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Obesity trends in Russia. The impact on health and healthcare costs

Ketevan Rtveladze[1*], Tim Marsh[1], Laura Webber[1], Fanny Kilpi[2], Yevgeniy Goryakin[3], Anna Kontsevaya[4], Antonina Starodubova[5], Klim McPherson[6], Martin Brown[1]

[1]Modelling Department, Micro Health Simulations, London, UK; [*]Corresponding Author: ketevan.rtveladze@heartforum.org.uk
[2]Department of Social Research, Population Research Unit, University of Helsinki, Helsinki, Finland
[3]The London School of Hygiene and Tropical Medicine, London, UK
[4]Department of Primary Prevention in Primary Care, National Research Center for Preventive Medicine, Moscow, Russia
[5]Department of Internal Disease No. 2, Therapeutic Faculty, Russian State Medical University (RSMU), Moscow, Russia
[6]New College, University of Oxford, Oxford, UK

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ABSTRACT

Similar to most developed countries, obesity rates in Russia have been steadily increasing. This has led to a high burden of obesity related diseases and associated healthcare costs. The micro-simulation model has been utilized to project body mass index (BMI) and BMI related disease burden and healthcare costs. Incidence, mortality, survival and healthcare costs were collected for thirteen diseases. The results have been simulated for 3 hypothetical scenarios to project a potential impact of policy interventions: 1) assuming no reduction in BMI; 2) 1% reduction in mean BMI across the population; 3) 5% reduction in mean BMI across the population. Nearly 58% of the female population was obese (BMI ≥ 30 kg/m²) or overweight (BMI 25 - 29.9 kg/m²) in 2010, and the prevalence is projected to decrease to 54% in 2050. The rates are predicted to increase for men from 51% in 2010 to 76% in 2050. The prevalence rates will triple for some obesity-related diseases. A one percent decrease in BMI across the population will save more than two billion US Dollars in 2030 and 2050. Despite female obesity prevalence starting at a higher point than the men, obesity is predicted to increase in males but not females. Disease and economic burden attributed to these obesity rates are still severe and the country should implement strong policies to tackle the obesity epidemic.

Keywords: Obesity; Trends; Russia; Health; Healthcare; Costs

1. INTRODUCTION

Since the collapse of the Soviet Union and emergence of the Russian Federation in 1991, the country has faced a significant number of public health challenges both as a consequence of the transition from a state funded health system to a predominantly privately supported system, and through the rise in risk behaviours and conditions such as obesity, smoking and alcohol consumption [1]. Studying the health of the Russian population is compounded by a number of factors. For instance men have very low life expectancy for a country of its wealth [2,3]. Similar to most developed countries the obesity rates in Russia have been on a steady increase. In 2004 overweight persons were more likely to become obese compared with the probability in 1995 [4]. This rise has led to a rise in the prevalence of diseases commonly associated with obesity. In 2000 the World Health Organisation (WHO) has listed Russia among the top 10 countries with the highest numbers of estimated cases of diabetes [5]. Ischemic heart disease is a leading cause of mortality in Russia [1]. Coronary heart disease (CHD) rate is double that found in many European countries [6]. Although these high rates are certainly in part a consequence of high rates of smoking and alcohol [7-11]. Obesity is also certainly implicated in the rise in rates of these diseases [12-15].

Ageing and sedentary lifestyle have certainly contributed to the growth of obesity, but dietary change and an economic transition could be the main causes for obesity growth in the Russian Federation. Russia is one of the most geographically diverse countries in the world (spanning nine time zones [16]) where the food consumption patterns vary much within regions. Severe climate could explain low fruit and vegetable consumption and reliance on meat and high protein and fat [12-14].

However for many, it is argued that, fruit and vegetables are easily accessible for a reasonable price and the main reason is the change in the traditional dietary pattern to a more westernised diet.

The dietary factors are considered to be the one of the main reasons for arterial hypertension [1,17]. In the former Soviet Union, diets were rich in meat, fish and dairy products [1], often higher than the recommended dose [18]. As a consequence of "price shocks" following the dissolution of the soviet Union, couple with enhanced unemployment and poverty, people tended to buy cheaper products and consumption of potatoes increased considerably. As a result, obesity rates have increased since 1994 [13,14] affecting more females than males [13,19]. The average individual BMI in 2004 was 1.2 units higher than in 1994 (27.4 vs 26.2) [13].

Despite the current disadvantageous health profile, an improvement in cardiovascular disease (CVD) mortality was observed in Russia [20]. The CVD rates reduced significantly in 1986 due to a new alcohol policy and more recently, due to economic improvements in 1998 [10,11,19]. Since 2005, a clear decreasing trend in CVD mortality has been observed [21], although CHD mortality rates still remaining high [6] this may be linked to obesity growth. Stroke and myocardial infarction mortality among men is increasingly associated with metabolic syndrome [22]. The role of nutrition was also connected to some cancers [19].

This is the first paper examining the consequences of body weight on Russia and the objective is to examine the impact of BMI change on the health profile of the country; its consequences on multiple diseases as well as potential healthcare costs. The authors also examine the effect of achievable obesity decreases on disease and economic burden which in turn can be used for policy planning and intervention.

2. METHODS

2.1. Disease Data Collection and Calculations

Multiple online resources have been searched both in English and Russian languages. In order to project the obesity trends in Russia, BMI data was taken from the best available, nationally representative data RLMS-HSE. The RLMS-HSE, a household-based survey series is designed to observe the consequences of reforms on the health and economic wellbeing of the Russian population [23]. The data from 1995 to 2009, in total 13 data points has been used for the purposes of this study[1]. Statistical Package for the Social Sciences (SPSS) was used to unpack the material. The data manipulation method is described in the Appendix 1. We categorised BMI data into three categories: not overweight, (≤24.9 kg/m^2, also includes underweight population), overweight (25 - 29.9 kg/m^2), and obese (≥30 kg/m^2). The BMI data is self-reported rather than measured which leads to potential anomalies which will be discussed later.

2.2. Statistical Methods

We undertook a two-part modelling process developed by Micro Health Simulations (MHS) based on the methods initially developed for the UK Foresight Tackling Obesities enquiry [24-26]. The first module implements a regression analysis based on a series of RLMS-HSE data. The second module implements a micro-simulation programme to produce longitudinal projections. In the first module we fit multivariate, categorical regression models to the cross-sectional BMI data series by sex. We included age and calendar year as covariates, and constrained the predicted proportions of population in each BMI category. We simulated five million individuals by sex and scaled up the simulated population to reflect the total population size in the population. The 95% confidence intervals for the projected prevalence were calculated from the Bayesian Posterior distribution of the regression parameters.

2.3. Micro-Simulation of Obesity and Related Disease Consequences

Within the Foresight micro-simulation framework [24-26], we created a virtual cohort of Russian individuals based on the projected BMI distributions 2010-2050. We probabilistically assigned the BMI values as a function of age, sex, and calendar year. Assuming one's BMI ranking (*i.e.* percentile) in the same-age cohort remains constant overtime, we longitudinally simulated the BMI trajectories of a large number of individuals as they age. Size and age distributions are based on published projections from the United Nation Population database [27] and every year, each simulated individual in the model had a probability of getting a specific disease if he or she was free of the disease at the beginning of the year. This risk is predetermined by age, sex, and BMI. For individuals with a disease, possible outcomes are recovery, continuation of the disease, or death from a particular disease or unspecified cause. The progress of any disease was determined by the appropriate survival and case-fatality statistics. A review of the epidemiological literature was undertaken to determine the country-specific incidence, case fatality rates, and approximate annual treatment costs for the following obesity-related diseases: type two diabetes, coronary heart disease, stroke, knee

[1]There are two phases of data collection in the RLMS-HSE involving 18 rounds. The phase I and Round V from phase II were not utilized for this project due to sampling differences within phase I and phase II.

osteoarthritis and obesity-related cancers[2] by age and sex. Relative risk of disease is taken from a systematic review of the epidemiological literature [28].

For the micro-simulation, incidence, mortality and disease survival data were collected where appropriate (Appendices 4-5). Obtaining reliable data for cancer survival was a particular challenge. We were able to obtain survival for only three cancers[3]; for other cancers the UK survival rate has been used assuming that it would be the same in Russia. The rectal cancer figure has been applied to the colorectal cancer. As we do not model colon and rectal cancers separately, and the mortality and incidence of these two conditions have been simply added. Because of the low prevalence of these cancers employment of this method should not unduly bias the results.

In the micro-simulation we usually use the disease incidence rather than prevalence rate to produce the outputs. For some diseases we were only able to obtain prevalence figures. We used prevalence to calculate the incidence for the diabetes and hypertension in this case. For a person aged a_k with gender s in year k we identify the following probabilities: $p_0(k)$ denotes the probability of being alive without disease d in year k, $p_1(k)$ denotes the probability of being alive with disease d in year k and $p_2(k)$ denotes the probability of being dead in year k, $p_{\Omega k}$ denotes the probability of dying from disease d in year k (gender s, age a_k) and $p_{\omega k}$ denotes the probability of dying from a cause other than disease d in year k (gender s, age a_k).

The probabilities of being alive with or without the disease (states 0 and 1) and being dead (state 2) are given by the recursive matrix equation:

$$\begin{bmatrix} p_0(k+1) \\ p_1(k+1) \\ p_2(k+1) \end{bmatrix} = \begin{bmatrix} (1-p_{\omega k})(1-p_{ik}) & 0 & 0 \\ (1-p_{\omega k})\,p_{ik} & \left(1-p_{\omega k}(1-p_{\Omega k})-p_{\Omega k}(1-p_{\omega k})\right) & 0 \\ p_{\omega k} & p_{\omega k}(1-p_{\Omega k})+p_{\Omega k}(1-p_{\omega k}) & 1 \end{bmatrix} \begin{bmatrix} p_0(k) \\ p_1(k) \\ p_2(k) \end{bmatrix}$$

Every column in this equation separately sums to unity. We suppose that we know the death statistics $p_{\Omega k}$ and $p_{\omega k}$. If the incidence statistics are known the equation allows the calculation of prevalence $p_1(k)$. And, with a little rearrangement, if the prevalence is known the equation allows calculation of the incidence. A slightly more complex version of this equation will allow for the inclusion of remission statistics—when these are known (remission statistics allow for the transition from state 1 to state 0). Like most life table statistical calculations it is assumed that the input statistics valid in some year Y are valid for all years k of the lifespan of the implicit pseudo cohort.

Though CVD is considered as one of the major causes of mortality in Russia, incidence data was difficult to obtain. Our program incorporates only data by sex and age. For many conditions only absolute incidence numbers were available. We believe that our CHD figures are underestimated as the mortality rates we have extrapolated from the charts are twice as low as from the WHO and include only acute ischemic heart disease (IHD). For stroke data we have used the paper with the detailed data from the 1980s [29] and applied the ratios to the absolute figure for 2006 [30]. The WHO figures have been used for the stroke mortality data. Only 30 days of case fatality was available for stroke, therefore, we have used it as one year survival. The knee osteoarthritis (OA) figures were not available by age or sex (data from 2008). In order to calculate the incidence ratios among men and women (by age groups), ratios from the UK have been used[4] [31]. As the Russian data was an absolute osteoarthritis incidence rate (not just the knee), the ratio for OA was applied to that number, then men-women ratio was calculated and at last, the incidence rates within the age groups was estimated.

2.4. Disease Costs

There is scarce literature available for the costs of health care in the Russian Federation. We were able to obtain total health care cost of diabetes and CVD. Despite extensive literature searches no reliable cancer costs could be obtained. For a more precise calculation of cancer and knee osteoarthritis costs the following method was been used: CHD cost was taken as a constant and reliable number. The ratios of the US health care costs [32] were applied to calculate costs for OA, breast cancer, kidney cancer, oesophageal cancer, endometrial cancer, gallbladder cancer, liver cancer and pancreatic cancer. These aggregated values were then divided by the total number of patients at baseline to estimate annual medical cost per case. As the costs were not all the same year, they were brought up to the same year for consistency. That is, diabetes cost was inflated for 2009[5] and applied to the model. We probabilistically assigned diseases and

[2]Breast cancer, kidney cancer, colorectal cancer, oesophageal cancer, endometrial cancer, gallbladder cancer, liver cancer and pancreatic cancer.

[3]Breast cancer, colorectal cancer and oesophageal cancer.

[4]Similar calculation method was carried out with the cost.

[5]The figure has been calculated using http://inflationinrussia.com/inflation_calculators.aspx

associated costs in all subsequent years as a function of the individual BMI trajectories using a Monte-Carlo simulation method [33]. Costs are presented in millions of US Dollars. Initially, the costs were projected in Russian Rubles and then converted to US Dollars[6]. The cost input data is presented in Appendix 3.

3. RESULTS

3.1. The BMI Distribution

After creating the population profile for the Russian Federation, the BMI database has been utilized within the program. **Tables 1** and **2** represent the BMI distribution among the male and female population of Russia. In **Table 2**, the age groups were aggregated and as seen, the prevalence of BMI $\geq$ 25 kg/m^2 among females is decreasing steadily. The opposite picture is observed among males. Our calculations show that 75% of men will be obese or overweight by 2050. Whether this really will be the case is difficult to predict as there will be a number of confounding factors, but clearly the trend represents a significant growth. Detailed five year age group projections have shown that obesity among all male adults goes up; the overweight and obesity rates increase within all age groups. Distribution of normal weight among women aged 20 - 49 is increasing, and as a consequence, overweight and obesity percentage goes down. Another exception is the group of women aged 60 - 69, where we see improvement of the BMI distribution. Overweight and obese women aged 50 - 59 and 70 - 79 outnumber the normal weight females (**Tables 1** and **2**).

3.2. The Micro-Simulation

Projecting BMI distribution was the first part of the project. After applying the distribution trend to the population, we have extrapolated 13 BMI related diseases. Prevalence of each disease was projected until 2050 assuming there would be no change in the BMI distribution. In **Table 3** eight cancers have been grouped as well as CHD and stroke. The prevalence numbers nearly double for all conditions. For example, hypertension was projected to be 18,833 cases per 100,000 reaching 36,438 only in 2050. The numbers triple for type two diabetes (from 1345 to 3301), knee osteoarthritis as well as for cancers, CHD and stroke. Please note that all the numbers represent untreated cases. See **Table 3**.

A slight change in the BMI distribution could have an effect on disease burden. The BMI distribution reported in this paper was simulated for three scenarios; scenario zero—unrestricted BMI growth as predicted; scenario one: one percent BMI reduction in 2010 relative to scenario zero and scenario 2: 5 percent BMI reduction in 2010 relative to scenario zero. We believe that a one percent decrease is achievable with the correct public health interventions. The modelling process highlights the very large impact that a just a small change in BMI can have upon obesity and disease rates. A five percent decrease is more difficult but certainly achievable provided enough interventions are implemented. Each simulation consisted of five million Monte-Carlo trials. Five million interactions were used to obtain more robust simulations and eliminate uncertainties. See **Table 4**.

The disease healthcare costs were also projected for cancer, CHD and stroke costs along with all 13 diseases for three scenarios (**Table 5**). Cancer costs will increase from $801 million to $1.3 billion in 2030 and to $2.1 billion in 2050, CHD and stroke costs will increase between $6.5 to $17.4 billion in 2050. For all modelled diseases costs are projected to increase to $48 billion in 2050 from $20 in 2010. Changes in obesity rates could save billions of US Dollars. One percent decrease in BMI will save $2.3 billion in 2050 and a 5 percent reduction in BMI will reduce the health care cost by $5.3 billion. Our modelling method does not consider applying discount rates; therefore, it has not been applied to these figures. For the presentation purposes the cost of the hypertension, knee osteoarthritis and type two diabetes have been aggregated and presented in the **Table 5**.

4. DISCUSSION

The results from this study show that despite female obesity rates starting at a higher point than the rates among men, obesity prevalence is predicted to increase among the male population of Russia, and not among females. It is difficult to explain the BMI distribution differences among various age groups among women. The decreasing patterns of obesity can be explained by possible underreporting from the female population. There is social desirability amongst women to be slimmer than men and overweight and obese women are more likely to underreport their weight than men [34]. Some of the studies found that older women are more likely to underreport body weight than younger females [35,36], but some found no link between age and underreporting [37,38]. Monteiro and colleagues argue that improving living standards in middle income countries have a different effect on BMI of men and women: clearly negative for women, and mixed to positive for men. Projected trends may be explained by this theory since the living standards in Russia have been improving for some time [39].

We have analysed the demographic changes according to United Nations (UN) population data [27]. Since the

[6]One Russian Ruble = 0.0341336 USD; Converted on March 1, 2012. www.xe.com.

Table 1. Projected distribution of BMI by age group and BMI group.

		2010			2020			2030			2040			2050		
		BMI %														
Male	**Age**	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30
	20 - 24	72	23	4	66	28	6	58	34	8	50	39	11	41	44	14
	25 - 29	57	33	10	47	38	14	37	43	20	28	46	26	20	47	32
	30 - 34	49	36	14	40	38	22	31	38	31	23	37	40	17	36	48
	35 - 39	44	40	16	36	43	21	28	46	26	21	47	32	16	47	37
	40 - 44	45	35	19	39	34	27	33	32	35	27	30	43	22	27	51
	45 - 49	42	38	20	38	37	25	34	35	31	30	33	37	26	31	43
	50 - 54	38	43	19	31	47	23	24	50	26	19	52	29	14	54	32
	55 - 59	39	42	19	33	46	21	27	50	26	22	53	25	17	55	27
	60 - 64	41	40	19	37	44	19	34	47	19	30	50	20	27	53	20
	65 - 69	37	40	23	33	39	28	29	37	34	25	36	39	22	34	44
	70 - 74	37	38	25	31	32	37	25	26	49	20	21	59	17	17	66
	75+	46	42	12	43	47	10	39	52	9	36	57	7	33	61	6
		BMI %														
Female	**Age**	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30	≤24.9	25 - 29.9	≥30
	20 - 24	83	13	4	86	10	3	89	8	3	92	6	2	97	5	1
	25 - 29	70	20	9	72	20	8	74	19	7	75	19	6	77	18	5
	30 - 34	60	25	15	62	23	15	64	21	15	66	20	14	68	18	14
	35 - 39	53	28	19	59	24	17	64	21	15	69	18	13	73	16	11
	40 - 44	41	32	26	46	29	24	52	26	22	56	23	20	61	21	18
	45 - 49	31	36	33	34	34	31	38	33	29	42	31	27	46	29	25
	50 - 54	20	37	43	17	39	45	14	41	46	11	42	47	9	43	47
	55 - 59	19	37	44	18	40	42	17	43	40	16	45	39	15	48	37
	60 - 64	21	38	41	22	40	37	24	42	34	25	44	30	27	46	27
	65 - 69	21	36	43	21	35	43	22	35	44	22	34	44	23	34	44
	70 - 74	22	35	42	22	33	45	22	31	47	21	29	49	21	28	52
	75+	31	33	36	27	30	43	23	27	50	20	24	56	17	22	62

Table 2. Projected prevalence of BMI among adults.

Prevalence of BMI < 25 kg/m^2 among adults					
Year	**2010**	**2020**	**2030**	**2040**	**2050**
Male	49%	41%	36%	29%	24%
Female	42%	43%	44%	45%	46%
Prevalence of BMI ≥ 25 kg/m^2 among adults					
Year	**2010**	**2020**	**2030**	**2040**	**2050**
Male	51%	59%	64%	71%	76%
Female	58%	57%	56%	55%	54%

dissolution of the Soviet Union in 1991 low birth rates and abnormally high death rates caused the Russian population to decline [1]. As a consequence there are an unusually small number of young people in Russia which will have a significant impact upon the future burden of diseases and subsequently, the health system as these young people enter middle age. Recent evidence suggests that in 2009 the Russian population began to grow for the first time in fifteen years [40]. The effects of the low life expectancy amongst men are also evident from the pyramid with a sharp decrease between the 50 - 59 and 60 - 69 groups (Appendix 2).

During the incidence data collection authors encountered a number of problems with the databases. We

Table 3. Projection of disease prevalence based on current trend. Numbers in square brackets indicate confidence intervals. Eight cancers have been grouped under the title: All Cancers.

Prevalence cases in year (per 100000)						
Scenario 0						
	Year	**All Cancers**	**CHD & Stroke**	**Knee Osteoarthritis**	**Diabetes**	**Hypertension**
	2010	695 [±8]	4455 [±19]	336 [±5]	1345 [±11]	18833 [±39]
	2020	910 [±10]	5845 [±24]	368 [±6]	1674 [±13]	22107 [±47]
	2030	1119 [±12]	7477 [±31]	470 [±8]	2222 [±17]	27006 [±58]
	2040	1421 [±15]	9656 [±40]	596 [±10]	2727 [±21]	31044 [±72]
	2050	1841 [±21]	12723 [±55]	792 [±14]	3301 [±28]	36438 [±93]
Scenario 1						
	Year	**All Cancers**	**CHD & Stroke**	**Knee Osteoarthritis**	**Diabetes**	**Hypertension**
	2010	693 [±8]	4435 [±19]	337 [±5]	1328 [±10]	18738 [±39]
	2020	895 [±9]	5780 [±24]	368 [±6]	1602 [±13]	21813 [±47]
	2030	1103 [±12]	7365 [±30]	463 [±8]	2062 [±16]	26468 [±57]
	2040	1392 [±15]	9432 [±40]	579 [±10]	2506 [±20]	30324 [±71]
	2050	1802 [±21]	12447 [±54]	770 [±13]	3051 [±27]	35624 [±92]
Scenario 2						
	Year	**All Cancers**	**CHD & Stroke**	**Knee Osteoarthritis**	**Diabetes**	**Hypertension**
	2010	682 [±8]	4362 [±19]	331 [±5]	1289 [±10]	18615 [±39]
	2020	868 [±9]	5614 [±24]	347 [±6]	1446 [±12]	21226 [±46]
	2030	1062 [±11]	7093 [±30]	438 [±7]	1781 [±15]	25420 [±56]
	2040	1349 [±15]	9036 [±39]	558 [±10]	2107 [±19]	28920 [±69]
	2050	1732 [±20]	11894 [±53]	746 [±13]	2493 [±24]	33824 [±89]

Table 4. Projection of BMI-related cumulative incidence cases avoided among all adults (relative to scenario 0). Numbers in square brackets indicate confidence intervals.

Cumulative incidence cases avoided from year 2010 (per 100000 of population in 2010)						
Scenario 1						
	Year	**All Cancers**	**CHD & Stroke**	**Knee Osteoarthritis**	**Diabetes**	**Hypertension**
	2010	4 [±5]	11 [±12]	−1 [±2]	4 [±3]	18 [±11]
	2020	20 [±17]	141 [±41]	1 [±7]	73 [±11]	276 [±38]
	2030	49 [±26]	357 [±64]	9 [±11]	193 [±18]	683 [±59]
	2040	121 [±36]	892 [±88]	25 [±15]	357 [±24]	1287 [±80]
	2050	284 [±49]	1848 [±120]	54 [±21]	608 [±32]	2281 [±106]
Scenario 2						
	Year	**All Cancers**	**CHD & Stroke**	**Knee Osteoarthritis**	**Diabetes**	**Hypertension**
	2010	7 [±5]	42 [±12]	2 [±2]	17 [±3]	77 [±10]
	2020	87 [±17]	506 [±41]	22 [±7]	226 [±11]	942 [±37]
	2030	214 [±25]	1268 [±63]	57 [±11]	539 [±17]	2276 [±58]
	2040	442 [±35]	2681 [±88]	109 [±15]	991 [±23]	4114 [±78]
	2050	879 [±48]	5318 [±119]	201 [±21]	1769 [±31]	7200 [±104]

Table 5. Estimated disease healthcare costs under 3 scenarios (USD).

	Scenario 0					Scenario 1					Scenario 2				
Year	All 8 Cancers	CHD & Stroke	All 13 Diseases	Males (13 diseases)	Females (13 diseases)	All 8 Cancers	CHD & Stroke	All 13 Diseases	Males (13 diseases)	Females (13 diseases)	All 8 Cancers	CHD & Stroke	All 13 Diseases	Males (13 diseases)	Females (13 diseases)
2010	**801**	**6522**	**19635**	**7770**	**11865**	**794**	**6423**	**19484**	**7746**	**11738**	**797**	**6536**	**19447**	**7828**	**11619**
2011	839	6809	20122	8043	12079	834	6772	20016	8028	11988	830	6653	19652	7971	11681
2012	867	7136	20648	8311	12337	860	7061	20476	8236	12240	849	6803	19876	8100	11776
2013	894	7377	21064	8566	12498	884	7281	20853	8456	12397	877	6940	20096	8215	11881
2014	913	7586	21462	8770	12692	906	7249	20988	8503	12486	897	7201	20457	8374	12082
2015	941	7664	21758	8985	12772	930	7534	21480	8830	12650	924	7336	20719	8543	12176
2016	971	7759	22089	9204	12886	956	7483	21632	8912	12719	946	7356	20864	8661	12203
2017	993	7833	22475	9398	13077	973	7622	22014	9119	12895	962	7566	21246	8877	12370
2018	1015	8027	22985	9659	13326	996	7838	22524	9382	13142	982	7826	21712	9221	12491
2019	1043	8213	23518	9910	13608	1020	8005	23006	9654	13353	1013	8145	22273	9549	12724
2020	**1064**	**8282**	**23953**	**10102**	**13851**	**1038**	**8115**	**23428**	**9870**	**13558**	**1034**	**8227**	**22595**	**9655**	**12940**
2021	1087	8816	24825	10661	14163	1064	8416	24040	10227	13814	1055	8517	23135	9971	13164
2022	1117	9002	25408	11000	14408	1092	8662	24652	10579	14073	1079	8541	23443	10102	13340
2023	1135	9019	25851	11138	14713	1113	8786	25180	10789	14391	1106	8741	23993	10464	13528
2024	1159	9140	26427	11471	14956	1135	8924	25704	11052	14653	1130	9023	24573	10772	13801
2025	1189	9539	27274	11956	15318	1166	9256	26433	11521	14912	1159	9202	25111	11064	14047
2026	1216	9732	27931	12259	15673	1198	9354	26955	11637	15318	1183	9411	25663	11344	14319
2027	1243	10096	28788	12703	16085	1221	9695	27772	12092	15680	1211	9778	26398	11659	14739
2028	1267	10346	29538	13055	16482	1242	10014	28501	12494	16007	1230	10017	27013	12076	14936
2029	1291	10426	30128	13361	16767	1271	10123	29037	12724	16313	1256	10287	27649	12356	15293
2030	**1313**	**10712**	**30938**	**13742**	**17196**	**1289**	**10437**	**29799**	**13173**	**16626**	**1273**	**10277**	**28016**	**12496**	**15520**
2031	1339	11124	31826	14192	17634	1317	10657	30423	13409	17014	1303	10589	28660	12761	15899
2032	1373	11438	32647	14600	18047	1343	11105	31320	13891	17429	1326	10896	29360	13045	16315
2033	1405	11769	33469	15076	18393	1383	11556	32210	14393	17817	1364	11141	29975	13379	16596
2034	1440	11799	34002	15092	18910	1421	11523	32599	14462	18137	1398	11181	30399	13560	16839
2035	1480	12204	34899	15627	19272	1461	11689	33206	14698	18509	1428	11455	31065	13971	17094
2036	1515	12418	35569	16012	19556	1487	12058	33976	15155	18821	1474	12004	31955	14422	17533
2037	1554	12743	36284	16277	20008	1529	12254	34563	15444	19119	1514	12197	32507	14535	17972
2038	1595	13029	37003	16848	20155	1562	12821	35537	16085	19452	1545	12723	33372	15188	18184
2039	1637	13262	37657	17181	20476	1606	12918	36051	16333	19719	1581	12889	33932	15481	18451
2040	**1678**	**13740**	**38648**	**17606**	**21042**	**1642**	**13256**	**36855**	**16698**	**20157**	**1631**	**12891**	**34356**	**15502**	**18855**
2041	1737	14394	39825	18357	21468	1690	13687	37771	17189	20582	1680	13253	35121	15775	19346
2042	1778	14563	40506	18689	21816	1728	13923	38493	17598	20895	1729	13727	35994	16293	19701
2043	1831	14801	41262	18973	22290	1775	14108	39171	17811	21360	1778	14069	36759	16767	19992
2044	1888	15174	42184	19415	22769	1821	14346	39952	18136	21816	1831	14075	37236	16862	20374
2045	1924	15263	42823	19860	22962	1860	14709	40864	18700	22163	1866	14589	38261	17357	20905
2046	1979	16098	44281	20577	23705	1910	14999	41768	19202	22566	1909	15049	39238	17806	21432
2047	2025	16304	45203	20839	24364	1969	15397	42863	19714	23149	1945	15158	39916	18123	21793
2048	2081	16794	46383	21442	24941	2030	16122	44267	20536	23731	1996	15803	41178	18809	22369
2049	2126	17146	47494	21898	25597	2073	16201	45039	20791	24248	2040	16202	42176	19210	22966
2050	**2180**	**17423**	**48417**	**22502**	**25915**	**2127**	**16632**	**46118**	**21334**	**24784**	**2096**	**16584**	**43120**	**19769**	**23351**
Total	**56921**	**461519**	**1307195**	**581124**	**726071**	**55715**	**445009**	**1257019**	**554601**	**702418**	**55230**	**440858**	**1188511**	**525912**	**662599**

believe that cancer, stoke, hypertension, knee osteoarthritis and type two diabetes incidence/prevalence data is accurate, reliable and represents the real picture despite some calculations carried out during the study. However, CHD incidence rates were not available, and as noted before, the data has been drawn from the acute IHD rates which lead to potential underestimation of the projected rates. The rates are likely to be much higher in Russia, due alcohol consumption rather than obesity.

The micro-simulation approach presents a unique opportunity to look at the BMI trends and BMI attributed disease burden, its costs and the impact of attenuating those trends in whole or segments of the population. However, this method, like all modelling, is dependent on the quality of the data inputs. Whilst there are clearly limitations in the availability of data to us as researchers, we feel that the value of the outputs in quantifying the future impact of obesity to the Russian Federation overcomes these limitations. The analysis carried out in this research clearly demonstrates the considerable benefits of even small changes in BMI at a population level; one point reduction is certainly not over ambitious, however our simulation can be used to show benefits of particular interventions. The Organisation for Economic Co-operation and Development (OECD), however, evaluated the cost-effectiveness of various prevention programmes in Russia and concluded that some of them are effective and could save up to 95,000 lives every year. Nevertheless, the most effective interventions are more costly and they are cost-effective in the long run but not in short. In fact, food labelling or fiscal measures will make a return short after the implementation. More lives could be gained by complex prevention programmes which would cost 1.18 USD per head annually [41].

The study has several limitations due to poor quality data and data scarcity. In this study we have had to rely on self-reported BMI data rather than the more objective measured anthropometric data which is more costly to obtain. Self-report may bias the results as height and weight is often misreported (Visschler *et al.*, 2006) and unfortunately it was not possible for us to correct for this [35]. Nevertheless, until more suitable data exist these type of data must be employed for calculating and assessing health care costs by Government agencies. It can help shape the health care system and disaggregate the funds to a more vulnerable sphere. The Russian Federation might have costs for each disease however, they were limited to public access, thus we had to carry multiple calculations to estimate some cancer and knee osteoarthritis costs. Obviously, we cannot require having costs for all the diseases we model, but some cancers carry out a vast burden of health care costs, and they cannot be ignored.

Our work demonstrates the value that the availability of good health and economic data to policy makers could have in determining the future burden and benefit of policies to prevent the future incidence of avoidable chronic diseases. It is of course both possible and plausible that data exist within Governments that are not accessible to researchers. We hope that the value of this work will demonstrate the need to make all data more widely available. A further analysis of the different data sets will be a valuable contribution to the obesity research.

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ABBREVIATIONS

RLMS-HSE: Russia Longitudinal Monitoring Survey-Higher School of Economics
BMI: Body Mass Index
US: United States
WHO: World Health Organization
CHD: Coronary Heart Disease
CVD: Cardiovascular Disease
SPSS: Statistical Package for the Social Sciences
MHS: Micro Health Simulations
UK: United Kingdom
IHD: Ischemic Heart Disease
UN: United Nations
USD: United States Dollar

APPENDICES

Appendix 1. The RLMS-HSE Data Manipulation Method

Rounds 6 to 14

1) Gender variable from file "**health**" was merged into file "**anutri**" file which contained BMI data. There was a lot more data in the 'health' file than the "anutri" file (~10,000 cases to ~7000) and so we sorted both files by "site", "census", "family", "person". We then merged the gender variable matching cases based on these four ID variables.

2) This created a lot of missing data - ~3000 cases where BMI was not available but gender was. We filtered out missing data and created a new data file with complete BMI data.

3) We calculated age in years from months.

Rounds 15-18

1) Round 15-18 did not include constructed variables and so we merged height and weight variables, date of interview, date of birth, gender from "**inadlt**" into a new data file.

2) We computed a new height in metres variable from the "htself" variable in cms.

3) We created date of birth and date of interview variables from their respective separate date, month and year variables. Then calculated age by subtracting date of birth from date of interview using the date/time function in SPSS.

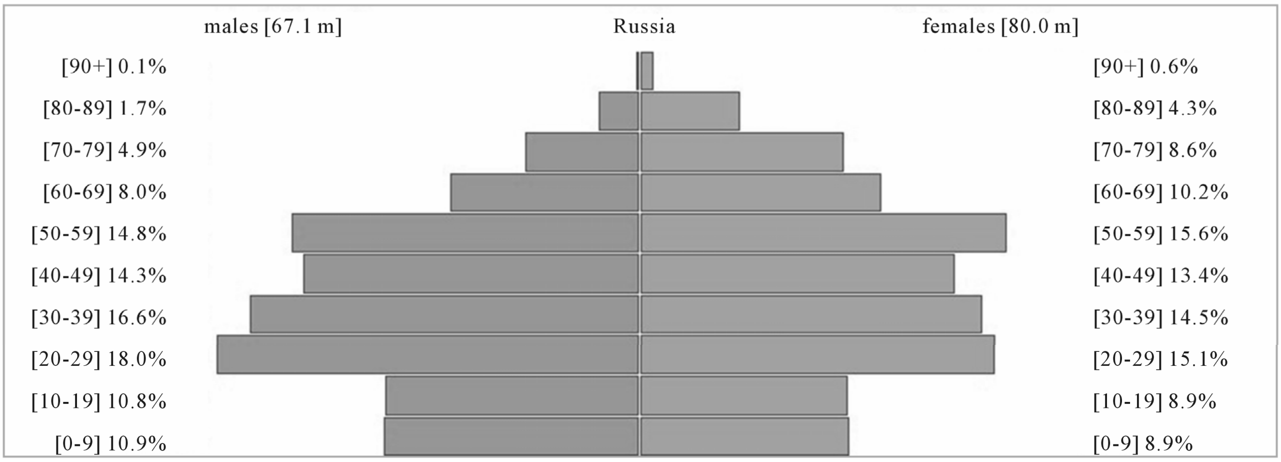
4) We calculated BMI (kg/m^2) from height and weight data and then WHO category (1 = uw, 2 = nw, 3 = ow, 4 = ob) from mean BMI data (syntax pasted below).

5) We created a "year" variable. Where years overlap e.g. round 8 (1998-1999) we have used the later year.

Syntax used to compute variables.

```
*Height in metres variable
COMPUTE Height_m = irhtself/100 .
EXECUTE .
COMPUTE Height_m = iqhtself/100 .
EXECUTE .
**BMI
COMPUTE BMI = iqwtself/(Height_m**2).
EXECUTE.
*to calc date of interview
* Date and Time Wizard: DateOfInterview.
COMPUTE DateOfInterview = DATE.DMY(iqintday, iqintmon, iqintyer).
VARIABLE LABEL DateOfInterview "Date of interview".
VARIABLE LEVEL DateOfInterview (SCALE).
FORMATS DateOfInterview (EDATE10).
VARIABLE WIDTH DateOfInterview(10).
EXECUTE.
*To calc DOB
* Date and Time Wizard: DOB.
COMPUTE DOB = DATE.DMY(iqbirthd, iqbirthm, iqbirthy).
VARIABLE LABEL DOB.
VARIABLE LEVEL DOB (SCALE).
FORMATS DOB (EDATE10).
VARIABLE WIDTH DOB(10).
EXECUTE.
*To calculate age
* Date and Time Wizard: Age.
COMPUTE Age = DATEDIF(DateOfInterview, DOB, "years").
VARIABLE LABEL Age "Age calculated from DOB and interview date".
VARIABLE LEVEL Age (SCALE).
FORMATS Age (F5.0).
VARIABLE WIDTH Age(5).
EXECUTE.
    *Change BMI in WHO BMI categories
RECODE
 BMI
(SYSMIS=Copy) (Lowest thru
18.499999999999999999 = 1) (18.5 thru
24.999999999999999 = 2) (25 thru
29.9999999999999999 = 3) (30 thru Highest = 4)
    INTO WHOcategory .
EXECUTE.
```


Appendix 2. Male and Female Population by Age in 2011 According to the UN Population Database [27]



Appendix 3. Annual Cost of Diseases Used in the Micro-Simulation

Disease	In Rubles (millions)	Cost Year	Reference
OA	1.12589E+11	2009	Calculated (US ratios)
Breast cancer	9970762505	2009	Calculated (US ratios)
CHD	1.03863E+11	2009	Kontsevaya *et al.*, 2011 (21)
Colorectal cancer	8585670853	2009	Calculated (US ratios)
Diabetes	1.7624E+11	2003	Suntsov YuI, Dedov II; Diabetes: 2, 2005, 2-5
Endometrial cancer	2181993697	2009	Calculated (US ratios)
Gallbladder cancer	758954329.6	2009	Calculated (US ratios)
Hypertension	55045140547	2009	Kontsevaya *et al.*, 2011 (21)
Kidney cancer	2181993697	2009	Calculated (US ratios)
Liver cancer	208712440.6	2009	Calculated (US ratios)
Oesophageal cancer	1081509920	2009	Calculated (US ratios)
Stroke	38550000000	2009	Kontsevaya *et al.*, 2011 (21)
Pancreatic cancer	256147086.2	2009	Calculated (US ratios)

Appendix 4. Cancer Data Sources

Cancers	Incidence	Mortality	Survival
Breast	http://www.oncology.ru/service/statistics/	http://www.oncology.ru/service/statistics/	www.mednet.ru
Kidney	http://www.oncology.ru/service/statistics/	http://www.oncology.ru/service/statistics/	-
Colorectal	http://globocan.iarc.fr/	http://globocan.iarc.fr/	www.mednet.ru
Oesophageal	http://www.oncology.ru/service/statistics/	http://www.oncology.ru/service/statistics/	www.mednet.ru
Endometrial	http://www.oncology.ru/service/statistics/	http://globocan.iarc.fr/	-
Gallbladder	http://www.oncology.ru/service/statistics/	http://globocan.iarc.fr/	-
Liver	http://www.oncology.ru/service/statistics/	http://www.oncology.ru/service/statistics/	-
Pancreas	http://www.oncology.ru/service/statistics/	http://www.oncology.ru/service/statistics/	-

Appendix 5. Disease References

CHD	Source (in an original language)	In English
Incidence	ВОЗРАСТНЫЕ АСПЕКТЫ ЗАБОЛЕВАЕМОСТИ ОСТРЫМИ ФОРМАМИ ИШЕМИЧЕСКОЙ БОЛЕЗНИ СЕРДЦАИ СМЕРТНОСТИ ОТ НИХ У МУЖЧИН И ЖЕНЩИН; С.А. Бойцов, С.С. Якушин, Н.Н. Никулина, Г.И. Фурменко, С.А. Акинина от лица исследователей Российского многоцЕнтрового эпидемиологического исследованияЗабОлеваемости, смертНости, кАчества диагНостики и лечения острых форм ИБС (РЕЗОНАНС), РФК 2010; 6(5): 639-644	Age-dependent aspects of acute coronary heart disease incidence rate and mortality in men and women; Boytsov SA, Yakushin SS, Nikulina NN, Furmenko GI, Akinina SA on behalf of researchers of RESONANCE (Russian multicenter epidemiologic study of acute coronary heart disease morbidity, mortality, diagnostic and treatment quality study, Rational Pharmacother. Card. 2010; 6(5): 639-644
Mortality	ВОЗРАСТНЫЕ АСПЕКТЫ ЗАБОЛЕВАЕМОСТИ ОСТРЫМИ ФОРМАМИ ИШЕМИЧЕСКОЙ БОЛЕЗНИ СЕРДЦАИ СМЕРТНОСТИ ОТ НИХ У МУЖЧИН И ЖЕНЩИН; С.А. Бойцов, С.С. Якушин, Н.Н. Никулина, Г.И. Фурменко, С.А. Акинина от лица исследователей Российского многоцЕнтрового эпидемиологического исследованияЗабОлеваемости, смертНости, кАчества диагНостики и лечения острых форм ИБС (РЕЗОНАНС), РФК 2010; 6(5): 639-644	Age-dependent aspects of acute coronary heart disease incidence rate and mortality in men and women; Boytsov SA, Yakushin SS, Nikulina NN, Furmenko GI, Akinina SA on behalf of researchers of RESONANCE (Russian multicenter epidemiologic study of acute coronary heart disease morbidity, mortality, diagnostic and treatment quality study, Rational Pharmacother. Card. 2010; 6(5): 639-644
Survival	Contribution of trends in survival and coronary event rates to changes in coronary heart disease mortality: 10-year results from 37 WHO MONICA Project population, Tunstall-Pedoe h, Kuulasmaa K, Mähönen M, Tolonen H, Ruokokoski E, Amouyel P, for the WHO MONICA (monitoring trends and determinants in cardiovascular disease) Project, The Lancet: 353, 1999, pp. 1547-1557	
Cost	Экономический ущерб сердечно-сосудистых заболеваний в Российской Федерации; Оганов Р.Г., Концевая А.В., Калинина А.М.Кардиоваскулярная терапия и профилактика, 2011; 4: 4-9	Economic burden of cardiovascular diseases in the Russian Federation; Kontsevaya AV, Kalinina AM, Oganov RG; Cardiovascular Therapy and Prevention, 2011; 4: 4-9
Stroke		
Incidence	Stroke Epidemiology in Novosibirsk, Russia: A Population-Based Study; Feigin Vl, Wiebers DO, Nikitin YuP, O'Fallon WM, Whisnant JP; Mayo Clinic Proc: 70, 1995, pp. 847-852 & www.mednet.ru	
Mortality	WHO, Mortality and burden of disease estimates for WHO member states	
Survival	Stroke Epidemiology in Novosibirsk, Russia: A Population-Based Study; Feigin Vl, Wiebers DO, Nikitin YuP, O'Fallon WM, Whisnant JP; Mayo Clinic Proc:70, 1995, pp. 847-852	
Cost	Экономический ущерб сердечно-сосудистых заболеваний в Российской Федерации; Оганов Р.Г., Концевая А.В., Калинина А.М.Кардиоваскулярная терапия и профилактика, 2011; 4: 4-9	Economic burden of cardiovascular diseases in the Russian Federation; Kontsevaya AV, Kalinina AM, Oganov RG; Cardiovascular Therapy and Prevention, 2011; 4: 4-9
Hypertension		
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Continued

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Osteoarthritis		
Prevalence	www.mednet.ru	
Cost	Calculated; Please see the cost calculation methods.	

