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Awareness of cardiovascular health in Russian population: comparison between self-reported and objectively measured parameters

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Draft of master’s thesis in Public Health

May 2022

Foreword

During the process of writing my master thesis, I gained great appreciation for research and for persons conducting it. Although writing process was long and demanding, it was first and foremost rewarding. I wrote about the topic which was very interesting for me, and this experience enhanced my learning process. First and foremost, I am thankful for my main supervisor Alexander V. Kudryavtsev, for taking his time to correct and understand my mistakes and answering every question I had. With him as my main supervisor, I wanted to write my thesis in best possible way, and I am thankful that he adjusted his supervision to my needs. I would also like to thank my co-supervisor Monica Hunsberger for her insights, feedback, and approach. I have learned that conducting research is time consuming, but nonetheless important as it helps us understand the world around us.

Tromsø
May 2022
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Abstract

Background

Russia has a higher cardiovascular disease (CVD) mortality rate compared to other European countries. This study aimed to investigate the awareness of hypertension, hypercholesterolemia, and diabetes mellitus among Russian adults with the objective presence of these conditions.

Material and Methods

We used cross-sectional data from a general population-based study of Russian adults aged 35-69 years, conducted in Arkhangelsk and Novosibirsk in 2015-2018 (Know Your Heart study, N=3803). Direct standardization by age and sex using Standard European Population 2013 was used to estimate the prevalence of awareness of hypercholesterolemia, hypertension, and diabetes mellitus among study participants with these CVD-related health conditions. Logistic regression models were used to investigate demographic, socio-economic, behavioural and health characteristics associated with the awareness for each of the three conditions.

Results

Age- and sex-standardized awareness prevalence among persons hypertension, hypercholesterolemia, and diabetes with was 79.3%, 44.7% and , 61.2% respectively. Older age, history of previous cardiovascular events, obesity, not being a smoker, and female sex were associated with higher odds of being aware of hypercholesterolemia and hypertension. Low household income and previous heart events were associated with higher odds of being aware of diabetes mellitus.

Conclusions

The proportions of awareness of hypertension, hypercholesterolemia, and diabetes mellitus among Russian adults with these conditions were relatively close to the same proportions estimated in populations of European countries. Therefore, we found no evidence that the higher CVD mortality in Russia, compared to CVD mortality in European countries, is explained by a lower awareness of CVD risk factors.

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Abbreviations

ATC	Anatomical therapeutic chemical code
BMI	Body mass index
BP	Blood pressure
CDC	American Centres for Disease Control and Prevention
CI	Confidence interval
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DM	Diabetes mellitus
GDM	Gestational diabetes mellitus
H2H	Heart to Heart
Hba1cl	Glycated hemoglobin
HDL	High density lipoprotein
HT	Hypertension
KYH	Know Your Heart study
LDL	Low density lipoprotein
MI	Myocardial infarction
mm/hg	Millimetres of mercury
mm/mol	Millimoles per litre

NHS	National Health service
OR	Odds ratio
ROS	Reactive oxidative spices
SBP	Systolic blood pressure
T2DM	Type 2 diabetes mellitus

Background

Cardiovascular diseases (CVDs) are a cluster of disorders of heart and blood vessels. They include ischemic heart disease, cerebrovascular disease, rheumatic fever, and other conditions. CVDs are the leading cause of death globally (1). In 2019 alone, 17.9 million people suffered from cardiovascular diseases around the globe accounting for 32% of premature deaths. One third of CVD death incidence occur prematurely in people under the age of 70 (1). Approximately 85 % of CVD deaths were attributed to heart attack and stroke (2).

Stroke is a cardiovascular event characterized by a lack of blood supply to the brain. This can be from a partial or completely restricted blood flow which results in brain damage as a result of insufficient oxygen and nutrients to brain cells. Symptoms of stroke include speech and comprehension difficulty, paralysis or numbness of face and extremities, sudden headache or blurred vision (1). In 2019 stroke was second-leading cause of death accounting for 6.5 million deaths (11.6% of total deaths worldwide (2). The most significant risk factors for stroke are being obese, physical inactivity, heavy drinking, tobacco use, high blood pressure, diabetes, unhealthy cholesterol and atrial fibrillation (1, 3).

Heart attack or myocardial infraction (MI) is defined as “myocardial cell death due to prolonged ischaemia”(4). The most prominent symptoms of such event are sensation of pressure or pain in thorax, nausea cold sweat and fatigue. Symptoms vary in each individual case in intensity, from mild to severe (5). Moreover, MI can occur suddenly or after recurrent chest pain caused by temporarily reduced blood flow into the heart muscle. This condition is also known as angina (5). MI is a major complication of ischemic heart disease (6) (5), which is leading cause of death worldwide accounted for 9.14 million deaths in 2019 (7). The most significant risk factors for heart attack are age, tobacco use obesity, physical inactivity, stress, diabetes, hypertension, unhealthy lipid levels (5, 6).

Hyperlipidaemia and Hypercholesterolemia

Hyperlipidaemia is an abnormal elevation of any or all lipid or lipoprotein levels in the blood (8). Individuals with any type of Hyperlipidaemia are approximately twice as likely of developing CVD compared to those with normal levels (9). High cholesterol levels lead to ischemic heart disease by accumulation of fatty deposits (plaques) on tunica intima (the inside wall of arteries and blood vessel). This condition is known as Atherosclerosis. Plaques can tear and rupture, break free and block the artery as they are carried downstream by blood flow. Atherosclerosis can cause life-threatening cardiovascular events such as heart attack (10, 11).

Hypercholesterolemia (High Cholesterol) is a form of Hyperlipidaemia. It is an asymptomatic cardiovascular condition defined as a presence of high low-density lipoprotein (LDL cholesterol) levels in blood system (10-12). In the United States, cholesterol is measured in milligrams per decilitre (13). In European countries, millimoles per litre (mmol/L) are used to indicate levels of cholesterol (13). Cholesterol tests include results for four types of blood fats including total cholesterol, LDL, high-density lipoprotein cholesterol (HDL), and triglycerides (13).

Total cholesterol refers to overall cholesterol content in blood system (13). High values of LDL-cholesterol are associated with atherosclerosis. On the other hand, HDL inhibits adverse effect of LDL by carrying it to liver which removes it from body (13, 14). Guidelines for benchmark of high total cholesterol differ. While United Kingdom National Health service (NHS) defines healthy total cholesterol levels as 5 mmol/L or lower (15), American Centres for Disease Control and Prevention (CDC) considers total cholesterol Below 5.18 mmol/L as desirable (16). Threshold for unhealthy LDL values also vary across the countries. CDC considers 2.6 mmo/L for LDL as borderline high (16), whereas NHS set healthy limit of LDL at 3 mmol/L (15). Despite of the different diagnostic threshold across the countries, in 2019, 4.40 million deaths were attributed to high LDL-cholesterol level globally (17). High LDL cholesterol levels are associated with MI. For example, hazard ratio of myocardial infarction in age group 70-79 years was 1.82 for LDL >5·0 mmol/L compared to LDL > 3·0 mmol/L (18).

Hypertension

Hypertension is a cardiovascular condition which is defined as a chronic elevation of systemic arterial pressure above a certain threshold value (19). If, untreated, congestive heart failure, cerebral haemorrhage and renal failure are most prominent complications. Among treated hypertensives, major complications are myocardial infraction and thrombotic stroke (20). Age standardized prevalence of hypertension worldwide in adults aged 30-79 years in 2019 was 32% and 34% among men and women respectively (21).

Blood pressure is measured in millimetres of mercury (mm Hg), and the results are shown in two numbers. Top (or first) number indicates systolic whereas bottom (or second) number indicates diastolic blood pressure. While systolic blood pressure indicates the pressure of blood flow when heart muscle contracts, diastolic blood pressure measures arterial pressure in between the heart beats (22). Seventh report of the Joint National Committee Detection, Evaluation, and Treatment of High Blood Pressure defines "prehypertension" as a Blood pressure of 120/80 mm Hg to 139/89 mm Hg (23). Next stage, Hypertension (HT) is defined by WHO, multiple public health national websites and scientific literature as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg (19, 24-31).

There are several pathways from HT to heart failure or death. Most frequent pathway from HT to MI is that HT induces left ventricular hypertrophy (left ventricular wall thickening) which develops as a response to excessive stress. Subsequently, left ventricular dilates, ejection fraction becomes low and heart failure occurs. Transition from left ventricular hypertrophy to dilated left ventricular is commonly accompanied by MI (32). Also, survival rate after cardiovascular event decreases with HT. For example, results from study in Norway suggest that after the first myocardial infarction, the 28-day case fatality rate is 24.5% and 35.6% for non-hypertensive and hypertensive men respectively. Risk gradient is lower although still significant between normotensive women (22.6%) compared to hypertensive women (28.2%) (33).

HT also leads to stroke by numerous pathways. For example, high blood pressure induces damage to endothelium (thin membrane inside the blood vessels), which alters function of intracerebral arteries. Altered endothelium and blood cell interaction leads to formation of thrombus (blood clot). HT also contributes to arteriosclerosis development, increases the probability of cerebral lesions, which are linked to stenosis and embolism originating from larger vessels or arteries (34). Cohort study in Japan analysed lifetime risk of stroke among men. Findings suggest that lifetime risk of stroke at the age of 45 was 17.21% and 32.79% for normotensive and hypertensive men respectively (35).

Diabetes Mellitus

Diabetes mellitus (DM) is a chronic metabolic disease defined by elevated blood sugar (Blood glucose) levels (36). The amount of glucose in blood is controlled by hormone insulin produced in Beta cells in pancreas gland (37). DM has three forms. Type 1 Diabetes mellitus is the consequence of autoimmune reaction which restricts Beta cells of the pancreas from synthesizing insulin (38). Type 1 DM cannot be prevented, it is typically diagnosed relatively early in life and accounts for 5%-10% of all cases of DM (39). Type 2 diabetes mellitus (T2DM), the most prevalent form of diabetes and accounts for 90-95% of all DM cases. T2DM is a result of insufficient production of insulin or build up insulin resistance (36). Gestational diabetes mellitus (GDM) is temporary form of DM which develops during pregnancy and subsides with the delivery of the child. However, women who develop GDM during pregnancies are at exceptionally higher risk of development of T2DM later in their life (40). Maternal GDM also increases the likelihood of obesity and occurrence of T2DM diabetes among offspring (39). In all cases, the most prominent symptoms of DM are polyuria, polydipsia, polyphagia, blurred vision, and fatigue. Diagnosis of DM involves Glycated hemoglobin (Hba1c) measurements, indicating the amount of sugar bonded with hemoglobin in blood (41). According to consistent agreement in multiple national healthcare websites (42-44), diagnostic cut-off for DM is HbA1c ≥ 6.5%.

Prevalence of diabetes in 2019 was 463 million cases worldwide which accounts for 9.3% of global population (45). Diabetes impacts cardiovascular health, such that, metabolic changes along with insulin resistance accelerate onset of atherosclerosis (46). Moreover, people with diabetes may develop diabetic cardiomyopathy, heart-muscle specific disease which increases risk of heart failure and death independent of vascular pathology (47). DM is thought to be a major cause of heart attack, stroke and lower limb amputation (39). Pathways from diabetes to serious CVD outcomes are well described even on molecular level. Excess of Hba1cl inflicts damage to cells through oxidative stress. Oxidative Stress is induced by means of reactive oxidative spices (ROS), molecules which have unpaired electrons in their orbit. This orbital feature enables ROS to produce chemical reaction often generated by dioxygen (48). Cellular disfunction or cellular death is likely to occur after cell is exposed to certain kind of ROS.

ROS are also associated with DNA breakage and increased levels of specific inflammatory markers (48). High Hba1cl levels therefore mediate pathway to MI by forming ROS, accelerating atherosclerosis, producing inflammation and inducing death of heart cells (48). Results from cohort study in Danish population suggest that incidence rate ratio for MI was 1.7 with diabetes compared to non-diabetics (49).
Stroke mortality was significantly associated with diabetes among men (Risk Ratio=1.8) and women (Risk ratio 2.2) after adjustment on comorbidities, age and heart events (50). Moreover, diabetic patients were 1.9 times likely to have early stroke progression compared to non-diabetic patients after hospital admission for acute stroke (51).

Cardiovascular disease continuum

The CVD continuum is a gradual progression of cardiovascular events starting with cardiovascular risk factors such as HT, hyperlipidaemia, and DM. If these factors are ignored or not treated early, they evolve into atherosclerosis, ischemic heart disease, or diastolic or systolic dysfunction and eventually progressing into heart failure and death (52). Instead of focusing on end-stages of cardiovascular continuum, intervention should be directed towards early diagnosis or preventative measures delaying the onset of hypercholesterolemia, DM, or HT. As cardiovascular conditions such as HT hypercholesterolemia and DM are usually asymptomatic or mild (11, 53), individual´s awareness of these conditions might not be present. If individuals with DM, HT or hypercholesterolemia are not aware of their cardiovascular health status, they are likely to proceed to later stages in cardiovascular continuum where treatment is more invasive and mortality more prevalent.

Awareness and agreement of CVD risk factors

Awareness of CVD risk factors refers to perceiving, feeling, or being conscious of CVD risk factors or its risk (56). Several studies have tried to access participant´s self-reported CVD status or CVD risk factors with objective medical measurements (25, 29-31, 54-63). Some of them assessed CVD self-reports in Russia´s neighbouring countries such as Finland and Norway (29, 54, 56, 59). Many previous studies on CVD self-reports had cross-sectional designs (30, 31, 57, 59, 62, 63), whereas other studies had cohort design (25, 29, 54, 60). While some papers limited their scope by investigating overall agreement of self-reports and medical records by Cohen´s kappa coefficient (58, 60), other studies compared self-reports with a "gold standard" using sensitivity and specificity analysis (30, 31, 54, 57, 62, 63). Other investigations combined both methods (25, 29, 59, 61).

Agreement between self-reported and medically measured HT varied across different studies and settings. Overall, Cohen's kappa coefficient (ϰ) was approximately 0.71-0.78 indicating substantial agreement between self-reports and medical diagnosis (25, 29, 58, 59). Sensitivity and Specificity of self-reported diagnosis of HT varied widely across the studies. While National Health Survey in Maryland reported self-reported HT diagnostic sensitivity and specificity 70% and 90% respectively (31), telephone survey findings report sensitivity 43%, suggesting lack of validity for the telephone self-report diagnostic test for HT (30). Other studies' findings suggest sensitivity of HT self-report around 80% (25, 29).

Findings from validation telephone survey of high cholesterol self-reports diagnostic report sensitivity around 45% (30, 63). Another cohort study taken in Canada suggest that accuracy of self-reported hypercholesterolemia was lower compared to DM and HT as only 57.5% of people with elevated cholesterol were aware of this condition (64).

Studies plotting DM self-reports against the objective measurements suggests that agreement between DM self-reports and clinical measurements are moderate to strong with Kappa point estimate oscillating around value 0.75-0.87 (25, 29, 58-60). Sensitivity of self-reported diagnostics varied from 66-80% and specificity from 80-92% (25, 29, 30).
Study findings investigating validity of self-reports of DM, Hypercholesterolemia and HT with respective sensitivities and kappa coefficient values are presented in Table 1.

Table 1: sensitivities and kappa coefficient values of respective CVD conditions.

Author	Year	N	Condition	Sensitivity%	Kappa[a]
Okura et. al (25)	2004	2300	Hypertension	82	0.72
Haapen et. al (29)	1997	600	Hypertension	80	0.78
Bush et. al (58)	1989	107	Hypertension		0.71
Vargas et. al (31)	1997	8409	Hypertension	71	
Bowlin et. al (30)	1993	626	Hypercholesterolemia	44	
Natarajan et. al (63)	2002	8236	Hypercholesterolemia	51	
Dey et. al (64)	2015	101	Hypercholesterolemia	57	0.37
Okura et. al (25)	2004	2300	Diabetes	66	0.76
Haapen et. al (29)	1997	600	Diabetes	80	0.75
Bowlin et. al (30)	1993	626	Diabetes	75	
Kriegsman et. al (60)	1996	2380	Diabetes		0.85

[a] Kappa value bellow 0.00 indicates poor agreement, 0.00-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 substantial agreement, 0.91-1.00 almost perfect agreement.

Agreement between the measured and self-reported CVD conditions may differ according to specific sociodemographic, economic, and socio-cultural characteristics such as sex age, education, and income (62). According to prior research, factors associated with higher agreement between self-reports and medical record data include age <65 years, being a woman, and having higher education (25).

Scientific evidence suggest that prevention and control of cardiovascular risk factors such as DM, HT and hypercholesterolemia are more important than treating CVD (52). Investigating the awareness of cardiovascular health and risk factors in a population is therefore important for public health promotion programs that aim at reducing CVD burden.

Cardiovascular Diseases in Russia

Russia has one of the highest age-standardized mortality rates from CVDs in Europe (65). Despite of recent improvements, age standardised CVD mortality rate in the Russian Federation was 368.8 per 100.000 deaths per 100 000 persons in 2015 (65).

In 2012-2016, Russians had approximately eight times higher CVD mortality rate in ages between 35-69 years compared to population of adjacent Norway (66). This phenomenon was addressed by the international project on CVD in Russia (67) and the related Heart to Heart (H2H) initiative by looking at differences in cardiovascular health between Russian and Norwegian populations (68). The Russian population also had a higher self-reported level of use of antihypertensive medications whereas less participants met treatment targets for blood pressure when compared to the Norwegian population (66). Another study suggested that adherence to antihypertensive medication in Russia was low and associated with financial accessibility of drugs, use of blood pressure monitoring, and anxiety. From sociodemographic factors, education was the most prominent factor for an antihypertensive therapy adherence (65). Previous research has tried to explain the high CVD mortality rate in Russia showing associations with historical events, government measures, and fluctuating life expectancy (69).

After 1984, an increase in life expectancy was associated with Gorbachev's anti-alcohol campaign. This tendency remained steady until 1990 when it lapsed as the result of lack of political will to restrict consumption after the Soviet Union dissolution (69). The available evidence suggests that the very high alcohol consumption, together with the habit of binge drinking, may be resulting in the excessively large number of deaths in middle age, that tend to be due to CVD (69). Decline of CVD mortality rates in Russia occurred again since 2005. National public health project introduced interventions for cardiovascular disease prevention and treatment in primary care, and significant decrease in ischemic heart disease mortality rates were observed across the country. From 2005 to 2013 age standardized CVD mortality rates in Russia decreased by 34.3% from 833.6 to 547.1 deaths per 100 000 people. Simultaneously, CVD morbidity increased by 15.9% from 2005 to 2012. This increase in CVD incidence was also attributed to improved screening. In 2013, new large-scale screening programme was launched which lifted incidence of CVD in Russia by 13.7% compared to 2012 (70).

Aim

This study aimed to investigate the awareness of hypertension, hypercholesterolemia, and diabetes mellitus among Russian adults with objectively assessed presence of these conditions.

The ultimate goal of the study is a contribution to the evidence about the causes of high CVD mortality in Russia.

Research questions

R1: What proportion of individuals with elevated blood pressure self-report hypertension?

R2: What proportion of individuals with elevated blood cholesterol levels self-report hypercholesterolemia?

R3: What proportion of individuals with elevated markers of blood sugar self-report diabetes mellitus?

R4: What are the demographic, socio-economic, behavioural and health-related correlates of the awareness (self-report of the condition in case of its medically assessed presence) of hypertension, hypercholesterolemia, and diabetes?

Materials and methods

This thesis is based on using data from the Know Your Heart study (KYH) - a study with cross-sectional design encompassing clinical and lifestyle components of cardiovascular health in Russian adult population.

Study population and Recruitment of Participants

Population sample was drawn from two Russian cities, Arkhangelsk and Novosibirsk, in 2015-2018. Arkhangelsk is a city in the Northern part of Russia with circa 350 000 inhabitants. Novosibirsk is located in Siberian part of Russia and is the third largest city with a population size of approximately 1500 000. Between 2012-2016, mortality rates in Novosibirsk from circulatory diseases in people between 35-69 years were slightly lower than national average, whereas in Arkhangelsk, mortality rates were slightly higher. The age and education distribution were similar to the national average in both cities with higher education slightly higher in Novosibirsk. In this study, population driven from Arkhangelsk and Novosibirsk serves as a representative sample of the Russian population (71). In each city, four districts were selected for recruitment of participants. Districts were selected deliberately to capture wide range of socio-demographic factors as well as mortality levels in each city. A sampling frame consisting of information of age, sex, and dweller´s addresses was drawn from regional health insurance fund. Due to data protection, regulation and privacy, research group was not provided with individuals' names. From sampling frame, random addresses were chosen for home visits, stratified by age sex and district. The purpose of this procedure was to recruit equal number of participants within each 5-year age group and sex in each city (71). Recruitment of participants was attained by home visits carried out by trained interviewers from a commercial survey company. After participants agreed to participate in the study, they underwent the baseline interview at home. Afterwards, participants were invited to health check at a polyclinic. In total, 5089 participants agreed to participate in the study and 4542 attended the health check (74). The response rate was 65.5% in Archangelsk and 34.1% in Novosibirsk. This percentage indicates proportion of all eligible participants of pertinent age sex and location who were approached and agreed to participate on the study (71). To assess non-response bias, participants of the study were compared to census. Observed distribution of age, sex and education in the study had no substantial difference than the distribution in census (expected distribution).

Data collection

The Health check consisted of two parts: questionnaire and physical examination. The questionnaire was administered by a nurse and contained questions about past medical history, including questions about having HT, hypercholesterolemia, and DM (71).

Measurements of blood pressure and medication use

The physical examination involved measurements of blood pressure using blood pressure monitor OMRON 705 IT (OMRON Healthcare) (71). Blood pressure was measured three times while seated in rest with 2 minutes intervals between the assessments. Data on use of antihypertensive medication were collected by asking participants to bring all the medication they use to the health check. Names of used medications, along with frequencies of use and doses were recorded for each person, regardless of whether medications were brought. Maximum seven used medications per individual were recorded.

Laboratory measurements of LDL-cholesterol and Hba1lc

Laboratory data on total and LDL cholesterol and Hba1cl was drawn from blood samples taken at the health check. Participants were asked to fast 4 hours prior the health check. Before the health check, participants were asked about their last meal as well as caffeine and alcohol consumption within last 24 hours. SST vacutainers used for LDL cholesterol analysis were exposed to room temperature for 30 minutes and then stored at 4°C. Subsequently, vials were centrifuged for fifteen minutes with the temperature of 4 °C and centrifugal force of 2100-2200g (71). Blood samples for Hba1cl analysis were collected into EDTA vacutainers stored into temperature of 4°C immediately after sampling. All biomarkers were anonymized by bar codes and after initial treatment, samples were frozen down to -20°C. After maximum of three weeks, samples were relocated into -80°C freezers. Frozen samples were transported to Moscow on dry ice (maximum temperature of -50°C) where they have been centrally analysed. Both Hba1Cl and cholesterol levels were measured by device AU 680 Chemistry System Beckman Coulter. Enzymatic color test was performed to determine LDL cholesterol levels in serum, whereas data on Hba1cl levels were obtained by immuno-turbidimetric test. (71).

Self-reported CVD risk factors

Data on self-reported HT was obtained on health check by participant´s positive or negative answer to question: “Have you ever been told by a doctor or nurse that you have high blood pressure?”. Data on self-reported hypercholesterolemia was obtained by participant´s positive or negative answer to question: “Have you ever been told by a doctor that you have high cholesterol?”. Data on self-reported DM was obtained by participant´s positive or negative answer to question “Have you ever been told by a doctor or nurse that you have diabetes mellitus?”.

Demographic and socio-economic factors

Age of participants at the time of health check was recorded as a part of the questionnaire at the health check. In our analyses, age was used as a categorical variable with three 10-year bands (35-44, 45-54, 55-64 years) and one 5-year band (65-69 years).

Data on education was obtained during the baseline interview. In our analyses we used two education categories “lower than higher education” and “higher education”. These categories were derived from participants’ answers to the question “What is your level of education?”, which implied selecting one of the suggested answer options. “Lower than higher education” was defined if a participant’s choice was “incomplete secondary or lower”, “complete secondary education”, “professional school (without secondary degree PTU)”, “professional school and secondary (e.g., PTU and secondary education)”, “specialised secondary (e.g., medical, pedagogical, college, technicum)” or “incomplete higher”. “Higher education” was defined for participants whose answer was “complete tertiary education” .

Data on financial situation of household was also collected during the baseline interview. In our analyses three categories defined as “upper income”, “low household income” and “middle income” were used. The categories were derived from participants’ answers to the question “Which of the phrases below best describes this household’s financial situation during the past year?", which required choosing one of several predefined answer options. "High household income" was defined if participants answered "We can afford to buy a large new car but would find it difficult to buy a flat or a house (or other property)" or "We have no financial constraints. We can afford to buy a flat or a house (or other property)" "Lower income" was defined by participants answers "There is not even enough money for food, it is difficult to make ends meet" and/or "We have enough money for food, but we find it difficult to afford clothes and other items". "Middle household income" was defined by participants answers "We have enough money for food and clothes, but would find it difficult to buy large domestic appliances" and "We can afford to buy large domestic appliances but would find it difficult to buy a large new car" .

Behavioural factors

Data on smoking and alcohol consumption was obtained at the health check. Smoking variable consisted of three categories "non-smoker" "ex-smoker" "current smoker". Category "non-smoker" is defined by participant´s answer "Never smoked" to question "Are you a current smoker"?. "Ex-smoker" is defined by participant´s answer "No, ex-smoker". Participant was defined as "current smoker' if the answer was "Yes, regular smoker" or "Yes, I smoke but less than 1 cigarette a day".

Data on alcohol consumption was collected using Alcohol Use Disorders Identification Test (AUDIT) (72).

Health parameters

Data on self-reported cardiovascular health and Body Mass Index was obtained at the health check. Presence of CVDs were assessed based on participants' answers to questions "Have you ever been told by a doctor (been diagnosed) that you have: Angina?", "Have you ever been told by a doctor (been diagnosed) that you have: Stroke?", "Have you ever been told by a doctor (been diagnosed) that you have: Myocardial Infarction/Heart attack?", "Have you ever been told by a doctor (been diagnosed) that you have: Atrial fibrillation"? and/or "Have you ever been told by a doctor (been diagnosed) that you have: Heart failure?". A positive answer to at least one of these questions was considered as having a CVD.

Weight was measured by body composition analyser Tanita BC 418 and height was measured by portable stadiometer Seca 217. Body mass index (BMI) was calculated from weight and height of participants, using formula BMI = kg/m2. Obesity was defined as present if BMI was ≥30.

Definitions of objectively measured CVD risk factors

Treatment thresholds for systolic and diastolic blood pressure differ across different comorbidities and ages (73). Based on 2018 ESC/ESH Guidelines for the management of arterial HT, this study defines HT as systolic blood pressure (SBP) >140 mmHg and/or diastolic blood pressure (DBP) >90 mmHg at the medical examination (average of the 2nd and the 3rd measurements) and/or self-reported daily taking anti-hypertensive medication, (73). Hypercholesterolemia is defined as total cholesterol ≥5.2 mmol/L and/or LDL cholesterol of >3.0 mmol/L and/or self-reported daily intake of lipid-lowering medication. DM is defined as HbA1C ≥ 6.5% and/or self-reported daily taking of antidiabetics. Medications are coded according to the Anatomical Therapeutic Chemical Code (ATC) (74). Diagnosis cut-offs values among with medication ATC codes used as objective measure of the HT, DM and hypercholesterolemia are shown in Table 2.

Table 2: Specific self-reported medication use expressed in ATC codes and diagnostic cut-off used as an objective diagnosis of HT, hypercholesterolemia, and DM.

Diagnosis	Diagnostic cut-off	Medication (ATC code)
Hypertension	SBP > 140 mmHg and/or DBP > 90 mmHg (average of 2nd and 3rd measurements)	Antihypertensives - C02 / C03 / C07 / C08 / C09
Hypercholesterolemia	total cholesterol ≥5.2 mmol/L and/or LDL>3.0 mmol/L	Lipid modifying agents - C10
Diabetes Mellitus (DM)	HbA1C ≥ 6.5%	Antidiabetics - A10

Definition of self-reported CVD risk factors

Self-reported HT was defined as a positive answer to the question "Have you ever been told by a doctor or nurse that you have high blood pressure?"; self-reported hypercholesterolemia – as a positive answer to the question "Have you ever been told by a doctor that you have high cholesterol?"; self-reported diabetes – as a positive answer to the question "Have you ever been told by a doctor or nurse that you have diabetes mellitus?".

Several factors were selected to instigate associations with agreements between objective (medical) and subjective assessments regarding the presence of conditions of interest. These included demographic factors (age, sex), socio-economic factors (education, household financial situation), behavioural factors (smoking, alcohol consumption), and selected health parameters (body mass index, self-reported ever diagnosed myocardial infarction, angina/coronary heart disease, stroke, heart failure, atrial fibrillation).

Statistical analysis

Awareness of high blood pressure, high lipids, and DM was assessed in those with objective presence of these conditions. The awareness was considered to be present when the objectively defined presence HT, hypercholesterolemia, and DM matched self-reports of having corresponding conditions. Non-awareness was defined when objective data and self-reports mismatched (presence of the condition according to objective data and negative self-report).

The awareness was estimated as proportion of those self-reporting a condition out of total with objectively present condition and presented as percentage with 95% confidence intervals (Cis). Age- and sex-standardized estimates of the prevalence of awareness for each condition were also estimated. Direct standardization of awareness was used for this purpose. Standardized estimates were drawn by applying age-specific rates of awareness in the study population to European Standard Population 2013 (75, 76).

Logistic regression models were used to investigate demographic (age, sex), socio-economic (education, household financial situation), behavioural (smoking, alcohol consumption) and health (BMI, self-reported CVDs) characteristics associated with the awareness for each of the three conditions.

Statistical analysis was performed using STATA V.17 (StataCorp, TX, USA).

Missing data

A total of 701out of the total of 4504 KYH participants were excluded from analyses for this study. Out of these, 27 participants were older than 69 years by the time of the health check, and 674 had missing or unusable data on one or more variables of interest. Among them, 333 had missing blood pressure data, 71 – had missing data on Total Cholesterol and LDL, 128 – on HbA1C, 13 – on smoking, 21 – on alcohol, 80 – on household financial situation, 15 – on

BMI (height and/or weight), and 442 had missing data on whether a doctor or nurse ever told them about having high blood pressure, high cholesterol, or diabetes.

In addition, there were 149 KYH study participants who found it difficult to answer questions regarding having ever been told by a doctor or nurse about their high blood pressure (7), high cholesterol (114), or diabetes (28). These were considered as self-reporting no corresponding conditions and were treated as unaware of the corresponding condition if the condition was objectively present.

Ethical approval

The Know Your Heart Study complies with Declaration of Helsinki and received the ethical approval from the London School of Hygiene & Tropical Medicine (approval number 8808, date 247/02/2015). Approval was also obtained from Novosibirsk State Medical University (approval number 75 approval received 21/05/2015), the Institute of Preventative Medicine (no approval number; approval received 26/12/2014), Novosibirsk and the Northern State Medical University, Arkhangelsk (approval number 01/01-15 received 27/01/2015) Signed informed consent was obtained at the health check (71).

Results

A total of 3,803 participants are included in analysis (41.9% men, 58.1% women). The mean age was 54 years and median age was 55 years.

Out of total 3,803 participants, 2,206 (58%) were hypertensive. Proportionately more men had high BP compared to women (63.9% vs 53.8). Proportion of individuals with hypercholesterolemia was 83.4% (N= 3,171). Total 8.7% (N=329) of participants had DM according to laboratory measurements and self-reported antidiabetic medication use.

Table 3: Characteristics of participants stratified by sex

Participants' characteristics	Male	(%)	Female	(%)	Total	(%)
Total	1,591	41.84	2,212	58.16	3803	100
Age						
35-44	314	19.74	511	23.10	825	21.69
45-54	451	28.35	600	27.12	1,051	27.64
55-64	542	34.07	709	32.05	1,251	32.90
65-69	284	17.85	392	17.72	676	17.78
Education						
Higher education	563	35.39	867	39.20	1,430	37.60
Lower than higher education	1,028	64.61	1,345	60.80	2,373	62.40
Household income						
Middle	1,219	76.62	1643	74.28	2,862	75.26
Upper	109	6.85	112	5.06	221	5.81
Lower	263	16.53	457	20.66	720	18.93
Smoking status						
Non-smoker	404	25.39	1482	67.00	1,886	49.59
Ex-smoker	586	36.83	365	16.50	951	25.01
Current smoker	601	37.77	365	16.50	966	25.40
Hazardous drinking						
Yes	393	24.7	42	1.9	435	11.4
No	1,198	75.3	2170	98.1	3,368	88.6
Obesity						
Yes	417	26.21	790	35.71	1,207	31.74
No	1,174	73.79	1422	64.29	2,596	68.26
Self-reported CVD						
Yes	379	23.81	562	25.4	941	24.7
No	1,212	76.2	1,650	74.6	2,862	75.3
Objectively defined hypertension [a]						
Yes	1,017	63.92	1,189	53.75	2,206	58.01
No	574	36.08	1023	46.25	1,597	41.99
Self-reported hypertension						
Yes	914	57.45	1310	59.22	2,224	58.48
No	677	42.55	902	40.78	1,579	41.52
Objectively defined hypercholesterolemia [a]						
Yes	1,325	83.28	1,846	83.45	3,171	83.38
No	266	16.72	366	16.55	632	16.62
Self-reported high cholesterol						
Yes	563	35.39	1,123	50.77	1,686	44.33
No	1,028	64.61	1,089	49.23	2,117	55.67
Objectively defined diabetes [a]						
Yes	122	7.67	207	9.36	329	8.65
No	1,469	92.33	2,005	90.64	3474	91.35
Self-reported diabetes						
Yes	105	6.6	193	8.73	298	7.84
No	1,486	93.4	2,019	91.27	3,505	92.16

[a] Derived from medical and laboratory measurements and self-reported medication use.

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Among all hypertensive participants, 83.6% (95% CI: 82.0 – 85.1) correctly self-reported that they have high blood pressure. However, participants treated on HT had substantially higher proportion of awareness of this condition (95.9%, 95% CI: 94.7 – 96.8) compared to untreated participants (61.3%, 95% CI: 57.8 – 64.6). Crude proportions of aware individuals with HT and proportions of awareness within group of treated and untreated hypertensive participants is presented in Figure 1.

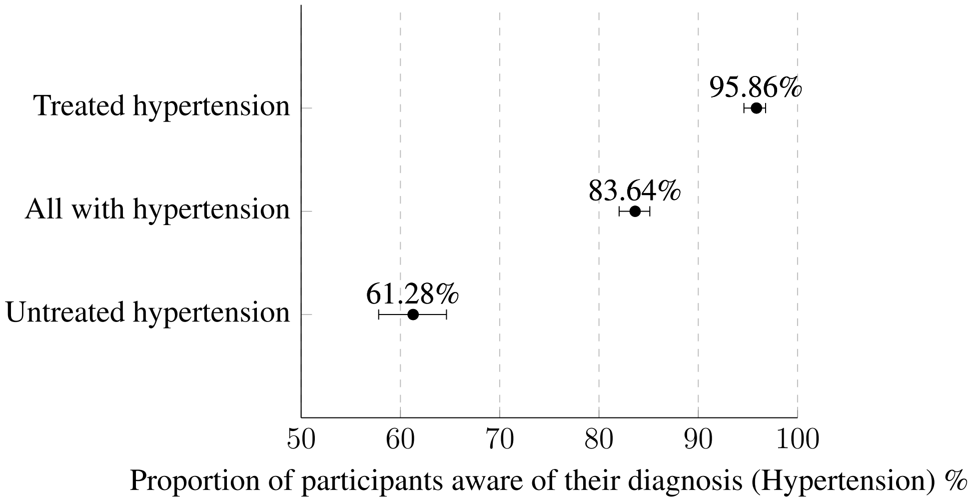

Figure 1: Proportions of the aware of hypertension among all hypertensive study participants and in subcategories by treatment (presented with 95% CIs).

Among all participants with elevated cholesterol levels, 50.3% (95% CI: 48.6 – 52.1) correctly self-reported that they have hypercholesterolemia. However, participants treated on hypercholesterolemia had substantially higher proportion of awareness (88.8%; 95% CI: 85.2 – 91.7) compared to untreated participants with hypercholesterolemia without treatment (45.3%; 95% CI: 43.5 – 47.1). Proportion of the aware of hypercholesterolemia among individuals with hypercholesterolemia is presented in Figure 2.

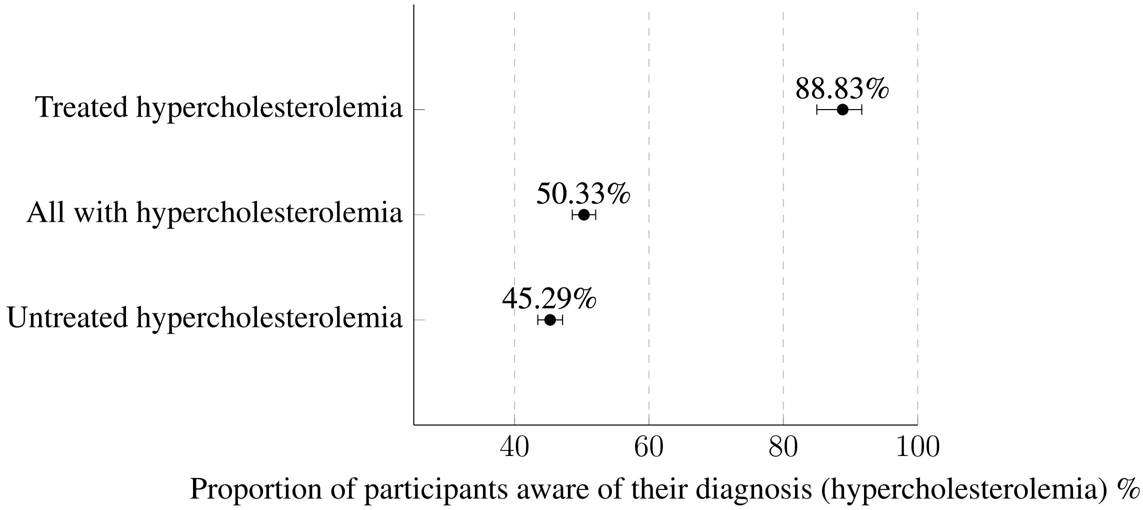

Figure 2: Proportions of the awareness of hypercholesterolemia among all study participants with hypercholesterolemia and in subcategories by treatment (presented with 95% CIs).

Proportion of the aware of DM among individuals with DM is presented in figure 3.Among participants with DM objectively present, 73.9% (95% CI: 68.8 – 78.3) correctly self-reported the condition. Awareness of DM was considerably lower among the diabetics without the treatment (34.4%, 95% CI: 25.4 – 44.8) compared to treated diabetics (88.7%, 95% CI: 84.0 – 92.2). Proportions of aware individuals of respective CVD risk factors with respective confidence intervals are shown in Figure 3.

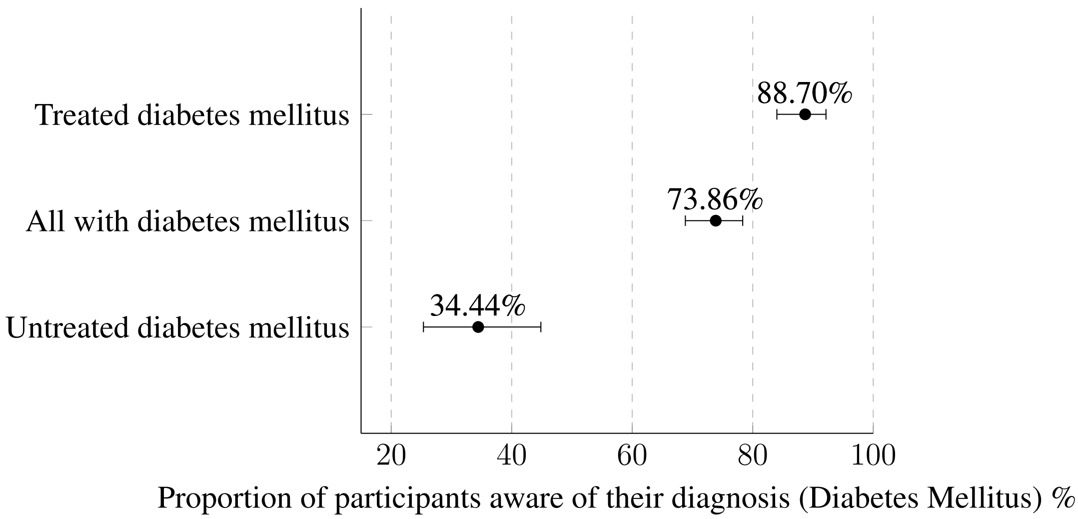

Figure 3: Proportions of the awareness of diabetes mellitus among all study participants with DM and in subgroups by treatment with 95% CIs.

There was a total 387 (24.2%) participants out of 1597 without objectively detected HT who self-reported it. Out of 632 persons without objectively detected hypercholesterolemia , 94 (14.9%) self-reported presence of abnormal cholesterol levels. A total of 55 (1.6%) out of 3474 participants without objectively detected DM self-reported DM it.

Age- and sex-standardized prevalence of awareness of HT among hypertensive participants was 79.3 (95% CI: 76.9% – 81.5%). Age-standardized prevalence of the awareness was higher among the hypertensive women (84.0; 95%CI: 80.6% – 86.9%) compared to hypertensive men (74.6%; 95% CI: 71.2% – 77.7%).

Age- and sex-standardized prevalence of awareness of abnormal lipid levels among people diagnosed with hypercholesterolemia was 44.7 (95% CI: 42.9% – 46.5%). Age-standardized prevalence of the awareness was higher among women with hypercholesterolemia (51.4%; 95% CI: 49.0% – 53.7%) compared to men with hypercholesterolemia (38.0%, 95% CI: 35.4% – 40.8%).

Age- and sex-standardized prevalence of awareness of DM among people diagnosed with DM was 61.2 (95% CI: 53.4% – 68.4%). Age-standardized prevalence of the awareness of DM was higher among the women with DM (61.8%; 95%CIs: 49.3% – 73.0%) compared to men with DM (61.2%, 95% CI: 53.4% – 68.4%).

Age- and sex-standardized prevalences of HT, DM, and hypercholesterolemia among awareness among people with CVD risk factors present are presented in Table 4.

Table 4: Overall age- and sex-standardized [a] and sex-specific age-standardized [a] awareness prevalence estimates for HT, hypercholesterolemia, and DM among study participants with corresponding conditions

CVD condition	Awareness prevalence (%)	95% Confidence interval
Hypertension		
Both sexes [b]	79.3	76.9 – 81.5
Males [c]	74.6	71.2 – 77.7
Females [c]	84.0	80.6 – 86.9
Hypercholesterolemia [b]		
Both sexes [b]	44.7	42.9 – 46.5
Male [c]	38.0	35.4 – 40.8
Female [c]	51.4	49.0 – 53.7
Diabetes [b]		
Both sexes [b]	61.2	53.4 – 68.4
Male [c]	60.5	51.1 – 69.1
Female [c]	61.8	49.3 – 73.0

[a] Direct standardization to Standard European Population 2013
[b] Age- and sex-standardized estimate
[c] Age-standardized estimate

After mutual adjustments of all covariates, odds of awareness for HT and hypercholesterolemia significantly higher within age ≥ 50 compared to age ≤ 44 years, in women vs men, and in participants with obesity and history of CVDs (angina, stroke, myocardial infarction, atrial fibrillation, heart failure) compared to those without these characteristics (Tables 5-6). Odds of awareness of HT and hypercholesterolemia were lower in current smokers relative to never-smokers, respectively.

Odds of DM awareness were lower in participants with higher income but higher with lower income, relative to participants in the middle-income category (Table 7). Presence of CVDs were also associated with higher odds of DM awareness.

Table 5: Participants' characteristics associated with awareness of having hypertension (N=2206)

Covariates	Model 1 [a]		Model 2 [b]		Model 3 [c]		Model 4 [d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, years								
- 35-44	*Reference*		*Reference*		*Reference*		*Reference*	
- 45-54	1.31	0.92 – 1.88	1.31	0.92 – 1.88	1.26	0.88 – 1.81	1.21	0.84 – 1.74
- 55-64	2.51	1.77 – 3.56	2.49	1.75 – 3.54	2.32	1.62 – 3.31	1.94	1.35 – 2.80
- 65-69	2.75	1.87 – 4.05	2.74	1.86 – 4.03	2.45	1.65 – 3.63	1.87	1.24 – 2.81
Sex								
- Man	*Reference*		*Reference*		*Reference*		*Reference*	
- Woman	2.34	1.85 – 2.97	2.31	1.82 – 2.94	2.01	1.53 – 2.64	1.79	1.35 – 2.36
Higher education								
- Yes			*Reference*		*Reference*		*Reference*	
- No			0.95	0.74 – 1.22	1.02	0.79 – 1.31	0.96	0.74 – 1.24
Income								
- Middle			*Reference*		*Reference*		*Reference*	
- Upper			0.63	0.39 – 1.00	0.63	0.39 – 1.00	0.69	0.43 – 1.12
- Lower			1.08	0.80 – 1.45	1.13	0.83 – 1.52	1.00	0.73 – 1.36
Smoking								
- Never smoker					*Reference*		*Reference*	
- Ex-smoker					0.91	0.66 – 1.24	0.85	0.62 – 1.17
- Current smoker					0.57	0.42 – 0.77	0.58	0.43 – 0.79
Hazardous drinking								
- No					*Reference*		*Reference*	
- Yes					0.99	0.71 – 1.36	1.05	0.75 – 1.46
Obesity								
- No							*Reference*	
- Yes							2.62	1.98 – 3.46
Self-reported CVDs								
- No							*Reference*	
- Yes							2.39	1.74– 3.28

[a] Model 1 – demographic factors;
[b] Model 2 – demographic factors, and socio economic factors;

[c] Model 3 – demographic factors, socio economic factors, and behavioural factors;

[d] Model 4 – demographic factors, socio economic factors, and behavioural factors and health parameters.

Table 6: Participant´s characteristics associated with awareness of their hypercholesterolemia in logistic regressions

Covariates	Model 1 [a]		Model 2 [b]		Model 3 [c]		Model 4 [d]	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Age, years								
- 35-44	*Reference*		*Reference*		*Reference*		*Reference*	
- 45-54	1.59	1.27 – 2.00	1.60	1.28 – 2.01	1.62	1.30 – 2.04	1.58	1.26 – 1.98
- 55-64	3.00	2.41 – 3.73	3.06	2.45 – 3.81	2.97	2.38 – 3.71	2.55	2.03 – 3.20
- 65-69	3.59	2.81 – 4.59	3.65	2.85 – 4.68	3.47	2.69 – 4.46	2.72	2.10 – 3.53
Sex								
- Man	*Reference*		*Reference*		*Reference*		*Reference*	
- Woman	2.06	1.78 – 2.39	2.06	1.78 – 2.39	1.97	1.66 – 2.34	1.93	1.62 – 2.30
Higher education								
- Yes			*Reference*		*Reference*		*Reference*	
- No			0.91	0.78 – 1.06	0.96	0.82 – 1.12	0.91	0.78 – 1.07
Income								
- Middle			*Reference*		*Reference*		*Reference*	
- Upper			0.98	0.72 – 1.34	0.96	0.70 – 1.32	1.01	0.73 – 1.38
- Lower			0.98	0.81 – 1.18	1.00	0.83 – 1.21	0.94	0.77 – 1.14
Smoking								
- Never smoker					*Reference*		*Reference*	
- Ex-smoker					1.22	1.01 – 1.48	1.18	0.97 – 1.43
- Current smoker					0.67	0.55 – 0.82	0.67	0.55 – 0.82
Hazardous drinking								
- No					*Reference*		*Reference*	
- Yes					0.94	0.72 – 1.21	0.97	0.75 – 1.25
Obesity								
- No							*Reference*	
- Yes							1.21	1.03 – 1.42
Self-reported CVDs								
- No							*Reference*	
- Yes							1.95	1.63 – 2.33

[a] Model 1 – demographic factors;

[b] Model 2 – demographic factors, and socio economic factors;

[c] Model 3 – demographic factors, socio economic factors, and behavioural factors;

[d] Model 4 – demographic factors, socio economic factors, and behavioural factors and health parameters.

Table 7: Participant´s characteristics associated with awareness of their Diabetes.

Covariates	Model 1 [a]		Model 2 [b]		Model 3 [c]		Model 4 [d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, years								
- 35-44	*Reference*		*Reference*		*Reference*		*Reference*	
- 45-54	1.03	0.34 – 3.09	0.82	0.26 – 2.62	0.87	0.27 – 2.84	0.87	0.26 – 2.92
- 55-64	2.61	0.95 – 7.15	2.21	0.77 – 6.39	2.35	0.79 – 7.02	1.80	0.59 – 5.51
- 65-69	3.12	1.11 – 8.79	2.65	0.89 – 7.86	2.73	0.89 – 8.36	1.75	0.55 – 5.58
Sex								
- Man	*Reference*		*Reference*		*Reference*		*Reference*	
- Woman	1.09	0.65 – 1.83	1.07	0.63 – 1.82	0.89	0.46 – 1.70	0.99	0.51 – 1.92
Higher education								
- Yes			*Reference*		*Reference*		*Reference*	
- No			1.37	0.79 – 2.38	1.35	0.78 – 2.35	1.33	0.75 – 2.36
Income								
- Middle			*Reference*		*Reference*		*Reference*	
- Upper			0.42	0.15 – 1.16	0.41	0.15 – 1.14	0.34	0.12 – 0.97
- Lower			2.50	1.25 – 4.99	2.54	1.26 – 5.09	2.20	1.09 – 4.46
Smoking								
- Never smoker					*Reference*		*Reference*	
- Ex-smoker					0.62	0.31 – 1.24	0.62	0.31 – 1.25
- Current smoker					0.81	0.37 – 1.77	0.77	0.34 – 1.71
Hazardous drinking								
- No					*Reference*		*Reference*	
- Yes					1.18	0.45 – 3.11	1.17	0.44 – 3.12
Obesity								
- No							*Reference*	
- Yes							0.86	0.49 – 1.54
Self-reported CVDs								
- No							*Reference*	
- Yes							2.89	1.58 – 5.28

[a] Model 1 – demographic factors;

[b] Model 2 – demographic factors, and socio economic factors;

[c] Model 3 – demographic factors, socio economic factors, and behavioural factors;

[d] Model 4 – demographic factors, socio economic factors, and behavioural factors and health parameters.

Discussion

This study have shown that proportions of awareness of hypercholesterolemia, HT and DM differed. The awareness of objectively present CVD risk factors differed across treated and untreated participants. Age >55 years, female sex, previous heart problems, smoking status, and obesity were significant correlates of awareness of present hypercholesterolemia and HT. Associated characteristics with the awareness of present DM were household income, and previous heart problems.

Demographic factors

Similar to findings from previous studies (25, 29, 63, 77), this study showed that odds of being aware of HT and hypercholesterolemia were higher among women compared to men and older ages compared to younger. This might be due to women´s higher interaction with health care systems to access birth control or reproductive health and child-related follow-ups where their health parameters are measured (77). Although this study didn´t show significant difference in awareness of DM between age categories in adjusted models, there is a trend that with age, awareness of DM rises. Higher prevalence of awareness within the group of older individuals compared to younger individuals might be explained by lower likelihood of using healthcare services as younger adults tend to have less morbidities (78).

Socio-economic factors

While some studies show that HT and DM awareness is higher among people with higher income and higher education (79, 80), other studies show that uneducated people are more knowledgeable of DM compared to educated (81). None of these findings were replicated in this study. From socio-economic factors, only lower household income was positively associated with awareness of DM, whereas people with high household income had lower odds of being aware of their DM compared to middle household income. No relationship was observed between socio-economic factors, hypercholesterolemia, and HT.

Behavioural factors

Although relationship between excessive alcohol consumption and some CVD risk factors such as HT is well established (82), hazardous drinking as behavioural factor was not associated with awareness of any of investigated CVD risk factors. On the other hand, current smokers had significantly lower odds of being aware of the hypercholesterolemia or HT compared to non-smokers. Previous findings show that individuals with non-smoking lifestyle are more likely to be aware of the risks and tend to be self-conscious about their health (83).

Health parameters

Odds of awareness among each of investigated CVD risk factors were higher among persons previous self-reported cardiovascular events and obese individuals. These findings are in agreement with other studies as health parameters such as cardiovascular events or obesity were positively associated with the awareness of CVD risk factors (25, 77). Individuals with clinical CVD are considered "high-risk" and tend to have specific treatment targets for CVD risk factors and close follow-up focused particularly on their cardiovascular health (73).

Standardized prevalence of awareness

Age-standardized proportions of awareness in this study were comparable to validation studies and sensitivity analyses of self-reports in European countries. Sensitivity is calculated as the number positives regarding a condition defined by a test, divided by the total number of tested individuals with the condition (84). With respect to self-report, sensitivity is de facto a proportion of those reporting the diseases among the total number of people with the disease. In our study, age- and sex-standardized prevalences of the awareness of HT hypercholesterolemia and DM were 79.3%, 44.7%, and 61.2% respectively. Women tended to self-report CVD risk factors more precisely than men. These findings are in agreement with study in neighbouring Finland showing sensitivity of self-report diagnostic test 80% and 75% for HT and DM, respectively (29). In Sweden, prevalence of awareness of hypercholesterolemia was 39% and 44% for men and women, respectively (85). These studies however, had slightly different settings as participants were aged 19-63, and took place long time ago as they have been published before 2000. Findings in non-European high-income countries were also similar to results of this study as self-reports diagnostic tests showed substantial agreement and sensitivity around 80% for HT (25, 31), roughly 50% sensitivity for hypercholesterolemia (30, 63, 64) and around 70% sensitivity for DM (25, 30).

One of the purposes of this study was a contribution to the evidence about the causes of high CVD mortality in Russia. The estimated proportions of awareness of CVD risk conditions were similar to those in high income European countries with significantly lower CVD mortality rates compared to in Russia (86). Moreover, awareness of hypercholesterolemia was least prevalent of all investigated conditions, but previous research on blood-based biomarkers comparing Russian and Norwegian population suggested that prevalence of abnormal lipid levels in Russian population was not explaining high CVD mortality rates in Russia (87). In addition, cross-sectional studies in France and Greece showed awareness of HT 37.5% and 68.2% respectively (77, 88), which is lower than in this study. Considering the similar proportions of the awareness of CVD risk factors in the Russian population and in European countries, the difference in awareness is unlikely the factor explaining higher CVD mortality rates in Russia compared to European countries.

Awareness by treatment

Untreated participants consistently showed lower degree of awareness than treated participants. Low awareness of one´s cardiovascular health might have serious implications as unaware individuals with untreated CVD risk factors can progress into later stages in cardiovascular continuum where development of CVD is more likely to occur compared to treated or aware individuals. Self-report as a diagnostic test for CVD risk factors should be used with caution or be regularly validated (31, 63, 64). Due to different proportions of awareness between treated and untreated, such screening with self-report diagnostic in Russian setting would hardly target correct population as aware individuals tend to be the ones who are already treated whereas unaware individuals would likely remain undetected and untreated. On the other hand, it is reasonable to expect that treated cases have higher awareness, as conditions such as HT and DM are chronic and require recurrent contact with healthcare system (25).

Total of 23.7% participants without HT, 14.2% of persons without hypercholesterolemia, and 1.6% participants without DM self-reported CVD risk factor although screening failed to show it. This discrepancy between medical measurements and self-reports might be caused by participant´s misconception of his or her health. Another explanation of the negative screening results and positive self-report diagnostic test mismatch is misclassification possible failure of the screening to detect the condition of interests. In such cases, participants could have correctly self-assessed their health status, or might have been told by doctor that they have CVD risk factors in the past, but the measured body parameters are not stable in time so health examination in a cross-sectional study may have missed the previously diagnosed elevated levels of blood pressure, hba1cl, or abnormal cholesterol. That was the reason for us to assess the awareness of the conditions among those with objectively confirmed conditions, but not to look into whether negative self-reports of the conditions were in line with the objectively assessed absence of the conditions of interest.

Strengths and limitations

Study had cross-sectional design and data were collected during single period of time instead of having participant´s follow up. Participants with the CVD risk factors present might have had measured normal levels of blood, hba1cl, despite they had been acquainted that they had CVD condition present in the past. To ensure more precise medical measurements of blood pressure, data from three subsequent measurements 2 minutes apart were averaged. Nevertheless, blood pressure readings in doctor's office might show higher values of blood pressure due to patient´s stress during the health check (89). This "white coat hypertension" might produce false positive cases during the screening. Cholesterol levels might be also imprecise as participants were asked to fast 4 hours instead of 12. Objective measurements were derived not only from body measurements but also from participants self-reported medication use.

Standard population enables better comparisons of morbidity between the countries. Potential limitation is that standardised age weights were proposed for EU-27 + EFTA. Russia is outside of the geographical coverage of these standardisation calculations and projections.

Therefore validity and the plausibility of the standardized rates produced might be compromised in populations with excessively different structures Disadvantage of direct standardisation is it´s sensitivity to small cell sizes, as it requires number of events per age group to be available (75). Main advantage of the direct standardization is comparison of awareness proportions over time and preserving the consistency between the compared populations (75).

Another possible limitation of this study is information bias stemming from predictors used in logistic regressions. Some correlates with awareness of cardiovascular health were drawn from self-reports. Participant´s responses on questions about smoking status or alcohol intake are prone to social desirability bias where people tend to under-report their smoking and drinking habits, which leads to underestimation of odds ratios in regression models. Responses on previous heart problems are also prone to reduce effect estimates due to recall bias, as participants remember previous events less accurately over time. Another limitation of this study is non-response bias as only 41,1% of the total of the approached and invited individuals agreed to take part in the study.

Conclusion

The proportions of awareness of hypertension, hypercholesterolemia, and diabetes mellitus among Russian adults with these conditions were relatively close to the same proportions estimated in populations of European countries. Therefore, we found no evidence that the higher CVD mortality in Russia, compared to CVD mortality in European countries, is explained by a lower awareness of CVD risk factors.

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