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Economic damage of risk factors associated with morbidity and mortality from major chronic non-communicable diseases in Russia in 2016

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Aim. To assess the socioeconomic damage of risk factors associated with morbidity and mortality from major chronic non-communicable diseases (CNCDs) in the Russian population in 2016.

Material and methods. The following RF were included in the analysis: smoking, alcohol abuse, high salt intake, insufficient consumption of vegetables and fruits, consumption of processed red meat, low physical activity, obesity, hypertension (HTN), which have a significant causal relationship with the major CNCDs: cardiovascular diseases (CVDs), type 2 diabetes, chronic obstructive pulmonary disease (COPD), cancer of 10 locations (lung, breast, cervix, ovary, prostate, kidney, stomach, liver, pancreas, colon). Based on the data on the RF prevalence in the Russian population by ESSE-RF study and relative risks by large studies, the population attributable risk for each CNCD was estimated. We used the data of the Federal State Statistics Service, annual forms of Federal Statistical Observation, as well as the results of the Government Guarantee Program for free medical care and the corresponding diagnosis-related groups for 2016. The direct costs of the healthcare system and economic losses due to morbidity and mortality from the major CNCDs associated with the considered RF are determined. The calculations were performed in Microsoft Excel 10.0.

Results. Indirect losses due to premature mortality prevail over direct costs of medical care and disability benefits in the economic damage structure of each RF. The largest damage of four major CNCDs was associated with HTN — 869,9 billion rubles, which is equivalent to 1,01% of gross domestic product (GDP). The next places were taken by obesity — 605,8 billion rubles (0,7% of GDP), smoking — 421,4 billion rubles (0,49% of GDP) and low physical activity — 273,0 billion rubles (0,32% of GDP). The contribution of improper feeding (high salt intake, insufficient consumption of vegetables and fruits, consumption of processed red meat) amounted to 0,17% of GDP (145,3 billion rubles), 0,19% of GDP (160,9 billion rubles) and 0,10% of GDP (83,4 billion rubles), respectively. Alcohol abuse made the smallest contribution to CNCD-related damage — 82,5 billion rubles (0,1% of GDP). This is due to the low prevalence of alcohol abuse in the Russian population according to ESSE-RF study.

Conclusion. Assessment of the economic damage of CNCD RF allows determining the priority areas in healthcare and substantiating the effectiveness of CNCD preventive measures aimed at reducing the RF impact, and, consequently, the burden on the healthcare system and the national economy.

Key words: economic damage, risk factors, chronic non-communicable diseases, relative risk, population attributive risk.

Relationships and Activities: none.

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Introduction

According to the World Health Organization (WHO), the following four groups of chronic noncommunicable diseases (NCDs) make the largest contribution to morbidity and mortality worldwide (71% of 57 million of all deaths in the world): cardiovascular disease (CVD), type 2 diabetes (T2D), cancer and chronic obstructive pulmonary disease (COPD) [1]. These diseases have common proven behavioral risk factors (RFs): smoking, excessive alcohol consumption (EAC), sedentary lifestyle (SL), unhealthy diet (UD) and metabolic RFs such as hypertension (HTN) and obesity [2].

According to the Prospective URban Epidemiological (PURE) study, 70% of cardiovascular morbidity and mortality is due to modifiable RFs, with the greatest contribution of HTN (22,3%). In general, behavioral RFs significantly contribute to all-cause mortality [3].

Globally, smoking is responsible for ~71% of lung cancers, 42% of chronic respiratory diseases, and ~10% of CVDs [2]. HTN is responsible for 51% of strokes and 45% of coronary artery disease (CAD) cases in the world [2]. According to the INTERHEART study, 90% of acute myocardial infarctions are associated with 9 RFs [4]. According to various estimates, inadequate fruit and vegetable consumption is the cause of ~14% of deaths from gastrointestinal cancer, 11% — from CAD, and 9% — from stroke [2]. The SL is related to ~21-25% of the breast and colon cancers, 27% of the T2D, and ~30% of the CAD in the world [2]. Alcohol contributes

to the development of >60 diseases and injuries and is the cause of ~30% of deaths from esophageal and liver cancers worldwide [2].

The contribution of RFs to the morbidity and mortality from NCDs is specified by their prevalence in a particular population and the associated risks of morbidity and mortality, which can also vary in different populations depending on socio-economic factors, ethnic characteristics, and other factors [3]. Assessment of the contribution of RFs to morbidity and mortality from NCDs will allow to determine the economic losses caused by these RFs and to identify priorities to improve public health, as well as justify the allocative efficiency of implemented measures.

A comparative analysis of the economic burden of RFs is carried out in many countries [5, 6], as well as on a global scale [7, 8]. Thus, the McKinsey&Company experts have shown that, on a global scale, the economic cost (EC) of smoking and obesity is comparable to all wars, terrorism and armed conflicts in the world [7].

In Russia, the EC of individual RFs was analyzed earlier [9-11]. A comparative analysis of EC of behavioral and metabolic RFs based on their contribution to morbidity and mortality from four main NCDs has not been performed previously.

The aim was to assess the socioeconomic damage of risk factors associated with morbidity and mortality from major NCDs in the Russian population in 2016.

Material and methods

The analysis included the RFs (smoking, EAC, high salt intake, inadequate fruit and vegetable consumption, consumption of processed red meat, SL, obesity, HTN), which have a causal relationship with the main NCDs — CVD, T2D, COPD, cancer of 10 localizations (lung, breast, cervix, ovary, prostate, kidney, stomach, liver, pancreas, colon).

The prevalence of the considered RFs in the Russian population was determined in a multicenter ESSE-RF study [12-13]. The prevalence of smoking was 23,6%, EAC — 3,8%, inadequate fruit and vegetable consumption — 41,9%, high salt intake — 49,9%, daily consumption of processed red meat — 22,5%, SL — 38,8%. The prevalence of HTN and obesity was 44% and 29,7%, respectively.

The relative risk (RR) of morbidity and mortality from NCDs associated with RFs was determined using the literature data. Based on the RF prevalence and RR, the population attributive risk (PAR) was calculated for each analyzed disease using the following formula:

$$PAR\,(\%) = \frac{P_{exp}\,(RR - 1)}{[P_{exp}\,(RR - 1)] + 1},$$

where: P_{exp} — proportion of individuals exposed to RF; RR — relative risk of a certain outcome for a given RF exposure.

For RR <1, PAR was determined by the reduction formula:

$$PAR = \frac{P_1 + P_0 / (RR - 1)}{P_1 + P_0 / RR},$$

where: P_1 — proportion of individuals with RF; P_0 — proportion of individuals without RFs; RR — relative risk of the disease development in accordance with literature data.

PAR, calculated for each analyzed NCDs, was used to determine the proportion of morbidity/mortality associated with RF. To assess the EC of RFs, the proportion of RFs in the morbidity and mortality from NCDs and then the proportion of the disease in EC was determined. By way of example, the calculation formula of CVD is shown below:

$EC_{RF} = (PAR_{morbidity\_CVD} \times DC_{CVD} + PAR_{mortality\_CVD} \times IC_{CVD})$, where: EC_{RF} — EC of RFs; $PAR_{morbidity}$ — PAR of RFs in CVD morbidity; DC_{CVD} — direct costs, associated with CVDs; $PAR_{mortality}$ — PAR of RFs in CVD mortality; IC_{CVD} — economic losses associated with premature mortality in economically active age due to CVDs.

The methodology for calculating the EC of CVD, T2D and COPD, as well as the results used in this analysis, were published earlier [14-16].

For the above-mentioned NCDs, direct medical costs for out- and inpatient and emergency care were calculated, as well as direct nonmedical costs for disability pensions and indirect costs due to the short-received contribution to GDP due to illness and premature termination of working practice.

Data on direct costs of the healthcare system for 2016 was determined on the basis of previously conducted studies. Based on the literature data on the cost of treating cancer patients, the direct costs were recalculated for 2016. The costs of the healthcare system on pancreatic cancer were not included in the calculation due to the lack of information.

To calculate treatment costs in 2016, the current direct medical costs was indexed to the actual inflation rate using the formula:

$COST_{dmc16} = COST_{dmc0} * In0 * In1 * ... * In16$,

where: $COST_{dmc16}$ — direct medical costs for 2016; $COST_{dmc0}$ — direct medical costs at the study time; In0 — growth rate of consumer price indices in the Russian Federation, following the year of analysis of direct medical costs; In1 and In16 — growth rates of consumer price indices up to 2016.

The healthcare costs per patient in 2016, calculated as described above, were multiplied by the number of people with corresponding cancer in 2016.

Indirect costs included the value of short received contribution to GDP due to premature mortality and disability at working age.

The analysis of mortality was carried out using WHO data and information on cancer mortality of the National Medical Research Radiological Center (Russia). Economic losses associated with premature mortality at the economically active age included GDP gap due to lost life years due to death from cancer, taking into account the employment rate. Future losses were calculated using a net present value of future losses with discounting of 3%.

GDP gap due to disability were defined as follows: first, the number of individuals with permanent disability in each of the disability groups was calculated, taking into account the employment rates. Then the estimated number of non-working disabled people of working age is multiplied by the net present value of GDP per capita.

MS Excel 10.0 software (Microsoft, USA) was used for statistical analysis.

Results

At the first stage, a review of large epidemiological studies was carried out to determine RR of morbidity

Table 1

PAR of RFs included in the analysis

Outcome	Smoking	EAC	High salt intake	Inadequate FVC	PRM	SL	Obesity	HTN
CVD: morbidity	0,088	0,044	0,065	0,048		0,070	0,229	0,306
CVD: mortality	0,128	0,030	0,048	0,048		0,070	0,229	0,346
CAD: morbidity	0,115	0,024		0,048	0,086	0,200	0,308	0,284
CAD: mortality	0,106	0,040		0,048	0,039	0,091	0,308	0,381
Stroke: morbidity	0,096	0,006	0,103	0,100	0,037	0,162	0,279	0,143
Stroke: mortality	0,056	0,004	0,166	0,100	0,037		0,279	0,599
COPD: morbidity	0,096	0,009				0,155		0,238
COPD: mortality	0,191	0,009				0,155		
T2D: morbidity	0,094	0,0005	0,177	0,012	0,090	0,248	0,461	0,183
T2D: mortality	0,115	0,001	0,177	0,012	0,090	0,248		0,013
Stomach cancer: morbidity	0,056	0,011	0,070	0,030	0,092	0,147		
Stomach cancer: mortality	0,078	0,011	0,070	0,030	0,092	0,147		
Colorectal cancer: morbidity	0,107	0,022		0,222	0,039	0,064	0,211	
Colorectal cancer: mortality	0,075	0,022		0,222	0,039		0,211	
Liver cancer: morbidity	0,068	0,004		0,141		0,051	0,209	
Liver cancer: mortality	0,072	0,004		0,141		0,051		
Pancreatic cancer: morbidity	0,039	0,044		0,030				
Pancreatic cancer: mortality	0,152	0,044		0,030				
Lung cancer: morbidity	0,253			0,086		0,133	0,029	0,117
Lung cancer: mortality	0,170			0,086		0,133	0,029	0,117
Breast cancer: morbidity	0,039	0,004				0,091	0,241	0,062
Breast cancer: mortality	0,109	0,005				0,091	0,241	0,062
Cervical cancer: morbidity	0,191						0,067	
Cervical cancer: mortality	0,047						0,067	
Ovarian cancer: morbidity	0,014					0,084	0,077	
Ovarian cancer: mortality	0,078						0,077	
Prostate cancer: morbidity	0,009	0,005				0,051	0,074	0,034
Prostate cancer: mortality	0,032	0,005					0,074	0,034
Kidney cancer: morbidity	0,109	0,004		0,042		0,147	0,082	
Kidney cancer: mortality	0,191	0,004		0,042		0,147	0,082	

Note: EAC — excessive alcohol consumption, FVC — fruit and vegetable consumption, PRM — processed red meat, SL — sedentary lifestyle, HTN — hypertension.

and mortality from the main NCDs associated with RFs. Based on the prevalence of RFs and the RR of morbidity and mortality from NCDs associated with RFs, the PAR of these RFs were calculated (Table 1). Smoking was associated with all NCDs included in the analysis, specifying 13% of mortality from CVD, 19% of mortality from COPD, 17% of mortality from lung cancer, and a significant proportion of mortality from other cancers included in the analysis. EAC was associated with CVD, T2D, COPD and some cancers included in the analysis, in particular, with pancreatic and colorectal cancer. By 4% and 4,4%, alcohol contributed to mortality from CAD and pancreatic cancer, respectively. High salt intake was associated with a high risk of CVD, T2D, and gastric cancer. The contribution of this RF to mortality from stroke was 16,6%, T2D2 — 17,7%, and gastric cancer — 7%. Inadequate fruit and vegetable consumption significantly contributed to the morbidity and mortality from gastrointestinal cancers (colorectal cancer — 22,2%, liver cancer — 14,1%) and CVD (stroke — 10%, CHD ~5%). Daily consumption of processed red meat contributed to morbidity of CAD and T2D in 8,6% and 9%, respectively. Among cancers, the largest contribution of this RF to morbidity and mortality from stomach (9,2%) and colorectal cancers (3,9%) was found. SL was associated with most of the analyzed NCDs, making a significant contribution to the morbidity of CVD, T2D, COPD and cancer of various localization (stomach, kidney, breast). Obesity was associated with a high risk of T2D, CVD, and colorectal, liver and breast cancers, also making a significant contribution to mortality from major NCDs (CVD — 22,9%, colorectal cancer — 21,1%, breast cancer — 24,1%). HTN as an independent metabolic RF was associated with an increased risk of CVD, T2D, COPD, and lung cancer. Hypertension accounts for almost 60% of the contribution to death from stroke.

Table 2

EC of RFs due to their contribution to the development of NCDs

Costs	Smoking	EAC	High salt intake	Inadequate FVC	PRM	SL	Obesity	HTN
Direct medical costs, million rubles	44 446,4	11 841,4	19 406,4	28 787,3	14 062,7	36 402,4	82 089,9	84 606,3
Disability benefits payments, million rubles	1 686,3	267,9	309,7	1 074,7	284,8	1 480,3	2 308,2	1 540,3
Direct costs, total, million rubles	46 132,7	12 109,3	19 716,1	29 862,0	14 347,5	37 882,7	84 398,1	86 146,6
Proportion of direct costs in the general EC pattern	10,9%	14,7%	12,3%	20,5%	17,2%	13,9%	13,9%	9,9%
GDP gap due to premature mortality, million rubles	375 276,1	70 385,6	141 208,4	115 456,6	69 066,3	235 263,4	521 375,7	783 789,5
EC, total, million rubles	421 408,8	82 494,9	160 924,5	145 318,6	83 413,9	273 146,1	605 773,8	869 936,0
EC per capita, rubles	2 876,51	563,11	1 098,46	991,94	569,38	1 864,48	4 134,97	5 938,13

Note: EAC — excessive alcohol consumption, FVC — fruit and vegetable consumption, PRM — processed red meat, SL — sedentary lifestyle, HTN — hypertension.

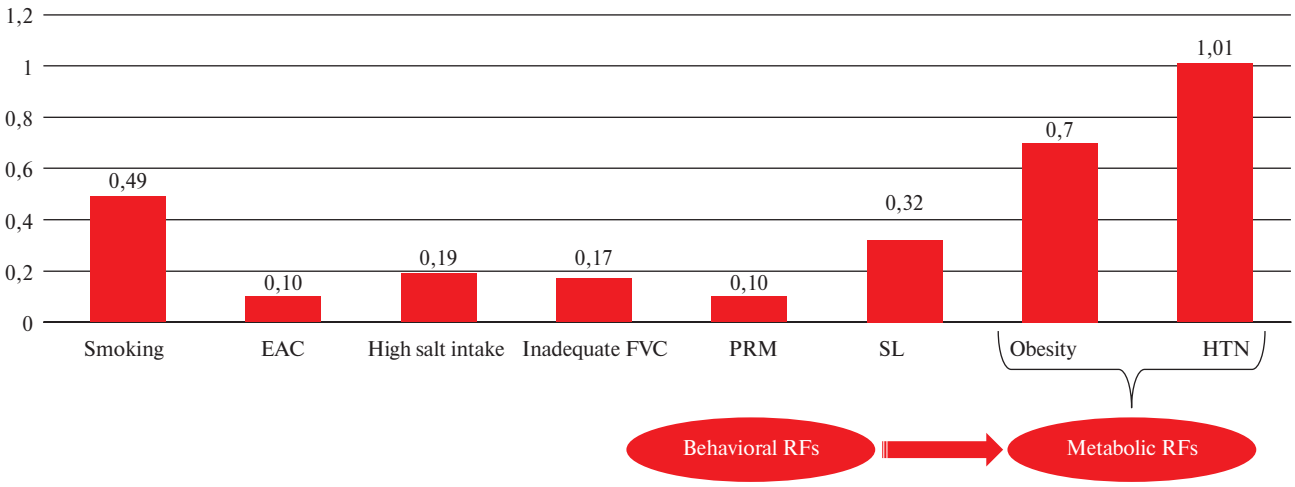

Figure 1. EC of RFs in Russia for 2016 (% of GDP).
Note: EAC — excessive alcohol consumption, FVC — fruit and vegetable consumption, PRM — processed red meat, SL — sedentary lifestyle, HTN — hypertension.

Table 2 and Figure 1 show the EC of RFs based on their contribution to the development of NCDs. In the EC pattern of each RF, indirect losses prevail over direct costs. The greatest damage from the four main NCDs is associated with HTN — 869,9 billion rubles, which is equivalent to 1,01% of GDP. Direct costs for HTN amounted to 86,1 billion rubles, while indirect costs — 783,8 billion rubles. The next largest contribution to EC was associated with obesity (605,8 billion rubles; 0,7% of GDP), smoking (>421,4 billion rubles; 0,49% of GDP) and SL (273,0 billion rubles; 0,32% of GDP). EC of inadequate fruit and vegetable consumption, high salt intake and daily consumption of processed red meat amounted to 0,17% of GDP (145,3 billion rubles), 0,19% of GDP (160,9 billion rubles) and 0,10% of GDP (83,4 billion rubles), respectively. Of all the analyzed RFs, the EAC had smallest contribution — 82,5 billion rubles (0,1% of GDP).

Discussion

RFs significantly contributed to the development of NCDs [3]. In the present study, we analyzed the contribution of behavioral and metabolic RFs to morbidity and mortality from the main NCDs — CVD, T2D, COPD and cancer of 10 localizations. Behavioral RFs specifies the development of metabolic RFs. For example, obesity is associated with diet and SL. The greatest contribution to CVD morbidity is made by such RFs as HTN (30%) and obesity (23%). Mortality from CVD in the Russian population is determined to the greatest extent by HTN (35%), obesity (23%) and smoking (13%). Smoking makes the largest contribution to mortality from COPD (19%). The morbidity of T2D was largely specified by such RFs as obesity (46%), SL (24,8%) and HTN (18%). The largest contribution to the morbidity and mortality of lung cancer was made by smoking (25,3% and 17%, respectively). The morbidity of colorectal cancer was largely determined by inadequate fruit and vegetable consumption (22%), obesity (21%), and smoking (10,7%), while mortality was determined by inadequate fruit and vegetable consumption (22%) and obesity (21%).

Similar studies carried out in other countries had comparable results. In the UK, tobacco smoking was

mostly associated with cancers and obesity (15,1% and 6,3%, respectively). More than 70% of cancers, including two of the five most common cancers (lung and skin cancers), were associated with behavioral RFs [17]. The greatest contribution to CVD morbidity in the populations of Iran, United States and Spain is made by HTN — 11,37%, 54% and 60%, respectively [18].

EC of NCDs all over the world is estimated from 60% to 75% of world GDP, while 30-60% of all NCDs are caused by behavioral RFs [19]. Accordingly, the contribution of the RFs to the EC of NCDs is significant.

According to our study, the highest EC associated with NCDs was caused by HTN and amounted to 869,9 billion rubles (5938,13 rubles per capita). Obesity and smoking were the next largest contributors to EC due to NCDs. EC due to obesity and smoking in Russia in 2016 amounted to 605 (4134,97 rubles per capita) and 421,4 billion rubles (2876,51 rubles per capita), respectively.

According to a large Canadian study assessing the five RFs in 2015 [5], the EC of overweight was the highest, amounting to $2,7 billion (34%). In second place was tobacco smoking ($2,1 billion (27%)), which coincides with the results of this study.

According to a literature review of 18 Australian studies in last 10 years, the highest EC was observed in obesity, ranging from $840 million to $14,9 billion in 1 year. The second position was occupied by tobacco smoking ($10,5 billion), while the lowest EC was observed from unhealthy diet, amounting to $561 million per year [6], which also generally coincides with the presented study.

In the present study, the EC of individual components of unhealthy diet, such as inadequate fruit and vegetable consumption, high salt intake and daily consumption of processed red meat, amounted to 145,3 billion rubles, 160 billion rubles and 83 billion rubles, respectively. In some studies, the EC of unhealthy diet was assessed by individual components, such as the inadequate fruit and vegetable consumption [6], and in others by the integral index [8]. Direct medical costs associated with excessive intake of saturated fat, salt and sugar in Germany in 2008 amounted to €16,8 billion, which is equivalent to 7% of the total treatment cost (€254 billion). Excessive consumption of saturated fatty acids led to losses of €2,9 billion, mainly due to treatment of diabetes, obesity, CAD, COPD [20]. The annual EC due to inadequate fruit and vegetable consumption is $4,39 billion in Canada [21]. Cadilhac AA, et al. estimated that inadequate fruit and vegetable consumption resulted in health care costs of $243,5 million, production losses of $75 million, 55000 disability adjusted life years (DALYs) and 5000 deaths in Australia [22, 23].

In the present study, the EC of EAC was relatively small compared to other RFs, since the prevalence of harmful alcohol consumption was low, and only this component of alcohol damage was included in the analysis. In Australia, the EC due to EAC ranged from $1,1 to 6,8 billion, and was in fourth place after obesity, tobacco smoking and SL, while in Canada — $10,7 billion and was in third place after obesity and smoking.

Losses due to premature mortality prevailed in the EC pattern in Russia and the proportion of direct costs was significantly lower (from 9,9% for HTN to 20,5% inadequate fruit and vegetable consumption). In the Canadian study, direct costs also accounted for a smaller share of losses compared to indirect losses, which included losses due to premature mortality, temporary and permanent disability, as in the present study, but overall, the proportion of direct costs was higher [5]. It is impossible to summarize the obtained EC due to the analyzed RFs of NCDs in Russia for 2016, since the analysis includes behavioral and metabolic RFs, and the former make a significant contribution to the development of the latter.

The results obtained can serve as an economic justification for population-based preventive measures aimed at reducing the RFs of NCDs, and, as a result, underline the priorities of public health programs.

Study limitations

During analysis of the contribution of RFs to morbidity and mortality from CVD, COPD, T2D, and cancers, we used the RRs from international studies, mainly meta-analyzes and large studies on the European population, since there are no large prospective long-term Russian studies, which could affect the accuracy of the PAR calculation. Russian prospective studies are needed to obtain an RR for the Russian population.

These costs cannot be considered completely to RFs, since many RFs are associated with the development of other diseases, injuries, etc. For example, EAC is associated with road traffic accidents, external cause mortality, etc. Smoking also contributes in an increased risk of tuberculosis. However, this was not the purpose of this study. Also, possible interactions of RFs (for example, high salt intake and HTN) were not taken into account.

Conclusion

For the first time, a comparative assessment of EC due to RFs (smoking, EAC, high salt intake, inadequate fruit and vegetable consumption, daily consumption of processed red meat, SL, obesity, HTN) associated with NCDs was carried out in the Russian Federation. Assessment of the economic damage of NCD RFs allows determining the priority areas in healthcare and substantiating the effectiveness of NCD preventive measures aimed at reducing the RF impact, and, consequently, the burden on the healthcare system and the national economy.

Relationships and Activities: none.

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