UDC 613.21: 616.056.5+613.6.027
DOI: 10.21668/health.risk/2024.2.07.eng

Read online

Research article

ASSESSMENT OF HEALTH RISK AND SOCIO-ECONOMIC LOSSES ASSOCIATED WITH NUTRITION-RELATED NON-COMMUNICABLE DISEASES

N.V. Efimova, O.G. Bogdanova

East-Siberian Institute of Medical and Ecological Research, 3 microdistrict 12a, Angarsk, 665827, Russian Federation

Mortality among the Irkutsk region population was chosen as a research object. The aim of this study was to assess socioeconomic losses and the epidemiological risk caused by nutrition-related non-communicable diseases, including diseases of the circulatory system, among adult working age population in the Irkutsk region.

The study was cross-sectional and observational. We analyzed data on mortality, gross regional product and employment provided by the Territorial office of the Federal State Statistic Service in the Irkutsk region over 2011–2020. Social and economic losses caused by early mortality among the population in the Irkutsk region were calculated in accordance with the Methodical Guidelines on using the Potential years of life lost (PYLL) indicator to establish priority health issues of the Russian population at the federal, regional and municipal level. Data were analyzed using Statistica 6.0.

The assessment revealed that over 2011–2020 mortality caused by nutrition-related non-communicable diseases on average accounted for 13.85 % (13.64; 14.07) of the overall population mortality. Average annual social losses equaled 154,827.00 (153,098.56; 156,555.44) person-years lost before a person reached the end of working age. Accompanying probable economic losses aggregated over the analyzed period ranged between 9,560.58 and 15,934.29 million rubles. We managed to build acceptable predictive models ($R^2 > 0.5$) on the growth in economic losses due to mortality caused by nutrition-related non-communicable diseases for both sexes and for males living in the Irkutsk region.

Our findings highlight the significance of socioeconomic losses caused by nutrition-related non-communicable diseases and give evidence of suboptimal diets being widely spread among the population of the Baikal region.

Keywords: *nutrition-related diseases, diseases of the circulatory system, population, nutrition, potential years of life lost, socioeconomic losses, epidemiological risk, Irkutsk region.*

Social determinants [1, 2] such as adverse effects of globalization, rapid urbanization, sedentary lifestyle, economic and social status make for prevalence of risk factors able to cause nutrition-related non-communicable diseases (NR NCDs) among population [3–5]. These unfavorable health outcomes cause serious anxiety in healthcare and demography due to growing prevalence of NR NCDs including diseases of the circulatory systems, cancer, type II diabetes mellitus and others [6–9]. Burden of these diseases is extremely high among population in many countries across the globe [10–14] as well as various regions of the Russian Federation [15–20], the Irkutsk region (IR) included [21–23].

As reported in the *Lancet*, non-communicable diseases (NCDs) account for 73 % of all global deaths [9, 24]. In this situation, it seems quite relevant to assess social and economic losses (SELs) due to early mortality among working age population caused by NR NCDs [1, 2, 6]. Analysis of research literature has established that similar profound investigations on the matter have never been accomplished in the Irkutsk region.

In this study, our aim was to assess socioeconomic losses and the epidemiological risk caused by nutrition-related non-communicable diseases (NR NCDs), including diseases of the circulatory system, among adult working age population in the Irkutsk region.

© Efimova N.V., Bogdanova O.G., 2024

Natalia V. Efimova – Doctor of Medical Sciences, Professor, Leading Researcher at the Laboratory of Ecological and Hygienic Research (e-mail: medecolab@inbox.ru; tel.: +7 (395) 558-69-10; ORCID: https://orcid.org/0000-0001-7218-2147).

Olga G. Bogdanova – Candidate of Medical Sciences, Senior Researcher at the Laboratory of Ecological and Hygienic Research (e-mail: olga.bogdanova2001@gmail.com; tel.: +7 (395) 558-69-10; ORCID: https://orcid.org/0000-0002-2358-2280).

Materials and methods. The study was cross-sectional and observational. We analyzed and comparatively assessed rates, dynamics, and structure of mortality among the Irkutsk region population caused by NR NCDs over 2011–2020 relying on data provided by the Territorial office of the Federal State Statistic Service in the Irkutsk region. Nosologic groups of diseases that were considered NR NCDs included only non-communicable diseases with such a leading factor of their development as failure to stick to a healthy diet: nutritional anaemias (D50–D53), endocrine, nutritional and metabolic diseases (E05–E16, E43–E85), hypertensive diseases (I10–I15), myocardial infarction (I21–I22), atherosclerotic heart disease (I25–I25.1), cerebrovascular diseases (I60–69), atherosclerosis (I70), diseases of the digestive system (K00–K29.1, K29.3–K67, K71–K85.1, K85.3–K85.9, K86.1–K93), diseases of the musculoskeletal system and connective tissue (M05–14, M15–M19, M60–63, M80–M94).

The 'Potential years of life lost' indicator (hereinafter PYLL) was calculated in accordance with the Methodical Guidelines on using the Potential years of life lost (PYLL) indicator[1]. At the first stage, the formula (1) was used for calculating lost years for each age group:

$$a_i = T - x_i, \quad (1)$$

where a_i is lost years within the age range (i);

T is the upper age limit for which a working age period is calculated;

x_i is the middle of the corresponding age range (i).

PYLL was calculated as the sum of the number of deceased multiplied by lost years in each age group:

$$PYLL = \sum i \cdot D_i \cdot a_i, \quad (2)$$

where $PYLL$ = potential years of life lost;

D_i is the number of deceased within the age range (i);

a is lost years within the age range (i).

PYLL values that were calculated for a specific age and sex group were then summed up to calculate the total loss of potential years of life for each specific age group. This sum of years lost before the end of a working age was reached by each specific generation is conventionally considered to be social losses.

At the second stage, the formula (3) was used for calculating a relative indicator, or PYLL rate:

$$Rate_{PYLL} = \frac{PYLL}{Pu} \cdot 100{,}000, \quad (3)$$

where $Rate_{PYLL}$ is PYLL rate per 100,000 people; P_u is the number of analyzed population aged between 1 year and T, that is, the end of working age (60 years for men and 55 years for women).

The PYLL indicator was standardized using the direct approach to minimize effects of age structure. Data obtained by the 2010 Russian census were taken as the standard population.

At the final stage, the formula (4) was used to calculate economic losses (ELs) due to early mortality. They were based on measuring a gross regional product that would be created by early deceased people over a future working age period [6, 25]. ELs borne by the society due to early mortality are given as:

$$\text{ELs} = PYLL\sum \cdot \text{GRP}_{\text{emp}}, \quad (4)$$

where ELs are economic losses;

$PYLL\sum$ is the sum of person-years lost prior to reaching the end of working age;

GRP_{emp} is the volume of gross regional product per one person employed in economy in a corresponding year.

[1] Metodicheskie rekomendatsii po ispol'zovaniyu pokazatelya «Poteryannye gody potentsial'noi zhizni» dlya obosnovaniya prioritetnykh problem zdorov'ya naseleniya Rossii na federal'nom, regional'nom i munitsipal'nom urovnyakh; utv. Predsedatelem obshcherossiiskoi obshchestvennoi organizatsii «Rossiiskoe obshchestvo po organizatsii zdravookhraneniya i obshchestvennogo zdorov'ya» akademikom RAN V.I. Starodubovym [The Methodical Guidelines on using the Potential years of life lost (PYLL) indicator to establish priority health issues of the Russian population at the federal, regional and municipal level; approved by V.I. Starodubov, RAS Academician, the Chairman of the Russian Public Organization The Russian Society for Organization of Healthcare and Population]. Moscow, 2014 (in Russian).

It is rather difficult to analyze socioeconomic losses caused by effects of NR NCDs on mortality since most diseases are polyetiological and some other factors may arise in economic estimations [6, 25, 26]. To determine ELs caused by mortality due to NR NCDs, we multiplied data on ELs due to all-cause mortality by the proportion of working age people who died from NR NCDs caused by insufficient or excessive intake of nutrients as compared with physiological needs in accordance with the Methodical guidelines[2].

Diseases of the circulatory system (CSDs, I00–I99) are the leading cause of population mortality [6, 27]. The proportion of nutrition-related CSDs was determined by epidemiological risk assessment. Relative risks (RR) with their 95 % confidence intervals (CI), standard deviation (STD), etiological fraction (EF), experimental event rate (EER) and control event rate (CER) were calculated for population samples. For more profound investigation, workers employed in various branches were randomly selected out of those who had a periodical medical check-up in 2021–2022 and were aged between 40 and 65 years. The male group included 177 people; the female one, 93 people. The nutritional status of the examined people was established as per the body mass index (BMI) and energy and nutritional value of a diet estimated by the frequency of food products consumption. The latter was established by questioning that relied on using the automated software program 'Nutrition Analysis' [28]. People were included into sub-groups with unhealthy diets if they met the following criteria: overweight (BMI $\geq$ 25) and energy value of a diet being higher than the upper boundary of the necessary energy value calculated on the basis of physical activity. CSDs were diagnosed by a cardiologist after relevant clinical, physical, instrumental and laboratory examination performed at the clinic of the East-Siberian Institute of Medical and Ecological Research (the chief physician is E.V. Katamanova, Doctor of Medical Sciences, professor). Examinations were performed after obtaining patients' informed written consents and approval of the Institute's Ethics Committee.

Statistical analysis was performed using Statistica 6.0 software and other conventional packages compatible with Microsoft Office (minimums and maximums, simple means and their errors (M (confidence interval)). Regression analysis was employed to predict dynamics of the analyzed indicators. Critical significance was taken at $p < 0.05$.

Results and discussion. In 2020, mortality due to NR NCDs equaled 93.86 among adult working aged population in the Irkutsk region; the decrease rate against 2011 was 25.55 %. A decrease by 1.57 times was established between 2011 and 2019 from 117.83 down to 75.06 cases per 100,000 accordingly, with a growth of 1.25 times in 2020.

The proportion of deceased due to NR NCDs amounted to 13.85 % (13.64; 14.07) in the all-cause mortality among working age population in the Irkutsk region over 2011–2020; it was equal to 13.58 % (13.43; 14.07) among men and 14.75 % (14.25; 15.24) among women (Table 1).

Comparative analysis depending on residence and sex established absence of any significant differences between urban and rural areas or between men and women either ($p > 0.05$).

The proportion of deceased due to NR NCDs tended to decline among adult working age people by 2020 against 2011. The decrease rate equaled -7.94 % for both sexes and varied from -12.48 % in rural areas to -4.42 % in urban areas; it was -33.86 % among women (from -34.92 % in urban areas to -34.04 % in rural areas) and -0.36 % among men, including -6.22 % among men in rural areas. The only exception was the trend among men in urban

[2] Drapkina O.M., Karamnova N.S., Kontsevaya A.V., Gorny B.E., Dadaeva V.A., Drozdova L.Yu., Yeganyan R.A., Eliashevich S.O. [et al.]. Russian Society for the Prevention of Noncommunicable Diseases (ROPNIZ). Alimentary-dependent risk factors for chronic non-communicable diseases and eating habits: dietary correction within the framework of preventive counseling. Methodological Guidelines. *Kardiovaskulyarnaya terapiya i profilaktika*, 2021, vol. 20, no. 5, pp. 2952. DOI: 10.15829/1728-8800-2021-2952 (in Russian).

Table 1

The proportion of people who died from nutrition-related non-communicable diseases in the all-cause mortality among adult working age population in the Irkutsk region over 2011–2020

Indicator	Both sexes	Men	Women
$M_{2011–2020}$ (CI)	13.85 (13.64; 14.07)	13.58 (13.43; 13.73)	14.75 (14.25; 15.24)
Growth/decrease rate by 2020, %	-7.94	-0.36	-33.86
Urban areas			
$M_{2011–2020}$ (CI)	13.47 (13.29; 13.65)	13.23 (13.06; 13.40)	14.25 (13.81; 14.70)
Growth/decrease rate by 2020, %	-4.42	4.47	-34.92
Rural areas			
$M_{2011–2020}$ (CI)	14.31 (14.01; 14.62)	13.98 (13.75; 14.21)	15.43 (14.82; 16.03)
Growth/decrease rate by 2020, %	-12.48	-6.22	-34.04
p (between urban and rural areas)	0.158	0.124	0.345
p (between men and women)		0.178	
p (between men and women in urban areas)		0.202	
p (between men and women in rural areas)		0.181	

Note: significant of differences is estimated using Student's t-test at $p < 0.05$.

areas where the growth rate of the proportion of deceased due to NR NCDs equaled 4.47 %.

According to [6, 8], CSDs account for the biggest proportion among NR NCDs; given that, we examined mortality rates due to this nosology. Over 2011–2020, the proportion of deceased due to CSDs among working age people on average equaled 53.59 % (49.05; 58.12) in the NR NCDs-related mortality, 57.55 % (52.82; 62.27) among men and 41.35 % (37.94; 44.76) among women. The lowest proportion for both sexes was established in 2015 when it was 43.62 %; the highest one or 63.02 %, in 2019. The same trend was established for men with its lowest value of 46.67 % established in 2015 and the highest one of 67.65 % in 2019. The lowest and highest proportion of CSDs in the NR NCDs-related mortality among women was established in different years from men, namely, 2014 and 2017 when it reached 32.57 % and 50.77 % accordingly.

The proportion of deceased due to CSDs among working age population on average was 7.36 % (7.25; 7.47) of the all-cause mortality among working age population over 2011–2020; it equaled 7.78 % (7.62; 7.94) among men and 6.0 % (5.87; 6.13) among women. The growth rate by 2020 reached 7.38 % for both sexes and 16.19 % among men. The proportion declined among women with its decrease rate by 2020 being -36.63 %.

Over the 10-year analyzed period, the lowest proportions of deaths due to CSDs were established for both sexes in 2014, 6.44 %; the highest ones, in 2018, 8.93 %; for men, 6.47 % in 2014 and 8.93 % in 2018; for women, 4.98 % in 2019 and 7.21 % in 2011. The proportion of men, who died from CSDs, if taken in dynamics over periods, was 1.16 times higher in 2018–2020 against 2011–2013 and equaled 8.52 (8.25; 8.78) and 7.34 (7.03; 7.66) accordingly ($p = 0.033$). The situation was the opposite among women: the proportion of women, who died from CSDs, was 1.26 times lower in 2018–2020 against 2011–2013, 5.29 (5.08; 5.49) and 6.68 (6.37; 6.99) accordingly ($p = 0.013$), and 1.14 times lower than in 2014–2017, 6.03 (5.83; 6.23) ($p = 0.048$). The remaining indicators steadied and were not significant ($p > 0.05$).

Data provided in Table 2 clearly indicate that PYLL due to all-cause mortality prevails among working age men in 2011–2020 and is 3.7 times as high as the same indicator among working age women.

Table 2

Social losses due to all-cause mortality in the Irkutsk region

Years	Potential years of life lost for working age population, absolute number		
	Both sexes	Men	Women
2011	187,808	149,478	38,330
2012	182,394	145,306	37,088
2013	178,035	140,903	37,132
2014	176,879	140,070	36,809
2015	168,305	131,582	36,723
2016	147,948	115,795	32,153
2017	129,933	101,526	28,407
2018	127,867	100,771	27,096
2019	121,579	94,061	27,518
2020	127,522	99,153	28,369
$M_{2011–2020}$ (CI)	154,827.00 (153,098.56; 156,555.44)	121,864.50 (120,438.99; 123,290.01)	32,962.50 (32,655.50; 33,269.50)
Growth / decrease rate by 2020, %	-47.27	-50.75	-35.11

PYLL tended to decline over 2011–2020 in the analyzed region. The decrease rate was -50.75 % among men and -35.11 % among women. The indicator reached its peak in 2011 when it was 187,808 person-years. The PYLL decrease rate was 1.45 times lower among women against men.

The analysis of standardized PYLL indicators revealed that losses of years of life were 1.89 times as high among the population in the Irkutsk region over 2011–2020 against the national average in the Russian Federation used as the standard (the data obtained by the 2010 Russian census), 1.68 times higher among men and 0.38 times higher among women. The PYLL decrease rate by 2020 against 2011 equaled -12.93 %, -16.89 % for men and -4.90 % for women.

Table 3 clearly shows that economic losses (ELs) due to all-cause mortality on average equaled 82,168.77 (78,696.64; 85,640.89) million rubles over 2011–2020; 66,251.43 (63,510.91; 68,991.96) million rubles for men and 15,917.33 (15,180.33; 16,654.33) million rubles for women. Our comparison of average ELs due to all-cause mortality in 2011–2013, 2014–2017 and 2018–2020 established a persistent growth in this indicator ($p < 0.05$).

Questioning accomplished among the examined people in the study sample revealed how frequently they tended to stick to unhealthy diets. Their prevalence reached 93.39 % among men and 83.57 % among women. We established that the lipid component prevailed in men's diets and the carbohydrate one in women's diets. The BMI was higher than 25.0 kg/m^2 in 78.56 % of men and 74.19 % of women. CSDs prevalence reached 29.30 % among the examined men; it was 32.0 % among men with overweight and obesity whereas it was 1.65 times lower among men with normal body weight, 19.39 %.

The CSDs relative risk (*RR*) equaled 1.977 (1.279; 3.056) for men, EF = 49.4 % (Table 4). CSDs prevalence reached 47.83 % among the examined women; it was 63.24 % among those with overweight and obesity and 3.79 times lower among women with normal weight, 16.67 %. The CSDs relative risk (*RR*) equaled 3.692 (1.479; 9.219), EF = 72.9 %. Therefore, frequency of unhealthy nutritional status reached 33.2 % among men with CSDs and 61.5 % among women with CSDs.

Table 3

Economic losses caused by mortality due to diseases of the circulatory system among working age population in the Irkutsk region in 2011–2020, million rubles

Years	Economic losses due to all-cause mortality			The proportion of deceased due to CSDs, %			Economic losses caused by CSDs		
	Both sexes	Men	Women	Both sexes	Men	Women	Both sexes	Men	Women
$M_{2011–2013}$ (CI)	59,766.19 (55,758.04; 63,774.35)	48,600.06 (45,255.44; 51,944.67)	11,166.14 (10,501.92; 11,830.35)	7.19 (6.98; 7.40)	7.34 (7.03; 7.66)	6.68 (6.37; 6.99)	4328.48 (3905.73; 4751.24)	3585.25 (3181.25; 3989.26)	743.23 (718.79; 767.67)
$M_{2014–2017}$ (CI)	84,135.37 (82,629.72; 85,641.02)	67,793.23 (66,680.54; 68,905.92)	16,342.14 (15,924.81; 16,759.46)	7.20 (6.81; 7.58)	7.55 (7.10; 8.01)	6.03 (5.83; 6.23)	6114.46 (5718.18; 6510.74)	5126.71 (4773.36; 5480.06)	987.75 (930.70; 1044.80)
$M_{2018–2020}$ (CI)	101,949.20 (99,599.37; 104,299.03)	81,847.08 (79,900.58; 83,793.57)	20,102.12 (19,444.09; 20,760.15)	7.75 (7.48; 8.01)	8.52 (8.25; 8.78)	5.29 (5.08; 5.49)	8032.69 (7700.86; 8364.52)	6971.69 (6667.19; 7276.20)	1061.00 (1030.65; 1091.35)
$M_{2011–2020}$ (CI)	82,168.77 (78,696.64; 85,640.89)	66,251.43 (63,510.91; 68,991.96)	15,917.33 (15,180.33; 16,654.33)	7.36 (7.25 7.47)	7.78 (7.62 7.94)	6.00 (5.87 6.13)	6154.14 (5834.68; 6473.59)	5217.77 (4925.47; 5510.07)	936.37 (905.94; 966.79)
Growth rate by 2020 against 2011, %	47.78	47.15	50.36	7.38	16.19	-36.63	52.59	55.71	32.18
p*	**0.001**	**0.001**	**0.000**	0.134	**0.033**	**0.013**	**0.001**	**0.002**	**0.001**
p**	**0.001**	**0.001**	**0.003**	0.324	0.162	**0.048**	**0.016**	**0.012**	0.358
p***	**0.001**	**0.001**	**0.001**	0.991	0.741	0.108	**0.026**	**0.032**	**0.019**

Note: p* between $M_{2011–2013}$ and $M_{2018–2020}$ in the IR; p** between $M_{2014–2017}$ and $M_{2018–2020}$ in the IR; p*** between $M_{2011–2013}$ and $M_{2014–2017}$ in IR.

Table 4

Description of the relative risk of circulatory system diseases in people with overweight

Indicator	Men	Women
Relative risk (*RR* (CI))	1.977 (1.279; 3.056)	3.692 (1.479; 9.219)
Etiological fraction (EF)	49.4	72.9
Standard deviation (STD)	0.222	0.467
Experimental event rate (EER)	0.332	0.615
Control event rate (CER)	0.168	0.167

Average annual economic losses due to overall NR NCDs-caused mortality were 11,259.88 (10,829.13; 11,690.64) million rubles in 2011–2020; of them, 8979.32 (8612.71; 9345.93) million rubles in male population and 2280.56 (2204.17; 2356.95) million rubles in female population. Annual economic losses due to CSDs-caused mortality (I10–I15, I21–I22, I60–69, I70) equaled 6154.14 (5834.68; 6473.59) million rubles over the analyzed period; of them, 5217.77 (4925.47; 5510.07) million rubles in male population and 936.37 (905.94; 966.79) million rubles in female population (Table 3).

Comparison between different periods established the lowest economic losses due to CSDs among both sexes in 2011–2013, 4328.48 (3905.73; 4751.24) million rubles. It was 1.86 times lower against 2018–2020, 8032.69 (7700.86; 8364.52) million rubles (p = 0.001); 1.41 times lower against 2014–2017, 6114.46 (5718.18; 6510.74) million rubles (p = 0.026). The highest economic losses due to CSDs were established in 2018–2020 when the indicator was 1.31 times higher against 2014–2017 (p = 0.016).

Similar trends were established for male population where economic losses due to

CSDs equaled 3585.25 (3181.25; 3989.26) million rubles in 2011–2013, which was 1.94 times lower against 2018–2020, 6971.69 (6667.19; 7276.20) million rubles ($p = 0.002$), and 1.43 times lower against 2014–2017, 5126.71 (4773.36; 5480.06) million rubles ($p = 0.032$). The highest economic losses due to CSDs were also established in 2018–2020 when they were 1.36 times higher against 2014–2017 ($p = 0.012$).

The lowest economic losses due to CSDs among female population were established in 2011–2013 when they reached 743.23 (718.79; 767.67) million rubles, which was 1.43 times lower against 2018–2020, 1061.00 (1030.65; 1091.35) ($p = 0.001$), and 1.33 times lower against 2014–2017, 987.75 (930.70; 1044.80) ($p = 0.019$). Economic losses due to CSDs identified among female population did not have significant differences between the periods 2014–2017 and 2018–2020 ($p > 0.05$).

Prediction based on regression models established a growing trend in economic losses due to NR NCDs-caused mortality among working age population of both sexes ($y = 6E+08x + 8E+09$; $R^2 = 0.6411$) and among men ($y = 5E+08x + 6E+09$; $R^2 = 0.7046$) by 2025 (Figure 1). This is likely associated with slower decline rates in the proportion of NR NCDs-caused mortality by 2020 (-7.94 % among both sexes, -0.36 % among men) and the proportion of employed people in the total working age population (-10.42 % among men). Prediction models were not authentic for women ($R^2 < 0.5$). According to the obtained prediction models, economic losses are expected to grow by 17.94 % among both sexes by 2025 against 2020 and reach 16,781.2 million rubles; an expected growth is 15.02 % (up to 13,905.9 million rubles) among men and 2.74 % (up to 2875.3 million rubles) among women.

The lowest economic losses due to NR NCDs were found in 2011–2013. However, the existing situation in the Irkutsk region cannot be considered favorable since the gross regional product values were the lowest during that period as well. On the contrary, the proportion of NR NCDs-caused mortality, PYLL and the proportion of employed population were the highest. A growth in economic losses due to NR NCDs-caused mortality was detected in 2018–2020. This indicator had the highest values despite a certain decline in potential years of life lost. This situation occurred due to a decrease in working age population and the proportion of employed people in the total working age population.

According to the studies [6–8, 29], nutrition contributes between 30 and 50 % into the development of cardiovascular diseases, diabetes, osteoporosis, obesity and some cancers. It is noteworthy that our study established a higher etiological fraction of CSDs

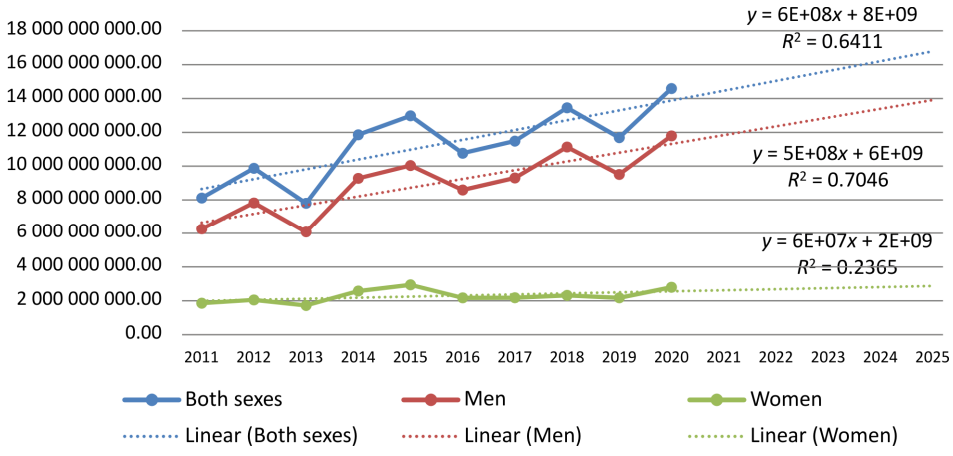

Figure 1. Economic losses due to mortality caused by nutrition-related non-communicable diseases among working age population in the Irkutsk region, rubles

development caused by unhealthy diets for women against men (72.9 against 49.4 %). This fact might be associated with other risk factors being more significant for men including smoking and occupational factors able to cause endothelial dysfunction as well as dependence of the angiotensin-renin system on testosterone levels [30]. Given that, probable economic losses due to NR NCDs caused by unhealthy diets will vary between 33,779.65 and 59,299.42 million rubles overall for both sexes in 2011–2020; between 26,937.97 and 44,896.61 million rubles in male population and between 6841.68 and 11,402.81 million rubles in female population considering employment in each analyzed population cohort. CSDs account for 54.66 % in the total economic losses due to NR NCDs among both sexes; 58.11 % among men and 41.06 % among women. Given that, we calculated economic losses due to this nosology considering epidemiological risk of effects produced by unhealthy diets and relying on data obtained for the population sample with diagnosed CSDs. Over the period 2011–2020, they annually equaled 2308.17 million rubles overall, including 1732.3 million rubles in male population and 575.87 million rubles in female population.

In general, our findings are consistent with those reported by Russian [6–8] and foreign [4, 5, 11] experts who think that a global surge in NR NCDs has negative influence on the population health, healthcare systems, and economy as well. According to O.M. Drapkina et al. (2021), economic losses due to expenditure on hospitalization and treatment provided for patients with chronic heart failure reached 81.86 billion rubles; care provided by relatives annually cost 72.4 million rubles. Our findings supplement data on a considerable NR NCDs-related burden and prevalence of unhealthy diets among people living in the Baikal region since similar assessment was conducted in Buryatia [31]. These problems can be solved by developing a set of activities able to mitigate effects of nutrition-related risk factors, improved NR NCDs diagnostics at early stages and educational activities provided for adults and children to raise their awareness about healthy diets.

Limitations of the study are associated with common issues typical for statistical data analysis. When examining mortality in 2020, we did not consider diagnoses caused by effects of the new coronavirus infection. Economic losses were calculated relying on average GRP levels.

Conclusions. Examination of adult working age population in the Irkutsk region revealed high prevalence of unhealthy diets and NR NCDs, CSDs included. On average in 2011-2020, the proportion of deceased due to CSDs in the overall NR NCDs-related mortality equaled 53.59 % (49.05; 58.12) among working age population, including 57.55 % (52.82; 62.27) in male population and 41.35 % (37.94; 44.76) in female population. We detected an elevated CSDs relative risk in people with the prevailing lipid component in diets (RR = 1.997 for men, RR = 3.692 for women); etiological fraction equaled 49.4 and 72.9 % accordingly. This caused social losses associated with lost person-years in 2011–2020, which reached 68,945 in the overall population, including 56,252 for men and 12,693 for women, as well as economic losses of 61,541.35 million rubles associated with mortality due to diseases of the circulatory system.

Funding. The study was accomplished within budget-funded research work.

Competing interests. The authors declare no competing interests.

References

1. Zaitseva N.V., Kleyn S.V., Glukhikh M.V. Determining priority socio-hygienic determinants of life expectancy at birth for the Russian Federation population. *Zdravookhranenie Rossiiskoi Federatsii*, 2022, vol. 66, no. 6, pp. 435–443. DOI: 10.47470/0044-197X-2022-66-6-435-443 (in Russian).

2. Shchepin V.O., Shishkin E.V. The basics of calculating the economic losses due to mortality of the working-age population. *Zdravookhranenie Rossiiskoi Federatsii*, 2018, vol. 62, no. 6, pp. 284–288. DOI: 10.18821/0044-197X-2018-62-6-284-288 (in Russian).

3. Tutelyan V.A., Nikityuk D.B., Baturin A.K., Vasiliev A.V., Gapparov M.M.G., Zhilinskaya N.V., Zhminchenko V.M., Kambarov A.O. [et al.]. Nutriome as the direction of the "main blow": determination of physiological needs in macro and micronutrients, minor biologically active substances. *Voprosy pitaniya*, 2020, vol. 89, no. 4, pp. 24–34. DOI: 10.24411/0042-8833-2020-10039 (in Russian).

4. Popkin B.M., Barquera S., Corvalan C., Hofman K.J., Monteiro C., Ng S.W., Swart E.C., Smith Taillie L. Towards unified and impactful policies to reduce ultra-processed food consumption and promote healthier eating. *Lancet Diabetes Endocrinol.*, 2021, vol. 9, no. 7, pp. 462–470. DOI: 10.1016/S2213-8587(21)00078-4

5. Coyle D.H., Huang L., Shahid M., Gaines A., Di Tanna G.L., Louie J.C.Y., Pan X., Marklund M. [et al.]. Socio-economic difference in purchases of ultra-processed foods in Australia: an analysis of a nationally representative household grocery purchasing panel. *Int. J. Behav. Nutr. Phys. Act.*, 2022, vol. 19, no. 1, pp. 148. DOI: 10.1186/s12966-022-01389-8

6. Drapkina O.M., Boytsov S.A., Omelyanovskiy V.V., Kontsevaya A.V., Loukianov M.M., Ignatieva V.I., Derkach E.V. Socio-economic impact of heart failure in Russia. *Rossiiskii kardiologicheskii zhurnal*, 2021, vol. 26, no. 6, pp. 4490. DOI: 10.15829/1560-4071-2021-4490 (in Russian).

7. Karamnova N.S., Rytova A.I., Shvabskaya O.B., Makarova Yu.K., Maksimov S.A., Balanova Yu.A., Evstifeeva S.E., Imaeva A.E. [et al.]. Associations of eating and drinking habits with cardiovascular disease and diabetes in the adult population: data from the ESSE-RF epidemiological study. *Kardiovaskulyarnaya terapiya i profilaktika*, 2021, vol. 20, no. 5, pp. 2982. DOI: 10.15829/1728-8800-2021-2982 (in Russian).

8. Eganian R.A., Kalinina A.M., Izmailova O.V., Kushunina D.V., Bunova A.S. Primary and repeated prophylactic medical examination of certain adult population groups: changes in diet-related risk factors for non-communicable diseases. *Profilakticheskaya meditsina*, 2019, vol. 22, no. 4, pp. 14–21. DOI: 10.17116/profmed20192204114 (in Russian).

9. GBD 2015 Mortality and Causes of Death Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*, 2016, vol. 388, no. 10053, pp. 1459–1544. DOI: 10.1016/S0140-6736(16)31012-1

10. Chen S., Guo L., Wang Z., Mao W., Ge Y., Ying X., Fang J., Long Q. [et al.]. Current situation and progress toward the 2030 health-related Sustainable Development Goals in China: A systematic analysis. *PLoS Med.*, 2019, vol. 16, no. 11, pp. e1002975. DOI: 10.1371/journal.pmed.1002975

11. Ajabshir S., Stumbar S., Lachica I., Gates K., Qureshi Z., Huffman F. Rate of Nutrition-Related Chronic Diseases Among a Multi-Ethnic Group of Uninsured Adults. *Cureus*, 2022, vol. 14, no. 9, pp. e28802. DOI: 10.7759/cureus.28802

12. Banna M.H.A., Hamiduzzaman M., Kundu S., Ara T., Abid M.T., Brazendale K., Seidu A.A., Disu T.R. [et al.]. The Association Between Bangladeshi Adults' Demographics, Personal Beliefs, and Nutrition Literacy: Evidence From a Cross-Sectional Survey. *Front. Nutr.*, 2022, vol. 9, pp. 867926. DOI: 10.3389/fnut.2022.867926

13. Tsugane S. Why has Japan become the world's most long-lived country: insights from a food and nutrition perspective. *Eur. J. Clin. Nutr.*, 2021, vol. 75, no. 6, pp. 921–928. DOI: 10.1038/s41430-020-0677-5

14. Demin A., Løge B., Zhiteneva O., Nishida C., Whiting S., Rippin H., Delles C., Karymbaeva S. [et al.]. Trans fatty acid elimination policy in member states of the Eurasian Economic Union: Implementation challenges and capacity for enforcement. *J. Clin. Hypertens. (Greenwich)*, 2020, vol. 22, no. 8, pp. 1328–1337. DOI: 10.1111/jch.13945

15. Popova A.Yu., Tutelyan V.A., Nikityuk D.B. On the new (2021) Norms of physiological requirements in energy and nutrients of various groups of the population of the Russian Federation]. *Voprosy pitaniya*, 2021, vol. 90, no. 4 (536), pp. 6–19. DOI: 10.33029/0042-8833-2021-90-4-6-19 (in Russian).

16. Baturin A.K., Pogozheva A.V., Keshabyants E.E., Soto S.H., Kobelkova I.V., Kambarov A.O. Features of the chemical composition of the diet and nutritional status of indigenous and newcomers in the Russian Arctic. *Gigiena i sanitariya*, 2019, vol. 98, no. 3, pp. 319–323. DOI: 10.18821/0016-9900-2019-98-3-319-323 (in Russian).

17. Frolova O.A., Tafeeva E.A., Frolov D.N., Bocharov E.P. Alimentary-dependent diseases of the population and the hygienic characteristic of the factors of the risk of their development in the territory of the Republic of Tatarstan. *Gigiena i sanitariya*, 2018, vol. 97, no. 5, pp. 470–473. DOI: 10.18821/0016-9900-2018-97-5-470-473 (in Russian).

18. Mitrokhin O.V., Matveev A.A., Ermakova N.A., Belova E.V. Assessing risk factors that can cause alimentary-dependent diseases among students due to their nutrition. *Health Risk Analysis*, 2019, no. 4, pp. 69–76. DOI: 10.21668/health.risk/2019.4.07.eng

19. Kodentsova V.M., Zhilinskaya N.V., Shpigel B.I. Vitaminology: from molecular aspects to improving technology of vitamin status children and adults. *Voprosy pitaniya*, 2020, vol. 89, no. 4, pp. 89–99. DOI: 10.24411/0042-8833-2020-10045 (in Russian).

20. Khotimchenko S.A., Sharafetdinov Kh.Kh. On the prevention of iodine deficiency. Message 2. *Voprosy pitaniya*, 2020, vol. 89, no. 3, pp. 126–128. DOI: 10.24411/0042-8833-2020-10037 (in Russian).

21. Tarmaeva I.Yu., Efimova N.V., Baglushkina S.Yu. Hygienic estimation of the nutrition and the risk of morbidity associated with its violation. *Gigiena i sanitariya*, 2016, vol. 95, no. 9, pp. 868–872. DOI: 10.18821/0016-9900-2016-95-9-868-872 (in Russian).

22. Zhdanova-Zaplesvichko I.G. Irrational nutrition as populattion health risk factor in Irkutsk region. *Health Risk Analysis*, 2018, no. 2, pp. 23–32. DOI: 10.21668/health.risk/2018.2.03.eng

23. Ushakova O.V., Efimova N.V., Tarasov A.Yu., Katamanova E.V. Assessment of loss of health of the population of an older age group. *Gigiena i sanitariya*, 2020, vol. 99, no. 10, pp. 1170–1176. DOI: 10.47470/0016-9900-2020-99-10-1170-1176 (in Russian).

24. Allen L.N., Nicholson B.D., Yeung B.Y.T., Goiana-da-Silva F. Implementation of non-communicable disease policies: a geopolitical analysis of 151 countries. *Lancet Glob. Health*, 2020, vol. 8, no. 1, pp. e50–e58. DOI: 10.1016/S2214-109X(19)30446-2

25. Budaev B.S., Mikheev A.S., Tarmaeva I.Yu., Khamnaeva N.I., Bogdanova O.G. The social economical losses because of mortality due to alcohol-associated causes. *Problemy sotsialnoi gigieny, zdravookhraneniya i istorii meditsini*, 2020, vol. 28, no. 1, pp. 29–33. DOI: 10.32687/0869-866X-2020-28-1-29-33 (in Russian).

26. Fattore G., Federici C., Drummond M., Mazzocchi M., Detzel P., Hutton Z.V., Shankar B. Economic evaluation of nutrition interventions: Does one size fit all? *Health Policy*, 2021, vol. 125, no. 9, pp. 1238–1246. DOI: 10.1016/j.healthpol.2021.06.009

27. Budaev B.S., Kitsul I.S., Tarmaeva I.Yu., Bogdanova O.G. The analysis of morbidity and mortality of population because of diseases of blood circulation system. *Problemy sotsial'noi gigieny, zdravookhraneniya i istorii meditsiny*, 2021, vol. 29, no. 4, pp. 865–870. DOI: 10.32687/0869-866X-2021-29-4-865-870 (in Russian).

28. Bogdanova O.G., Molchanova O.A., Pankov V.A. Assessment of nutrition and risks of development of the main general pathological syndromes in workers at industrial enterprises. *Meditsina truda i promyshlennaya ekologiya*, 2023, vol. 63, no. 1, pp. 53–60. DOI: 10.31089/1026-9428-2023-63-1-53-60 (in Russian).

29. Pogozheva A.V., Sorokina E.Yu., Baturin A.K., Peskova E.V., Makurina O.N., Levin L.G., Soto S.Kh., Aristarkhova T.V. [et al.]. The role of the Consultative and Diagnostic Centre «Healthy Nutrition» in the diagnosis and nutritional prevention of non-communicable diseases. *Voprosy pitaniya*, 2014, vol. 83, no. 6, pp. 52–57. DOI: 10.24411/0042-8833-2014-00061 (in Russian).

30. World Health Organization. The health and well-being of men in the WHO European Region: better health through a gender approach. *WHO*, 2018. Available at: https://www.who.int/europe/publications/i/item/9789289053532 (May 29, 2024).

31. Bogdanova O.G. Socio-economic damage caused by nutritionally-dependent diseases of the population. *Gigiena i sanitariya*, 2023, vol. 102, no. 12, pp. 1354–1360. DOI: 10.47470/0016-9900-2023-102-12-1354-1360 (in Russian).

Efimova N.V., Bogdanova O.G. Assessment of health risk and socio-economic losses associated with nutrition-related non-communicable diseases. Health Risk Analysis, 2024, no. 2, pp. 74–84. DOI: 10.21668/health.risk/2024.2.07.eng

Received: 15.12.2023
Approved: 03.06.2024
Accepted for publication: 20.06.2024