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COSTS ASSOCIATED WITH OBESITY IN KAZAKHSTAN

Master of Public Health Thesis Project
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ABSTRACT

Objective: The aim of this study is to estimate direct medical costs attributable to obesity in Kazakhstan from the governmental perspective for 2008, 2020 and 2030.

Method: Cost-of-illness prevalence-based approach was used to estimate the medical direct costs including hospital care, drugs, physician and nursing care covered by the government. There are three types of data required for this study including the actual and predicted estimates of prevalence of the obesity in Kazakhstan for 2008, 2020 and 2030, relative risks for IHD, stroke and T2D and costs on specific disease treatment. All the required information was taken from the secondary data. Thus, the main formula includes multiplying Population Attributable Fraction by the costs for diseases' treatment.

Results: Medical direct costs estimation showed the overall increasing trend through 2008, 2020 and 2030 years for every disease. By 2030 the costs for IHD will reach 7,452,576.96 USD, for stroke - 4,275,743.073 USD, and for T2D - 80,739,123.58 US. So, comparing to the costs estimates for 2008 direct medical costs covered by government in Kazakhstan are going to increase twice for IHD and stroke and by ⅓ for T2D complications by 2030.

Discussion and Conclusion: Costs associated with IHD, stroke and T2D complications attributable to obesity in Kazakhstan by 2020 will reach 81,608,691 KZT accounting for 11.3% from the money dedicated for 2019 of the Governmental Program for Healthcare Development "Densaulyk" for 2016-2019. Taking into account that no adjustments were used for the future currency changes, medical services and drug costs the future direct medical costs might be significantly higher than it was estimated in the study. It should be mentioned that significant amount of money might be saved in the future if required actions are taken by the government.

Key words: Obesity; overweight; Kazakhstan; cost; cost of illness

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LIST OF ABBREVIATIONS

BMI - Body Mass Index

CVD - Cardiovascular Diseases

GPHD - Governmental Program for Healthcare Development

GPoFMH - Guaranteed Package of Free Medical Help

IHD - Ischemic Heart Disease

PAF - Population Attributable Fraction

T2D - Type 2 Diabetes

EUR - Euro

KZT - Tenge

USD - US dollars

1. INTRODUCTION

Recently Asian countries have experienced fast economic development. It has been resulted in turning from the agriculture to the manufacturing and service that, in turn, led to physical inactivity and available cheap food products. Although it gave opportunity to decrease wasting and stunting, it followed by overeating and needless weight increase. The phenomenon of changed eating pattern resulted from economic growth has been called "global nutritional transition" (Helbe & Francisco, 2017).

As a result, global nutritional transition had a major effect on the public health including both, communicable and non-communicable diseases. Since the vaccines development and sanitation has been progressing over the years there has been significant drop in communicable disease spread. However, the trend of non-communicable diseases attributable to excess body weight is increasing steadily requiring immediate healthcare solutions (Helbe & Francisco, 2017).

There is a substantial amount of evidence showing causal association between overweight and obesity and co-morbidities causing further extended costs for the treatment. According to meta-analysis conducted by Guh et al. (2009) there are 18 co-morbidities associated with overweight and obesity which are type II diabetes, different types of cancer (breast, colorectal, endometrial, esophageal, kidney, ovarian, pancreatic, and prostate), CVDs (including hypertension, coronary artery disease, congestive heart failure, pulmonary embolism, stroke) and other such as asthma, gallbladder disease, osteoarthritis, chronic back pain.

For this purpose, a number of studies has been conducted on the obesity cost estimates among developed countries, whereas there are a few for Asian regions and developing countries. For example, evaluated costs for overweight and obese population in the US are around 2,741 USD per year. Moreover, taking into account decreased productivity and absenteeism at the

workplaces business costs spending increases to 66 billion USD per year (Helbe & Francisco, 2017).

Economic costs of obesity have not been evaluated enough for many Asian regions including Kazakhstan in spite of extensive knowledge regarding prevalence, determinants and consequences.

1.1 DEFINITION OF OBESITY

Overweight and obesity have been defined as body condition with extra body fat and, consequently, body weight that might negatively affect individual's health. Major sources determine overweight and obesity using a body mass index (BMI) equal to or more than 25 and 30, respectively. BMI is calculated by dividing the weight in kilograms by the square of the height in meters (kg/m2) (WHO, 2018). It should be noticed, however, there are alternative measures for the overweight and obesity including waist circumference, waist to height ratio, waist to hip ratio and body fat measure. One of the reasons for replacing BMI with other measures is that some ethnicities have different body type as well as different perceptions of normal body ratio. Specifically, Asian people were found to have increased mortality risk at BMI more than 25 in comparison with US population. In addition, Asian population tends to have a central obesity which is a major factor for developing cardiovascular and metabolic disorders (Lear et al., 2007). Since BMI has been commonly used in studies related to overweight and obesity it was also used in this research.

1.2 TRENDS OF OBESITY IN KAZAKHSTAN

According to a number of studies Kazakhstan has been showing increasing trend of overweight and obesity among adult population. As Helbe and Francisco (2017) showed in their research, Kazakhstan among countries of Central Asia like Armenia, Azerbaijan,

Georgia, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan was the leading in absolute numbers of obese people from 1990 to 2013. Specifically, in 2013 Kazakhstan was the second obese country among those mentioned. Moreover, change percentage of obesity prevalence in Kazakhstan (about 16.6 %) was more than the mean for Central Asia (around 16.4%) (Helbe and Francisco, 2017). Studies conducted by the Kazakh Academy of Nutrition in 2014 revealed that 55.5% of women, 49.2% of men and 14.7% of children suffer from overweight or obesity in Kazakhstan (Kazakh Academy of Nutrition, n.d.).

Data provided by WHO (2017) also demonstrates steady rise of overweight and obesity prevalence in Kazakhstan from 1975 to 2016 among adult population. According to WHO (2013) in 2020 about 45% of male and 29% of female are expected to be obese. Moreover, by 2030 the prevalence of obese men will reach 74% and women - 36% (WHO, 2013). These predicted estimates highlights the importance of introducing programs to reduce overweight and obesity prevalence among Kazakhstan population.

1.3 DISEASES ASSOCIATED WITH OBESITY IN KAZAKHSTAN

According to Guh et al. (2009) there are 18 co-morbidities associated with overweight and obesity including type II diabetes, different types of cancers, CVDs and other such as asthma, gallbladder disease, osteoarthritis, chronic back pain. Moreover, as BMI increases the risk of getting coronary heart disease, ischemic stroke, type II diabetes and types of cancers including breast, colon, prostate and other organs also rises significantly (WHO, 2009). It was estimated that 44% of diabetes, 23% of ischemic heart disease and 7–41% of particular cancers are attributable to overweight and obesity worldwide (WHO, 2009). Some of these disorders have been the leading causes of mortality and morbidity in Kazakhstan.

It was also reported in Governmental Program for Healthcare Development “Densaulyk” for 2016-2019 that the leading cause of mortality among Kazakhstan population is

cardiovascular diseases accounting for 22.3% of all deaths. The most often met among CVD are ischemic heart failure, cerebrovascular injury from which annually dies about 30,000 people. In addition, there is a positive trend of CVD rise from 2010 to 2014 on almost 15% (Governmental Program for Healthcare Development for 2016-2019).

The second cause of mortality in Kazakhstan is malignant neoplasm accounting for 12.1%. Every year there are approximately 17,000 people die from it (Governmental Program for Healthcare Development for 2016-2019). It was estimated that approximately 3.6% of cancer mortality in adults in 2012 was related to increase BMI. Specifically, in Asian regions the population attributable fraction for all cancers ranged from 0.4% to 0.9% in males and from 1.7% to 3% - females (Arnold et al., 2015).

In meta-analysis by Guh et al. there were nine studies demonstrating that increased BMI is highly associated with type II diabetes in men and women. Since 1995 the rate of type II diabetes has been increasing in Kazakhstan. For example, in 1995 there were 35 newly diagnosed patients with type II diabetes for 100,000 people, while in 2007 - 116 patients. An increase in the number of urban population, increase in the life expectancy of Kazakhstan population and increase in the incomes of the population in the next decade will lead to a rapid increase in the number of patients suffering from type II diabetes. According to official statistics, 5% of the population in country has diabetes. However, screening and analysis of ongoing studies show that in fact the number of people with diabetes can reach 5-7%, which is consistent with international practice (Tukalevskaya N.N., n.d.). Diabetes requires significant amount of money for medical and non-medical care, especially related to its major complications including blindness, renal failure, peripheral vascular disease, neuropathy, lower limb amputation and CVDS. It was estimated that in 70-80 % of diabetes cases patients died because of CVDs caused by diabetes (A.Zh. Ilmalieva et al., 2016).

Thus, diseases associated with obesity including CVDs, cancers and diabetes in Kazakhstan significantly affect morbidity and mortality rates among population. Moreover, medical care of these disorders is mostly covered by government through the special medical services package called "Guaranteed package of free medical help" (Resolution of the Government of the Republic of Kazakhstan of January 27, 2014 No. 29). As the prevalence of CVDs, cancers and diabetes is increasing steadily in Kazakhstan there is expected increase of the expenses related to them. Since obesity has been found to be one of the major causes for these conditions there is a possibility to reduce morbidity by preventing obesity prevalence. In this study only three particular diseases has been chosen for the costs estimation which are Ischemic Heart Disease, Stroke and Type II Diabetes complications. The main reason is the lack of detailed data on prevalence of obesity associated diseases and their costs covered by the government.

2. METHODS AND MATERIALS

2.1 Methods

The aim of study is to estimate direct medical costs associated with obesity from the governmental perspective for 2008, 2020 and 2030. For this purpose, we used cost-of-illness approach with governmental perspective to calculate direct medical costs associated with obesity based on secondary data. Cost-of-illness approach is used to relate the costs to the specific disease and evaluate the expenses that could potentially be saved or gained in case of declined rates or eradication of the disease. This approach is commonly used in public health policy sphere because it emphasizes the value of the impact of an illness on society and help to decide whether it should be addressed by healthcare (Segel, 2006). Cost-of-illness method includes prevalence-based and incidence-based approaches (Henriksson et al,. 2000). Prevalence-based approach is used to estimate the costs of the illness in one period despite of

the date of its onset. This approach also needs less data and fewer assumptions in comparison with incidence-based studies. There is only one year related data required ignoring the rates of survival and disease course. The main assumption required for this method is that the structure of costs and discounting will not change in the future (Segel, 2006). Since this approach includes the annual medical costs it is more advantageous method for chronic diseases. Therefore, cost-of-illness prevalence-based approach has been chosen for this particular study (Henriksson et al,. 2000).

2.2 Data sources

There are three types of data required to use in the estimations for this study. The first type of data is actual and predicted obesity prevalence for 2008, 2020 and 2030 which was taken from the WHO (2013) (see Table 1). Relative risks for the obesity attributable diseases to calculate PAF were taken from the World obesity official website (World Obesity, 2015) (see Table 2). Since required data of the direct medical costs related to IHD, stroke and T2D complications from the governmental perspective are not available in public registers costs estimates were taken from the secondary data (A.Zh. Ilmalieva et al., 2016) (see Table 3). Thus, these calculations reflect costs that really affect the health care system in the form of costs for hospitalization, concomitant pharmacotherapy and the provision of medical services (A.Zh. Ilmalieva et al., 2016).

The costs of specific diseases attributable to obesity were derived by multiplying the PAFs (Population Attributable Fractions) for disease prevalence (see Table 4) and medical costs (Botticello et al., 2015).

2.3 ESTIMATING THE DIRECT COSTS OF OBESITY

2.3.1 Calculating PAFs for T2D, IHD and stroke

Formula used to calculate Population Attributable Fraction (PAF) (Botticello et al., 2015):

$$P(E)*(RR-1)/((P(E)*(RR-1))+1$$

where P(E)is defined as a proportion of the obesity exposed population; RR stands for relative risk for specific diseases associated with obesity (Botticello et al., 2015).

Note: all the necessary calculations for this study are shown in the **7. Table and Figures** and called "Calculation part".

2.3.2 Calculating medical direct costs for T2D, IHD and stroke

Medical direct costs were estimated using the following formula (Botticello et al., 2015):

PAF of disease * Costs for disease treatment per one patient* Disease prevalence

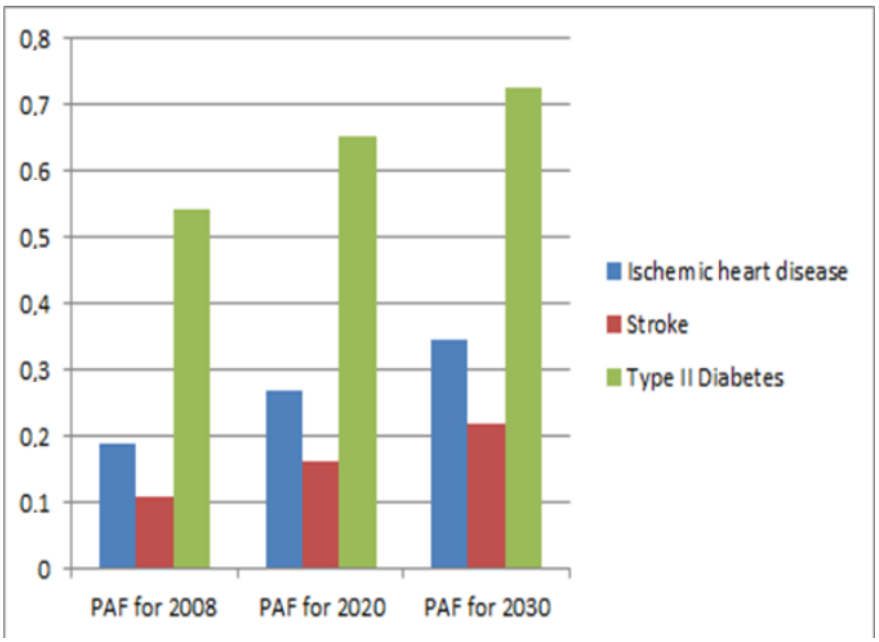
PAF of diseases is calculated according to the previously mentioned formula. Costs for disease treatment per one patient are taken from the secondary data by A.Zh. Ilmalieva et al. (2016) (see Table 2). It should be mentioned that available costs were only for 2013, so these costs were used in calculations for 2008, 2020 and 2030. Also the conversion from KZT to USD was according to 2013 currency rates. Disease prevalence is the prevalence of particular disease taken from the secondary data (see Table 3). The main assumption that should be taken into account is that the relative risks, costs for the treatment and obesity associated disease prevalence taken from the secondary data were the same through the calculation process. It means that the only changing variable in the formula was Population Attributable Fraction due to increasing obesity prevalence actual and predicted estimates for 2008, 2020 and 2030.

Note: all the necessary calculations for this study are shown in the **7. Table and Figures** from Table 5 to Table 10.

3. RESULTS

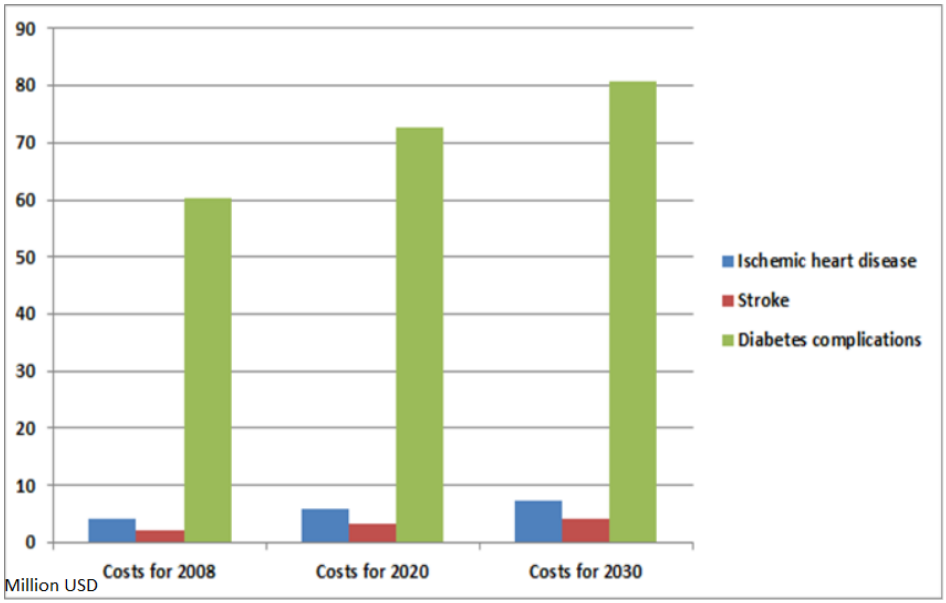
The results of PAF estimation showed the overall increasing trend through 2008, 2020 and 2030 years for every disease. Since PAF depends directly on obesity prevalence it is expected that overall PAF trend would be positive as obesity prevalence is predicted to increase over years. According to Figure 1, in general, the biggest PAFs were related to T2D. It is explained by the highest relative risk of getting T2D due to obesity which is 5.5 for men and 7.0 for women. Relative risks for IHD and stroke are considerable lower indicating 2.0 for both sexes and 1.5 for men and 1.55 for woman, respectively. So, PAFs related to IHD for 2008, 2020 and 2030 were 0.19, 0.2675 and 0.345, respectively; stroke PAFs were 0.1095, 0 .161 and 0.2175 for 2008, 2020 and 2030, respectively; T2D accounted for 0.5425, 0.651 and 0.725 (see Table 11).

Figure 1. Results of the calculations of PAFs for 2008, 2020 and 2030 years



According to Figure 2, medical direct costs estimation also showed the overall increasing trend through 2008, 2020 and 2030 years for every disease. Since PAF showed increasing rate through the provided years it is expected to see increasing rate of the costs. In general, the biggest PAFs were related to T2D which is also explained by highest relative risk for T2D attributable to obesity. So, direct costs related to IHD for 2008, 2020 and 2030 were 4,105,120.939 USD, 5,778,447.353 USD and 7,452,576.96 USD, respectively; stroke costs were 2,152,615.478 USD, 3,165,032.803 USD and 4,275,743.073 USD for 2008, 2020 and 2030; T2D accounted for 60,415,137.31 USD, 72,665,211.23 USD and 80,739,123.58 USD (see Table 12).

Figure 2. Estimated medical direct costs related to IHD, stroke and T2D diabetes for 2008, 2020 and 2030



4. DISCUSSION

It was reported by WHO (2009) that non-communicable chronic diseases will become the major cause for morbidity and mortality in the nearest future. It was estimated that by 2020 about two-thirds of all disease would be non-communicable chronic diseases. In connection with the practical widespread increase in the frequency of obesity, WHO describes it as an

epidemic disease that has tangible economic consequences. In developed countries, the total cost of treating obese patients and their consequences is about 10% of total health care expenditure, and the direct costs of 3% to 5% of total expenditure (Kazakh Academy of nutrition, n.d.). It was also estimated that obese individuals tend to spend 30% greater on their medical services than those, with normal weight (Withrow, D., & Alter, D. A., 2011).

Results of this study showed that the estimated costs for IHD and stroke would increase twice by 2030 and increase by ⅓ for T2D complications. Combined direct medical costs for these three disorders accounts for 100 million USD and the actual future costs most probably will increase significantly due to currency changes, medical service and drug costs increase and country's economic status.

There is a free medical help for the population which is provided by the government of Kazakhstan through the special medical services package called "Guaranteed package of free medical help" (hereafter - GPoFMH). GPoFMH is granted to citizens of the Republic of Kazakhstan and oralmans at the expense of budgetary funds and includes preventive, diagnostic and therapeutic medical services with the highest proven effectiveness. It includes 1) ambulance; 2) out-patient care, including primary health care; 3) inpatient medical care; 4) rehabilitation; 5) palliative care and nursing care for the categories of the population established by the Government of the Republic of Kazakhstan (Resolution of the Government of the Republic of Kazakhstan of January 27, 2014 No. 29).

According to the Governmental Program for Healthcare Development "Densaulyk" for 2016-2019 there is 1,969,729, 500 KZT dedicated for this program. From this budget 128,034,799 KZT is dedicated for 2016; 408,080,865 KZT - for 2017; 709,797,105 KZT - for 2018 and 723,816,732 KZT for 2019. So, according to the obtained results, costs associated with IHD, stroke and T2D attributable to obesity in Kazakhstan by 2020 will reach 81,608,691 KZT accounting for 11.3% from the money dedicated for 2019 of the Governmental Program for

Healthcare Development “Densaulyk” for 2016-2019. That is considerable proportion of share for only three diseases taking into account that the estimated costs most probably is the minimum expenses country is going to be spent in the future. These estimations demonstrate the value of introducing effective interventions against obesity.

Taking into account that in 98% of cases obesity develops when the energy intake exceeds its consumption, and for a long time, as well as the above changes in the structure of nutrition, it should be stressed about the enormous importance of explanatory work and the promotion of a healthy lifestyle to help people to change the behavior pattern in order to prevent not only overweight and obesity, but also other non-infectious diseases (Center of Healthy Lifestyle Development of Astana, n.d.). If the appropriate effective measures are not taken immediately, the costs related to obesity might become catastrophic not only due to significant rise in medical service costs but also from declined worker productivity including physical and psychological disabilities (Hojjat T. A., 2015).

There are expected indicators of obesity for 2016-2019 reported in Governmental Program of Healthcare Development “Densaulyk”. So, the actual estimates for 2014 were 278,3 obese people per 100,000 and the expected reduction is to 256,5 people per 100,000 in 2016, 243,6 - in 2017, 231,4 - 2018 and 220,0 - in 2019 (Governmental Program for Healthcare Development, 2016-2019). Although the reduction rate is gradual there is no described clear strategy to reach these indicators. Nevertheless, there are newly established Public Health Services and already functioning Centers for Healthy Lifestyle Development and National Center for problems of healthy lifestyle formation one of the functions is to target the issue of healthy lifestyle in Kazakhstan population including obesity prevalence reduction (Governmental Program for Healthcare Development, 2016-2019). However, there is not enough information on the official sites of these centers on the programs to tackle the problem of adult obesity in Kazakhstan or particular cities and regions of Kazakhstan.

There are general recommendations on tackling obesity worldwide provided by WHO in Global Strategy on Diet, Physical Activity and Health:

• Public and private sector, including all individuals and organizations engaged in the production, promotion and sale of food, should review their policies (both on a voluntary basis and on the basis of appropriate legislation) that should be oriented towards the prevention of obesity;

• Professional organizations should support measures aimed at the prevention and treatment of obesity and related diseases;

• Consumer organizations should join forces in order to better inform the public about obesity;

• Intergovernmental organizations should endeavor to ensure that concerted action is taken at the international level, and for this purpose they should develop and adopt appropriate guidelines and policy recommendations (Kazakh Academy of Nutrition, n.d.).

There are also some approaches to solve the issue of obesity prevalence described by Hojjat, T. A. (2015). The first one is food policy interventions at the national and international level to make healthy food available financially and geographically. WHO reported that the one of the approaches to maintain normal weight is to consume fresh nutrient-rich foods. One of the approaches to reach this target is to reduce the demand for products and to change the lifestyle that contributes to obesity by educating population, taxing products and food labeling (Hojjat, T. A., 2015). The second way is to decline the provision side by cutting subsidies of agricultural products so the costs still are low. So, imposing taxes on fats and sweets at schools could lead to limited access to vending machines containing beverages and snacks (Hojjat, T. A., 2015). For example, recently in Kazakhstan universities and schools banned the sale of sweet fizzy and energy drinks (tengrinews.kz). Another approach is to provide incentives for the agricultural sector to produce healthier goods. For example, it was

calculated that 73 percent of corn-derived sweeteners per person per year is consumed in USA. The main reason is subsidizing corn-derived production by the government resulting in production of unhealthy sweeteners instead of contributing to the healthier natural sweeteners Hojjat, T. A. (2015).

Some studies provide unordinary approach to reduce adult obesity. It was suggested and supported by evidence that walking and playing with dogs could change sedentary lifestyle and promote healthy lifestyle resulting in obesity reduction. It was recommended to investigate this approach to address the issue of obesity (Boisvert, J. A., & Harrell, W. A., 2014).

Thus, there are several ways to target adult obesity, globally, and the government should take this issue under control to prevent future negative consequences both, public health and financial.

4.2 STRENGTHS AND LIMITATIONS

There are several strengths and limitations for this study. Although there is extensive knowledge regarding prevalence, determinants and consequences of obesity there is no official published articles related to this topic in Kazakhstan. So, this research reveals first estimates of the costs associated with obesity in Kazakhstan and provide valuable information for the further possible cost-effectiveness and cost-benefit analyses (Segel, 2006). The second strength is that the results of this research might be used to estimate the risks of the obesity prevalence in Kazakhstan and grab government's attention to the adult overweight and obesity and financial consequences related to this issue.

One of the limitations to be mentioned is the lack of detailed costs for the outpatient and inpatient services, drug costs, rehabilitation, nursing care and other expenses per patient in Kazakhstan. If necessary data on costing would be provided the range of included diseases in

this study could be extended including different cancer types, CVDs and other obesity-associated disorders. To obtain more accurate results D.Razzouk (2017) recommends to collect individual data through a micro-costing bottom-up method.

4.3 FURTHER RECOMMENDATIONS

One of the further research recommendations related to this topic would be including more diseases in the analysis to cover extended range of consequences attributable to overweight and obesity. Moreover, in-direct medical costs are also considerable part of the expenses taken by population, so it is important to conduct researches including in-direct costs associated with obesity.

From the practical perspective it would be beneficial to use the results to inform the government and population about significant expenses related to the obesity so the necessary actions would be taken to prevent future negative consequences.

5. CONCLUSION

According to the results of this study the direct medical costs covered by government in Kazakhstan are going to increase twice for IHD and stroke and by ⅓ for T2D complications by 2030. Taking into account that no adjustments were used for the future currency changes, medical services and drug costs the future direct medical costs might be significantly higher than it was estimated in the study. Specifically, interventions targeting adults who are already overweight and obese are as important as obesity prevention programs targeting children and teenagers. The main purpose of this research was to inform, using economic rationale, the governmental planning of obesity control initiatives. It should be mentioned that significant amount of money might be saved in the future if required actions are taken by the government.

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Tables and Figures

Table 1. Obesity prevalence for 2008, 2020 and 2030 in Kazakhstan

	2008 (actual estimates)	2020 (predicted estimates)	2030 (predicted estimates)
Male	19.1%	45%	74%
Female	27.6%	29%	36%

Reference: WHO, 2013

Table 2. Estimated relative risk of diseases attributable to obesity

Disease	RR Obesity (men)	RR Obesity (women)
IHD	2.00	2.00
Stroke	1.50	1.55
T2D	5.50	7.00

Reference: World obesity, 2015

Table 3. Medical costs covered by government per patient

Disease	Costs for one treated case established by order of Ministry of healthcare for 2013 (KZT)
Stroke	62,051
Myocardial infarction	183,411
Blindness	36,300
IHD	67,503.3
Heart failure	71,743

Stenocardia	106,509
Amputation	41,499
Microvascular complications	61,423
Cataract	57,238

Reference: A.Zh. Ilmalieva, G.K. Moldabek, Zh.A. Akanov, 2016.

Table 4. Prevalence of IHD, stroke and T2D in Kazakhstan in 2008

Disease	**Prevalence for 2008**
IHD	49,067 cases
Stroke	48,577 cases
T2D	144,440 cases

References: Data for IHD is retrieved from https://online.zakon.kz/Document/?doc_id=37488639#pos=1;-161 - Statistics of the incidence and prevalence of socially significant diseases in Kazakhstan., n.d.

Data for stroke is retrieved from Morozova T.M., 2016

Data for diabetes is retrieved from https://online.zakon.kz/Document/?doc_id=37488639#pos=1;-161 - Statistics of the incidence and prevalence of socially significant diseases in Kazakhstan., n.d.

Calculation part

Calculations of PAFs for 2008 year

IHD (men) = 0.191*(2-1)/0.191*(2-1)+1 = 0.16
IHD (women) = 0.276*(2-1)/0.276*(2-1)+1 = 0.22
IHD (average) = (0.16+0.22)/2 = 0.19

Stroke (men) = 0.191*(1.5-1)/0.191*(1.5-1)+1 = 0.087
Stroke (women) = 0.276*(1.55-1)/0.276*(1.55-1)+1 = 0.132
Stroke(average) = (0.087+0.132)/2 = 0.1095

T2D (men) = 0.191*(5.5-1)/0.191*(5.5-1)+1 = 0.462
T2D (women) = 0.276*(7.0-1)/0.276*(7.0-1)+1 = 0.623

T2D (average) = (0.462+0.623)/2 = 0.5425

Calculations of PAFs for 2020 year

IHD (men) = 0.45*(2-1)/0.45*(2-1)+1 = 0.31
IHD (women) = 0.29*(2-1)/0.29*(2-1)+1 = 0.225
IHD (average) = (0.31+0.225)/2 = 0.2675

Stroke (men) = 0.45*(1.5-1)/0.45*(1.5-1)+1 = 0.184
Stroke (women) = 0.29*(1.55-1)/0.29*(1.55-1)+1 = 0.138
Stroke (average) = (0.184+0.138)/2 = 0.161

T2D (men) = 0.45*(5.5-1)/0.45*(5.5-1)+1 = 0.67
T2D (women) = 0.29*(7.0-1)/0.29*(7.0-1)+1 = 0.635
T2D (average) = (0.67+0.635)/2 = 0.6525

Calculations of PAFs for 2030 year

IHD (men) = 0.74*(2-1)/0.74*(2-1)+1 = 0.425
IHD (women) = 0.36*(2-1)/0.36*(2-1)+1 = 0.265
IHD (average) = (0.425+0.265)/2 = 0.345

Stroke (men) = 0.74*(1.5-1)/0.74*(1.5-1)+1 = 0.27
Stroke (women) = 0.36*(1.55-1)/0.36*(1.55-1)+1 = 0.165
Stroke (average) = (0.27+0.165)/2 = 0.2175

T2D (men) = 0.74*(5.5-1)/0.74*(5.5-1)+1 = 0.77
T2D (women) = 0.36*(7.0-1)/0.36*(7.0-1)+1 = 0.68
T2D (average) = (0.77+0.68)/2 = 0.725

Table 5. Calculations of costs for IHD and stroke for 2008 year

Disease	**Calculations of the costs (PAF*Costs per patient)**	**Results per one patient**	**Calculations for all cases (results per one patient*disease prevalence)**	**Total results (KZT)**	**Total results (USD)**
IHD	0.19*67 503.3	12,825.627	12,825.627*49,067	629,315,040	4,105,120.939
Stroke	0.1095*62,051	6,794.5845	6,794.5845*48,577	330,060,531.3	2,152,615.478

Table 6. Calculations of costs for IHD and stroke for 2020 year

Disease	Calculations of the costs (PAF*Costs per patient)	Results per one patient	Calculations for all cases (results per one patient*disease prevalence)	Total results (KZT)	Total results (USD)
IHD	0.2675*67,503.3	18,057.13275	18,057.13275*49,067	88,600,9332.6	5,778,447.353
Stroke	0.161*62,051	9,990.211	9,990.211*48,577	485,294,479.7	3,165,032,803

Table 7. Calculations of costs for IHD and stroke for 2030 year

Disease	Calculations of the costs (PAF*Costs per patient)	Results per one patient	Calculations for all cases (results per one patient*disease prevalence)	Total results (KZT)	Total results (USD)
IHD	0.345*67,503.3	23,288.6385	23,288.6385*49,067	1,142,703,625	7,452,576.96
Stroke	0.2175*62,051	13,496.0925	13,496.0925*48,577	655,599,685.4	4,275,743.073

Table 8. Calculations of costs for T2D complications for 2008 year

T2D complication type	Calculations of the costs (PAF*Costs per patient)	Results per one patient	Calculations for all cases (results per patient*coefficient(*)*disease prevalence)	Total results (KZT)	Total results (USD)
CVD	0.5425*55,2640.3	299,807.3628	299,807.3628 *0.1605*144,440	6,950,320,165	45,329,160.41
Retinopathy	0.5425*93,538	50,744.365	50,744.365 *0.3045*144,440	2,231,837,646	14,555,779.34
Amputation	0.5425*41,499	22,513.2075	22,513.2075*0.025 *144,440	81,295,192.28	530,197.5627
TOTAL					60,415,137.31

Note: CVD includes stroke, myocardial infarction,IHD,heart failure, stenocardia, microvascular complications;

retinopathy includes blindness and cataracts
Coefficient stands for the risk of getting particular complication due to T2D and retrieved from Gan, D. (2003).

Table 9. Calculations of costs for T2D complications for 2020 year

T2D complication type	Calculations of the costs (PAF*Costs per patient)	Results per one patient	Calculations for all cases (results per patient* coefficient(*) *disease prevalence)	Total results (KZT)	Total results (USD)
CVD	0.6525*552,640.3	360,597.7958	360,597.7958 *0.1605*144,440	8,359,601,673	54,520,326.57
Retinopathy	0.6525*93,538	61,033.545	61,033.545 *0.3045*144,440	2,684,376,155	17,507,181.6
Amputation	0.6525*41,499	27,078.0975	27,078.0975 *0.025*144,440	97,779,010.07	637,703.0592
TOTAL					72,665,211.23

Note: CVD includes stroke, myocardial infarction,IHD,heart failure, stenocardia, microvascular complications; retinopathy includes blindness and cataracts
Coefficient stands for the risk of getting particular complication due to T2D and retrieved from Gan, D. (2003).

Table 10. Calculations of costs for T2D complications for 2030 year

T2D complication type	Calculations of the costs (PAF*Costs per patient)	Results per one patient	Calculations for all cases (results per patient* coefficient(*) *disease prevalence)	Total results (KZT)	Total results (USD)
CVD	0.725*552,640.3	400,664.2175	400,664.2175 *0.1605*144,440	9,288,446,302	60,578,140.62
Retinopathy	0.725*93,538	67,815.05	67,815.05 *0.3045*144,440	2,982,640,173	19,452,424.01
Amputation	0.725*41,499	30,086.775	30,086.775 *0.025*144,440	108,643,344.5	708,558.9547
TOTAL					80,739,123.58

Note: CVD includes stroke, myocardial infarction,IHD,heart failure, stenocardia, microvascular complications; retinopathy includes blindness and cataracts
Coefficient stands for the risk of getting particular complication due to T2D and retrieved from Gan, D. (2003).

Table 11. Results of the calculations of PAFs for 2008,2020 and 2030 years

Disease	PAFs for 2008	PAFs for 2020	PAFs for 2030
IHD	0.19	0.2675	0.345
Stroke	0.1095	0 .161	0.2175
T2D	0.5425	0.651	0.725

Table 12. Estimated medical direct costs related to IHD, stroke and T2D diabetes for 2008, 2020 and 2030

Disease	Costs for 2008 (USD)	Costs for 2020 (USD)	Costs for 2030 (USD)
IHD	4,105,120.939	5,778,447.353	7,452,576.96
Stroke	2,152,615.478	3,165,032.803	4,275,743.073
T2D complications	60,415,137.31	72,665,211.23	80,739,123.58

LIST OF JOURNALS FOR PUBLICATION

#	**Journal name**	**Impact Factor**
1	International Journal of Public Health	2.327
2	Journal of Public Health	2.125
3	International Health	1.784
4	International Journal of Health Economics and Management	1.100
5	Health Care Analysis	0.820