RESEARCH ARTICLE
https://doi.org/10.17059/ekon.reg.2022-3-5
UDC 330.4

Liudmila A. Leonova ✉, *Valeriya V. Lakshina*, *Anna S. Aladyshkina*
HSE University, Nizhny Novgorod, Russian Federation

HETEROGENEOUS EFFECTS OF INDIVIDUAL SOCIO-ECONOMIC CHARACTERISTICS AND REGIONAL ENVIRONMENTAL CONDITIONS ON SELF-REPORTED HEALTH[1]

Abstract. Health is a comprehensive phenomenon with many determinants. The influence of environmental conditions on human health poses challenges for public health scientists. One of the main issues is the availability and relevance of the data on public health, including such indicators as morbidity and decease prevalence. In this study, we overcome this obstacle by using micro data on self-reported health from the Russia Longitudinal Monitoring Survey of Higher School of Economics. The study analyses the influence of environmental conditions on individual self-rated health in Russia, taking into account the heterogeneity of coefficients among self-rated health levels. We used generalised ordered probit model with random effects and embedded procedure for parallel line assumption violation testing. The characteristics of air, water and the quantity of pollutants in each region were considered as independent factors. The study showed significant negative influence of environmental factors on self-rated health throughout Russia. It is also demonstrated that higher self-rated health estimates are given by respondents whose level of education is no lower than that of vocational or trade school, who are married, and who are regularly engaged in physical activity. The results obtained can be used to improve regional state programmes aimed at improving the quality of life of the population in groups with different levels of health, for example, to the development and targeting of a set of health policy measures. Additionally, these findings can be utilised in programmes to improve the quality of the environment, which can increase the overall level of self-assessment of health in a particular region.

Keywords: federal districts, regional difference, socio-economic factors, self-rated health, environment, heterogeneity, RLMS-HSE, discrete dependent variable, panel data, employment, income

For citation: Leonova, L. A., Lakshina, V. V. & Aladyshkina, A. S. (2022). Heterogeneous Effects of Individual Socio-Economic Characteristics and Regional Environmental Conditions on Self-Reported Health. *Ekonomika regiona/Economy of regions,* 18(3), 687-698, https://doi.org/10.17059/ekon.reg.2022-3-5.

[1] © Leonova Liudmila A., Lakshina Valeriya V., Aladyshkina Anna S. Text. 2022.

ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

Л. А. Леонова ✉, *В. В. Лакшина*, *А. С. Аладышкина*
Национальный исследовательский университет «Высшая школа экономики»,
г. Нижний Новгород, Российская Федерация

Разнородное влияние индивидуальных социально-экономических характеристик и региональных экологических условий на самооценку здоровья

Аннотация. Здоровье — комплексное явление, определяемое множеством факторов. Одной из основных проблем в области общественного здравоохранения является вопрос влияния условий окружающей среды на здоровье человека. В изучении этого вопроса важную роль играет доступная и актуальная информация о состоянии здоровья населения, включающая такие показатели, как заболеваемость и распространенность заболеваний. В настоящем исследовании были использованы микроданные о самооценке здоровья, полученные в рамках Российского мониторинга экономического положения и здоровья населения НИУ ВШЭ. Влияние экологических условий на самооценку здоровья в России проанализировано с учетом неоднородности показателей самооценки. Для анализа были применены обобщенная модель упорядоченного выбора для панельных данных со случайными эффектами и функция для проверки нарушения допущения параллельного тренда. В качестве независимых факторов рассматривались характеристики воздуха и воды, а также количество загрязняющих веществ в каждом регионе. Проведенное исследование продемонстрировало значимое негативное влияние экологических факторов на самооценку здоровья в масштабах всей России. Также показано, что респонденты, имеющие среднее профессиональное образование и выше, состоящие в браке и регулярно занимающиеся физической культурой, выше оценивают своё здоровье. Полученные результаты могут быть использованы для совершенствования региональных государственных программ, направленных на повышение качества жизни различных групп населения, например, для разработки комплекса мер в области здравоохранения. Кроме того, полученные данные могут быть использованы в программах по улучшению качества окружающей среды, реализация которых может привести к повышению общего уровня самооценки здоровья в конкретном регионе.

Ключевые слова: федеральные округа, региональные различия, социально-экономические факторы, самооценка здоровья, окружающая среда, неоднородность, РМЭЗ-ВШЭ, дискретная зависимая переменная, панельные данные, занятость, доход

Для цитирования: Леонова Л. А., Лакшина В. В., Аладышкина А. С. (2022) Разнородное влияние индивидуальных социально-экономических характеристик и региональных экологических условий на самооценку здоровья. *Экономика региона,* Т. 18, вып. 3. С. 687-698. https://doi.org/10.17059/ekon.reg.2022-3-5.

1. Introduction

Health plays an important role in human capital development. Human capital determines an individual's behaviour in the marketplace, and declining health, especially at an advanced age, may become a critical factor in making decisions about labour market participation. Hence, there is an increase in the popularity of research and literature on the influence of health on labour supply, early retirement, workforce productivity, etc. (Bartel, Taubman, 1979; Koopman et al., 2002; Goetzel et al., 2003; Karpansalo et al., 2004; van den Berg et al., 2010; Goryakin et al., 2014; Akogun et al., 2017). In this respect, health becomes an important economic factor, especially since Russia, along with many other countries, continues a heated debate over raising the retirement age.

Health is a comprehensive phenomenon with multiple variables. In many ways, it is often determined by purely medical factors such as genetics. But if in the 1950s physical health and disease rate were seen as purely biological processes, the more recent developments in the medical sociology and health economics have enabled us to consider them now as a function of social, psychological, and behavioural factors (House, 2002). There is research that shows the correlation of health with economic capital (e.g., income levels or self-rated financial status) and social capital (involvement in civil society, level of trust for individuals or institutions, etc. (Ecob, Smith, 1999; Hemstrom, 2005; Ferlander, Mäkinen, 2009; Eriksson et al., 2011)) and their joint influence. It has been demonstrated that low levels of social and/or economic capital are tied to poor heath (Ahnquist, Wamala,

Lindstrom, 2012). Social and demographic factors are also connected to health (e.g., (Marmot, Wilkinson, 2018). Prus has modified House's theoretical model, which ties health to social determinants, by complementing the socio-demographic factors (such as age, race, gender, and marital status) with socioeconomic variables (such as education, income, and employment) (Prus, 2011). In addition, he postulates that socio-demographic factors may influence an individual's heath not only directly but also indirectly, through socioeconomic determinants which mainly trigger risk factors that affect health — for instance, choice of physical exercise, body mass index (BMI), smoking, access to health services, etc. (Prus, 2011).

Considering the limitations of available aggregate public health data, one potential way of removing such limitations could be to use self-rated health. A widely-known and effective tool, self-rated health has already proven to be a reliable measurement of respondents' health (Idler, Benyamini, 1997; Wu et al., 2013). Typically, it presupposes a person's response to the question about their health when asked to rate it on a scale of one to five. Thus, the Russia Longitudinal Monitoring Survey of Higher School of Economics (RLMS-HSE, 2018), a representative self-rated health survey throughout Russia, includes the question: "How would you rate your health? Would you say that it is…" with five response options (very good; good; fair, neither good nor poor; poor; very poor). The wording of the question and the five-response scale is typical for many different countries such as Sweden (Ahnquist, Wamala, Lindstrom, 2012), Canada and the USA (Prus, 2011) and Costa Rica (Brenes-Camacho, 2011). Another alternative is using health indices, in which case, a person's health index is calculated: using the standard ordered probit model, we evaluate the regression of categorical self-assessment based on the respondent's diagnosed illnesses, health limitations, and socio-economic characteristics.

The Russian survey data have inspired a number of research projects on self-rated health, which seek to identify determinants, study the dynamics of public health, and examine the combination of factors contributing to healthy lifestyles (Bobak et al., 2000; Rose, 2000; Cockerham, 2000; Perlman, Bobak, 2008; Ferlander, Mäkinen, 2009; Goryakin et al., 2014).

The other examples of studying the determinants of public health based on self-rates include (Kozyreva, Smirnov, 2020; Rusinova, Saphronov, 2012; Kaneva, 2016; Nazarova, 2014; Kaneva, Baidin, 2018; Lebedeva-Nesevria, Barg, Solovev, 2017; Sinelnikov, 2012).

It is also necessary to highlight the works devoted to characteristics of the health perception by various groups of the population, depending on the place of residence. In particular, Papanova (2020) investigated the differences in self-assessments of health between Moscow residents and the residents of other regions; Antonov, Karpova and Novoselova (2020) focused on the analysis of self-assessments of health among urban residents.

Medical science has long studied the effects of various types of environmental pollution on people's health, using both experiments in controlled conditions and real life environmental data, which inevitably leads to statistical difficulties since it is impossible to control and measure all the parameters. Graff Zivin and Neidel (2013) discuss how economists could potentially contribute to this research, looking at three principal areas where economists have already expanded our understanding of correlation between the environment and public health. It has been demonstrated that optimisation of individuals' behaviour may be connected with the non-random distribution of pollution. For instance, while remaining the principal sources of pollution, big cities nonetheless attract highly qualified specialists due to better employment opportunities. At the same time, thanks to higher incomes, the same population group makes larger investments into their health through attending health clubs and sports facilities, making use of paid medical services, etc. Failure to include these investments into the analysis will result in incorrect estimates of the correlation between pollution and public health. On the other hand, since the quality of air is capitalised in housing prices (Chay, Greenstone, 2005), populations with higher incomes will probably congregate to places with better air quality. Since pollution may potentially be endogenous, in evaluating its effect on public health and human capital, it is imperative that we take into consideration its potential influence on the quality of resulting estimates and pay special attention to cause and effect correlations.

Economic research of environmental pollution has expanded the range of traditional health measurements, shifting the emphasis onto such public health determinants as human capital and productivity. To an extent, this echoes earlier economic models by Smith and Ricardo, who saw the environment — principally land and natural resources — as an important industry factor (Graff Zivin, Neidell, 2013).

The World Health Organisation proposes to use indicators of public health (morbidity, mortal-

ity, life expectancy) to assess the severity of environmental problems (Kudryavtseva, Khilchenko, 2010).

Gorborukova and Kiku (2009) presented the results of a study of health self-assessments of residents of different bioclimatic zones of Primorsky krai. The authors identified the differences in the residents' assessments of the influence of various environmental factors on health, depending on the environmental load and the type of bioclimatic zone. The respondents who are in the most ecologically stressed zones note the connection between the state of health and technogenically altered living conditions.

According to the study of the emergency medical workers' health self-assessment, factors related to the environmental situation do contribute to the deterioration of health, which is confirmed by about 23 % of the respondents (Polyakov, Dobritsyna, Zelenskaya, 2012).

Davydov and Biblin (2019) analysed the differences in the perception of environmental problems by the respondents, depending on their health self-assessment level. It was found that environmental concerns are mainly in the middle of the list of factors that can affect the health of the respondent. However, the specific manifestations of environmental problems affecting, in the opinion of the respondents, their level of health, turned out to be dependent on how the respondents assess their health.

The focus of this particular paper is to investigate self-rated health, show possibilities of using microdata to assess the relation between self-rated health and socioeconomic and socio-demographic variables with environmental factors specific to individuals' place of residence. Given the multinomial dependent variable, the possible parallel line assumption violation and the panel nature of the sample, a generalised ordered probit model with random effects (Pfarr, Schmid, Schneider, 2011) is the appropriate model specification.

The remainder of the article is structured as follows. The Model section describes variables choice and explains the data set and model choice; the estimation's results are described in the Results section; in the Discussion section, the results are discussed and the main conclusions are presented.

2. Model

The primary goal of this paper is to study the heterogeneity of self-rated health in Russia. In order to test this hypothesis, we used the data for individuals of the Russian Longitudinal Monitoring Survey of Higher School of Economics (RLMS-HSE[1]) for 2008–2015. This longitudinal survey on the health and economic welfare of households and individuals in Russia is based on multiphase stratified probability sampling and provides data, which is representative on the level of federal districts.[2]

This longitudinal survey on the health and economic welfare of households and individuals in the Russian Federation, conducted by Higher School of Economics, is a series of annual national representative surveys based on multiphase stratified probability sampling, developed in collaboration with the world's leading experts. It monitors the daily life of the same individuals over a long period of time, thus opening possibilities not only for statistical but also for dynamic analysis. The sample includes only those individuals who were at least 18 years old in 2008.

We were interested in studying the influence of aggregated ecological conditions on different levels of self-rated health. Our measure of self-rated health is a multinomial variable, which contains answers to the question: "How would you rate your health? Would you say that it is…" with five response options — very good (coded as 5); good; fair, neither good nor poor; poor; very poor (coded as 1).

Figure 1 demonstrates self-rated health distribution in respect to gender. Individuals tend to rate their health as fair or average; neither of the extreme categories has any significant occurrence: fewer than 4 % individuals rate their health as very good or very poor. No significant gender-based differences in self-rated health have been observed; however, men's self-rated health tends to favour the right side of the diagram.

Given the high non-normality of the data, we use bootstrap confidence intervals in order to illustrate the difference of average air pollution level across five self-rated health levels (Figure 2). For example, respondents, who rated their health as 5 (very good), in average live in more polluted federal districts. The tendencies for the other ecological indicators in the sample are similar.

---

[1] «Russia Longitudinal Monitoring Survey, RLMS-HSE», conducted by National Research University «Higher School of Economics» and OOO "Demoscope" together with Carolina Population Center, University of North Carolina at Chapel Hill and the Institute of Sociology of the Federal Center of Theoretical and Applied Sociology of the Russian Academy of Sciences. (RLMS-HSE web sites: https://rlms-hse.cpc.unc.edu, https://www.hse.ru/org/hse/rlms)

[2] The subdivision of the Russian Federation consists of 8 federal districts and 85 federal subjects in 2020. Until 2010, Southern and North Caucasian federal districts were united and we treat them as one federal district during the whole sample.

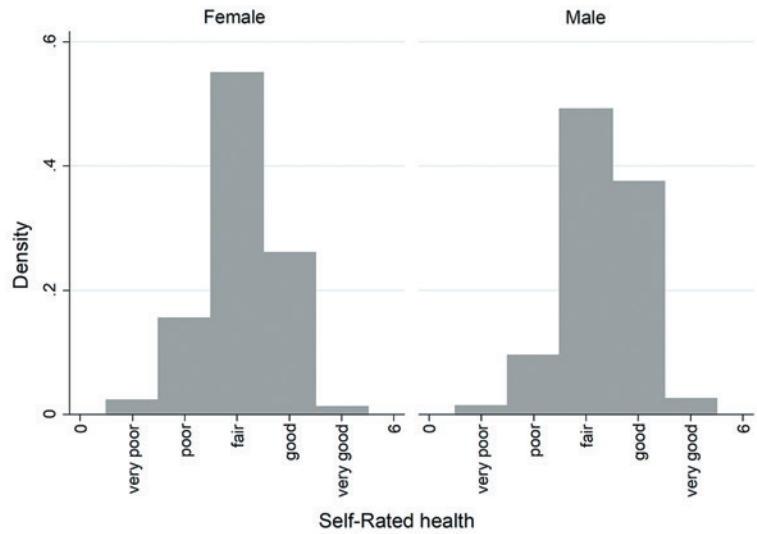

Fig. 1. *Self-rated health distribution (source: Calculations by the authors, RLMS-HSE, 2008–2015)*

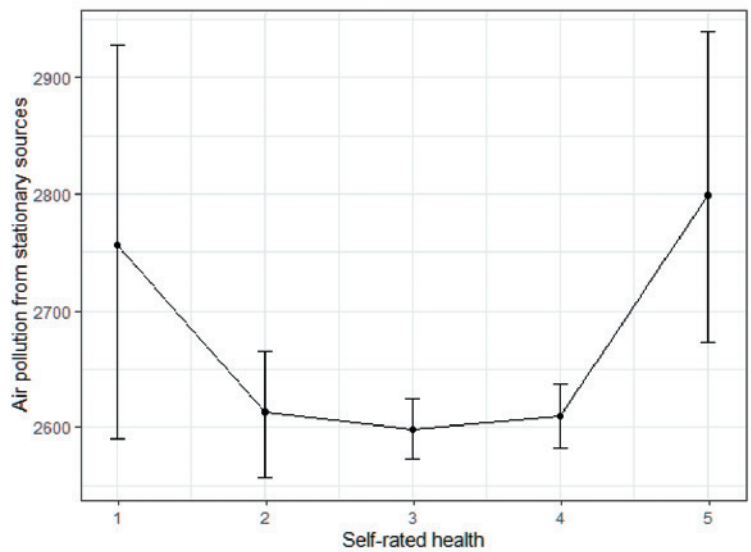

Fig. 2. *Bootstrap confidence intervals of mean air pollution from stationary sources for different self-rated health groups (source: Author calculations using RLMS-HSE)*

Therefore, the contingency table may seem informative to analyse the dependence between self-rated health levels and ecological situation in federal districts (Table 1).

The variables, reflecting environmental conditions, are collected on the level of the federal districts. The environmental data are taken from the reports of the Federal State Statistics Service.[1] The environmental indicators, related to air pollution, are air pollution through emissions from stationary sources; the total volume of pollutants discharged into the atmosphere during the 2nd quarter; volume of pollutants discharged into the air without treatment and the number of air pollution sources at the end of the year. Besides, all the specifications include the variable that reflects the volume of polluted water within all wastewater discharges.

The impact of environmental pollutants on health is very complex and diverse. Each person is a consumer of ambient air, as a result of which the quality of atmospheric air becomes an important indicator affecting self-esteem of health. It should be noted that the list of environmental indicators that can be used to assess the atmospheric air quality is limited by the available statistical data.

Water quality is just as important as air quality. Water consumed from water supply sources has a significant effect on the human body, because it has contact with human skin and is eaten. Based on the analysis of available statistical indicators characterising water quality, the model includes the "Water pollution in wastewater discharge" indicator.

[1] http://www.gks.ru/ (Date of Access: 25.06.2020).

Table 1

Contingency table for self-rated health levels and federal districts

Self-rated health level	Federal districts						
	Central	Northwestern	Southern and North Caucasian	Volga	Ural	Siberian	Far Eastern
1	72	26	79	66	29	35	7
2	2175	784	1575	1466	521	963	331
3	3554	1364	1962	2540	1006	1864	734
4	945	297	469	635	194	405	144
5	115	57	45	98	26	49	24

Source: Author calculations using RLMS-HSE.

Along with the environmental indicators whose range is limited by the available data, we have used individual socio-demographic characteristics, which may influence self-rated health (Bobak et al., 2000; Prus, 2011; Ahnquist, Wamala, Lindstrom, 2012). These characteristics include education (high school or lower; trade or vocational college; higher education) and marital status (official marriages and civil unions are combined into one category; all other individuals are treated as single). Income is an important factor in determining an individual's diet as well their access to various types of health services and health-supporting systems (including both paid medicine and various means for improving health and maintaining a healthy lifestyle) (Ecob, Smith, 1999; Hemstrom, 2005).

As the explanatory variable, we decided to use not the individual's salary at their principle place of work, but their overall income (all income factors in monetary equivalents are used in real values relative to the prices of 2015, cited in the Consumer Price Index of (Federal State Statistics Service, 2018)). This indicator was chosen since we wanted both to take into account monies from various other sources and to include people with various types of employment status: the employed, the unemployed, and the economically inactive (specifically, students and senior citizens). To ensure a comprehensive analysis of income factors, we have also included the specification of the household income, since the expenses related to maintaining a healthy lifestyle may be carried not by the individuals themselves but by their family members. The binary variable that reflects active employment at the time of the survey (the individual's principal employment status is "employed," discounting maternity leave) was also included, since a person's work may be linked to certain risks factors in terms of disease (Kaleta, Makowiec-Dabrowska, Jegier, 2008; Hämmig, Gutzwiller, Kawachi, 2014; Kwon et al., 2016).[1]

On the one hand, work may lead to high stress levels and thus to lower self-rated health scores; on the other hand, employment may have a positive effect both in terms of individual self-actualisation and a higher income that gives access to health maintenance activities. Smoking has a negative effect on a person's health, so, to ensure better outcome accuracy, the binary variable that takes the value of 1 if the individual is a smoker at the time of the survey, is also included into the model. Since health indicators vary depending on the person's body mass index (BMI) and physical activity, the calculations also include the BMI, based on individuals' responses about their height and weight. The questionnaires contain questions about various types of physical activity that the individual has engaged into at least 12 times over the previous 12 months. The constructed variable that reflects the individual's loyalty towards physical activity takes the value of 1 if they have engaged in at least one type of physical activity.

As control variables, we have used the individuals' gender, age, and type of residential community (city/other).

Model Choice

There are several sources of heterogeneity in self-rated health estimates. First, individuals may assess differently the distance between various self-rated health levels. Secondly, some explaining factors may demonstrate heterogeneous effects across self-rated health levels, so called parallel line assumption violation. Thirdly, due to panel nature of the data, the heterogeneity may come from some factors, which are fixed over time, but vary across individuals. To sum up, it seems necessary for the model to have varying thresholds and slope coefficients for the probability of different dependent variable levels and individual effects included.

[1] All income factors in monetary equivalents are used in real values relative to the prices of 2015, cited in the Consumer Price Index of the Federal State Statistics Service: http://www.gks.ru/free_doc/new_site/prices/potr/tab-potr1.htm (Date of Access: 25.06.2020).

There are several ways to conduct an empirical estimation of self-rated health determinants, including a set of binary choice regressions (Bobak et al., 2000; Weich, Lewis, Jenkins, 2002; Ichida et al., 2009), ordered binary choice model (McLeod et al., 2003; Goldman, Glei, Chang, 2004; Gravelle, Sutton, 2008), generalised ordered choice model (Inagami, Cohen, Finch, 2007; Vaillant, Wolff, 2010; Dowd, Todd, 2011; Galenkamp et al., 2011), and each alternative has its own limitations. The first two models neglect possible heterogeneous effects of some explaining factors across the levels of the dependent variable. In contrast, the third model allows all coefficients to vary across the categories, which may seem an implausible assumption and sometimes leads to overfitting. Moreover, the models mentioned imply that the threshold values are identical for all individuals, which is highly debatable assumption (Pfarr, Schmid, Schneider, 2011; Greene, Hensher, 2010).

In this paper, we use the generalised ordered probit model with random effects and embedded procedure for testing heterogeneity across dependent variable levels (Pfarr, Schmid, Schneider, 2011). This model is a tradeoff between two extreme cases — a set of binary choice regressions and generalised ordered binary choice model. Another type of heterogeneity, which this model can capture, is individual effects, i. e. set of unobserved characteristics that are constant over time. The embedded procedure for testing heterogeneity across dependent variable levels implies performing the Wald test to find out if the parallel line assumption is violated for each regressor.

Stata 13.1 was used for all analyses.

3. Results

Table 2 displays the estimated results. First, we estimate ordered probit (oprobit) and ordered probit with random effects (oprobit RE), specification 1–4 are estimated by the generalised ordered probit model.

Following on, we use the generalised ordered probit model. Since it enables us to monitor the influence of explanatory variables for each outcome of the dependent variable, Table 2 presents either four (if parallel line assumption is violated) or one (if parallel line assumption is fulfilled) coefficient estimates for each of the characteristics used. For instance, the first coefficient demonstrates the effect of vocational school attendance on self-rated health of category 1 (“very poor”) against categories 2–5 (from “poor” to “very good”), and the second coefficient demonstrates the effect on responses 1–2 relative to 3–5 and so on. Remarkably, according to the model 1, there is no factor for which the parallel line assumption is fulfilled.

As far as ecological variables are concerned, the outcomes demonstrate that poorer environmental conditions, detected in any of the environmental characteristics used in this research, significantly lower the likelihood of people reporting good health. One must note that the robustness of these outcomes has been confirmed by the alternative specifications with different sets of explanatory variables. All the alternative descriptors of air quality that have been used clearly demonstrate a consistent negative effect — meaning that any increase in the volume of pollutants from stationary sources and the total volume of emissions (including untreated emissions) is consistently tied to poorer self-rated health scores. Water pollution also has a negative effect on self-rated health: increased volumes of polluted water discharge decrease the likelihood of people rating their health as “good.” Another possible explanation of this may be that living in regions with greater strain on the environment poses a significant risk for people’s health, and it is reflected in lower self-rated health scores.

At the same time, on the average, increases in sources of pollution are consistently tied to higher self-rated health scores. This outcome may be explained by the fact that the regions with many sources of pollution (including industrial equipment which releases pollutants into the atmosphere, spoil-heaps, reservoirs, etc.) are more likely to have well-developed industries and thus create more wealth than the regions where this is not the case. In addition, economically successful regions stand a greater chance of offering their populations better healthcare and social security services, which may explain higher self-rated health scores for the categories with lower levels of health. In must be noted, that for respondents from categories with good health this effect is insignificant.

In order to test the robustness of the outcomes, we have looked at several specifications presented in Table 1, models 2–4. Within the set of socioeconomic determinants, changes were made only in using alternative measures of income: in all the models, except model 2, we used an individual’s personal income and in model 2 — the household income. Models 3 and 4 include alternative measures of environmental characteristics related to air pollutants emission, namely, the total volume of pollutants discharged into the atmosphere during the specified time period, 2nd quarter (model 3); volume of pollutants discharged into the air without treatment / filtering (model 4).

Table 2

Assessing effect of environmental factors on self-rated health

Variable / Model	oprobit	oprobit RE	1	2	3	4
Socioeconomic variables						
Trade / vocational school	0.042***	0.068***	0.187***	0.178***	0.187***	0.187***
			0.176***	0.188***	0.176***	0.178***
			0.012	0.015	0.012	0.011
			–0.016	0.044	–0.016	–0.016
Higher education	0.121***	0.204***	0.354***	0.337***	0.354***	0.364***
			0.356***	0.367***	0.356***	0.363***
			0.186***	0.186***	0.186***	0.192***
			0.035	0.112**	0.035	0.042
Married / cohabiting	0.074***	0.118***	0.252***	0.243***	0.252***	0.250***
			0.284***	0.238***	0.284***	0.281***
			0.036*	0.025	0.036*	0.032
			0.089**	0.120***	0.089**	0.083*
Working at the main place of employment	0.250***	0.267***	0.709***	0.580***	0.710***	0.698***
			0.656***	0.642***	0.656***	0.654***
			0.111***	0.133***	0.111***	0.109***
			–0.157***	–0.100**	–0.156***	–0.163***
Natural natural logarithm of individual income [1]	0.057***	0.084***	–0.126***		–0.126***	–0.125***
			0.060***		0.060***	0.060***
			0.087***		0.087***	0.092***
			0.101***		0.101***	0.106***
Natural natural logarithm of household income [2]				–0.014		
				0.073***		
				0.111***		
				0.065***		
Smoking	–0.099***	–0.113***	0.071	0.029	0.071	0.058
			0.010	–0.015	0.010	0.001
			–0.181***	–0.171***	–0.181***	–0.189***
			–0.103**	–0.101**	–0.102**	–0.107**
BMI	–0.015***	–0.015***	0.005	0.004	0.005	0.004
			–0.014***	–0.015***	–0.014***	–0.014***
			–0.024***	–0.022***	–0.024***	–0.024***
			0.001	0.003	0.001	0.001
Exercise	0.165***	0.164***	0.231***	0.221***	0.231***	0.250***
			0.228***	0.226***	0.228***	0.235***
			0.117***	0.105***	0.116***	0.118***
			0.272***	0.221***	0.272***	0.271***
Age	–0.036***	–0.057***	–0.040***	–0.043***	–0.040***	–0.040***
			–0.049***	–0.049***	–0.049***	–0.048***
			–0.058***	–0.057***	–0.058***	–0.058***
			–0.038***	–0.038***	–0.038***	–0.037***
Male	0.189***	0.324***	–0.091	–0.096*	–0.091	–0.079
			0.088***	0.112***	0.088***	0.095***
			0.477***	0.476***	0.477***	0.482***
			0.419***	0.452***	0.419***	0.423***
Living in the city	–0.120***	–0.177***	0.007	–0.036	0.007	–0.016
			–0.052*	–0.083***	–0.052*	–0.069**
			–0.124***	–0.116***	–0.123***	–0.136***
			0.132***	0.198***	0.133***	0.123***
Ecological variables						
Air pollution: emissions from stationary sources (mln tons)	–0.034***	–0.053***	–0.036***			
			–0.021***			
			–0.074***			
			–0.055***			

The end of Table 2 on next page

The end of Table 2

Variable / Model	oprobit	oprobit RE	1	2	3	4
Water pollution in wastewater discharge (bln m^3)	–0.086***	–0.108***	–0.152***	–0.165***	–0.152***	–0.079***
			–0.131***	–0.134***	–0.131***	–0.083***
			–0.088***	–0.089***	–0.087***	–0.085***
			–0.214***	–0.256***	–0.213***	–0.236***
Number of air pollution sources, at the end of the year, total (units) /100000	0.010*	0.031***	0.126***	0.120***	0.125***	
			0.088***	0.090***	0.088***	
			0.018	0.013	0.015	
			–0.018	–0.015	–0.020	
Pollutants released into the atmosphere without filtering or treatment, total (mln tons)						–0.006
						0.025***
						–0.031***
						–0.019
Pollutants released into the atmosphere in the time period covered by the report (Q2), total volume (mln tons)				–0.077***	–0.071***	
				–0.033**	–0.041***	
				–0.124***	–0.150***	
				–0.095***	–0.112***	
Number of observations	72 616	72616	76 698	80 296	76 698	76 698
Logarithm of the likelihood function	–66 243	–57 879	–60 398	–63 421	–60 395	–60 467
Wald test	***	***	***	***	***	***

Notes: *, **, *** — significance on the 10 %, 5 % and 1 % level respectively.
Source: Authors calculations using RLMS–HSE.

[1] Taking the log of individual income was done only for individuals with positive income, since the sample contains a significant number of people without income, which could lead to inaccurate results.

[2] Ln (household income +1).

The selected control variables, such as education, employment, income level, BMI, bad habits (smoking) and physical activity have proven to be significant determinants of health. It has been demonstrated that higher self-rated health estimates were given by respondents whose level of education is no lower than that of vocational or trade school, who are married, and who are regularly engaged in physical activity. Conversely, the negative effect on self-rated health has been clearly demonstrated for such regressors as a high BMI and smoking. For low self-rated health scores, a higher income has been demonstrated to have a negative effect, which can be explained by the prevalence of other, non-monetary factors that lead to especially poor health.

4. Discussion

Based on the data provided by Federal State Statistics Service and the Russian Longitudinal Monitoring Survey for 2008–2015, this paper examines self-rated health. We used the random effects generalised probit panel data model with random effects and embedded procedure for testing heterogeneity across dependent variable levels (Pfarr, Schmid, Schneider, 2011).

It is shown that standard estimation procedures can be misleading while interpreting the influence of independent variables on the self-rated health levels. Self-rated health scores are seen as cases of individual heterogeneity and violation of assumptions about the threshold values identical for all individuals. The parallel lines assumption leads to the postulation that estimated coefficients of independent variables in ordered choice models do not change for all categories of the dependent variable. If, in analysing self-rated health scores, we remember that for different health estimates (very good; good; fair, neither good nor poor; poor; very poor) the effects of the explanatory factors listed above may be different, we should really make use of generalised ordered choice models where threshold values are not fixed (parallel) and may vary from one individual to another.

Some potential limitations of this study must be considered. First, the environmental indicators are aggregated over large areas. One reason is connected to the fact that the RLMS data is representative by federal districts only and cannot be used for the analysis of smaller territories such as federal subjects. Second, the sample is unbalanced, so different respondents were impacted by the ecological conditions of their federal district different amounts of time.

For better understanding of the relations between self-rated health and ecological conditions, it could be useful to consider perceived air pollution as an independent variable (Kamimura et al., 2017; Ma et al., 2017).

To summarise, this article analyses the influence of environmental conditions and socio-economic characteristic on individual self-rated health taking into account the heterogeneity of coefficients among self-rated health levels. The obtained results prove our assumption about the influence of the quality of the regional ecological situation on the self-assessment of the health of the population.

Quantitative assessments make it possible to predict the health status of the population depending on various factors, including environmental ones. The research findings can be used to enhance regional government programmes aimed at improving the quality of life of the population in groups with different health levels, for example, the development and targeting the complex of health policy measures, as discussed by Klimin (2008). The introduction of additional policy measures to improve the quality of atmospheric air and water sources will increase the overall level of the self-rated health in particular region.

References

Ahnquist, J., Wamala, S. P. & Lindstrom, M. (2012). Social determinants of health — a question of social or economic capital? Interaction effects of socioeconomic factors on health outcomes. *Social Science & Medicine, 74,* 930-939. DOI: 10.1016/j.socscimed.2011.11.026.

Akogun, O. B., Dillon, A., Friedman, J., Prasann, A. & Serneels, P. M. (2017). *Productivity and Health: Alternative Productivity Estimates Using Physical Activity.* World Bank Policy Research Working Paper No. 8228, 38. Retrieved from: https://ssrn.com/abstract=3064991 (Date of access: 20.06.2020).

Antonov, A., Karpova, V. & Novoselova, E. (2020). Health in the subjective assessments of married urban residents. *Sotsialnye aspekty zdorovya naseleniya [Social aspects of population health], 66(6).* DOI: 10.21045/2071-5021-2020-66-6-7. (In Russ.)

Bartel, A. & Taubman, P. (1979) Health and Labor Market Success: The Role of Various Diseases. *The Review of Economics and Statistics, 61(1),* 1-8. DOI: 10.2307/1924825.

Bobak, M., Pikhart, H., Rose, R., Hertzman, C. & Marmot, M. (2000). Socioeconomic factors, material inequalities, and perceived control in self-rated health: cross-sectional data from seven post-communist countries. *Social Science & Medicine, 51(9),* 1343-1350. DOI: 10.1016/s0277-9536(00)00096-4.

Brenes-Camacho, G. (2011). Favourable changes in economic well-being and self-rated health among the elderly. *Social Science & Medicine, 72(8),* 1228-1235. DOI: 10.1016/j.socscimed.2011.02.027.

Chay, K. Y. & Greenstone, M. (2005) Does Air Quality Matter? Evidence from the Housing Market. *Journal of Political Economy, 113(2),* 376–424. DOI: 10.1086/427462

Cockerham, W. C. (2000). Health lifestyles in Russia. *Social Science & Medicine, 51,* 1313-1324. DOI: 10.1016/S0277-9536(00)00094-0.

Davydov, A. A. & Biblin, A. M. (2019). Self-assessment of health status and perception of environmental problems by the population of the Northwestern Federal District of the Russian Federation. In: *N. P. Zhukova (Ed.), Proceedings of the international scientific-practical conference «Health and the Environment»* (pp. 16-19). Minsk: State educational institution «Republican Institute of Higher Education». (In Russ.)

Dowd, J. B. & Todd, M. (2011). Does self-reported health bias the measurement of health inequalities in US adults? Evidence using anchoring vignettes from the Health and Retirement Study. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66(4),* 478-489. DOI: 10.1093/geronb/gbr050.

Ecob, R. & Smith, D. G. (1999). Income and health: what is the nature of the relationship? *Social Science & Medicine, 48(5),* 693–705. DOI: 10.1016/s0277-9536(98)00385-2.

Eriksson, M., Ng, N., Weinehall, L. & Emmelin, M. (2011). The importance of gender and conceptualization for understanding the association between collective social capital and health: A multilevel analysis from northern Sweden. *Social Science & Medicine, 73(2),* 264-273. DOI: 10.1016/j.socscimed.2011.05.013.

Ferlander, S. & Mäkinen, I. H. (2009). Social capital, gender and self-rated health. Evidence from the Moscow Health Survey 2004. *Social Science & Medicine, 69(9),* 1323-1332. DOI: 10.1016/j.socscimed.2009.08.009.

Galenkamp, H., Braam, A. W., Huisman, M. & Deeg, D. J. H. (2011). Somatic multimorbidity and self-rated health in the older population. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66(3),* 380-386. DOI: 10.1093/geronb/gbr032.

Goetzel, R. Z., Hawkins, K., Ozminkowski, R. J. & Wang, S. (2003) The health and productivity cost burden of the "top 10" physical and mental health conditions affecting six large U.S. employers in 1999. *Journal of Occupational and Environmental Medicine, 45(1),* 5-14. DOI: 10.1097/00043764-200301000-00007.

Gorborukova, T. V. & Kiku, P. F. (2009). Influence of a way of life on health of inhabitants of Primorye territory. *Zdorove. Meditsinskaya ekologiya. Nauka [Health. Medical ecology. Science], 4–5,* 61–63. (In Russ.)

Goryakin, Y., Rocco, L., Suhrcke, M., Roberts, B. & McKee, M. (2014). The Effect of Health on Labour Supply in Nine Former Soviet Union Countries. *The European Journal of Health Economics, 15,* 57-68. DOI: 10.1007/s10198-012-0455-y.

Graff Zivin, J. & Neidell, M. (2013). Environment, Health, and Human Capital. *Journal of Economic Literature, 51(3),* 689-730. DOI: 10.1257/jel.51.3.689.

Gravelle, H. & Sutton, M. (2008). Income, relative income, and self-reported health in Britain 1979-2000. *Health Economics, 18(2),* 125-145. DOI: 10.1002/hec.1354.

Greene, W. H. & Hensher, D. A. (2010). *Modeling ordered choices: A primer.* Cambridge University Press, 365.

Goldman, N, Glei, D. A. & Chang, M. C. (2004). The role of clinical risk factors in understanding self-rated health. *Annals of epidemiology, 14,* 49-57. DOI: 10.1016/s1047-2797(03)00077-2.

Hämmig, O., Gutzwiller, F. & Kawachi, I. (2014). The contribution of lifestyle and work factors to social inequalities in self-rated health among the employed population in Switzerland. *Social Science & Medicine, 121,* 74-84. DOI: 10.1016/j.socscimed.2014.09.041.

Hemstrom, O. (2005). Health inequalities by wage income in Sweden: The role of work environment. *Social Science & Medicine, 61(3),* 637–647. DOI: 10.1016/j.socscimed.2004.12.028.

House, J. S. (2002). Understanding Social Factors and Inequalities in Health: 20th Century Progress and 21st Century Prospects. *Journal of Health and Social Behavior, 43(2),* 125-142.

Ichida, Y., Kondo, K., Hirai, H., Hanibuchi, T., Yoshikawa, G. & Murata, C. (2009). Social capital, income inequality and self-rated health in Chita peninsula, Japan: a multilevel analysis of older people in 25 communities. *Social Science & Medicine, 69(4),* 489-499. DOI: 10.1016/j.socscimed.2009.05.006.

Idler, E. L. & Benyamini, Y. (1997) Self-Rated Health and Mortality: A Review of Twenty-Seven Community Studies. *Journal of Health and Social Behavior, 38(1),* 21-37. DOI: 10.2307/2955359.

Inagami, S., Cohen, D. A. & Finch, B. K. (2007). Non-residential neighborhood exposures suppress neighborhood effects on self-rated health. *Social science & medicine, 65(8),* 1779-1791. DOI: 10.1016/j.socscimed.2007.05.051.

Kaleta, D., Makowiec-Dabrowska, T. & Jegier, A. (2008). Employment status and self rated health. *International Journal of Occupational Medicine and Environmental Health, 21(3),* 227–236. DOI: 10.2478/v10001-008-0023-y.

Kaneva, M. A. (2016). Socio-economic, behavioral and psychological determinants of the Russian population's self-reported health assessment. *Natsionalnye interesy: prioritety i bezopasnost [National Interests: Priorities and Security], 12(6),* 158–171. (In Russ.)

Kaneva, M. & Baidin, V. (2018). Heterogeneity in reporting self-assessed health of the Russians. *Applied Econometrics, 51,* 102-125.

Kamimura, A., Armenta, B., Nourian, M., Assasnik, N., Nourian, K. & Chernenko, A. (2017). Perceived environmental pollution and its impact on health in China, Japan, and South Korea. *Journal of Preventive Medicine and Public Health, 50,* 188-194. DOI: 10.3961/jpmph.17.044.

Karpansalo, M., Manninen, P., Kauhanen, J., Lakka, T. & Salonen, J. (2004) Perceived health as a predictor of early retirement. *Scandinavian Journal of Work, Environment & Health, 30,* 287-292. DOI: 10.5271/sjweh.796.

Klimin, V. G. (2008). The priority ways of the development of the regional health protection. *Ekonomika regiona [Economy of region], S2,* 91-100. (In Russ.)

Koopman, C., Pelletier, K., Murray, J. F., Sharda, C. E., Berger, M. L., Turpin, R. S., … Bendel, T. (2002) Stanford Presenteeism Scale: Health Status and Employee Productivity. *Journal of Occupational and Environmental Medicine, 44,* 14-20.

Kozyreva, P. M. & Smirnov, A. I. (2020). Russian citizens' health self-assessment dynamics: relevant trends of the post-soviet era. *Sotsiologicheskie issledovaniya [Sociological studies], 4,* 70–81. DOI: 10.31857/S013216250009116-0. (In Russ.)

Kudryavtseva, T. I. & Khilchenko, N. V. (2010) Priorities of regional environmental policy: the issues of diagnostics. *Ekonomika regiona [Economy of region], 1(21),* 96-104. (In Russ.)

Kwon, K., Park, J. B., Lee, K.-J. & Cho, Y.-S. (2016). Association between employment status and self-rated health: Korean working conditions survey. *Annals of Occupational and Environmental Medicine, 28,* 43. DOI: 10.1186/s40557-016-0126-z.

Lebedeva-Nesevria, N. A., Barg, A. O. & Solovev, S. S. (2017). Self-rated health of the working population in Russia. *Izvestiya Uralskogo federalnogo universiteta. Ser. 3. Obshchestvennye nauki [Tempus et Memoria], 12(3),* 108-115. (In Russ.)

Ma, J., Mitchell, G., Dong, G. & Zhang, W. (2017). Inequality in Beijing: A Spatial Multilevel Analysis of Perceived Environmental Hazard and Self-Rated Health. *Annals of the American Association of Geographers, 107(1),* 109-129. DOI: 10.1080/24694452.2016.1224636.

Marmot, M. & Wilkinson, R. (Eds.). (2018). *Social Determinants of Health.* Oxford: Oxford University Press, 376.

McLeod, C. B, Lavis, J. N., Mustard, C. A. & Stoddart, G. L. (2003). Income Inequality, Household Income, and Health Status in Canada: A Prospective Cohort Study. *American Journal of Public Health, 93,* 1287-1293. DOI: 10.2105/ajph.93.8.1287.

Nazarova, I. B. (2014). Health and life quality of Russia's population. *Sotsiologicheskie issledovaniya [Sociological studies], 9,* 139–145. (In Russ.)

Papanova, E. K. (2020). Determinants of differences in self-rated health between Moscow and the rest of Russia. *Sotsialnye aspekty zdorovya naseleniya [Social aspects of population health], 66(1).* DOI: 10.21045/2071-5021-2020-66-1-11. (In Russ.)

Perlman, F. & Bobak, M. (2008). Determinants of self-rated health and mortality in Russia — are they the same? *International Journal for Equity in Health, 7,* 19. DOI: 10.1186/1475-9276-7-19.

Pfarr, C., Schmid, A. & Schneider, U. (2011). Estimating Ordered Categorical Variables Using Panel Data: A Generalised Ordered Probit Model with an Autofit Procedure. *Journal of Economics and Econometrics, 54,* 7-23.

Polyakov, I. V., Dobritsyna, A. A. & Zelenskaya, T. N. (2012). The evaluation of health of medical personnel of ambulance care and impacting factors. *Problemy sotsialnoy gigieny, zdravookhraneniya i istorii meditsiny [Problems of Social Hygiene, Public Health and History of Medicine], 1,* 25–28. (In Russ.)

Prus, S. G. (2011). Comparing social determinants of self-rated health across the United States and Canada. *Social Science & Medicine, 73(1),* 50-59. DOI: 10.1016/j.socscimed.2011.04.010.

Rose, R. (2000). How much does social capital add to individual health? *Social Science & Medicine, 51(9),* 1421-1435. DOI: 10.1016/s0277-9536(00)00106-4.

Rusinova, N. L. & Saphronov, V. V. (2012). Trends in the social stratification of health in Russia: 1990s and 2000s. *Sotsiologicheskiy zhurnal [Sociological Journal], 1,* 28–46. (In Russ.)

Sinelnikov, A. B. (2012). Influence of family and demographic status on health and self-evaluation of health. *Sotsialnye aspekty zdorovya naseleniya [Social aspects of population health], 28(6).* (In Russ.)

Vaillant, N. & Wolff, F. C. (2010). Origin differences in self-reported health among older migrants living in France. *Public Health, 124,* 90-98. DOI: 10.1016/j.puhe.2010.01.005.

van den Berg, T. I. J., Elders, L. A. M. & Burdorf, A. (2010) Influence of Health and Work on Early Retirement. *Journal of Occupational and Environmental Medicine, 52(6),* 576-583. DOI: 10.1097/JOM.0b013e3181de8133.

Weich, S., Lewis, G. & Jenkins, S. P. (2002). Income inequality and self rated health in Britain. *Journal of Epidemiology & Community Health, 56(6),* 436-41. DOI: 10.1136/jech.56.6.436.

Wu, S., Wang, R., Zhao, Y., Ma, X., Wu, M., Yan, X. & He, J. (2013) The relationship between self-rated health and objective health status: a population-based study. *BMC Public Health, 13(1),* 320. DOI: 10.1186/1471-2458-13-320.

About the authors

Liudmila A. Leonova — Cand. Sci. (Econ.), Associate Professor, Department of Mathematical Economics, HSE University; Scopus Author ID: 57195936451; Researcher ID: J-3562-2015; https://orcid.org/0000-0002-9583-8310 (25/12, Bolshaya Pecherskaya St., Nizhny Novgorod, 603155, Russian Federation; e-mail: lleonova@hse.ru).

Valeriya V. Lakshina — Cand. Sci. (Econ.), in Economics, Associate Professor, Department of Mathematical Economics, HSE University; Researcher ID: K-9373-2015; https://orcid.org/0000-0003-1447-9377 (25/12, Bolshaya Pecherskaya St., Nizhny Novgorod, 603155, Russian Federation; e-mail: vlakshina@hse.ru).

Anna S. Aladyshkina — Cand. Sci. (Soc.), Associate Professor, Department of Economic Theory and Econometrics, HSE University; Researcher ID: L-6631-2015; https://orcid.org/0000-0003-3885-8849 (25/12, Bolshaya Pecherskaya St., Nizhny Novgorod, 603155, Russian Federation; e-mail: aaladyshkina@hse.ru).

Информация об авторах

Леонова Людмила Аркадьевна — кандидат экономических наук, доцент кафедры математической экономики, Национальный исследовательский университет «Высшая школа экономики»; Scopus Author ID: 57195936451; Researcher ID: J-3562-2015; https://orcid.org/0000-0002-9583-8310 (Российская Федерация, 603155, г. Нижний Новгород, ул. Большая Печерская, 25/12; e-mail: lleonova@hse.ru).

Лакшина Валерия Владимировна — кандидат экономических наук, доцент кафедры математической экономики, Национальный исследовательский университет «Высшая школа экономики»; Scopus Author ID: 57190960533; Researcher ID: K-9373-2015; https://orcid.org/0000-0003-1447-9377 (Российская Федерация, 603155, г. Нижний Новгород, ул. Большая Печерская, 25/12; e-mail: vlakshina@hse.ru).

Аладышкина Анна Сергеевна — кандидат социологических наук, доцент кафедры экономической теории и эконометрики, Национальный исследовательский университет «Высшая школа экономики»; Scopus Author ID: 54904762400; Researcher ID: L-6631-2015; https://orcid.org/0000-0003-3885-8849 (Российская Федерация, 603155, г. Нижний Новгород, ул. Большая Печерская, 25/12; e-mail: aaladyshkina@hse.ru).

Дата поступления рукописи: 11.12.2020.
Прошла рецензирование: 10.03.2021.
Принято решение о публикации: 27.05.2022.

Received: 11 Dec 2020.
Reviewed: 1à Mar 2021.
Accepted: 27 May 2022.