Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

What Socioeconomic Factors Explain Type 2 Diabetes Prevalence?

Author: **Veranika Makarevich**

Supervisor: **PhDr. Jana Votápková**

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, July, 2016

Signature

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Abstract

The study aims to identify the influence of socioeconomic factors on the prevalence of type 2 diabetes for individuals aged 27 and older in the Republic of Belarus. We analyze data from the Diabetes Survey conducted by the Endocrinology Medical Center in Minsk and the Ministry of Health of the Republic of Belarus from 2011 to 2015. The association between socioeconomic factors and the prevalence of type 2 diabetes is examined using logistic regression with sequential adjustments for clinical and behavioral predictors. Our findings indicate that individuals with lower income and educational levels are more likely to suffer from type 2 diabetes than those in higher income and education groups. Moreover, the prevalence of type 2 diabetes decreases as income and educational level go up. Furthermore, this association remains significant even after further adjusting for various behavioral and clinical factors. In addition, we confirm that type 2 diabetes is more prevalent among overweight / obese, physically inactive and older individuals. These findings suggest that strategies for preventive diabetes programs should be focused on socioeconomic environment rather than on individual risky behavior only.

JEL Classification	A 12, I 12, I 18, C 35
Keywords	Type 2 Diabetes, Prevalence, Socioeconomic Factors, Logit Model

Author's e-mail	vermakarevich@gmail.com
Supervisor's e-mail	jana.votapkova@gmail.com

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Acronyms

T2DM Type 2 Diabetes Mellitus

BMI Body Mass Index

IDF International Diabetic Federation

WHO World Health Organization

NCD Non-communicable Disease

AFR Africa

EUR Europe

MENA Middle East and North Africa

NAC North America and Caribbean

SACA South and Central America

SEA South-East Asia

WP Western Pacific

IDF International Diabetic Federation

WHO World Health Organization

MLE Maximum Likelihood Estimation

OR Odds Ratio

AIC Akaike Information Criterion

BIC Bayesian Information Criterion

Master's Thesis Proposal

Author:	Veranika Makarevich
Supervisor:	PhDr. Jana Votápková
Defense Planned:	September 2016

Proposed Topic:

What socioeconomic factors explain type 2 diabetes prevalence?

Motivation:

The rapid spread of type 2 diabetes mellitus has become a major 21st century health challenge. Yet, the disease is essentially preventable and non-communicable. The mortality rate from type 2 diabetes, however, has been increasing since mid-1980s and today it is the eighth leading cause of death in the world according to the World Health Organization (WHO).

Because of its chronic and incurable nature, the severity of manifestations such as skin and eye complications, and neuropathy (Millett et al., 2007), diabetes is a costly disease which requires constant medication, constant monitoring of blood sugar and periodically more technologically complicated tests and examinations, special diets, and lifestyle itself. As a result the expenditures on treatment and care are high and constantly escalating, which in turn, entail individual and health care providers to be under economic and social pressures (Currie et al., 2010).

Most existing studies on type 2 diabetes prevalence mainly analyze clinical factors such as family history, obesity, chronic diseases, high blood pressure, impaired glucose tolerance, history of gestational diabetes, increasing age, ethnicity, unhealthy nutrition, poor nutrition during pregnancy and pernicious habits. For instance, previous studies show the people who are diagnosed with type 2 diabetes in the developed countries are obese (Narayan et al., 2007), older (Lipscombe and Hux, 2007), have bad eating habits and do not lead a healthy lifestyle in general (Hwang and Shon, 2014).

However, despite solid empirical evidence of the influence of such clinical factors in type 2 diabetes prevalence as obesity and increasing age, the statistics of recent years show that the frequency of the onsets of type 2 diabetes in middle-aged people with normal body mass index is constantly increasing (WHO, Public health in the Republic of Belarus, 2015). Therefore, there is a lack of studies about how clinical factors are related with the incidence of type 2 diabetes in middle-aged people. This is because research usually uses samples that include only clinical determinants and focuses on the relationship between type 2 diabetes incidence and dominant risk factors, and only infrequently on associations between diabetes prevalence and socioeconomic factors.

The characteristic features and aetiology of type 2 diabetes show it is a multifactorial disease (Balabolkin, 2010). Thus, it is equally important to acknowledge a broad range of factors both clinical and socioeconomic in understanding disease risk.

The previous studies about socioeconomic factors of type 2 diabetes prevalence demonstrate that diabetes is more common among the most socioeconomically deprived (Demakakos et al., 2012, Raphael et al., 2003, Hux et al., 2002). Patients with lower income are more prone to be run a greater risk of type 2 diabetes in comparison with those who have higher income (Espelt et al., 2013). Furthermore, disability and premature mortality rates resulting from type 2 diabetes and its complications have increased among Canadians, especially among people who are at higher risk like Hispanic, South Asian or African ethnicity (Dinca-Panaitescu et al., 2012). Previous research has used clinical and socioeconomic determinants of type 2 diabetes separately. We will thus fill this research gap and will consider these two types of factors jointly. Our analysis will help reveal a more complex picture of the causes of the disease. We will analyze a Belarusian longitudinal dataset in the period 2012 – 2014.

Hypotheses:

1. Middle-aged people are more prone to have type 2 diabetes.
2. Poorer people run a greater risk of type 2 diabetes.
3. Patients with lower education level have a higher probability to be diagnosed with type 2 diabetes.
4. Moderate physical activity may lead to type 2 diabetes.
5. Individuals with normal body mass index are less likely to have type 2 diabetes.

Methodology:

Logistic regression model will be used to estimate the probability of individuals being diagnosed with type 2 diabetes. The dependent variable is a dummy which takes a value 1 if type 2 diabetes is diagnosed and 0 if type 2 diabetes is not diagnosed:

$$D_i = \begin{cases} 1 \; if \; yes \\ 0 \; if \; no \end{cases}.$$

Socioeconomic and clinical characteristics of individuals such as age, gender, marital status, income, education, region, body mass index, family history of diabetes, hypertension (high blood pressure), impaired glucose tolerance, physical activity, smoking and alcohol consumption will be included as the primary independent variables.

The logistic model is as follows:

$$D_i = \beta_o + \beta_1 x_i + \beta_2 q_i + \varepsilon_i,$$

where βs are the parameters of the model; x_i is a matrix of the socioeconomic characteristics of patients; q_i is a matrix of the clinical characteristics of individuals; i is an index of patients and ε_i is the error term. The variance of ε_i is assumed to be equal to $\frac{\pi^2}{3}$.

To achieve the aims of the thesis, we will use the dataset of the Endocrinology Medical Center (Minsk, Belarus) and the Ministry of Health of the Republic of Belarus. The databases capture socioeconomic and clinical information about patients in the population of Minsk and the Minsk province (pop. 3,304,600 in 2013).

Expected Contribution:

In contrast to the previous analyses, our study will be the first attempt estimate socioeconomic and clinical factors jointly. The contribution of the study is expanding the clinical scope with socioeconomic factors of type 2 diabetes prevalence that would help to elucidate the association between socioeconomic determinants of type 2 diabetes onsets. We expect to contribute to the field of research by analyzing a recent Belarusian sample, as a representative of middle-income countries. Furthermore, since diabetes mellitus is an evoked disease that requires a self-management, the estimates can contribute to the formation of preventive diabetes programs and its effective management.

Outline:

Introduction.

Background.

Literature Review.

Data.

Methods.

Results.

Concluding remarks.

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Author   **Supervisor**

Chapter 1

Introduction

Diabetes mellitus has globally become a major 21st century health challenge. According to the International Diabetes Federation in 2015, about 415 million people worldwide, or 8.8% of the adults aged 20 – 79 years, suffer from type 2 diabetes. This figure is projected to rise to around 642 million people by 2040 (Diabetes Atlas, 2015). Moreover, according to the diabetes forecast, the largest increases in diabetes onsets will be in the low- and middle-income countries (Diabetes Atlas, 2015). In 2014 the statistical data showed that the prevalence of diabetes among adults in Belarus affected 467.6 thousand people or 6.3 % of the adult population (IDF, 2016). Whereas, the prevalence of diabetes in Belarus is only a little less than the world average: 6.3% in the country versus 8.33% worldwide (Diabetes Atlas, 2015).

Various diabetes-related studies assert that the disease is largely influenced by clinical characteristics of the patients, such as family medical history, obesity, chronic diseases, impaired glucose tolerance, history of gestational diabetes, increasing age, and ethnicity. The studies show that people who are diagnosed with type 2 diabetes in the developed countries are obese (Narayan et al., 2007), older (Lipscombe and Hux, 2007), have bad eating habits and follow unhealthy lifestyles in general (Hwang and Shon, 2014). At the same time, various studies about socioeconomic factors of type 2 diabetes prevalence demonstrate that diabetes is more common among the most socially and economically deprived segments of the people (Dinca-Panaitescu et al., 2011; Demakakos et al., 2012; Raphael et al., 2003). For instance, individuals with lower income are more prone to a greater risk of type 2 diabetes in comparison with those who have higher incomes (Dinca-Panaitescu et al., 2011; Espelt et al, 2013).

However, despite the dominance of clinical factors in the explanation of the prevalence of type 2 diabetes, the statistics of recent years show that the frequency of the onsets of type 2 diabetes in middle-aged people with normal body mass index has been constantly increasing (WHO, 2015). This evidence is in contrast with the assertion that obese, older and physically inactive individuals are at a higher risk for type 2 diabetes development. It suggests that clinical factors do not fully explain the prevalence of type 2 diabetes. Therefore, a lack of explanation about how clinical factors are related to the incidence of type 2 diabetes provides a stimulus to expand the study of clinical factors with socioeconomic determinants of type 2 diabetes prevalence since it is equally important to acknowledge all risk factors for type 2 diabetes development in order to understand the differences in their influence and disease risk. This is why the two domains of risk factors deserve to be studied jointly.

The present study attempts to contribute to the discussion in the following ways. First, we apply a logistic regression methodology as it is widely used for analyzing and predicting the outcomes of a dependent variable. It allows us to reveal the effect of socioeconomic factors on the prevalence of type 2 diabetes. Second, we sequentially adjust a primary model with various behavioral and clinical determinants to capture the significance of effect of the major socioeconomic factors: income and educational level. Generally, the aim of this study is to estimate to what extent socioeconomic factors influenced the prevalence of type 2 diabetes in people aged 27 years and older in the Republic of Belarus between the years 2012 and 2014 and, also, analyze the contribution of the traditional clinical factors and other possible risk-mediators of the type 2 diabetes onsets.

Estimating the association between socioeconomic factors and the prevalence of type 2 diabetes may elucidate the association between socioeconomic determinants of type 2 diabetes onsets that in turn allows the potential findings reveal a more complex picture of the causes of the disease, and it contributes to the formulation of preventive diabetes programs and effective treatment management.

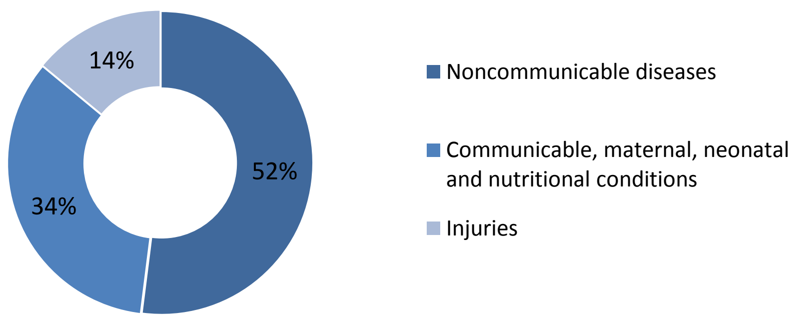
The thesis is structured as follows. Chapter 2 provides a brief description of the prevalence and economic burden of type 2 diabetes in the world. Chapter 3 presents the literature review on the socioeconomic determinants in the prevalence of type 2 diabetes. Chapter 4 introduces the dataset and presents summary statistics. Chapter 5 presents empirical methodology and describes the econometric model employed. Chapter 6 reports the empirical results of the analysis. Chapter 7 discusses the results, summarizes, concludes and provides motivation for further research. The Bibliography and Appendix are given in the end of the thesis.

Chapter 2

The prevalence and economic burden of type 2 diabetes in the world

Non-communicable diseases (NCD) are not only being increasingly recognized to be a major threat to health of humans but also to be a major cause of the economic burden in all income group countries: low, middle, and high. Diabetes mellitus, cardiovascular diseases, cancer, chronic respiratory disease are the largest sources of this burden, especially in the developed countries, where cardiovascular diseases account for more than one quarter of the total disease burden (WHO, 2015). In 2012 non-communicable diseases cause more than a half of all deaths: 52% of all deaths under the age 70 were due to NCDs, and two-thirds of those deaths were caused by chronic diseases such as: diabetes mellitus, cardiovascular diseases, cancer, and respiratory diseases.

Figure 2.1: Proportion of global deaths under age 70 by cause of death, 2012



Sources: World Health Organization, 2015

The increase in the non-communicable disease prevalence is caused not only by factors common to all countries—trends such as ageing, urbanization, and the globalization of unhealthy lifestyles, especially unhealthy nutrition, but also by the interaction between health, economic growth, and social development as a whole.

Type 2 diabetes mellitus, commonly known as diabetes, is one of the non-communicable metabolic disorders, which in recent decades affects a large number of adult individuals worldwide, and various studies assert that number of type 2 diabetics will continue to increase (Ballesta et al., 2006; Soriguer et al., 2011).

Table 2.1: Diabetes estimates in 2015

	2015	**2040**
Total world population	7.3 billion	9.0 billion
Adult population (20-79 years)	4.72 billion	6.16 billion
Type 2 diabetes (global prevalence)	8.8%	10.4%
Number of deaths due to diabetes	5.0 million	
Total expenditure due to diabetes, USD	673 billion	802 billion

Sources: Diabetes Atlas, 2015

Type 2 diabetes is a global health problem because of its high prevalence in developed and developing countries (Table 2.1), high treatment costs, premature disability and co-morbidities (Ruiz-Ramos et al, 2006). It leads to the decrease in productivity, diminished personal income, and increased inequality in labour access (Bloom et al., 2011).

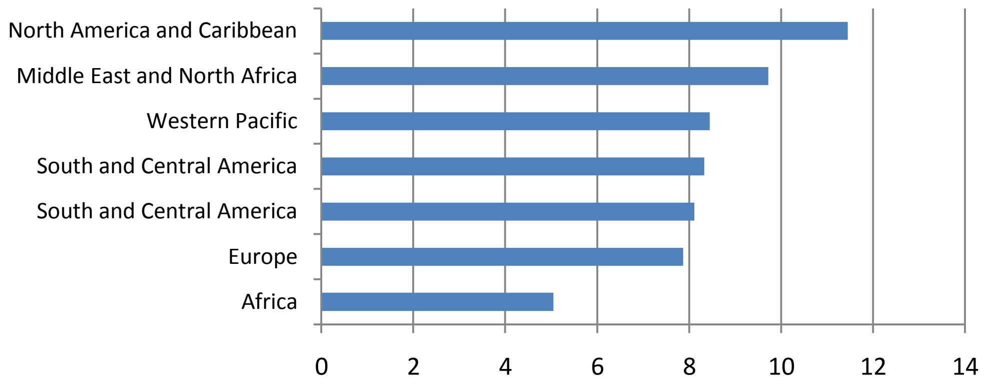
Table 2.2: Top 10 countries for number of people with diabetes (20 – 79 years), 2015 and 2040

Rank	**Country**	**Number of people with diabetes in 2015 (mln)**	**%**	**Rank**	**Country**	**Number of people with diabetes in 2040 (mln)**
1	China	109.6	7.9	1	China	150.7
2	India	69.2	5.8	2	India	123.5
3	United States of America	29.3	9.4	3	United States of America	35.1
4	Brazil	14.3	7.4	4	Brazil	23.3
5	Russian Federation	12.1	8.4	5	Mexico	20.6
6	Mexico	11.50	10.6	6	Indonesia	16.2
7	Indonesia	10	4.2	7	Egypt	15.1
8	Egypt	7.8	9.8	8	Pakistan	14.4
9	Japan	7.2	5.7	9	Bangladesh	13.6
10	Bangladesh	7.1	4.3	10	Russian Federation	12.4

Sources: Diabetes Atlas, 2015

Globally in 2015, about 415 million people, or 8.8% of the adults aged 20 – 79, had type 2 diabetes and this number is going on to rise to 642 million within the next twenty years (Diabetes Atlas, 2015). For many years diabetes mellitus was considered as “a disease of the wealthy” in high-income countries, however, the evidence of recent years shows that 77% of people with diabetes live in low- and middle-income countries, and the socially and economically disadvantaged people are the most vulnerable to the disease (Dinca-Panaitescu et al., 2011; Hwang and Shon, 2014). According to the diabetes forecast, the largest increases in diabetes onsets will be in the low- and middle-income countries (Diabetes Atlas, 2015).

Figure 2.2: Diabetes national prevalence (%), 2014



Sources: International Diabetic Federation, 2015

Even though, population ageing is one of the key contribution factors for the prevalence of type 2 diabetes (Dinca-Panaitescu et al., 2011), however, current epidemiological studies claim that there are 320.5 million people of working age diagnosed with diabetes, and 94.2 million among people aged 65–79 years (Diabetes Atlas, 2015). It evidences a considerable increase in the prevalence of diabetes among the middle-aged people.

Table 2.3: Age distribution of people with diabetes in 2015

Age range (year)	2015 Number of people with diabetes (mln)	2040 Number of people with diabetes (mln)	Increase, %
20-64	320.5	441.3	37.7
65-79	94.2	200.5	112.8

Sources: Diabetes Atlas, 2015

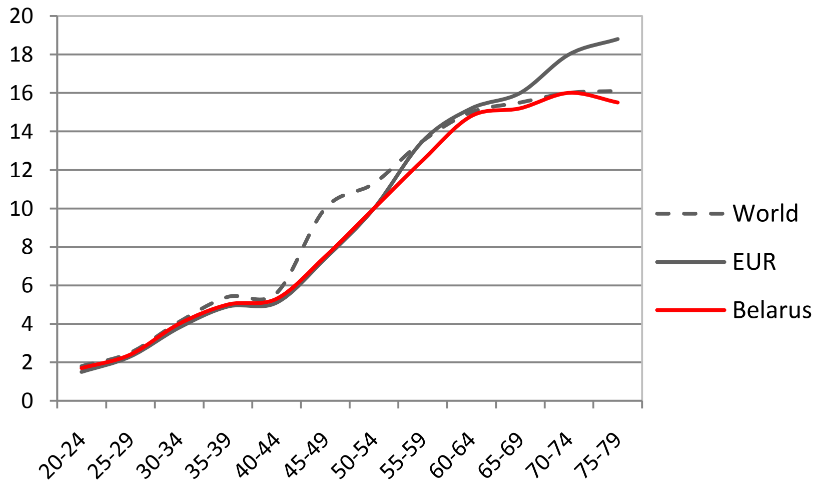
According to the gender distribution of diabetes there is a disparity with 15.7 million more men than women with diabetes: 215.2 million men versus 199.5 million women (Diabetes Atlas, 2015). However, women suffer higher direct and indirect costs of diabetes and its severe complications (Lesniowska et al., 2013). In the future, the age and gender distribution disparity are expected to decline.

More people with diabetes live in urban areas than in rural ones — 269.7 million versus 145.1 million, respectively (Diabetes Atlas, 2015). In low- and middle-income countries, the number of people with diabetes in urban areas is 186.2 million compared to 126.7 million people in rural ones. This disparity is to expand to 477.9 million people in urban areas and 163.9 million in rural ones (Diabetes Atlas, 2015).

In 2014, the prevalence of diabetes among adults in Belarus accounts for 467.6 thousand people or 6.3 % of the adult population (IDF, 2016). The prevalence of diabetes in Belarus is less than the world average: 6.3% versus 8.33% worldwide (Diabetes Atlas, 2015). The figure 2.3 shows which age groups of the population are diagnosed as having type 2 diabetes. In middle- and low-income countries adults under the age of 60 years are more often diagnosed with type 2 diabetes compared to the world average (Anjana et al., 2011; Hwang and Shon, 2014). Meanwhile, in high-income countries, a population over the age of 60 years makes up the largest proportion of diabetes prevalence (Diabetes Atlas, 2015).

Figure 2.3: Prevalence of diabetes in adults by age 2015 (%)

Belarus vs World



Sources: Diabetes Atlas, 2015

Diabetes is not a single disease; its chronic nature leads to the severe complications which affect the human body in different ways and often become chronic diseases themselves. They are the so-called diabetes co-morbidities. (Millett et al., 2007; Balabolkin, 2010). Therefore, high level of type 2 diabetes prevalence, its severe co-morbidities, and complications, premature disability and mortality, a progressively ageing population entail significant increases in the use of healthcare products and services, and, also, decrease in individuals' quality of life. In other words, economic and social burden will increase in the near future (Economic costs of diabetes in the U.S. in 2012, 2013).

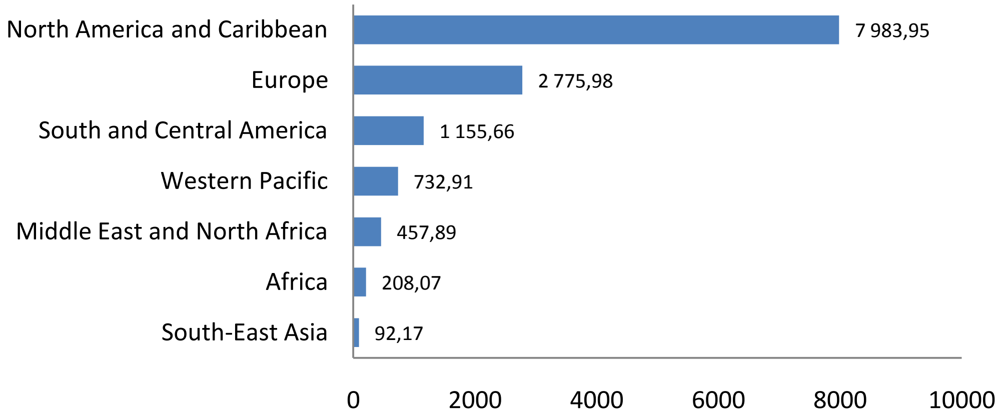
The economic burden of type 2 diabetes is not only related to direct healthcare costs, but also to indirect costs caused by loss of productivity due to premature disability, mortality and disability pention (Barcelo et al., 2003). Hence, recognizing that having a solid economy is more crucial in times of financial crisis, the study of the overall costs of type 2 diabetes, including what impact diabetes might have on economic growth seems to be undoubting today. Yet, the disease is essentially preventable, the economic burden and mortality rate from type 2 diabetes has been increasing since mid-1980s and today it is the eighth leading cause of death in the world according to the World Health Organization (WHO, 2015). In 2014, type 2 diabetes caused approximately 5 million deaths of individuals in age 20 – 79 worldwide (Diabetes Atlas, 2015) and it accounts for 14.5% of global all-cause mortality among people in this age group (Diabetes Atlas, 2015). In 2013 the number of deaths caused by diabetes exceeded the number of deaths from the infectious diseases: 1.5 million deaths from HIV/AIDS, 1.5 million – tuberculosis and 0.6 million – malaria (WHO, 2015). The highest number of deaths from diabetes occurred in countries with the largest numbers of people with diabetes: China, India, the USA and the Russian Federation (Diabetes Atlas, 2015).

Because of its chronic and incurable nature, the severity of manifestations such as skin and eye complications, and neuropathy (Millett et al., 2007), type 2 diabetes is a high cost disease which affects not only the health of the individual but requires constant medication, constant monitoring of blood sugar and periodically more technologically complicated tests and examinations, special diets, and lifestyle itself. As a result the expenditures on treatment and care are high and constantly escalating, which in turn, entail individual and health care providers to be under economic and social pressures (Currie et al., 2010).

The prevalence and economic burden of type 2 diabetes in the world

A recent research in the United States demonstrates that about 20% of medical costs are generated by the diabetes-related complications (Economic costs of diabetes in the U.S. in 2012, 2013). In 2014, global healthcare costs on diabetes accounts for 612 billion US dollars in healthcare expenditures alone (IDF, 2015). The mean diabetes-related expenditure in 2014 is shown in Figure 2.4. Meanwhile, healthcare expenditures due to type 2 diabetes are expected to increase by 12% by 2040.

Figure 2.4: Mean diabetes-related expenditure per person with diabetes (US dollar), 2014



Sources: International Diabetes Federation, 2016

Diabetes-related expenditures are not evenly distributed across age and gender groups (Zhang et al., 2010). About 75% of the global expenditures in 2010 were used for individuals in age 50 – 80 years old. Statistics show women spent more money on diabetes treatment compared to men (Zhang et al., 2010). There is also a disparity in healthcare expenditures on diabetes between countries. More than 80% of the global expenditures on diabetes were incurred in the high-income countries (Zhang et al., 2010). In the United States, diabetes-related expenditure account for 198 billion US dollars, or 52.7% of global expenditure. India, the country with the largest population of people living with diabetes, spent 2.8 billion US dollars, or less than 1% of the global total (Zhang et al., 2010). Moreover, in India diabetes is highly prevalent among the people with a high socioeconomic status (Corsi and Subramanian, 2012) while diabetes-related complications are higher among the low income people that may cause the increased economic burden of disease and in general (Tharkar et al., 2010).

Type 2 diabetes constitutes a considerable burden on the economy of each country in the form of increased treatment and care costs which push individuals into cycle of catastrophic expenditures and impoverishment (IDF, 2015). In general, the annual medical expenditures of people who are diagnosed with diabetes are around 2.3 times higher compared to those of people without the disease (ADA, 2016).

Thus, the rise in economic burden of type 2 diabetes results from (i) the increase in the number of diabetes incidence (IDF, 2015); (ii) the increase in the chronic diabetes-related of complications (Zhuo et al., 2013); and finally, (iii), the use of costly high-technology in diagnosis and treatment of the disease, especially in high-and upper-middle- income countries (Alexander et al., 2008).

From the above, it may be seen that a better understanding of the economic burden of diabetes and its risk factors may help in healthcare decision-making process aimed to reduce not only the economic burden of disease but also mitigate its consequences for society.

2.1 Direct and indirect costs of diabetes

Traditionally, the costs of any illness are separated into three cost groups: (i) direct costs are attributable to a disease and health conditions which are complications of diabetes (the costs of hospitalization, consultations, laboratory tests, detection, pharmaceuticals, and outpatient care); (ii) indirect costs are associated with the losses, first of all, in fall in the patient's productivity due to the diseases and the consequent permanent disability leading on to an early retirement, premature mortality and death; (iii) intangible costs arise from the changes in the quality of life of patients and careers as well (Henriksson and Jönsson, 1998). The direct costs of any disease mainly fall on the healthcare sector; indirect costs – to society and government; and intangible costs which mean adverse effects on quality of life and which are difficult to estimate, are borne by the individual (Mohan et al., 2004).

The direct costs which are estimated on a country-by-country basis are taken from the International Diabetes Federation (Diabetes Atlas, 2011). In 2010, diabetes cost the global economy almost 500 billion US dollars, and the figure will have been supposed to increase up to 745 billion US dollars by 2030 (Bloom et al., 2011). In 2010, in high-income countries which have about 26% of the total population of people with diabetes, the direct costs of diabetes account for 90% of the global costs (Bloom et al., 2011). In low- and lower-middle income countries with 40% of people with diabetes, the direct costs account for 1.7% (Bloom et al., 2011). The shift in cost structure is also projected: by 2030, the share of indirect costs can go up (Diabetes Atlas, 2011).

The American Diabetes Association estimated that in 2012 direct medical costs of people diagnosed with type 2 diabetes accounted for 306 billion US dollars; in other words, more than 1 of 5 US dollars was spent on medical care of diabetes (ADA, 2016). Diabetes related chronic complications lead to higher direct cost than diabetes per se (Jonsson, 2002). It is confirmed by the study conducted in Poland that the diabetic-related complication costs are more than five times greater than the costs of diabetes treatment; and these propensities correspond to the tendencies observed in other European countries (Lesniowska et al., 2013). In Belarus, diabetes costs are also very high matching those in many countries: the direct and indirect costs of type 2 diabetes and its complications constitute 429.41 US dollars per person in 2014 (Diabetes Atlas, 2015). Type 2 diabetes per se in Belarus accounts for 21% of the health care cost and 19% of the productivity loss (Public health in the Republic of

Belarus in 2014, 2015). In general type 2 diabetes in Belarus leads to a severe burden on the healthcare budget and personal wealth being.

The indirect costs are mostly attributed to society resulting in productivity loss because of inability to work caused by type 2 diabetes or its complications (Lesniowska et al., 2013). The empirical evidence demonstrates that indirect costs could be higher than the direct costs of type 2 diabetes, which therefore, cannot be ignored in healthcare decision-making policy (Lesniowska et al., 2013). In the 1998 study by the American Diabetes Association, the direct costs of diabetes in the US were estimated at 44 billion US dollars per year, compared with an indirect cost estimate of 54 billion US dollars (Economic costs of diabetes in the U.S. in 2002, 2003).

Table 2.1.1: Global cost of diabetes, 2010 (US dollar)

High-income countries currently pay most of the costs of diabetes…

Income Group	Direct Costs (bln)	Disability Costs (bln)	Mortality Costs (bln)	Direct Costs as % of World Total	Indirect Costs as % of World Total
High	341.5	41.7	5.8	90.8	49.8
Upper-Middle	28.1	33.1	2.1	7.5	36.8
Lower-Middle	6.0	11.3	0.8	1.6	12.6
Low	0.4	0.7	0.1	0.1	0.8
Total	376	86.8	8.8	100	100
		… but middle-income countries will take over in 2030			
High	123.6	54.3	7.2	25.4	24.1
Upper-Middle	55.8	131.9	9.5	11.5	55.4
Lower-Middle	294.5	44.8	4.4	60.6	19.3
Low	12.2	2.6	0.6	2.5	1.3
Total	486.1	233.6	21.6	100	100

Source: World Health Organization, 2015

The overall distribution of costs is projected to change: the direct costs from low and lower-income countries are expected to rise by 300 billion US dollars as the number of individuals with type 2 diabetes rapidly will increase next 15 years in these countries (WHO, 2015).

Chapter 3

Literature Review

Researchers define diabetes mellitus as one of the most prevalent, non-communicable diseases characterized by a chronic hyperglycemia – a condition that is commonly known as high blood sugar, occurring due to the insufficient production of insulin and leading to a lower quality of life and premature mortality (Deshpande et al., 2008; Kaku, 2010). Diabetes mellitus is currently classified into the following four forms based on aetiology: type 1 diabetes, which is usually diagnosed in childhood or early adulthood; type 2 diabetes is diagnosed in middle or old age representing the majority of all diabetic cases; gestational diabetes, which occurs during pregnancy; and other diabetic types that occur from genetic defects, drug or chemical use, infections, or other diseases (Balabolkin, 2010; Black, 2002). Around 90% of all people with diabetes are diagnosed with type 2 diabetes, 7% – have type 1 diabetes and 3% – have other types of diabetes in the world (Bruno et al., 2005).

Most of the researches in diabetes acknowledge the multifactorial nature of type 2 diabetes (Dinca-Panaitescu et al., 2011) demonstrating that type 2 diabetes is greatly dependent on a number of various factors: physical characteristics of patients, their socioeconomic status, family medical history, lifestyle and nutrition habits. Yet the estimates of the reasons of global rise in its prevalence are not unambiguous. Evidence on this issue can help to determine what the greatest risk of the type 2 diabetes onset are, which cohort of the population are at the higher risk group, and which variables have to be included in the analysis.

All risk factors of type 2 diabetes are classified into two categories: modifiable or non-modifiable, and in turn they are categorized into clinical and socioeconomic factors. It is within the capacity of the individual to delay or prevent if not reverse completely the onset of type 2 diabetes by resorting to abstention from smoking and excessive alcohol consumption, taking up greater physical mobility or activity, healthy eating, and the like. The non-modifiable risk factors beyond human control would be genetics, ethnicity, family history of diabetes, age and gender

(Public Health Agency of Canada, 2011). In 2013, Canadian Diabetes Association expanded the list of the modifiable risk factors for type 2 diabetes to include inability to manage blood pressure, cholesterol, and glucose levels (CDA, 2016).

Table 3.1: Risk factors of type 2 diabetes prevalence

Clinical factors	**Socioeconomic factors**
Ethnicity	Education
Genetics	Income
Aging	Region
Gender	Marital status
Family history of diabetes	Unhealthy nutrition
Chronic diseases (obesity, hypertension, impaired glucose tolerance etc)	Physical inactivity
	Smoking
Inability to manage blood pressure, cholesterol and glucose levels	Alcohol consumption

Source: Canadian Diabetes Association, 2016

Various studies dealing with the aetiology of type 2 diabetes assert that the disease is largely influenced by both modifiable and non-modifiable factors such as clinical characteristics of the patients, their socioeconomic status, family medical history and its increasing prevalence are mostly common among socially and economically deprived segments of the people (Dinca-Panaitescu et al., 2011). Analyzing the data provided by the Korea National Health and Nutrition Examination Survey, Hwang and Shon (2014) discover that type 2 diabetes is significantly more prevalent among physically inactive people with lower education and lower income. However, "…lower income was associated with a higher prevalence of type 2 diabetes in women while there was no significant relationship between income and type 2 diabetes in men". Similarly, Lee et al. (2011) find that lower educational attainment and income is strongly and significantly associated with increased prevalence of type 2 diabetes in women. In the light of this finding, Narayan et al. (2007) also conclude that socioeconomically disadvantaged people have higher risk of obesity, physical inactivity and chronic disease. However, Kim et al. (2015) find that socioeconomic determinants of the prevalence of type 2 diabetes do not have any significant effect on people aged 63 and above. The similar results have been found in a study by Corsi and Subramanian (2012) in India. The authors discover that income is not associated with the type 2 diabetes prevalence. In general, Mozaffarian et al. (2009) confirmed the dominance of modifiable factors and the changes in lifestyle habits, particularly, in dietary and physical activity as a whole may elucidate the rapid prevalence of type 2 diabetes.

Genetic factors are believed to play an essential role in the prevalence of type 2 diabetes. Various studies indicate that a wide prevalence of type 2 diabetes among certain ethnicities and races is associated with the genetic insulin secretion abnormality that makes ethnic groups to be more diabetes-susceptible (Unoki et al., 2008). Kaku (2010) finds that genetic abnormalities account for around 30% of the genetic factors of type 2 diabetes onsets. In other words, type 2 diabetes is associated with a combination of genetic factors causing impaired glucose tolerance and insulin resistance (Balabolkin, 2010; Kaku, 2010). Powers (2012) assert that ethnic differences in insulin sensitivity is caused by the differences in genetics. Kaku (2010) finds that the ethnic groups Hispanic and Asian, and Africans have more diabetes-sensitive genes and, therefore, type 2 diabetes is more prevalent among them. Similarly, Tran et al. (2013) in their research indicate that Asian immigrants in some Western countries have higher rates of diabetes than the native-born general populations. Jenum et al. (2012) confirm the findings of Tran et al. (2013) and claim that the prevalence of type 2 diabetes among the Vietnamese immigrants in Norway is higher than in native-born Norwegians in 2002. Hill et al. (2013) find the similar results which demonstrate that Hispanics are 66% more likely to develop type 2 diabetes, and non-Hispanic blacks have a 77% greater risk of developing in comparison with non-Hispanic whites. Type 2 diabetes is almost twice prevalent among African-American women in comparison with non-Hispanic white women (Mokdad et al., 2000).

Genetic susceptibility to type 2 diabetes development is clearly related to a family history of diabetes. The presence of any type of diabetes in family medical history increases risk for diabetes development in the next generation (Jahromi, 2011). Millward (1986) finds that "…the highest risk is naturally observed in monozygotic twins (100% sharing) followed by first, second, and third degree relatives (50%, 25%, 12.5% sharing, respectively)". Zafar et al. (2011) confirm the above-mentioned findings: family history of diabetes among close relatives is strongly associated with having diabetes, whereas family history of diabetes among distant relatives is not significant.

The age of the individual is one of the major risk factors for type 2 diabetes (Balabolkin, 2010). Dinca-Panaitescu et al. (2011) confirm that type 2 diabetes mellitus is still a disease of the elderly with 13.5% of people aged 60 and older are diabetes-diagnosed in comparison with 5.8% of 45 – 59 and 1.3% of people in age 30 – 44 in Canada. Moreover, there is no gender-difference in diabetes prevalence in population aged less than 60, but men aged 60 and older are at the higher risk being diabetic (Dinca-Panaitescu et al., 2011). Evidence from the KORA Survey 2000 among the elderly in Germany highlights the fact that the older the individual, the greater the risk for type 2 diabetes development and progression (Rathmann et al., 2005). Demakakos et al., (2012) find the same results for male and female populations in Great Britain. Results of the study by Rahmanian et al. (2013) also indicate a strong association between the type 2 diabetes prevalence and advancing age, from 4% in individuals between the ages of 30 and 39 to 22.9% in people aged 60 and older in Iran. The age of the individual has a highly significant effect on type 2 diabetes prevalence in Pakistan; older people are at a higher risk of developing diabetes mellitus (Zafar et al., 2011). Therefore, the ageing of the population contributes to a higher prevalence of type 2 diabetes both in developed and developing countries (Lipscombe and Hux, 2007; Sobers-Grannum et al., 2015; Zafar et al., 2011). However, these results are in conflict with the recent morbidity tendencies. A number of chronic diseases that was considered as age-related diseases has become middle-aged diseases and type 2 diabetes mellitus is in line with this phenomenon. Anjana et al. (2011) discover that the take-off point in age-specific weighted prevalence of type 2 diabetes is between age 25 and 34, and it declines from age 65 years and older. Hwang and Shon (2014) aver the similar results: "…a higher prevalence of diabetes, approximately 53.3%, was observed in respondents who were middle-aged (aged 45–64 years)". Kim et al. (2015) find that the level of income has a prominent effect on type 2 diabetes prevalence among individuals aged 30 – 64 years rather than among individuals aged 65 years and older. Lysy et al. (2013) confirm the findings of Kim et al. (2015) that type 2 diabetes prevalence in accordance to income is not equal among population: women and people aged less than 40 years old are the most vulnerable to the type 2 diabetes. Hence, type 2 diabetes has increased among people in age of below 50, in particular, in young women. This rise in diabetes prevalence is supposed to be due to an excessive rise in obesity among younger rather than among older adults (Lipscombe and Hux, 2007).

The majority of researches report that men have a greater or at least similar risk for type 2 diabetes compared to women, despite other clinical risk factors such as high age, obesity (Corsi and Subramanian, 2012; Njolstad et al., 1998). Tang (2003) asserts that the association between socioeconomic factors and the prevalence of diabetes is slightly higher among men rather than women: 6.6% versus 5.1%. The same results for the elderly were confirmed by Hwang and Shon (2014) in Korea. The type 2 diabetes prevalence is 10% higher in males than in females: 55.5% of men versus 45.5% of women (Hwang and Shon, 2014). Another survey on prevalence of diabetes in England in 2006 confirms a male predominance (Forouhi et al., 2006). However, the gender-specific weighted prevalence of type 2 diabetes is not convincingly unambiguous. Sobers-Grannum et al. (2015) find that Caribbean females are more likely to suffer type 2 diabetes. It suggests that women more often have obesity and they are more physically inactive. Larranaga et al. (2005) confirm results of the study by Sobers-Grannum et al. (2015): type 2 diabetes prevalence is weaker among men and stronger in women. Haghdoost et al. (2009) also indicate that type 2 diabetes is more common in women: the findings show that diabetes prevalence was 1.7% more among women than in men in Iran. Greater type 2 diabetes prevalence in females is also observed in other studies in different time and coutries as well (Malik et al., 2005; Musaiger, 1992; Sobers-Grannum et al., 2015).

The extensive number of studies capture body mass index as the most consistent and most strongly associated mediator risk factor of type 2 diabetes. Narayan et al. (2007) find that "overweight and especially obesity, particularly at younger ages, substantially increase lifetime risk of diagnosed diabetes, while their impact on diabetes risk, life expectancy, and diabetes duration diminishes with age". Lipscombe and Hux (2007) find a strong association between BMI and the prevalence of type 2 diabetes analyzing population-based geographically and ethnically diverse data: increase in obesity rates result in increase in the number of type 2 diabetics among Canadians. Later, the findings of Demakakos et al. (2012) confirm the results of the study by Lipscombe and Hux (2007): obesity in both men and women highly contributes to the prevalence of type 2 diabetes in Canada. Lee et al. (2011) find the same results demonstrating that BMI is a leading risk factor for type 2 diabetes prevalence using data from the Nurses' Health Study: "higher BMI is associated with elevated level of the prevalence of type 2 diabetes". Hwang and Shon (2014) also discovered the evidence of highly BMI-dependent type 2 diabetes in Korea. Furthermore, Kaku (2010) claims that even mild obesity causes a four- to five-fold increase in the risk of type 2 diabetes onsets. However, some results are gender-specific. Tang and Chen (2000) estimated that type 2 diabetes is more prevalent among individuals with overweight and, in accordance to gender, men are at higher risk for type 2 diabetes onset than women in Canada (60 versus 40%). It may be explained that men usually visit their dietitians less and they are less tried to lose weight.

Blood pressure is not commonly attributed to risk factor of being diabetic but it has a consistent effect on the prevalence of type 2 diabetes. Zafar et al. (2011) find a significant positive relation between both systolic and diastolic blood pressure and the prevalence of type 2 diabetes. Increased values of systolic and diastolic blood pressure increase the odds of the diabetes in 11.65 and 42.91 times more compared to normal subjects. Similar results are discovered in study of Shera et al. (2007). Kim et al. (2015) also assert that type 2 diabetes prevalence is less among individual with lower systolic blood pressure living in urban area. It suggests that, firstly, older people are at the higher risk cohort for being diagnosed with type 2 diabetes and they usually have more co-morbidities compared to the middle-aged, and, secondly, recently cardio-vascular conditions have become the leading disease worldwide.

Physical activity has captured the attention as a non-genetic risk factor for the development of type 2 diabetes which is largely associated with obesity. Obese BMI resulting from physical inactivity and unhealthy nutrition leads to insulin resistance, and finally it is resulted in the increase in the prevalence of type 2 diabetes among all ages (Balabolkin, 2010). Physically inactive people are more likely to have diabetes. Larranaga et al. (2005) find a clear association between physical activity and the prevalence of type 2 diabetes. Similarly, Kim et al. (2015) confirm that frequent and intensive physical activity is inversely associated with type 2 diabetes. Nevertheless, literature analyzing the relationship between physical activity and the prevalence of type 2 diabetes is controversial. Some researches indicate a significant impact of physical activity (Lynch et al. 1996), while other studies do not document such relationship (Njolstad et al., 1998). Zafar et al. (2011) confirm the study of Njolstad et al. (1998) and find that physical activity does not have any significant association with type 2 diabetes mellitus.

Smoking is a lifestyle risk factor for the prevalence of type 2 diabetes. However, there is no strong evidence that smoking contributes to such metabolic dysfunction as type 2 diabetes mellitus. De Cosmo et al. (2006) claim that smoking is associated with a low glomerular filtration rate, thus it may influence the risk of type 2 diabetes development. A similar association was reported by Kowall et al. (2010). Nevertheless, smoking contributes to the range of factors associated with type 2 diabetes. For example, smoking activate systematic inflammation resulting in type 2 diabetes and other endothelia disorder or toxic effect on pancreas, a result that is consistent with the higher risk of the prevalence of type 2 diabetes (Kowall et al., 2010). Thus from a pathophysiological point of view a relation between smoking and type 2 diabetes is consistent.

Alcohol consumption is another independent lifestyle predictor of the prevalence of type 2 diabetes. De Cosmo et al. (2006) claims that excessive alcohol consumption is associated with a higher prevalence of type 2 diabetes. These results are in line with the estimates of the Korean population by Hwang and Shon (2014).

Difference in an area of residence has a controversial effect in the existing literature. Anjana et al. (2011) find that "at every age interval, the prevalence of diabetes in urban areas was higher compared with rural areas". Ning et al. (2009) discover that Chinese population in urban area is more prone to diabetes mellitus. The results account for 19.2% (men) and 16.1% (women) in urban areas and 14.2% (men) and 13.8% (women) in rural areas. Corsi and Subramanian (2012) confirm that the prevalence of type 2 diabetes is higher in urban areas: 2.0% in urban versus 1.0% in rural. Similar empirical evidence was observed in the study by Hwang and Shon (2014): the prevalence of type 2 diabetes is higher among populations living in urban area, while individuals in rural area are less prone to have type 2 diabetes. However, Dinca-Panaitescu et al. (2011) indicate that the prevalence of type 2 diabetes is higher among the Canadians living in rural areas: 5.0% versus 4.5% in urban areas.

Although there is no strong evidence to consider marital status as a possible risk factor for type 2 diabetes, some studies assert significant association. Rahmanian et al. (2013) find that the prevalence of type 2 diabetes is not associated with marital status. In their study "no significant difference was observed in the prevalence of diabetes between the married and singles". However, other studies document that the singles including the divorced and widowed are significantly associated with the prevalence of type 2 diabetes. Dinca-Panaitescu et al. (2011) find that the higher prevalence of the type 2 diabetes was observed for the singles (widowed and divorced) rather than the partnered: 13.2% versus 5.3%.

Lower educational level populations have a higher prevalence of diabetes and greater mortality (Kanjilal et al., 2006). Furthermore, lower education is associated with an increased diabetes-related complications and hospitalization rate among individuals with type 2 diabetes (Booth and Hux, 2003). Rahmanian et al. (2013) confirmed the statistically significant inverse relation between type 2 diabetes and education. Their findings demonstrate that type 2 diabetes prevalence has the highest value in the low education segment – 17.9%, medium – 6.8% and high educational segment – 6.5%. These results are consistent with other studies. In the Hwang and Shon (2014) study, low education is associated with higher risk for type 2 diabetes. Espelt et al. (2013) analyzing sample of the European population over 50 years of age reported that the prevalence of diabetes is inversely associated with educational attainment. According to educational level, Kim et al. (2015) find that the inverse education-diabetes relation is more consistent than between income and diabetes. Lee et al. (2011) also indicate that diabetes decreases with an increase of education among women. A similar pattern in the prevalence of type 2 diabetes was claimed in study by Maty et al. (2005) which claims that people with 12 years education have 50% higher risk of being diabetes-diagnosed compared with more educated individuals. However, other researchers find no association between education and type 2 diabetes (Azimi-Nezhad et al., 2008; Hayashino et al., 2010; Rahmanian et al., 2013). Rahmanian et al. (2013) report no difference in the prevalence of diabetes in both men and women regardless of educational level.

In addition to education, income is the key socioeconomic factor significantly influencing type 2 diabetes prevalence. Hwang and Shon (2014) find that the lowest income is associated with a greater risk for type 2 diabetes among age-adjusted, gender-adjusted, BMI-adjusted, smoking and alcohol-adjusted models. “In the fully adjusted model individuals in the lowest income quartile were 35% more likely to have diabetes compared with those in the highest income quartile” (Hwang and Shon, 2014). Kim et al. (2015) as well find that income and the type 2 diabetes is inversely associated among people aged 30 year and older. Dinca-Panaitescu et al. (2011) claim that the prevalence of type 2 diabetes in the lowest income group is about 4,14 times higher than in the highest income group among the Canadian population, thus, the prevalence of type 2 diabetes decreases as income increases. Lysy et al. (2013) used a population-based study to estimate possible effect of income on the prevalence of type 2 diabetes. The authors find a significantly higher prevalence of type 2 diabetes among lower income groups of population. It may be supposed that individual with lower income may have more barriers to physical activity and healthy nutrition due to additional tangible and intangible costs.

Thus, it suggests that the prevalence of type 2 diabetes is concentrated among the most socioeconomically disadvantaged people (Demakakos et al., 2012; Dinca-Panaitescu et al., 2011). However, Corsi and Subramanian (2012) assert that “…the more well-off segments of the Indian population are at greatest risk” for type 2 diabetes. The finding of income-diabetes association is positive and statistically significant across all the states in India. Moreover, the income effect remains positive and consistent even in fully adjusted models, while caste and education effects are attenuated (Corsi and Subramanian, 2012). The finding of Maty et al. (2005) is consistent with the study of Corsi and Subramanian (2012) and indicates that “…income was also not associated with increased diabetes risk”.

Generally, it can be concluded that previous studies discover that the prevalence of type 2 diabetes is influenced by a huge range of interconnected economic, social, behavioral, cultural factors such as ageing, increasing urbanization, increased physical inactivity, increased sugar and fast food consumption and low consumption of fruit and vegetable, household income, and as a result its prevalence is mostly socially and economically disproportionated in all populations in developed and developing countries.

In order to study the connection between socioeconomic determinants and the probable type 2 diabetes prevalence, previous studies employed different models and datasets. Espelt et al. (2013) analyzed the dataset which contained information on health, socioeconomic position, and family networks of individuals aged ≥ 50 years from 11 European countries (Austria, Belgium, Denmark, France, Germany, Greece, Italy, Spain, Sweden, Switzerland and The Netherlands) in 2004 and 2006. A Poisson regression model with robust variance was employed for the analysis of age-adjusted and country-adjusted prevalence ratio and relative risk. Lysy et al. (2013) employed multivariable Poisson regression. The dataset contained individuals of the province of Ontario, Canada above the age 20 between April 1st 2006 and March 31st 2007.

Hwang and Shon (2014) employed a logistic regression to estimate the effect of socioeconomics characteristics on type 2 diabetes prevalence. The dataset used in the analysis contains a sample of 14,330 individuals from 30 to 65 and older in Korea. Larranaga et al. (2005) employed a logistic regression on the dataset obtained from a cross-sectional survey in Spain, a sample containing 65,651 individuals above 24 years. Lipscombe and Hux (2007) performed a logistic regression on population-based data of adults aged 20 and older in Canada. Rahmanian et al. (2013) estimated associations between type 2 diabetes and variables of age, sex, education and marital status in an Iranian urban population using binary logistic regression. Dinca-Panaitescu et al. (2011) used multiple logistic regression to analyze data covering approximately 98% of the Canadian population in age of 12 and over with regard to examine the relation between income and type 2 diabetes mellitus prevalence. Tang (2003) assessed the effects of socioeconomic factor on the prevalence of type 2 diabetes using multiple logistic regression models for men and women above 40 years of age separately. Dataset analyzed by Tang (2003) contained totally 39,021 subjects: 17,730 males and 21,291 females aged 40 and older in 1996 – 1997. Multiple logistic regression models were employed for males and females separately to estimate the effect of socioeconomic factors on the diabetes prevalence. Corsi and Subramanian (2012) used a dataset which contained 168,135 individuals aged 18 – 49 years (women) and 18 – 54 years (men) in India. They employed a multilevel logistic regression to estimate the probability of diabetes onsets. Le et al. (2011) conducted a cross-sectional survey in China from 2007 to 2010. They applied a multivariate logistic regression on the sample of 10,007 individuals aged 18 years and older. Kowall et al. (2010) employed a multivariate logistic regression models to estimate the association between smoking status and type 2 diabetes prevalence. The dataset contained 1,223 respondents at baseline and 887 respondents at follow-up aged 55–74 years between 1999 and 2001 in Southern Germany.

Krishnan et al. (2010) analyzed the data from the Black Women's Health Study which contained 46,382 Afro-American woman aged 30–69 in the United States. They employed clustered survival regression models to estimate type 2 diabetes incidence rate ratios.

Narayan et al. (2007) employed a Markov model to estimate lifetime risk of being diabetes diagnosed by age, race, sex, and BMI on the National Health Interview Survey data containing 780,694 respondents in the United States in 2004.

Mozaffarian et al. (2009) applied Cox proportional hazards models on the sample of 4,883 men and women aged 65 years or older to project the relative risk of diabetes incident. Lee et al. (2011) employed Cox proportional hazards models to estimate hazard ratios for incident type 2 diabetes on the dataset of 23,992 women obtained from the Women's Health Study. The study of Demakakos et al. (2012) employed the same regression to find the results. The authors used data from the English Longitudinal Study of Ageing and the analytic sample contained 7,432 women and men aged 50 and older.

In contrast to the previous analyses which have used clinical and socioeconomic determinants of the prevalence of type 2 diabetes separately, our study will be the first attempt to estimate socioeconomic and clinical factors jointly in the Republic of Belarus. The contribution of the study is expanding the clinical scope with socioeconomic factors of type 2 diabetes prevalence that would help to reveal a more complex picture of the causes of the disease.

Chapter 4

Data

4.1 Data description

The study used longitudinal data from the Diabetes Survey conducted by the Endocrinology Medical Center in Minsk[1] and the Ministry of Health of the Republic of Belarus in the period 2011 – 2015. The Diabetes Survey is the first health survey in the Republic of Belarus collecting information on a wide range of clinical, behavioural and psychological indicators, including as well socioeconomic characteristics of respondents and family medical history. This survey was designed to estimate probable risk factors for diabetes mellitus and pre-diabetes mellitus prevalence.

To achieve the aims of the thesis, the selection of independent variables is based on the various theoretical and empirical researches studying the association between socioeconomic status and the prevalence of type 2 diabetes. The dataset extracted for the analysis captures socioeconomic and clinical information about individuals in the resident population of Minsk and the Minsk province[2] in the period 2012 – 2014.

The total dataset younger than 27 years due to the aetiology and pathogenesis of type 2 diabetes which is diagnosed in middle or old age and representing the majority of all diabetic cases. Individuals diagnosed with pre-diabetes, type 1 diabetes and gestational diabetes (or other type of diabetes) are excluded from the sample, and observations reported with incomplete information have been dropped. Finally, some data are categorized in a study-specific approach, and in accordance with the results of the previous empirical studies on the prevalence of type 2 diabetes.

[1] Minsk is the capital of the Republic of Belarus with population 1,959,800 people in 2015.
[2] The population of the Minsk province is 1,417,400 people in 2015.

The final sample contains a total of 15,138 individuals: 6,436 males and 8,702 females aged between 27 and 101 years old living in Minsk and the Minsk province.

There are not any negative or extreme values as the data have been already cleared by the Endocrinology Medical Center in Minsk. It should be noted that respondents are not repeated over the interview, implying that the dataset consists of 15,138 unique observations.

4.2 Dependent variable

The dependent variable is a dummy variable which takes a value 1 if type 2 diabetes is diagnosed and 0 if type 2 diabetes is not diagnosed.

4.3 Independent variables

Independent variables are organized in two domains: clinical and socioeconomic characteristics of individuals. Clinical variables reflect the health status of individuals and consist of the following characteristics: family history of diabetes, BMI, age, gender and hypertension. Socioeconomic variables include educational level, income, region, marital status, and lifestyle of individual, i.e. physical activity, smoking, excessive alcohol consumption. Some independent variables have more than two alternatives, and then a series of dummy variables is created for the analysis. The number of dummy variables is one less than the number of alternatives. The reference category of variable is that category which has less probability to contribute to type 2 diabetes onsets.

4.3.1 Clinical factors

Family history of diabetes

The family history of diabetes is a dummy variable which takes the value 1, if the individual has diabetes among his/her close relatives, and 0 otherwise. Millward (1986) and Zafar et al. (2011) find that people with diabetes in their family medical history, especially among the first degree relatives are more likely to have type 2 diabetes. The findings of the previous study allow the assumption that the impact of family history of diabetes is obvious**.** It is expected that the results of estimation will show a positive correlation between dependent variable and family history of diabetes.

Gender

Gender is a dummy variable, which equals to 1 if the respondent is female and 0 if it is a male. Corsi and Subramanian (2012), Njolstad et al. (1998), Tang (2003) find that men have a greater or at least similar risk for type 2 diabetes onsets compared to women. On the contrary, Sobers-Grannum et al. (2015), Larranaga et al. (2005), Haghdoost et al. (2009) indicate that type 2 diabetes is more common in women. Women more often have obesity and they are more physically inactive and gestational type of diabetes could be diagnosed only in women. Thus, the gender effect is mixed. But we expect a positive sign of this variable, which will be in line with the studies of Sobers-Grannum et al. (2015), Larranaga et al. (2005), Haghdoost et al. (2009).

Age

Three categories of age have been considered: the young (27 – 44 years), the middle-aged (45 – 64 years) and the older (65 years and over). The young is taken as the reference category; the middle-aged equal to 1, if the age of the individual is in this age range and 0 otherwise; the older individual equals to 1, if the individual is aged 65 or older, and 0 otherwise. Balabolkin (2010), Dinca-Panaitescu et al. (2011), Rathmann et al. (2005), Demakakos et al. (2012) assert that type 2 diabetes mellitus remains a disease of the elderly people. The older the individual, the greater the risk for type 2 diabetes development and progression (Rathmann et al., 2005). However, these results are in conflict with the last 15-year morbidity tendencies. A number of chronic diseases, which were considered before as age-related diseases, became middle-aged diseases and type 2 diabetes mellitus as well became common among this age group (Anjana et al., 2011). It is attributed to an unprecedented rise in obesity among the younger population (Lipscombe and Hux, 2007). In Belarus, we expect that age has a significant influence on the probability of occurring type 2 diabetes.

Body Mass Index

Variable BMI is calculated and classified into four categories: underweight, normal, overweight, and obese. A series of three dummy variables is used to characterize BMI: obese ($BMI \geq 30\ kg/m^2$), overweight ($BMI\ 25 - 29.9\ kg/m^2$), normal ($BMI\ 18.5 - 24.9\ kg/m^2$), underweight ($BMI \leq 18.5\ kg/m^2$). Obese BMI takes the value 1 and 0 otherwise; overweight BMI takes 1 and 0 otherwise; normal BMI takes 1 and 0 otherwise. The underweight BMI is taken as a reference category. A positive sign of this variable is expected as being consistent with the various studies (Narayan et al., 2007; Demakakos et al., 2012; Hwang and Shon, 2014; Kaku, 2010). Even mild obesity causes a four- to five-fold increase in the risk for type 2 diabetes onsets (Kaku, 2010). In the main, obesity is caused by the lack of physical activity and unhealthy nutrition. Both these determinants also contribute to the type 2 diabetes development; moreover, they intensify the influence of each other.

Hypertension

Dummy variable hypertension takes the value 1 if the individual has a high level of both systolic and diastolic blood pressure and 0 otherwise. The hypertension is not commonly attributed to risk factor for the prevalence of type 2 diabetes. However, a consistent effect of this variable is observed in study of Zafar et al. (2011), Shera et al. (2007) and Kim et al. (2015): type 2 diabetes prevalence is less among individual with lower blood pressure. We expect to get the same effect in the analysis as there are two leading tendencies in health in Belarus according to WHO: (i) the ageing of the population and (ii) increase in cardio-vascular conditions. Hence, older people are more likely to have hypertension and they are at the higher risk cohort for being diagnosed with type 2 diabetes.

4.3.2 Socioeconomic factors

Education

Information on the educational attainment is classified with accordance to the International Standard Classification of Education 2011. The variable representing educational level is considered as the following categories: lower secondary education, upper secondary education, and tertiary education. Education is measured using two dummy variables: upper secondary education taking 1, if individual has such level of education and 0 otherwise; tertiary education is 1, in case the education level of individual is tertiary and 0 otherwise. Lower secondary education is a reference category. Various studies allow the conclusion that the influence of education is mixed. Espelt et al. (2013), Hwang and Shon (2014), Kanjilal et al. (2006), Lee et al. (2011), Rahmanian et al. (2013) discover the statistically significant inverse relation between type 2 diabetes and education, that is, lower educational level populations have a higher prevalence of diabetes and greater mortality. But on the other hand, Azimi-Nezhad et al. (2008), Hayashino et al. (2010) find no difference in the prevalence of diabetes in both men and women regardless of educational levels. In the Republic of Belarus, we expect a negative sign of the variable, the more educated people tend to take care more of their health.

Income

Variable income indicates the monthly wage of individuals in Minsk and the Minsk province (Belarus). Belarus is an upper-middle income country with average monthly wages of 595.3 US dollars in 2012, 577.9 US dollars in 2013, and 447,8 US dollars in 2014 (National Statistical Committee of the Republic of Belarus, 2016). Monthly income of the individuals is reported in three categories: less than 500 US dollars, 500 – 1000 US dollars, and over 1000 US dollars. These categories are reflected in the average monthly wage in Belarus and self-reported wage range of participants. Middle income level equals to 1, if an annual income level is 500 – 1000 US dollars and 0 otherwise; high-level income is defined as over 1000 US dollars and variable equals to 1 and 0 otherwise. Low-level income, less than 500 US dollars, is a reference category. Hwang and Shon (2014), Kim et al. (2015), Dinca-Panaitescu et al. (2011), Lysy et al. (2013) assert that the prevalence of type 2 diabetes is higher among lower income groups of population. Individuals with lower income in comparison with people with higher income have more barriers to physical activity, healthy nutrition, and to the access to information due to additional tangible and intangible costs. The negative influence of this variable is supposed.

Region

Dummy variable region takes the value 1 if individual lives in urban area and 0 if – in rural area. The prevalence of diabetes in urban areas is higher in comparison with its prevalence in rural area (Anjana et al., 2011). Similar empirical findings are observed in study by Ning et al. (2009), Corsi and Subramanian (2012), Hwang and Shon (2014). We expect the same effect as found in above-mentioned studies. On the contrary, Dinca-Panaitescu et al. (2011) find opposite results: the Canadians living in rural areas are more likely to be diagnosed with type 2 diabetes compared to those who live in urban area.

Marital status

Variable marital status is categorized into single and married status; moreover, the single category includes the divorced and the widowed. It is a dummy variable which takes the value 1 if individual is married and 0 if he/she is single. Although there is no strong evidence to consider marital status as a possible risk factor for type 2 diabetes, some studies assert a significant association between the diabetes prevalence and the marital status (Dinca-Panaitescu et al., 2011). But Rahmanian et al. (2013) find that there is no significant difference in the prevalence of type 2 diabetes between the married or the singles. However, Dinca-Panaitescu et al. (2011) assert that the singles are at the greater risk for being type 2 diabetics compared to the married. We suppose the same effect of this variable in the analysis.

Physical activity

Variable physical activity will be presented as a series of two dummy variables. Dummy variable physical activity takes the value 1 if individual has physical activity and 0 otherwise. In case of positive respond, physical activity is categorized into moderate and intense physical activities and another dummy variable for physical activity will take place taking the value 1 if intensive, and 0 if moderate. From the various studies, it may be concluded that physically inactive people are more likely to have type 2 diabetes (Balabolkin, 2010; Kim et al., 2015; Larranaga et al., 2005; Lynch et al., 1996). We expect a negative sign of this variable which is in line with previous studies. It is supposed that obese BMI resulted from physical inactivity which leads to the increase in the prevalence of type 2 diabetes. Nevertheless, Njolstad et al. (1998) do not document significant "physical activity-diabetes" relationship. Zafar et al. (2011) confirm the study of Njolstad et al. (1998) and find that physical activity does not have any significant association with type 2 diabetes mellitus.

Smoking

Variable smoking is a dummy variable which equals to 1 if individual smokes currently and 0 if he/she does not smoke. There is no strong evidence that the effect of smoking contribute to such metabolic dysfunctions as type 2 diabetes mellitus. Nevertheless, De Cosmo et al. (2006) claim that smoking is associated with a low glomerular filtration rate, thus it may influence the risk of type 2 diabetes development. We expect a positive effect of this variable because smoking contributes to the occurrence of the range of factors associated with type 2 diabetes, for example, smoking activates endothelia disorder and pancreatitis (Kowall et al., 2010).

Excessive alcohol consumption

Dummy variable alcohol consumption takes the value 1 if individual has excessive alcohol consumption and 0 if otherwise. Excessive alcohol consumption is defined as consumption of four cups of alcohol in a day and more often than three times a week. We expect a positive sign of this variable which is consistent with the studies of De Cosmo et al. (2006) and Hwang and Shon (2014): excessive alcohol consumption is associated with a higher risk for prevalence of type 2 diabetes.

Table 4.3.1: Expected sign of independent variables

Variable	Categories	Expected sign
Family history of diabetes	Yes/No	+
Gender	Male/Female	+
Age (year)	27 – 44	
	45 – 64	+
	65 and over	
BMI	Obese ($BMI \geq 30\ kg/m^2$)	
	Overweight ($BMI\ 25 - 29.9\ kg/m^2$)	+
	Normal ($BMI\ 18.5 - 24.9\ kg/m^2$)	
	Underweight ($BMI \leq 18.5\ kg/m^2$)	
Hypertension	Yes/No	+
Education	Lower secondary education	
	Upper secondary education	-
	Tertiary education	
Income	Low income level (less than 500 US dollars)	
	Middle-level income (500 – 1000 US dollars)	-
	High-level income (over 1000 US dollars)	
Region	Urban/Rural	+
Marital status	Married/Single	+/-
Physical activity	Intensive/Moderate	-
Smoking	Yes/No	+
Alcohol consumption	Excessive alcohol consumption (4 cups of alcohol in a day and more than three times a week)	+

Source: Author’s assumption

4.4 Summary statistics

The correlation matrix of the independent variables is presented in the Appendix A (Table A.1). There is no strong correlation among independent variables, only temperate positive relationships between family history of diabetes and hypertension; education and income are documented. The rest of variables do not report other statistically significant relation. Table 4.4.1 provides summary statistics of dependent and all independent variables.

Table 4.4.1: Summary statistics

	Obs	Mean	Std. Deviation	Minimum	Maximum
Type 2 diabetes	15138	.0744419	.0121957	0	1
Age	15138	51.93249	21.64622	27	101
Gender	15138	.5748197	.5000008	0	1
Marital status	15138	.7592073	.5000159	0	1
Region	15138	.6811891	.5000151	0	1
Education	15138	.7182825	.4154693	0	1
Monthly income (US dollar)	15138	707.577	439.1137	132	2010
Family History of Diabetes	15137	.05623596	.4961124	0	1
Body Mass Index	15138	28.21213	10.38098	15.00042	47.99773
Hypertension	15138	.3274742	.2934893	0	1
Excessive Alcohol Consumption	15138	.1125631	.2965616	0	1
Smoking	15138	.27530493	.4653034	0	1
Physical Activity	15136	.4245587	.4999957	0	1

Source: Author's computations

In conclusion, a summary of the main issues is presented below.

· Out of the whole sample 7.4% of respondents are diagnosed with type 2 diabetes, and accordingly 92.6% individuals are not.

· The average age of individual is 52 years, with oldest individual being 101 and the youngest 27 years old. Average age among women is 52.1 and men – 51.8 years.

· The gender proportion of the sample is 43% for male, and 57% for female.

· On average 76% of respondents are married.

· 68% of individuals live in urban area and only 32% are from the rural area.

· In general, education attainment is on average upper-secondary level. And according to the Table 4.4.2 females have higher educational level compared to males.

· Summary statistics reports that 5.6% of individuals have diabetes mellitus in their family history of health.

· Almost 33% of individual have hypertension.

· Average monthly income of individuals in the sample is higher than the average income in Belarus and equals to 707 US dollars.

· On average 11% of individuals have excessive alcohol consumption rate.

· Average BMI in the sample is 28 kg/m^2.

· On average, 27.5% of individuals smoke and 42% of them are physically active.

Table 4.4.2: Summary statistics by gender – mean and number of observations

	Males		Females	
	Obs	**Mean**	**Obs**	**Mean**
Type 2 diabetes	6436	.0851782	8702	.0637056
Age	6436	51.79854	8702	52.06643
Marital status	6436	.817598	8702	.700817
Region	6436	.654872	8702	.707506
Education	6436	.618752	8702	.8157813
Monthly income (US dollar)	6436	756.97	8702	658.18
Family History of Diabetes	6436	0.05487	8702	0.057602
Body Mass Index	6436	29.5978	8702	26.81642
Hypertension	6436	.301457	8702	.353491
Excessive Alcohol Consumption	6436	.174587	8702	.050539
Smoking	6436	.297854	8702	.252756

Source: Author's computations

Chapter 5

Methodology

To analyze the influence of socioeconomic and clinical characteristics on the prevalence of type 2 diabetes, a logistic regression models with sequential adjustments for clinical and socioeconomic variables have been employed. The first model examines the relationships between the prevalence of type 2 diabetes and socioeconomic factors excluding socioeconomic behavioral (lifestyle) factors. The second model has been adjusted for socioeconomic behavioral factors to estimate the same relationships. Finally, the third model is fully adjusted for clinical factors.

Logistic regression is a statistical method which is well suited to model the outcomes of a categorical outcome variable. In the logistic regression model the categorical outcome is measured with a binary or dichotomous variable and it is conventionally coded as 1 or 0 to represent categories (Seltman, 2015). In the given study, binary outcome variable is modeled as: being diagnosed with type 2 diabetes or not diagnosed with type 2 diabetes that is as follows:

$$D_i = \begin{cases} 1 \; if \; yes \\ 0 \; if \; no \end{cases}. \tag{5.1}$$

In the study, categorical outcome variable depends on a range of clinical and socioeconomic characteristics of individuals such as age, gender, body mass index, hypertension (high blood pressure), family history of diabetes, income, educational level, region, marital status, physical activity, smoking and excessive alcohol consumption as well as on an error term.

The logistic model is:

$$D_i = \beta_o + \beta_{x_i} x_i + \beta_{q_i} q_i + \varepsilon_i, \tag{5.2}$$

where βs are the parameters of the model; x_i is a matrix of the socioeconomic characteristics of patients; q_i is a matrix of the clinical characteristics of individuals; i is an index of patients and ε_i is the error term.

The error term is assumed to be distributed logistically, with $Var(\varepsilon) = \frac{\pi^2}{3}$ (Long and Freese, 2006) and the binary logit model with the equation (5.2) is constructed as follows:

$$Prob(Y = 1|x, q) = \frac{e^{\beta_o + \beta_{x_i} x_i + \beta_{q_i} q_i}}{1 + e^{\beta_o + \beta_1 x_i + \beta_2 q_i}} \tag{5.3}$$

The results are interpreted using a measure of association called the odds ratio because in the binary logit model the probability on the left-hand side is between 0 and 1, but the predictors on the righ-hand side may take any real value. In order to have predictions between 0 and 1, the logit transformation should be applied. Nevertheless the coefficients of categorical predictors are reported as well to demonstrate the association between coefficients and the odds ratio.

The odd ratio is defined as a measure of association which "… approximates how much more likely (or unlikely) it is for the outcome to be present among those with $x = 1$ than among those with $x = 0$" (Hosmer and Lemeshow, 2004). Specifically, the odds ratio is the ratio which reports association between and exposure and an outcome.

$$\Omega = \frac{\Pr(y = 1)}{\Pr(y = 0)} = \frac{\Pr(y = 1)}{1 - \Pr(y = 1)} \tag{5.4}$$

Consider a logit model with the equation (5.2):

$$\ln\left\{\frac{\Pr(y = 1|x)}{1 - \Pr(y = 1|x)}\right\} = \ln \Omega(x) = \beta_o + \beta_{x_i} x_i + \beta_{q_i} q_i \tag{5.5}$$

then

$$\Omega(x, x_i) = e^{\beta_o} e^{\beta_{x_i} x_i} e^{\beta_{q_i} q_i} \tag{5.6}$$

Let x_i changes by 1

$$\Omega(x, x_i + 1) = e^{\beta_o} e^{\beta_{x_i}(x_i + 1)} e^{\beta_{q_i} q_i} = e^{\beta_o} e^{\beta_{x_i} x_i} e^{\beta_{x_i}} e^{\beta_{q_i} q_i} \tag{5.7}$$

then odds ratio:

$$OR = \frac{\Omega(x, x_i + 1)}{\Omega(x, x_i)} = \frac{e^{\beta_o} e^{\beta_{x_i} x_i} e^{\beta_{x_i}} e^{\beta_{q_i} q_i}}{e^{\beta_o} e^{\beta_{x_i} x_i} e^{\beta_{q_i} q_i}} = e^{\beta_{x_i}} \tag{5.8}$$

In other words, the exponential function of the regression coefficient is the odds ratio which is associated with a one-unit change in the exposure (Hosmer and Lemeshow, 2004). The given relation between the coefficient of categorical independent variable and the odds ratio make logistic regression to be one of the widely-used analytical tools. The odds ratio has a multiplicative effect, this means that "positive effects are greater than one and negative effects are between zero and one" (Long and Freese, 2006).

As the logistic regression predicts probabilities rather than just classes, the parameters of the binary logit model are typically estimated by the maximum likelihood method which is preferred in comparison with other methods, for example, the weighted least squares approach (Schlesselman and Stolley, 1982). The likelihood is then:

$$L(\beta_0, \beta) = \prod_{i=1}^{N} F(x_i\beta)^{y_i}\left(1 - F((x_i\beta)^{1-y_i})\right) \tag{5.9}$$

In general, the maximum likelihood method is designed to select the set of values of the model parameters that maximizes the likelihood function.

The log-likelihood function:

$$\ln L(\beta) = \sum_{i=1}^{N}\left[Y_i \ln F(x_i\beta) + (1 - Y_i)\ln\left(1 - F(x_i\beta)\right)\right] \tag{5.10}$$

The maximum likelihood estimation principle claims that, "…the value that makes the likelihood of the observed data largest should be chosen" (Wooldridge, 2008). In other words the higher the ratio, the better the fit of the model with the predictors (Peng and So, 2002).

For years, among different measures it has been assumed that the Cox-Snell R^2 is preferred over others R^2s, and even over the McFadden's R^2 as well, but Allison (2009) believes that McFadden's R^2 "is a better choice". However, he also supports another R^2 with good properties.

In our analysis the McFadden's R^2 measure of fit is used for evaluation of the goodness of fit of the binary logit model:

$$R_{McF}^2 = 1 - \frac{\ln(L_M)}{\ln(L_0)} \quad (5.11)$$

where L_0 is the value of the likelihood function for a model with no predictors; L_M is the likelihood function for the estimated model being; $\ln(.)$ is the natural logarithm.

Another measure to evaluate the overall performance of the logit regression model is focused on the predictive accuracy of the model. In general the predictive accuracy shows the percentage of correctly classified observations. In particular it comprises sensitivity, specificity, positive predictive value and negative predictive value (Peng and So, 2002).

"A prediction is classified as positive if, $p_j \geq c$ and otherwise is classified as negative. The classification is correct if it is positive $y_j = 1$ and or of it is negative and $y_j = 0$. Sensitivity is the fraction of $y_j = 1$ observations that are correctly classified. Specificity is the percentage of $y_j = 0$ observations that are correctly classified" (Stata, 2015). The predictive accuracy of the logit regression model is calculated from the classification table. It is worth noting that "the classification table is most appropriate when classification is a stated goal of the analysis; otherwise it should only supplement more rigorous methods of assessment of fit" (Hosmer and Lemeshow, 2004).

In addition, to evaluate goodness of fit for the logistic regression, the Hosmer-Lemeshow test is employed. The Hosmer-Lemeshow test suggests that observed and predicted numbers have to match closely, i.e. "null hypothesis of a good model fit to data is tenable" (Peng et al., 2002):

$$HL = \sum_{g=1}^{G} \frac{\left(n_g \bar{y}_g - n_g \bar{\pi}_g\right)^2}{n_g \bar{\pi}_g \left(1 - \bar{\pi}_g\right)} \quad (5.12)$$

A good fit to the data is considered when low values with high p-value while high values with low p-values $p < 0.05$ indicate a poor fit (Peng et al., 2002). The advantage of the Hosmer-Lemeshov test is that "… it provides a single, easily interpretable value that can be used to assess fit" (Hosmer and Lemeshow, 2004). However, the Hosmer-Lemeshow test should be employed with caution, since this measure greatly depends on the process of grouping (the number of chosen groups), then "…an important deviation from fit due to a small number of individual data points may be missed" (Hosmer and Lemeshow, 2004). Hence, it may be a great disadvantage. Generally "it is better to think of this statistic as a guide to assessing the fit of a model rather than a formal test" (Long and Freese, 2006).

Chapter 6

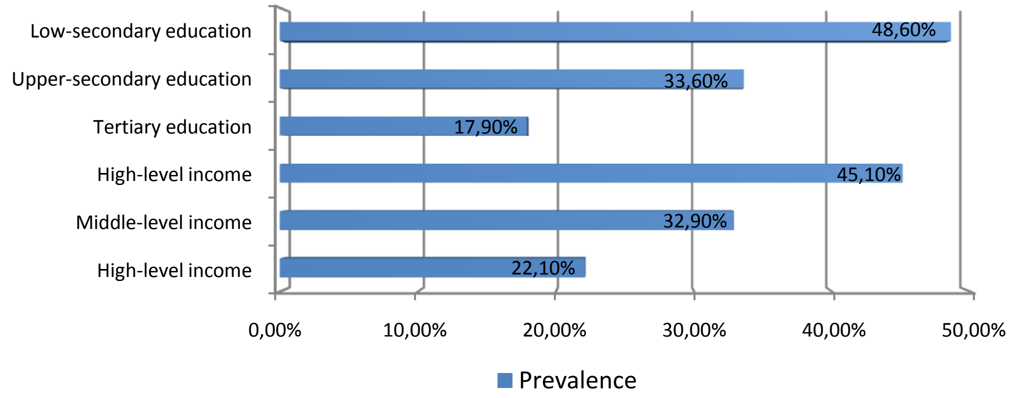
Results

A logistic regression model was employed to study the data to test the research hypothesis in order to find out what socioeconomic determinants may explain the prevalence of type 2 diabetes. The logistic regression analysis is carried out using Stata, and the results are reported in terms of odds ratio with 95% confidence intervals. Differences are considered significant at $p < 0.05$.

The socioeconomic and clinical characteristics of 15,138 individuals are listed in Table 6.1. Among the estimated respondents aged over 27 years, 1,127 individuals (7.4%) are reported as being type 2 diabetics with slightly higher prevalence in males than among females (621 versus 506). Across age characteristics, a higher prevalence of type 2 diabetes, about 62.1%, is observed among the population aged 65 years old and over. In relation to BMI and physical activity, type 2 diabetes is more than 2 times prevalent in the obese BMI range compared to normal BMI and also 2.2 times more frequent among physically inactive respondents (69% versus 31%).

With respect to income and education, the prevalence of type 2 diabetes is higher among individuals with lower educational levels (48.1% versus 17.9% in tertiary education group) and lower income (45.1% versus 22.1% in high income range). Hence, the inverse relationship between both educational attainment and income and the type 2 diabetes prevalence is identified.

Figure 6.1: Type 2 diabetes prevalence by income and educational level groups



Of the individuals with type 2 diabetes, 48.8% have hypertension and 31% have diabetes in their family health history. A higher prevalence of type 2 diabetes is found in urban population than in rural (52.1% versus 47.9%) and among the married rather than single (64.4% versus 35.4%). The prevalence of type 2 diabetes is similar in respect to the two lifestyle factors: smoking and excessive alcohol consumption—approximately 33.3% respondents with type 2 diabetes are smoker and 18.9% have excessive alcohol consumption rate. Thus, type 2 diabetes is more prevalent in non-smoking and non-excessive drinking group of individuals (66.7% and 81.9 % respectively).

Table 6.1: General characteristics of the prevalence of type 2 diabetes

Characteristic	Sample	Sample with type 2 diabetes	%
	15138	1127	7.4%
Gender			
Male	6436	621	55.1%
Female	8702	506	44.9%
Age			
Young (27 – 44)	4254	59	5.2%
Middle-aged (45 – 64)	6252	369	32.7%
Older (65 years and over)	4632	699	62.1%
BMI			
Underweight	878	26	2.3%
Normal	7175	215	19.1%
Overweight	4057	316	28.1%
Obese	3028	569	50.5%
Family history of diabetes			
Yes	851	350	31.0%
No	14287	777	69.0%
Hypertension			
Yes	4957	550	48.8%
No	10181	577	51.2%
Education			
Lower secondary	4731	547	48.6%
Upper secondary	5310	378	33.6%
Tertiary	5097	201	17.9%
Income			
Low-level income	5197	508	45.1%
Middle-level income	7122	370	32.9%
High-level income	2819	249	22.1%
Region			
Rural	4826	540	47.9%
Urban	10312	587	52.1%

Characteristic	Sample	Sample with type 2 diabetes	%
Marital status			
Single	3645	399	35.4%
Married	11493	728	64.6%
Physical activity			
Yes	6427	349	31.0%
Yes (moderate)	1887	242	21.4%
Yes (intensive)	4540	108	9.6%
No	8711	778	69.0%
Smoking			
Yes	4168	375	33.3%
No	10970	752	66.7%
Excessive Alcohol consumption			
Yes	1704	213	18.9%
No	13434	914	81.1%

Source: Author's computations

Table 6.2 summarizes the results of logistic regression analysis of the prevalence of type 2 diabetes. Across all the models, odds ratio of being diagnosed with type 2 diabetes is negatively related to educational attainments. Although the association between the prevalence of type 2 diabetes and education level is slightly reduced with sequential adjustments with socioeconomic, behavioral factors (Model 2) and clinical factors (Model 3) educational level remains a significant factor contributing to type 2 diabetes prevalence. In the fully adjusted model, the odds of being diagnosed with type 2 diabetes decrease by 22.7% $(100 * (\exp^{-0.25748} - 1))$, if individuals have upper secondary education compared with those who have lower secondary education, holding all other variables constant. The similar effect is observed for individuals with tertiary education: the prevalence of type 2 diabetes in this educational level group is 45.6% less than in upper secondary education group, holding all other variables constant. All levels of income are significantly associated with the prevalence of type 2 diabetes, demonstrating a clear gradient from the low to high income levels among both males and females. In the fully adjusted model, if individuals have a middle-level income as opposed to low-level income, the odds of type 2 diabetes are 50.5% less, holding other variables constant. In addition to the middle-income level, the odds of the prevalence of type 2 diabetes in the high-income group are 74.5% less in comparison to group of individuals with low-level income, holding all other variables constant. The results of all models show that people living in urban areas are slightly more prone to have type 2 diabetes than individuals from rural areas with 8.1% odds of type 2 diabetes prevalence in Model 1; 7.3%–in Model 2, and 3.7%–odds in Model 3, holding all other variables constant. Type 2 diabetes is more prevalent among married people rather than among those who are single, widowed or divorced. According to the estimates of the fully adjusted model, married people are 44.9% more likely to be type 2 diabetics, holding all other variables constant.

In the patient behavior-adjusted model (Model 2), physical activity is associated with a lower prevalence of type 2 diabetes in both men and women: totally physically active individuals are 27.6% less likely to have type 2 diabetes, and those who have intensive physical activity are 48.9% less prone to the type 2 diabetes, holding all other variables constant. The odds ratio of this variable in Model 3 has slightly decreased; however, it is significant and confirms the finding of the previous model that physical inactivity is a significant risk factor for type 2 diabetes.

The results of the Model 2 and Model 3 confirm the findings of previous studies that there is no significant relationship between smoking and type 2 diabetes prevalence. People with high-risk drinking behavior are 11.3% more likely to have type 2 diabetes as estimated in Model 2, holding all other variables constant. The value of odds in the clinically-adjusted model (Model 3) has decreased a little and it accounts for 8.4%, holding all other variables constant.

The influence of clinical factors on the prevalence of type 2 diabetes is highly significant. According to the fully adjusted model, the odds of having type 2 diabetes are 41.3% less in females than in males, holding all other variables constant.

Across Model 3, the odds of having type 2 diabetes are positively related to age and positively related to BMI. In other words, the higher the age or BMI, the more likely it is that an individual would be a type 2 diabetic. In the study, the odds of onset of type 2 diabetes are 38.2% higher among middle-aged people compared to the young, holding all other variables constant. This trend is found among older people who are 73% more likely to have type 2 diabetes with reference to the young, holding all other variables constant. All values of BMI are significantly associated with onset of type 2 diabetes, showing that among overweight or obesity individuals BMI as opposed to underweight BMI, the odds of the onset of type 2 diabetes increase by 76.1% and 175% respectively, holding all other variables constant.

Among the all clinical factors, family history of diabetes is the second most significant risk factor for the prevalence of type 2 diabetes. Family history of diabetes is associated with 24.5% increased in odds of being diagnosed with type 2 diabetes, holding other variables constant. In addition to age, BMI and family history of diabetes, variable hypertension is significant and positively related to dependent variables. Individuals with hypertension in their anamnesis have 6.6% larger odds of the onset of type 2 diabetes, holding all other variables constant.

Table 6.2: Results of multivariate logistic regression analysis for the prevalence of type 2 diabetes

	Model 1					**Model 2**					**Model 3**				
	Coef.	**Odds ratio**	**P-value**	**95% Conf. Interval**		**Coef.**	**Odds ratio**	**P-value**	**95% Conf. Interval**		**Coef.**	**Odds ratio**	**P-value**	**95% Conf. Interval**	
Education[1]															
Upper secondary	-0.197	0.821	<0.001	0.721	0.973	-0.208	0.812	<0.001	0.700	0.965	-0.257	0.773	<0.001	0.635	0.944
Tertiary	-0.442	0.643	<0.001	0.541	0.825	-0.472	0.624	<0.001	0.501	0.751	-0.609	0.544	<0.001	0.441	0.693
Income[2]															
Middle-level income	-0.635	0.530	0.000	0.411	0.661	-0.664	0.515	0.000	0.322	0.741	-0.704	0.495	0.000	0.293	0.714
High-level income	-1.143	0.319	0.000	0.223	0.515	-1.268	0.281	0.000	0.140	0.433	-1.367	0.255	0.000	0.091	0.366
Region															
Urban	0.078	1.081	0.002	1.012	1.221	0.070	1.073	0.002	1.011	1.184	0.036	1.037	0.002	1.012	1.166
Marital status															
Married	0.454	1.575	0.002	1.318	1.899	0.431	1.539	0.003	1.302	1.799	0.371	1.449	0.003	1.323	1.612
Physical activity															
Yes						-0.323	0.724	<0.001	0.613	0.854	-0.393	0.675	<0.001	0.587	0.756
Yes (intensive)						-0.671	0.511	<0.001	0.322	0.621	-0.753	0.471	<0.001	0.348	0.614

Reference categories:
[1]Lower secondary education
[2] Low income level

	Model 1					Model 2					Model 3			
	Coef.	Odds ratio	P-value	95% Conf. Interval	95% Interval	Odds ratio	P-value	95% Conf. Interval		Coef.	Odds ratio	P-value	95% Conf. Interval	
Smoking														
Yes					0.088	1.092	0.198	0.988	1.342	0.132	1.141	0.256	0.887	1.325
Excessive Alcohol Consumption														
Yes					0.107	1.113	0.0021	1.012	1.243	0.081	1.084	0.002	1.011	1.212
Gender														
Female										-0.533	0.587	0.000	0.443	0.730
Age[3]														
Middle-aged (45 – 64)										0.324	1.382	0.000	1.191	1.576
Older (65 years and over)										0.548	1.730	0.000	1.542	1.971
BMI[4]														
Normal										0.131	1.140	0.000	1.011	1.255
Overweight										0.566	1.761	0.000	1.543	1.981
Obese										1.012	2.750	0.000	2.445	3.174
Family history of diabetes														
Yes										0.219	1.245	0.000	1.111	1.393
Hypertension														
Yes										0.064	1.066	<0.001	1.051	1.112

Source: Author's computations

Reference categories:
[3] The young (27 – 44 years)
[4] Underweight BMI

Finally, in order to assess the soundness of the logistic model, we will analyze the overall model evaluation, goodness-of-fit statistics and validation of predicted probabilities.

Overall measure how well the model fits is evaluated by the likelihood parameters. A logistic regression model provides a better fit to the data if it demonstrates an improvement over the null model since such a model does not contain any predictor. Thus, it becomes a good baseline. The higher the likelihood of observed data, the better the model fits. Therefore, the higher the likelihood function, the higher the log likelihood the model will have. The measures of fit of the fully adjusted model are reported in Table 6.3.

Table 6.3: Measure of fit for logit regression model

Log-Lik Intercept Only:	-10490.847	**Log-Lik Full Model:**	-6338.479
D(15122):	12676.959	**LR(18):**	8304.736
		Prob > LR:	0.000
McFadden's R2:	0.395	**McFadden's Adj R2:**	0.394
Maximum Likelihood R2:	0.422	**Cragg & Uhler's R2:**	0.563
McKelvey and Zavoina's R2:	0.552	**Efron's R2:**	0.505
Variance of y*:	7.340	**Variance of error:**	3.290
Count R2:	0.851	**Adj Count R2:**	0.699
AIC:	0.840	**AIC*n:**	12714.959
BIC:	-132821.616	**BIC':**	-8131.488

Source: Author's computations

The value of log likelihood of the final model has no meaning by itself. This parameter is used to compare the current model with a nested model. Log likelihood is equal to -6338.479 corresponding to the value of the log likelihood at convergence.

Log likelihood ratio chi-squared is the value of a likelihood ratio chi-squared to test of the null hypothesis that all the coefficients which are associated with independent variables are equal to 0 (Long and Freese, 2006). The p-value is indicated by $Prob > chi2$. The number in parenthesis denotes the number of degrees of freedom (Long and Freese, 2006). In the current model, there are eighteen predictors; therefore there are eighteen degrees of freedom. According to the current model, the likelihood ratio is 8304.735 with p-value provide evidence in favor of the current model which fits significant better than the intercept-only model. Moreover, since p-value for the overall model fit statistic is less than 0.05, it has necessitated the rejection of the null hypothesis. Additionally, McFadden's R^2 or likelihood ratio index is used in order to evaluate the goodness of fit of the logit regression model. The given measure ranges from 0 to under 1 (it can never equal to 1), and value which is close to 0 indicates low or absent of predictive power. McFadden's R^2 which is computed by Stata as $Pseudo\ R2$ equals to 0.394, and it indicates the improvement of log likelihood of the fitted model in comparison with null model.

The next measures of fit used in the given logit regression analysis are Akaike Information Criterion and Bayesian Information criterion. AIC is a mean to compare different models on a given outcome, i.e. it allows to compare both nested and non-nested models (Long and Freese, 2006). Regarding AIC, the model with a smaller AIC fits better. In other words, a model with a lower AIC is preferred over one with a higher AIC. In the given analyses, AIC equals to 0.840. BIC is based on the empirical log likelihood and closely related to the AIC. The penalty term of BIC is potentially more severe compared to the penalty term of AIC and it is preferred mostly for simpler models. The model that fits better is identified by the minimum value of BIC, i. e. "the more negative the BIC, the better the fit" (Long and Freese, 2006). In the given analysis BIC equals to -132821.616. The Hosmer-Lemeshov test is an inferential goodness-of-fit test that in the current study yields 23.415 with insignificant p-value ($p > 0.3548$) suggesting that the model fits the data well.

Another way to determine the goodness of fit is through the classification table which documents the validity of predicted probabilities. The results of cross-classifying the dependent variable with binary variables which values are expressed from the estimated logistic probability are presented in Table 6.4.

Table 6.4: Classification table

Classified	D (y_i=1)	~D (y_i=1)	Total
+ ($p_i \geq c$)	2638	1382	4020
- ($p_i < c$)	2830	8288	11118
Total	5468	9670	15138
Classified + if predicted Pr(D) >= 0.5			
True D defined as Diabetes != 0			
Sensitivity		Pr(+ | D)	48.24%
Specificity		Pr(- | ~D)	85.71%
Positive predictive value		Pr(D | +)	65.62%
Negative predictive value		Pr(~D | -)	74.55%
False + rate for true ~D		Pr(+ | ~D)	14.29%
False - rate for true D		Pr(- | D)	51.76%
False + rate for classified +		Pr(~D | +)	34.38%
False - rate for classified -		Pr(D | -)	25.45%
Correctly classified			72.18%

Source: Author's computations

According to the Table 6.4, with the cutoff of 0.50, the prediction for not being diagnosed with type 2 diabetes is more accurate than for being diagnosed with type 2 diabetes. The observation is supported by the magnitude of sensitivity (48.24%) compared to the magnitude of specificity (85.71%). Sensitivity indentifies the proportion of correctly classified event, in the study, people who are type 2 diabetics, while specificity – the proportion of correctly classified nonevents, those not type 2 diabetics. The false positive rate is 51.76% and identifies "… the proportion of observations misclassified as events over all of those classified as events" (Peng and So, 2002). The false negative parameter equals to 14.29% and measures "…the proportion of observations misclassified as nonevents over all of those classified as nonevents" (Peng and So, 2002).

The overall rate of correct classification is estimated as 72.18% $\left[\frac{(2638+8288)}{15138}\right] 100\%$, the improvement over the chance level.

Chapter 7

Discussion and Conclusion

Type 2 diabetes mellitus is one of the most prevalent chronic disorders in nearly all countries, characterized by the multifactorial nature of risk factors of occurring and leading to a lower quality of life, premature mortality, and increased economic burden caused by the disease (Dinca-Panaitescu et al., 2011; Kaku, 2010). Thus, it is equally important to acknowledge a broad range of factors, both clinical and socioeconomic, in understanding disease risk.

In order to explore the predictive effect of socioeconomic factors on the type 2 diabetes prevalence, we employed the logistic regression models with a binary dependent variable, which equals to 1, if type 2 diabetes is diagnosed and 0 if type 2 diabetes is not diagnosed. Three different models were tested. In the first model we examined the relationships between the prevalence of type 2 diabetes and socioeconomic factors only. The second model was adjusted for behavioral factors. Finally, the third model was fully adjusted for both clinical and behavioral factors.

The dataset covers 15,138 observations from the Diabetes Survey in the Republic of Belarus in the period 2012 – 2014. The survey captures a vast array of characteristics about the individuals in the resident population of Minsk and the Minsk province, including age, gender, marital status, BMI, chronic diseases, family history of diabetes, education attainment, monthly income, smoking, alcohol consumption, nutrition habits, and area of residence.

The results of the thesis provide a strong and consistent evidence that the risk of type 2 diabetes is influenced not only by the traditional clinical factors but also by a variety of socioeconomic factors among which individual income and educational attainment are the most prominent. Our analysis indicated a trend of higher prevalence of type 2 diabetes towards to the lower income and lower educational level even after sequential adjustments for various socioeconomic and clinical risk factors. In other words, educational attainment and income are negatively associated with the prevalence of type 2 diabetes among men and women aged 27 years or older.

The higher prevalence of type 2 diabetes is observed among people with lower educational attainment than among individual with higher educational level. There are several potential explanations for this association. First, people with different levels of education may have different perceptions of health and healthy lifestyle. Second, education is considered as a strong indicator of ability to perceive information regarding health issues, disease prevention, particularly, risk factors for disease onsets and knowledge of nutritional value of food. Third, educational levels reflect health outcome, for instance, a lower educational level may result in poor health outcomes and treatment management. Fourth, people in lower educational group may have limits on healthy behaviors and lack of motivation to follow healthy lifestyle. Finally, educational attainment implies income level that in its turn significantly influences the development of type 2 diabetes. In this way, we conclude that a higher educational attainment ensures better understanding of risk factors for type 2 diabetes onset, and better treatment management in case if diabetes mellitus is already diagnosed. The effect of educational level on the prevalence of type 2 diabetes has slightly attenuated with adjustment for other variables but it still remains significant.

In addition to education effect, our analysis reveals a clear inverse association between income level and the prevalence of type 2 diabetes. This association implies that higher income provides access to higher-quality goods and services. Indeed, higher income level is strongly associated with less risky health behavior and access to better healthcare services (Dinca-Panaitescu et al., 2011). It suggests that individuals with lower income spend a higher proportion of their income on food, consume poor diet – unsecured food such as fat and carbohydrate saturated food and have financial (cost) barriers. In contrast, people in higher income group pay more attention to food and its contents and they are less likely to have barriers in accessing an environment conducive to healthier lifestyle and, in particular, physical activity. The effect of income on the type 2 diabetes prevalence remains stable with further adjustments for clinical factors such as age and overweight / obese BMI that are recognized as the strongest risk factors in development of type 2 diabetes.

Our results concerning the effect of income and education on the prevalence of type 2 diabetes remain stable even after further adjustment for behavioral factors such as physical activity, smoking, and excessive alcohol consumption, and confirm the results of the previous studies that risky unhealthy behavior of individual does not greatly contribute to the onset of type 2 diabetes. The present findings reveal that understanding the income and educational level contributions in the prevalence of type 2 diabetes may contribute to effective diabetes prevention programs and treatment management.

The results of our study document that type 2 diabetes is more prevalent among married individuals and people living in urban area. The results concerning marital status are explained by the aetiology and pathogenesis of type 2 diabetes which suggests that the disease is not diagnosed in young age. As our dataset included individuals aged 27 years and older, it is naturally, that most of them are married, and, therefore, the higher the proportion of the married population, the higher the probability of type 2 diabetes among them. Moreover, the single individual may be more prone to stress. Chronic stress may imply insulin resistance which leads to type 2 diabetes or pre-diabetes development (Krishnan et al., 2010). According to our results, people living in urban area are more likely to have type 2 diabetes. The explanation of this finding is linked to the lack of time, stress and the fact that a westernized diet is widespread in cities rather than in rural area. These findings remain quite stable in adjusted models as well.

Physical activity is associated with a lower prevalence of type 2 diabetes in both men and women. Moreover, people with regular and intensive physical activity are less prone to type 2 diabetes in comparison with those who have moderate physical activity. Another socioeconomic behavioral factor is excessive alcohol consumption which is positively linked to the type 2 diabetes development. Our results find that excessive alcohol consumption considerably affects the type 2 diabetes prevalence. People with high-risk drinking behavior are 11.3% more likely to have type 2 diabetes as estimated in our study. A possible explanation is a high calorie dense of alcohol products. As to smoking, our results confirm the findings of previous studies that there is no significant relationship between smoking and the type 2 diabetes prevalence.

BMI and age are the traditional predictors among clinical factors which capture most of the attention as significant and most strongly associated risk factors for type 2 diabetes onsets. In our study, middle-aged people are more likely to have type 2 diabetes compared to the young, and in turn, individuals in middle age are less likely to be diagnosed with the type 2 diabetes than the older people. These findings allow us to conclude that type 2 diabetes mellitus is a disease occurring at older ages.

Like many other metabolic diseases, type 2 diabetes is influenced by the health and socioeconomic status of individual results which become more apparent with age, as health status deteriorates.

It is well-known that type 2 diabetes is positively associated with overweight and obesity. We find that the higher the BMI, the more likely it is that an individual would be a type 2 diabetic. Specifically, risk of type 2 diabetes onsets is strongly affected by BMI and its effect is the same in both sexes. We observe a significant increase in a likelihood of the prevalence of type 2 diabetes among obese individuals. One possible explanation for this association is that overweight or obesity is the major cause for many chronic diseases, particularly, for metabolic disorders. Type 2 diabetes may thus be considered as a consequence of obesity.

Family history of diabetes is the next important risk factor for the development of type 2 diabetes. Our results prove that the presence of diabetes mellitus in family medical history increases the risk for type 2 diabetes development in the following generation. It may be implied that genetic susceptibility to type 2 diabetes is genetically transmitted, especially, between two generations (close relatives). Moreover, certain ethnicities and races are highly prone to the genetic insulin secretion abnormality that makes these ethnic groups even more diabetes-susceptible (Unoki et al., 2008).

In addition to age, BMI and family history of diabetes, we find that hypertension is significant and positively associated with the prevalence of type 2 diabetes. Individuals with hypertension in their anamnesis are at a higher risk to be diagnosed with type 2 diabetes. It is believed that hypertension damages blood vessels as blood pumps with higher pressure and damaged blood vessels may not cope properly with blood circulation of the pancreatic gland.

In sum, we find that lower-income and lower-educated individuals, and also physically inactive and with overweight / obese BMI are at a higher risk of type 2 diabetes onsets. This association remains significant after further adjustment for various behavioral and clinical factors.

The results of our analysis have not only strengthened the evidence for the association between socioeconomic factors and the prevalence of type 2 diabetes, but have also extended the researches by highlighting the crucial role of socioeconomic factors in individual's health regarding type 2 diabetes. It uncovers the fact that it is not only traditional factors such as age and overweight / obese BMI have strong influence on the prevalence of type 2 diabetes. In other words, both clinical and socioeconomic factors play a significant role in the development of type 2 diabetes.

Our findings have important implications for health care policy, especially, for the formulation of preventive diabetes programs, effective diabetes treatment management and resources allocation. They directly imply changes that have to be employed in the preventive diabetes programs which should be more focused on socioeconomic environment rather than on individual risky behavior.

While the thesis presents some meaningful findings, it has several limitations. First, our analysis does not include other potentially influential factors such as ethnicity, immigration, house ownership and a domain of psychological factors related to diabetes mellitus. Second, the inaccuracy of self-reported data on socioeconomic and clinical characteristics may cause problems with measurement errors and bias in self-reported health issues. Moreover, the actual prevalence of type 2 diabetes may be understated as the presence of type 2 diabetes is self-reported and it also has a tendency to be under diagnosed. Even with these limitations, our study is the first which addresses the influence of socioeconomic factors on the prevalence of type 2 diabetes in the Republic of Belarus.

To sum up, the findings of our study emphasize the necessity to pay more attention to the socioeconomic environment in the formulation of strategies of diabetes prevention, as well as popularization of healthy lifestyle behavior.

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APPENDIX A.1

Table A.1: Correlation matrix

	Family History of diabetes	Hypertension	BMI	Alcohol	Physical Activity	Smoking	Gender	Age	Marital status	Region	Education	Monthly income
Family History of diabetes	1											
Hypertension	0.570	1										
BMI	-0.0000959	0.368	1									
Alcohol	0.0305	0.0172	0.0179	1								
Physical Activity	0.154	0.127	-0.00472	-0.325	1							
Smoking	0.354	0.270	0.00578	0.123	-0.120	1						
Gender	-0.0182	-0.0196	0.00764	0.326	-0.0124	-0.00304	1					
Age	-0.0113	-0.0155	0.00534	0.00295	-0.00359	-0.00263	-0.00251	1				
Marital status	-0.00473	-0.00347	-0.0110	-0.0121	-0.00857	-0.0113	-0.00675	0.00743	1			
Region	-0.00534	-0.0113	0.00541	-0.00327	0.00772	0.00181	-0.0108	0.00674	-0.00171	1		
Education	0.0120	0.0133	0.00907	-0.00474	-0.0170	0.0123	-0.00731	0.00569	-0.000489	-0.00469	1	
Monthly income	0.00633	-0.000666	-0.00755	-0.00194	-0.00335	-0.00758	0.0392	-0.00968	-0.00830	0.00206	0.325	1

APPENDIX A.2

Table A.2: Relationship between probability, odds and log odds

$\Pr(Y = 1)$	$\Pr(Y = 0)$	Odds	Log Odds
0	1	0	$-\infty$
0.5	0.5	1	0
1	0	∞	∞