for explanatory variables are presented in Table 2A in the Supplementary materials.

estimation bias arising due to a non-normal distribution of time to event (death) and right censoring. Proportional hazard survival models are widely applied to studies of mortality and are based on the estimation of the likelihood that the spell ends at time t on the condition that the spell lasts until time t. This likelihood is referred to as hazard rate. In mortality studies the hazard rate at age t is the probability of dying at age t, conditional on surviving to this age. The regression model can be written as:

$$\lambda(t, X, \beta, \lambda_0) = \phi(X, \beta)\lambda_0 \quad (3)$$

where λ is the expected hazard at time t, λ_0 is the base hazard, corresponding to $\phi(.) = 1$, $\phi(X, \beta) = \exp(X'\beta)$, X is the vector of explanatory variables, and β are the estimated coefficients. The non-parametric Cox proportional hazard model allows for a flexible baseline hazard function. The model is estimated in two specifications. Specification one controls only for non-cognitive measures (either the Big Five or locus of control) and socio-demographic factors. Specification 2 also includes health behaviors. Independent variables include gender, education, marital status, presence of children, number of family members, type of settlement, and employment status.

The survival model uses the fact of the reported death of a respondent determined from the household survey. If the household is surveyed at least two rounds in a row, the head of the household reports the absence of the household members who took part in the survey during the previous round. The reasons of absence can be the following: 1) the household member moved to another address; 2) the household member formed a new household; 3) the household member died (with a cause of death collected from 2001); 4) other reasons. We divide causes of death into external and health-related. From 2012 to 2021 there were a reported 1,749 all-cause deaths among the survey participants, 154 of them were due to external causes and 1,595 were related to medical conditions. The distribution of the reported deaths across years and genders is presented in Table 1.

Table 1. Reported death cases in RLMS, by year

Year of reported death	Frequency (All-cause mortality)	Frequency (Health-related mortality)	Male sample (Health-related mortality)	Female sample (Health-related mortality)
2012	221	202	115	87
2013	220	195	103	92
2014	209	185	105	80
2015	180	156	78	78
2016	146	136	72	64
2017	143	129	64	65
2018	175	168	85	83
2019	146	134	71	63
2020	154	146	80	66
2021	155	144	70	74
Total	1,749	1,595	843	752

Results

a. Non-cognitive skills and health self-assessment

Tables 2-5 provide evidence on the association between non-cognitive skills and health self-assessments, controlling and not controlling for health behaviours (full results are available in the Supplementary materials). First, there is a clear association between self-assessed health and health habits in both genders and in both the Big Five and locus of control models. Quantitatively, the most pronounced effects arise between alcohol consumption and self-assessed health, although it is controversial. Alcohol consumption is negatively associated with very bad and bad health self-assessments, but positively with average health. Among men, the predicted probability of bad and very bad health is 9 percent for those drinking alcohol and 16 percent for abstainers. In contrast, probability of average health is 55 percent among non-abstainers and 47 percent among abstainers. It is likely that excessive drinking might have negative effects on health, while moderate consumers, which comprise most of the sample, do not experience any negative influences on health. The observed associations are consistent in both genders. In contrast, smoking is positively associated with the probability of bad health in the female sample, increasing it by 2.7 percentage points, but slightly negatively with very good health for males. In the locus of control models, the effect is more notable with smoking reducing the probability of good health by almost 4 percentage points among males and by 2 percentage points among females. Although it may seem that small size effects contradict the common knowledge about negative health effects of smoking and alcohol consumption, it is important to keep in mind that, first, the observed effects are statistically significant after controlling for a large set of variables, and second, this is subjective health measure rather than objective. When it comes to objective longevity, the size effects are significantly more pronounced (see section "Non-cognitive skills and longevity" of the Results).

Second, there is a positive association between health self-assessment and education on Russian data before and after controlling for health habits, which is observed only on the female sample. Higher education implies a higher probability of good health (approximately 2 percentage points in both the Big Five and locus of control before and after controlling for habits) and a reduced probability of bad (approximately 3 percentage points) and very bad health (approximately 1 percentage point). The size of the effect is slightly reduced after the introduction of health habits.

Third, we observe a significant association between health and non-cognitive skills, proxied with different psychological instruments. From the Big Five, there is a beneficial association between health and conscientiousness, both before and after controlling for habits. Higher conscientiousness is positively associated with a better health assessment and negatively with worse. The size of the effect is only slightly reduced after controlling for physical activity, smoking, and drinking. In contrast, neuroticism is associated with the reduced probability of good health (for the male sample, one standard deviation increase decreases the probability of good health by 4 percentage point, respectively; for the female sample, by 3.7 percentage point) and the increase of bad and very bad health, which is also in line with the literature (Friedman et al. 1995).

The other Big Five categories demonstrate fewer stable results and are less consistent across genders. Extraversion demonstrates an increased probability of good health, a reduced probability of average health, and mixed results for bad and very bad health in the female sample. Openness demonstrates a reduced probability of good health in both genders, but a higher probability of average health. Agreeableness shows a very small positive associ-

ation with very good health and low significance on the female sample. Finally, internal locus of control is associated with better self-assessed health both before and after controlling for health-related habits. For both genders, a standard deviation increase in internality is associated with a 3-percentage point lower probability of bad health and 4 percentage point higher probability of good health. Figures 1-2 graphically illustrate the observed direct effects of non-cognitive skills in terms of predicted probabilities of various health outcomes.

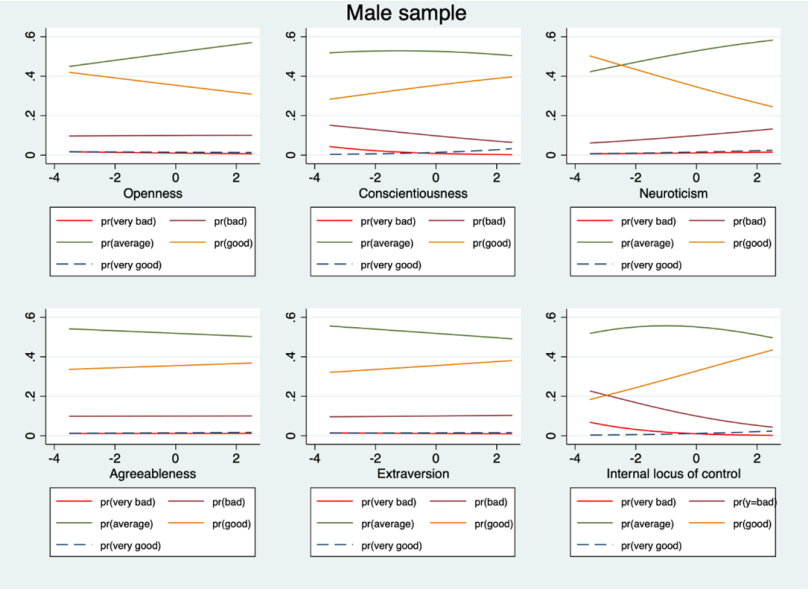

Figure 1. Marginal effects, male sample

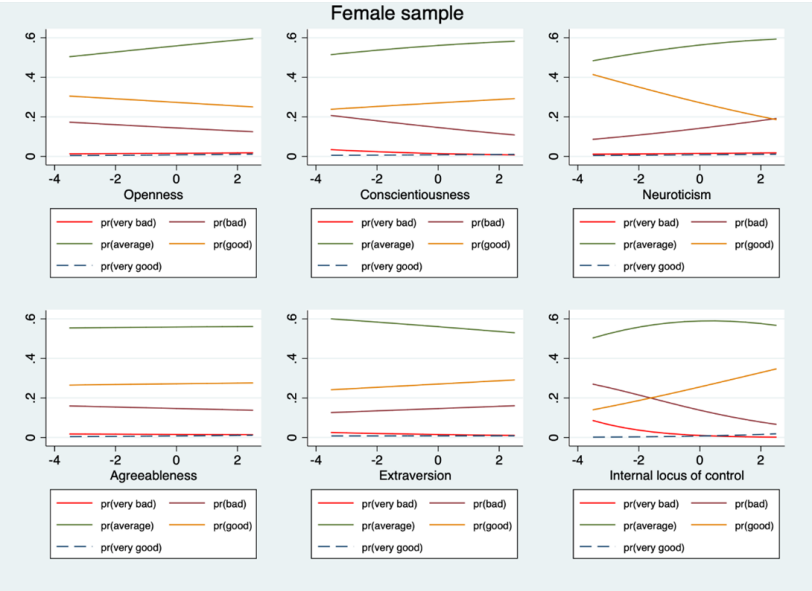

Figure 2. Marginal effects, female sample

Table 2. The relationship between self-assessed health and the Big Five for the male sample, marginal effects from multinomial logit regression[1]

	Very bad	Bad	Average	Good	Very good	Very bad	Bad	Average	Good	Very good
Openness	-0.00166	0.000661	0.0202***	-0.0185***	-0.000638	-0.00189	-0.000547	0.0193***	-0.0163***	-0.000507
	(0.00141)	(0.00372)	(0.00670)	(0.00604)	(0.00128)	(0.00142)	(0.00376)	(0.00676)	(0.00603)	(0.00127)
Conscientiousness	-0.00542***	-0.0142***	-0.00399	0.0185***	0.00508***	-0.00592***	-0.0141***	-0.00547	0.0201***	0.00533***
	(0.00149)	(0.00373)	(0.00682)	(0.00619)	(0.00132)	(0.00160)	(0.00379)	(0.00686)	(0.00617)	(0.00132)
Extraversion	-0.000813	0.00121	-0.0108*	0.00995*	0.000448	-0.00114	0.000235	-0.0110*	0.0115**	0.000356
	(0.00114)	(0.00337)	(0.00590)	(0.00531)	(0.00101)	(0.00116)	(0.00342)	(0.00597)	(0.00534)	(0.000992)
Agreeableness	5.58e-05	0.000270	-0.00653	0.00529	0.000918	0.000202	0.000530	-0.00690	0.00508	0.00109
	(0.00139)	(0.00359)	(0.00641)	(0.00585)	(0.00123)	(0.00148)	(0.00366)	(0.00649)	(0.00587)	(0.00124)
Neuroticism	0.00148	0.0123***	0.0257***	-0.0424***	0.00290***	0.00142	0.0127***	0.0256***	-0.0425***	0.00278**
	(0.00117)	(0.00331)	(0.00591)	(0.00541)	(0.00112)	(0.00121)	(0.00342)	(0.00599)	(0.00541)	(0.00111)
Higher education	0.00604**	0.000363	-0.00824	0.00243	-0.000603	0.00463	-0.00573	-0.0121	0.0115	0.00171
	(0.00294)	(0.00823)	(0.0144)	(0.0131)	(0.00303)	(0.00305)	(0.00849)	(0.0142)	(0.0128)	(0.00287)
College	0.00332	0.00971	-0.0154	-0.000407	0.00278	0.00336	0.00737	-0.0158	0.00160	0.00344
	(0.00283)	(0.00841)	(0.0143)	(0.0128)	(0.00265)	(0.00297)	(0.00847)	(0.0144)	(0.0128)	(0.00265)
Physical	-0.0151***	-0.0259***	0.00213	0.0344***	0.00449*					
	(0.00361)	(0.00797)	(0.0125)	(0.0111)	(0.00231)					
Smoke	0.0000	-0.000165	0.0226**	-0.0158	-0.00663***					
	(0.00233)	(0.00644)	(0.0113)	(0.0101)	(0.00214)					
Drink	-0.0113***	-0.0509***	0.0731***	-0.00942	-0.00149					
	(0.00239)	(0.00561)	(0.0111)	(0.0104)	(0.00225)					
N of observations			20,057					20,174		
N of clusters			4,299					4,302		

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

1 The results*100 can be interpreted as percentage points

Table 3. The relationship between self-assessed health and the Big Five for the female sample, marginal effects from multinomial logit regression

	Very bad	Bad	Average	Good	Very good	Very bad	Bad	Average	Good	Very good
Openness	0.000785	-0.00798**	0.0152***	-0.00916**	0.00120	0.0000	-0.0105***	0.0174***	-0.00818*	0.00125
	(0.00135)	(0.00352)	(0.00554)	(0.00463)	(0.000781)	(0.00134)	(0.00357)	(0.00557)	(0.00461)	(0.000781)
Conscientiousness	-0.00390***	-0.0158***	0.0102*	0.00882*	0.000683	-0.00403***	-0.0164***	0.0110**	0.00885*	0.000575
	(0.00129)	(0.00360)	(0.00551)	(0.00467)	(0.000831)	(0.00129)	(0.00366)	(0.00556)	(0.00466)	(0.000832)
Extraversion	-0.00229*	0.00575*	-0.0119**	0.00834**	0.000130	-0.00235**	0.00473	-0.0112**	0.00863**	0.000153
	(0.00119)	(0.00328)	(0.00486)	(0.00402)	(0.000608)	(0.00118)	(0.00331)	(0.00488)	(0.00399)	(0.000609)
Agreeableness	-0.000528	-0.00360	0.00102	0.00177	0.00133*	-0.000625	-0.00390	0.00142	0.00178	0.00132*
	(0.00131)	(0.00354)	(0.00510)	(0.00433)	(0.000780)	(0.00131)	(0.00359)	(0.00514)	(0.00433)	(0.000786)
Neuroticism	0.00113	0.0184***	0.0164***	-0.0370***	0.00105	0.000996	0.0186***	0.0166***	-0.0373***	0.00101
	(0.00121)	(0.00316)	(0.00483)	(0.00415)	(0.000753)	(0.00120)	(0.00321)	(0.00486)	(0.00413)	(0.000759)
Higher education	-0.0135***	-0.0255***	0.0143	0.0232**	0.00145	-0.0160***	-0.0338***	0.0220*	0.0262***	0.00165
	(0.00354)	(0.00813)	(0.0116)	(0.00942)	(0.00142)	(0.00366)	(0.00816)	(0.0115)	(0.00925)	(0.00139)
College	-0.00285	-0.00772	0.0140	-0.00407	0.000669	-0.00360	-0.0104	0.0165	-0.00302	0.000601
	(0.00221)	(0.00674)	(0.0105)	(0.00893)	(0.00160)	(0.00223)	(0.00680)	(0.0106)	(0.00892)	(0.00160)
Physical	-0.0178***	-0.0301***	0.0368***	0.0102	0.000892					
	(0.00336)	(0.00656)	(0.00912)	(0.00739)	(0.00135)					
Smoke	0.00218	0.0265**	-0.0196	-0.00938	0.000310					
	(0.00403)	(0.0103)	(0.0136)	(0.0102)	(0.00174)					
Drink	-0.0122***	-0.0469***	0.0546***	0.00480	-0.000371					
	(0.00226)	(0.00538)	(0.00788)	(0.00657)	(0.00114)					
N of observations			32,255					32,411		
N of clusters			6,619					6,620		

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

Table 4. The relationship between self-assessed health and internal locus of control for the male sample, marginal effects from multinomial logit regression

	Very bad	Bad	Average	Good	Very good	Very bad	Bad	Average	Good	Very good
Internal locus of control	-0.00730***	-0.0278***	-0.0107**	0.0419***	0.00394***	-0.00797***	-0.0284***	-0.0121**	0.0442***	0.00431***
	(0.00113)	(0.00284)	(0.00531)	(0.00495)	(0.000955)	(0.00119)	(0.00291)	(0.00535)	(0.00496)	(0.000972)
Higher education	0.00219	-0.00697	0.00503	0.00118	-0.00142	0.000579	-0.0109	-0.00422	0.0139	0.000644
	(0.00242)	(0.00747)	(0.0125)	(0.0116)	(0.00213)	(0.00254)	(0.00768)	(0.0124)	(0.0114)	(0.00200)
College	0.00206	-0.000779	0.0135	-0.0151	0.000337	0.00188	-0.00273	0.0109	-0.0110	0.000942
	(0.00252)	(0.00720)	(0.0122)	(0.0112)	(0.00208)	(0.00261)	(0.00726)	(0.0123)	(0.0112)	(0.00208)
Physical	-0.0173***	-0.0128*	0.00338	0.0239**	0.00280					
	(0.00364)	(0.00685)	(0.0108)	(0.00978)	(0.00180)					
Smoke	-0.00259	0.00494	0.0414***	-0.0376***	-0.00611***					
	(0.00209)	(0.00556)	(0.00952)	(0.00861)	(0.00167)					
Drink	-0.0134***	-0.0539***	0.0810***	-0.0130	-0.000684					
	(0.00201)	(0.00485)	(0.00966)	(0.00919)	(0.00182)					
N of observations			33,422					33,622		
N of clusters			5,191					5,193		

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

Table 5. The relationship between self-assessed health and internal locus of control for the female sample, marginal effects from multinomial logit regression

	Very bad	Bad	Average	Good	Very good	Very bad	Bad	Average	Good	Very good
Internal locus of control	-0.0107***	-0.0335***	0.00642	0.0349***	0.00292***	-0.0115***	-0.0364***	0.00979**	0.0350***	0.00303***
	(0.00123)	(0.00294)	(0.00436)	(0.00356)	(0.000746)	(0.00129)	(0.00294)	(0.00436)	(0.00354)	(0.000757)
Higher education	-0.00558**	-0.0267***	0.0112	0.0205**	0.000608	-0.00728***	-0.0349***	0.0170*	0.0244***	0.000736
	(0.00274)	(0.00716)	(0.00997)	(0.00806)	(0.00117)	(0.00278)	(0.00722)	(0.00993)	(0.00792)	(0.00115)
College	-0.000786	-0.00942	0.0179*	-0.00572	-0.00195	-0.00117	-0.0129**	0.0199**	-0.00378	-0.00204
	(0.00198)	(0.00613)	(0.00918)	(0.00766)	(0.00135)	(0.00199)	(0.00621)	(0.00926)	(0.00767)	(0.00134)
Physical	-0.00774***	-0.0289***	0.0290***	0.00623	0.00141					
	(0.00252)	(0.00613)	(0.00812)	(0.00642)	(0.00102)					
Smoke	0.00236	0.0214**	-0.00660	-0.0181**	0.000945					
	(0.00357)	(0.00933)	(0.0117)	(0.00855)	(0.00142)					
Drink	-0.0128***	-0.0497***	0.0674***	-0.00651	0.00158					
	(0.00191)	(0.00455)	(0.00668)	(0.00559)	(0.00106)					
N of observations			55,442					55,723		
N of clusters			7,960					7,962		

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

b. Non-cognitive skills and health behaviours

Tables 6-7 shed further light on health behaviours as possible mechanisms, mediating the effect of non-cognitive skills on health (full results are available in the Supplementary materials). Openness to experience is positively associated with the probability of physical activity for both males (one standard deviation increase in openness raises the probability by 3 percentage points) and females (by 5 percentage points), while extraversion is positively significant only for the male sample. The probability of smoking is reduced by 3 percentage points by conscientiousness in the male sample but increased by 2 percentage point by extraversion in the female sample, and by neuroticism in both samples (by 2 percentage points for males and 1 percentage points for females). With more neurotic individuals, smoking may serve as a coping mechanism for stress, while more extraverted individuals may use smoking as a social activity. Probability of drinking alcohol is reduced by conscientiousness by 2 percentage points and 1 percentage point with agreeableness in the male sample, although the effect is of low statistical significance. In both genders, drinking is positively related to extraversion. Internal locus of control is positively associated with physical activity in both genders (2-3 percentage point increase in the probability) and negatively with smoking in the male sample (4 percentage point reduction), while positively with drinking only for the female sample (3 percentage point increase, respectively).

Table 6. Health behaviours and the Big Five, logit model marginal effects

	Male sample			Female sample		
	Physical activity	**Smoking**	**Drinking**	**Physical activity**	**Smoking**	**Drinking**
Openness	0.0335***	-0.00754	0.00539	0.0505***	0.00566	0.0192***
	(0.00540)	(0.00832)	(0.00672)	(0.00481)	(0.00488)	(0.00605)
Conscientiousness	0.00513	-0.0297***	-0.0204***	-0.000459	-0.00535	-0.00458
	(0.00551)	(0.00842)	(0.00714)	(0.00472)	(0.00498)	(0.00603)
Extraversion	0.00832*	-0.00160	0.0169***	0.00456	0.0196***	0.0230***
	(0.00475)	(0.00749)	(0.00588)	(0.00412)	(0.00429)	(0.00525)
Agreeableness	0.00531	0.00195	-0.0116*	-0.00603	-0.00574	-0.00285
	(0.00525)	(0.00801)	(0.00659)	(0.00428)	(0.00456)	(0.00565)
Neuroticism	-0.00726	0.0239***	0.00374	-0.00664	0.00910**	0.0135***
	(0.00466)	(0.00738)	(0.00612)	(0.00411)	(0.00421)	(0.00522)
Higher education	0.139***	-0.217***	0.0369***	0.136***	-0.116***	0.0414***
	(0.0107)	(0.0169)	(0.0142)	(0.00942)	(0.0102)	(0.0122)
College	0.0455***	-0.0856***	0.00453	0.0445***	-0.0499***	0.0166
	(0.0118)	(0.0168)	(0.0143)	(0.00957)	(0.00851)	(0.0112)
N of observations	20,344	20,332	20,229	32,626	32,605	32,482
N of clusters	4,306	4,306	4,303	6,629	6,629	6,627

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

Table 7. Health behaviours and internal locus of control, logit model marginal effects

	Male sample			Female sample		
	Physical activity	Smoking	Drinking	Physical activity	Smoking	Drinking
Internal locus of control	0.0211***	-0.0420***	0.00304	0.0275***	-0.00647	0.0320***
	(0.00418)	(0.00691)	(0.00552)	(0.00340)	(0.00422)	(0.00470)
Higher education	0.149***	-0.224***	0.0319**	0.141***	-0.109***	0.0368***
	(0.00907)	(0.0156)	(0.0129)	(0.00747)	(0.00974)	(0.0105)
College	0.0523***	-0.0865***	0.00566	0.0497***	-0.0433***	0.0255***
	(0.00969)	(0.0157)	(0.0129)	(0.00760)	(0.00832)	(0.00957)
N of observations	33,946	33,936	33,740	56,146	56,111	55,884
N of clusters	5,196	5,196	5,195	7,969	7,969	7,967

Note: 1) Standard errors, clustered at individual level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

c. Non-cognitive skills and longevity

Finally, Table 8 shows the results of the duration analysis, which accounts for the problem of reversed causality (full results are available in the Supplementary materials). First, health habits demonstrate a statistically significant association with longevity. Although the observed results do not contradict the models with health self-assessment, there are some surprising differences. Physical activity, which was previously statistically significant for health self-assessment both in male and female samples, reduced the risks of mortality for women by 61 percentage points in the Big Five model, and by 43 percentage points in the locus of control model. At the same time, smoking, which did not show large positive correlations with worse health assessments, is highly predictive of the actual mortality. Smoking increases individual risks of mortality by 61 and 87 percentage points for males in the Big Five and locus of control models, respectively, and by 76 and 153 percentage points for females. Smoking was also considered one of the main contributors to adult mortality during the economic transition in Russia (Denisova 2010). Alcohol consumption reduces the mortality risks in the Big Five model for the male sample, but the result is highly unstable. As suggested before, the used measure of alcohol consumption does not differentiate between consumption insensitivity, bringing mixed results.

Second, higher education reduces the risks of mortality in both genders, although in self-assessed health models it was only statistically significant for the female sample. In the locus of control models, higher education reduces the risks by 40 percentage points for males and by 32 percentage points for females before controlling for health behaviours. The effect is slightly reduced after their introduction. In the Big Five models, the size of the effect is similar but higher education loses its significance in the model with health habits. The difference in findings can be explained by a shorter period covered by the Big Five models.

Third, non-cognitive skills demonstrate a significant association with longevity. Conscientiousness from the Big Five appears to be the most consistent characteristic, reducing the probability of health-related mortality in both male and female samples. One standard deviation increase in conscientiousness reduces the risk of death by 20 percentage points for males and by 12 percentage points for females after controlling for health habits. One

standard deviation increase of neuroticism increases the risks of mortality by 12 percentage points. At the same time, there is a positive effect of openness to experience for females: one standard deviation increase in openness increases the mortality risk by 13 percentage points. Finally, internal locus of control is associated with the reduced risks of mortality for both men (by 11 percentage points) and women (10 percentage points).

Table 8. Determinants of mortality, total adult sample, non-parametric Cox regression results, hazard ratios[1]

	Male sample				Female sample			
Openness	0.971	0.969			0.866*	0.853*		
	(0.0686)	(0.0675)			(0.0703)	(0.0702)		
Conscientiousness	0.797***	0.780***			0.880*	0.870**		
	(0.0637)	(0.0629)			(0.0592)	(0.0587)		
Extraversion	1.065	1.073			1.030	1.031		
	(0.0907)	(0.0927)			(0.0566)	(0.0576)		
Agreeableness	1.039	1.034			1.076	1.073		
	(0.0696)	(0.0669)			(0.0854)	(0.0851)		
Neuroticism	1.121*	1.130*			1.007	1.012		
	(0.0726)	(0.0767)			(0.0842)	(0.0854)		
Internal locus of control			0.887**	0.874***			0.903*	0.888**
			(0.0473)	(0.0426)			(0.0530)	(0.0529)
Higher education	0.778	0.683**	0.697***	0.601***	0.808	0.732*	0.728*	0.681**
	(0.139)	(0.122)	(0.0970)	(0.0888)	(0.137)	(0.137)	(0.137)	(0.126)
College	0.849	0.804	0.877	0.835	0.940	0.915	0.924	0.908
	(0.153)	(0.141)	(0.0987)	(0.0944)	(0.194)	(0.186)	(0.125)	(0.124)
Physical	0.759		0.758		0.386***		0.565***	
	(0.151)		(0.143)		(0.0973)		(0.118)	
Smoke	1.610***		1.876***		1.767*		2.534***	
	(0.206)		(0.192)		(0.526)		(0.590)	
Drink	0.810		0.722***		0.957		0.982	
	(0.109)		(0.0685)		(0.157)		(0.138)	
N of observations	19,178	19,298	32,069	32,272	30,890	31,045	53,121	53,398
N of subjects	4,282	4,285	5,168	5,169	6,594	6,597	7,926	7,929
N of failures	266	268	527	531	266	266	460	461

Note: 1) Standard errors, clustered at regional level, in parenthesis; 2) *** p<0.01, ** p<0.05, * p<0.1

1 The reported hazard ratios are $\exp^{\beta}$. The effect in percentage points is calculated as $100*(\exp^{\beta} - 1)$.

Discussion and conclusion

Non-cognitive skills are a rapidly developing research topic in social sciences which might well be of education policy relevance. Previous research for Russia suggests that non-cognitive skills, primarily proxied by valid psychological concepts such as the Big Five and locus of control, are related to labour market outcomes (Rozhkova 2019; Gimpelson et al. 2020), education acquisition (Rozhkova and Roshchin 2021), alcohol consumption patterns (Rozhkova et al. 2023), and vaccination intentions (Roshchina et al. 2022). This paper, for the first time ever using RLMS-HSE data for 2011-2021, establishes the relationship between non-cognitive skills and health, measured with subjective self-assessment and objective longevity. Using duration analysis design, as well as binary and multinomial probability models, this study provides several notable findings.

First, non-cognitive skills are predictive of self-assessed health in both men and women. Higher conscientiousness and emotional stability from the Big Five demonstrate a consistent positive association with better health, which is in line with most of the existing empirical literature, both in the field of psychology (e.g., Friedman et al. 1995) and partly in economics (e.g., Savelyev and Tan 2019). Conscientiousness may affect the attention given to one's own health, the necessary rigour in following medical prescriptions, and exposure to preventive medicine. In contrast, neuroticism reflects the susceptibility towards stress which may provoke the onset of actual diseases or simply affect one's subjective perception of health during self-assessments. The other Big Five categories demonstrate fewer stable results and are less consistent across genders. There is a positive statistically significant association with extraversion, especially in males. Extraversion is rarely found to be associated with health outcomes. Savelyev (2022) also reported a positive effect of extraversion on health and longevity only for the male sample. Openness demonstrates a reduced probability of good health in both genders, but a higher probability of average health. Internal locus of control is associated with better self-assessed health in both genders.

Second, non-cognitive skills are not only relevant for a subjective measure of health but also for objective ones, such as longevity. Conscientiousness and internal locus of control consistently reduce the risks of mortality in both genders. Savelyev (2022), on a sample of high-ability individuals, also showed a positive effect of conscientiousness on longevity, but only for males. While the positive effect of conscientiousness is well-known in literature (Savelyev 2022; Chapman et al. 2011), less evidence exists for locus of control. Therefore, this study adds to this limited literature. Moreover, there are gender differences in the observed effects for the remaining Big Five categories: while openness to experience has a positive statistically significant effect on longevity only for females, neuroticism only implies a penalty for males. Previously, Savelyev and Tan (2019) reported the health-beneficial effects of openness for females, although they found a contrary effect for males, which is not supported by the Russian data.

Third, only a small part of the observed effect of non-cognitive skills is transmitted via health behaviour variables, such as physical activity and smoking. Openness to experience and internal locus of control in both genders are positively associated with the probability of regular sports activities, while conscientiousness (negative, in males), extraversion (positive, in females), neuroticism (positive, in both genders), and internal locus of control (negative, in males) have a statistically significant link with smoking. Controlling for health behaviours only slightly reduces the size of the effect on non-cognitive skills. Therefore, other transition mechanisms should be carefully reassessed. Adding non-cognitive skills into health analysis

makes our idea about health investments more heterogeneous than it is commonly assumed. Non-cognitive skills should be carefully considered, especially when "education-health gradient" is assessed.

Fourth, a positive relationship between higher education and health, which is well-established in research literature, reveals itself based on the Russian data, although a statistically significant and noticeable effect only arises for the female sample. Highly educated individuals are more likely to occupy safer jobs, pursue healthy lifestyles (including higher probability of physical activity), have better access to qualified medical services, and to be future-oriented, demonstrating preferences towards long-term health investments (Cutler and Lleras-Muney 2010).

This study has several limitations. First, there is no control for cognitive abilities which are often seen as a confounding factor in education-health gradient. However, studying the impact of education on health or vice versa is not the focus of this paper. In this analysis, we assume that controlling the level of education also absorbs the effect of cognitive abilities. Second, the time for which non-cognitive measures are available (especially the Big Five) is limited. This may affect the results of the survival analysis. Still, the obtained results provide valuable and rare insights for Russia, concerning the effect of personality on individual health inequalities. From an education policy perspective, promoting such non-cognitive skills as conscientiousness, internal locus of control, and emotional stability as part of early socialisation during the initial stages of education may positively affect health and longevity in the long run.

Data sources

Data is openly available at https://www.hse.ru/en/rlms/

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