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Childhood obesity and its impact on health status in adulthood

Research report

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Студијата е изработена со финансиска поддршка од канцеларијата на УНИЦЕФ во Скопје. Искажаните ставови припаѓаат само на авторите и не ги отсликуваат ставовите и политиките на УНИЦЕФ.

Abbreviations

BMI	Body mass index
COSI	WHO European Childhood Obesity Surveillance Initiative
CVDs	Cardiovascular diseases
DALYs	Disability-Adjusted Life Years
GBD	Global Burden of Disease
GBP	Great Britain Pound
GDP	Gross Domestic Product
EU	European Union
EU-SILC	European Union Statistics on Income and Living Conditions
HIF	Health Insurance Fund
IHME	Institute for Health Metrics and Evaluation
IPH	Institute of Public Health
MDGs	Millennium Development Goals
MKD	North Macedonian Denar
NCDs	Non-communicable diseases
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
SDGs	Sustainable Development Goals
UNICEF	United Nations Children's Fund
USD	United States Dollar
WHA	World Health Assembly
WHO	World Health Organisation
YLLs	Years of Life Lost

Executive summary

In North Macedonia, an analysis of the causes of mortality shows that, similar to many other European countries, diabetes is among the top ten causes of mortality. Such outcome might be attributed to prevailing unhealthy habits and behaviour, including unbalanced diet and low physical activity. The country is seeing a steady upward trend in numbers of diabetes patients, which raises concerns about increasing health costs, and more importantly – reduced quality of life and life expectancy.

With the current status of its health and nutrition-related SDG indicators, the country has to speed up and reshape its interventions, if it is to make significant change for its population, and for the children in particular, so to ensure healthy start and better quality and performance throughout their life-course. The country has committed to the delivery on the UN 2030 Agenda and its Sustainable Development Goals (SDGs), in which nutrition and health are recognized as important factors contributing to economic development and social wellbeing. As evidenced by the international literature, obesity is one of the main risk factors for developing diabetes in adolescence/early adulthood as well as for other non-communicable diseases, such as cardiovascular diseases.

Purpose and methodology of the study. As response to the above challenges, the UNICEF Office in Skopje commissioned the London School of Economics and Political Sciences (LSE) and the Centre for Regional Policy Research and Cooperation "Studiorum" to conduct a research aimed at development of an econometric model to test the association between obesity and some of the most widely associated NCDs; and development of a costing model that would account for costs associated with the obesity related NCDs. This analytical exercise was based on available secondary data on obesity and overweight in children and adolescents, including nutrition and physical activity habits and status, epidemiology and healthcare utilisation, and household income. The main datasets used in the analysis were from the regular and periodic national surveys as well as administrative data, including the European Union Statistics on Income and Living Conditions (EU-SILC), WHO European Childhood Obesity Surveillance Initiative (COSI), outpatient visits from the Health information system 'Moj termin', and also data from international repositories, such as the Global Burden of Disease (GBD) database. Regression analysis was used to establish correlations between main socio-demographic indicators and overweight/obesity in children and adolescents. Data from GBD database was used to estimate the costs associated with overweight-related NCDs. A few findings stem from this very first attempt to conduct a systematic study on overweight/obesity in North Macedonia.

The level of physical activity is associated with lower likelihood of being overweight/obese. This finding based on the data from EU-SILC survey, is in line with what the existing literature has suggested.

Urban children are 1.7 times more likely to be overweight/obese relative to rural children. More specifically, based on the COSI 2019 dataset we find that the share of children who are overweight/obese is lower in schools where children are allowed to use the sports gymnasium during and outside of school hours. This is also in correlation with the literature on the association between urbanization and overweight and obesity.

Some of the epidemiological transition in North Macedonia has already happened in that the socio-economic status and overweight/obesity relationship resembles the relationship observed in high income countries. More specifically, based on the EU-SILC data we find that adolescents from the lower socio-economic groups are more likely to be overweight/obese relative to those from the higher socio-economic groups.

Other school-based characteristics, such as food advertising, are also important for child/adolescent overweight/obesity. Based on the COSI 2019 data, we find that the share of children who are overweight/obese is higher in schools which do not prohibit advertising of foods rich in calories but poor with nutrients. While we caution against direct causal link in this case, the established correlational pattern could create the basis for important policy recommendations.

There are some limitations to the findings of this study. For example, the findings from the COSI dataset could not be generalized to the entire population given that the data is collected on a non-representative set of second graders in the country. In addition, while the results from the EU-SILC data are representative for the population of the country, given the nature of the dataset, we only include adolescents and young people (i.e. the children are not included in the analysis). Finally, perhaps the biggest limitation to the study is that given how data exigent the process of estimating the burden of disease is, the study was unable to derive some of the standard indicators (e.g. premature mortality due to NCDs associated with overweight/obesity as well as total of life years lost as a result of the said NCDs). Hence, we rely on the data from the Global Burden of Disease project. In addition (and as further elaborates in the recommendation section), we provide some further pointers as to what data is needed to accurately estimate the overall burden of NCDs associated with overweight/obesity.

Study results imply two types of recommendations: those stemming from the available data and existing policies, and those from the lack of these. Data analysis suggests the need for policy interventions in ensuring healthy choices in and out of schools, such as creating enabling environments and promoting physical activity; reinforcement of advertising policies and investment into their appropriate implementation; and working on behaviour change for healthy eating habits. While available data offered the above findings and subsequent recommendations, its limitations suggest need for additional surveillance. In order to further understand the drivers of overweight/obesity in a causal manner we propose generating further evidence by the way of collecting longitudinal/ panel data on children which will be followed over a certain period of time. This would enable establishing a causal link between some of the main correlates, such as socio-economic status, physical activity and overweight/obesity, at the same time becoming a useful tool for studying the effectiveness of both broader and targeted policies and interventions.

Background

Health status by key indicators

North Macedonia, a small land-locked country on the Balkan Peninsula with population of approximately 2 million inhabitants, has similar demographic and epidemiological patterns to many upper middle income countries in the region. The country has seen an increase of average life expectancy at birth from 71.1 years to 75.5 years in 1991 and 2013 respectively, making it comparable to the new EU member states (EU13 average of 76.9 years) but still lies below the EU average of 80.7 years in 2013 (WHO Regional Office for Europe, 2019). Yet, as in many other countries, the gap between female and male life expectancy is substantial; the difference of 4.6 years in 1991 widened to 5.7 years in 2005, but narrowed to 3.9 years in 2012. However, unlike many other countries North Macedonia averted the mortality crisis that many central and Eastern European countries experienced in the early 1990s (Nolte, McKee & Gilmore, 2004) with decreasing mortality rates since 1995 (Table 1); however, death rates for the non-communicable diseases were nearly twice as high as the respective EU averages. An analysis of the causes of mortality shows that, similar to many other European countries, diabetes is among the top ten causes of mortality (WHO Regional Office for Europe, 2019). Such outcome might be attributed to prevailing unhealthy habits and behaviour, including unbalanced diet, high rate of smoking and drinking and low physical activity (Milevska-Kostova et al 2017). For example, unhealthy habits are also present in nutrition with average daily intake of fats of 34.1% (compared to <30% recommended intake), exceptionally high sodium intake of 7883 mg, compared to the recommended values (500-2500 mg) and high salt intake which are results of high consumption of processed foods (Institute of Public Health, 2014).

According to the Ministry of Health's 'Programme for insulin, glucagon, insulin needles, glucose test strips, and education on the treatment and control of diabetes for 2019', in 2018 the National health electronic system (Moj termin) recorded 85,000 people in North Macedonia with diabetes mellitus. About 40,000 of them are on insulin therapy (of which 3,000 persons for diabetes type 1, and 37,000 for diabetes type 2). The steady upward trend of number of diabetes mellitus patients in the country raises concerns about increasing health costs, and more importantly – reduced quality of life and life expectancy (MoH, 2018).

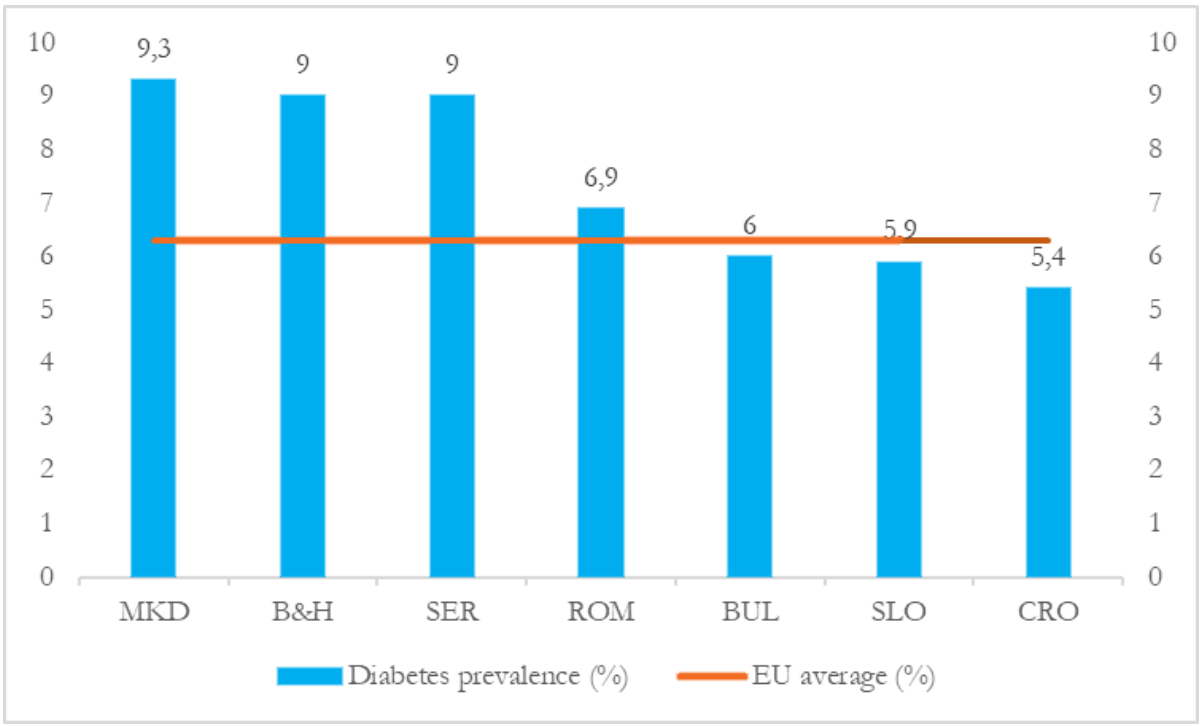
Table 1. Main causes of death from non-communicable diseases, selected years (standardized death ratio, all ages per 100 000)

	1995	2000	2005	2010
ALL CAUSES	**1055.9**	**1014.5**	**1032.7**	**939.5**
NONCOMMUNICABLE DISEASES				
Diseases of circulatory system	603.8	582.2	621.0	553.0
Cerebrovascular diseases	189.3	192.8	206.0	183.7
Malignant neoplasms	149.2	163.6	160.3	171.5
Cervical cancer	3.6	5.7	3.7	2.8
Breast cancer (female)	22.8	25.2	20.2	27.7
Diabetes	21.9	30.2	35.8	34.1
Diseases of the respiratory system	46.8	36.8	41.2	34.4
Diseases of the digestive system	21.2	18.8	17.3	17.2
Mental disorder & disease of nervous system & sense organ	7.5	9.0	8.6	8.4
EXTERNAL CAUSES				
Selected smoking related causes	360.8	367.0	372.8	331.2
Selected alcohol related causes	47.0	52.1	43.3	43.1
External cause (injury and poison)	30.8	37.9	30.0	28.3
Motor vehicle traffic accidents	4.9	5.4	6.4	6.3
Suicide and self-inflicted injury	7.5	7.6	7.1	5.7
Transport accidents	5.6	5.8	6.8	6.4

(Source: Milevska-Kostova et al 2017)

One of the key targets of the Sustainable Development Goal 3 is Target 3.4 which aims by 2030 to reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being. Some progress has been made. Judging by the World Development Indicators, while the share of the three most common NCDs (diabetes, cancer and cardiovascular diseases) was 22.5% of the total number of deaths worldwide in 2000, it has dropped to 18.7% in 2016 (World Development Indicators, 2019). Nevertheless, this is still not a cause for celebration as the prevalence of some of the NCDs mentioned above has been increasing. For example, while, worldwide, the prevalence of diabetes has been 6.4% in 2010, it has jumped by almost 2.5 percentage points to 8.8% in 2019 (World Development Indicators, 2019). In 2019, the diabetes prevalence in North Macedonia was 9.3%, slightly higher than the global average, and much higher than the EU average of 6.3% (Figure 1).

Figure 1. Prevalence of diabetes, North Macedonia and selected countries compared to EU average, 2019, in %

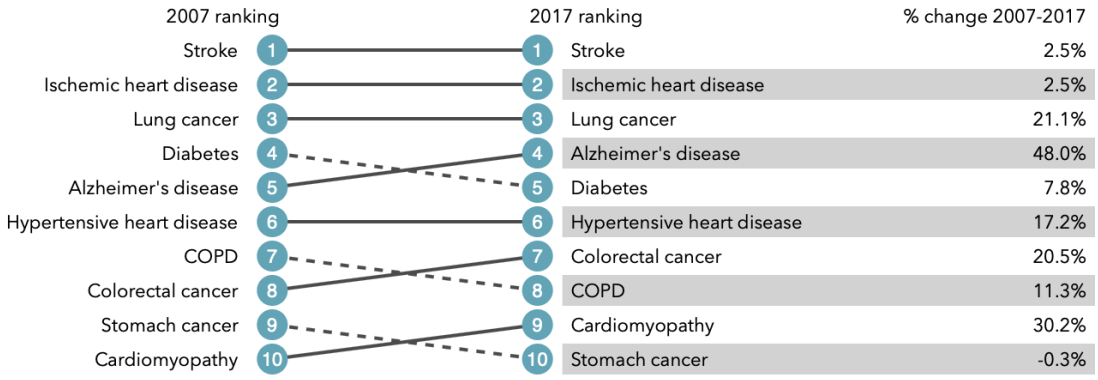


(Source: World Development Indicators, 2020)

In the national landscape, diabetes continues to be among the top ten causes of mortality (Figure 2) and premature mortality (Figure 3). In 2017, diabetes ranked 5th and 4th respectively, next to stroke, ischaemic heart disease and lung cancer.

Figure 2. Top 10 causes of death in North Macedonia in 2017, and percent change 2007-2017, all ages, rank

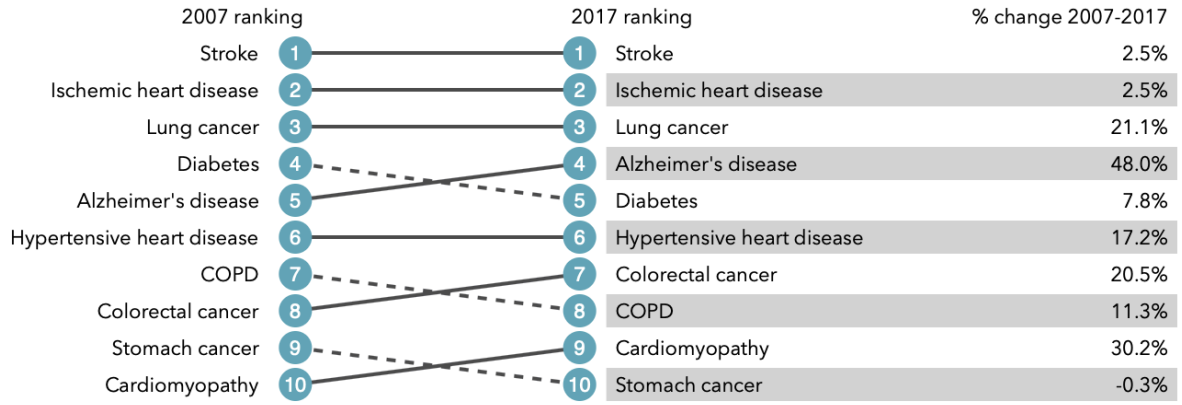
What causes the most deaths?



(Source: IHME, 2020)

Figure 3. Top 10 causes of premature death in North Macedonia in 2017, and percent change 2007-2017, all ages, rank

What causes the most premature death?



(Source: IHME, 2020)

Health risk factors relevant to the study

Nutrition

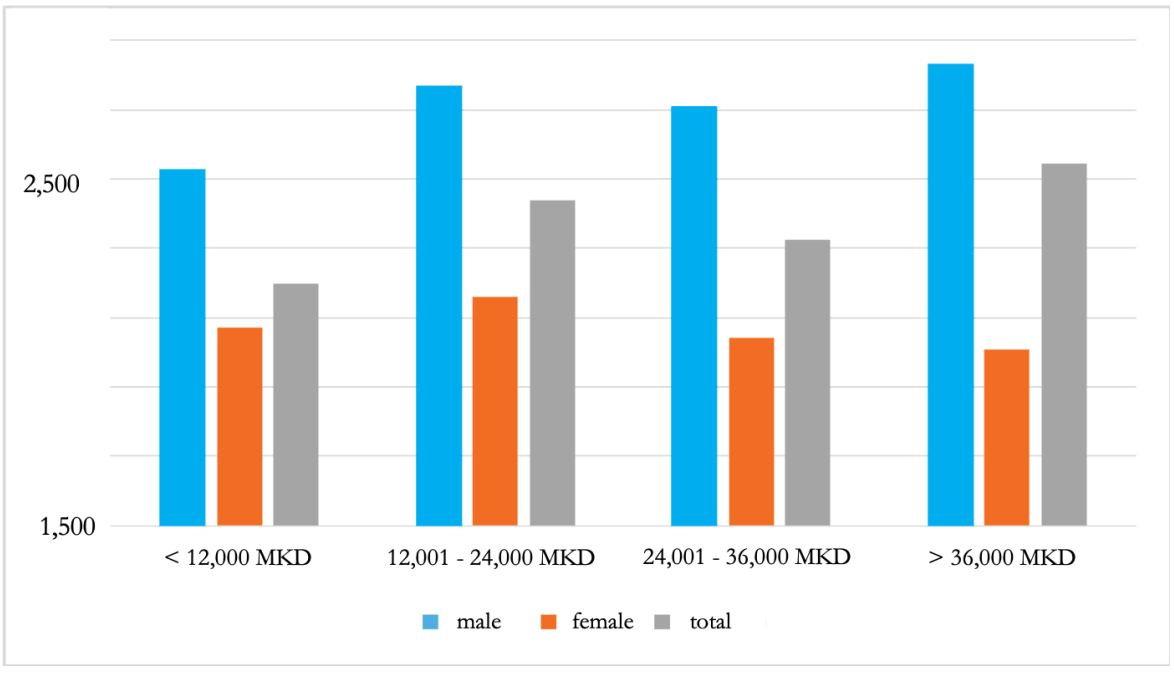
Healthy nutritional habits are key to preventing overweight and chronic noncommunicable diseases. Poor nutrition with excessive consumption of food and beverages with a high content of fats, sugars, and salt is related to an increased risk of overweight, and hence with a number of chronic diseases. Multiple studies have shown that there is an inverse correlation between social class and overweight and risk of obesity (Ball, Mishra & Crawford 2003).

Social differences in nutrition go both ways, namely undernutrition is more common is poorer countries and higher rates of obesity in lower-income populations are more common in high income countries (Whitehead & Dahlgren 2006).

According to the IPH Study (IPH, 2015), energy intake tends to increase with the increase in income, so that persons with income higher than MKD 36,000 per month on average consume 16% more kcal than persons with income lower than MKD 12,000 per month. Disaggregated by gender, this difference is more apparent in men with 12%, while in the case of women, the increase in monthly income shows a negligible decrease in energy intake from food by 3% (Figure 4).

According to the Global Burden of Disease database, in 2017, among the top ten risk factors contributing to most death and disability in North Macedonia were: dietary risks, high fasting blood glucose, high body mass index (BMI) and high LDL levels (Figure 5).

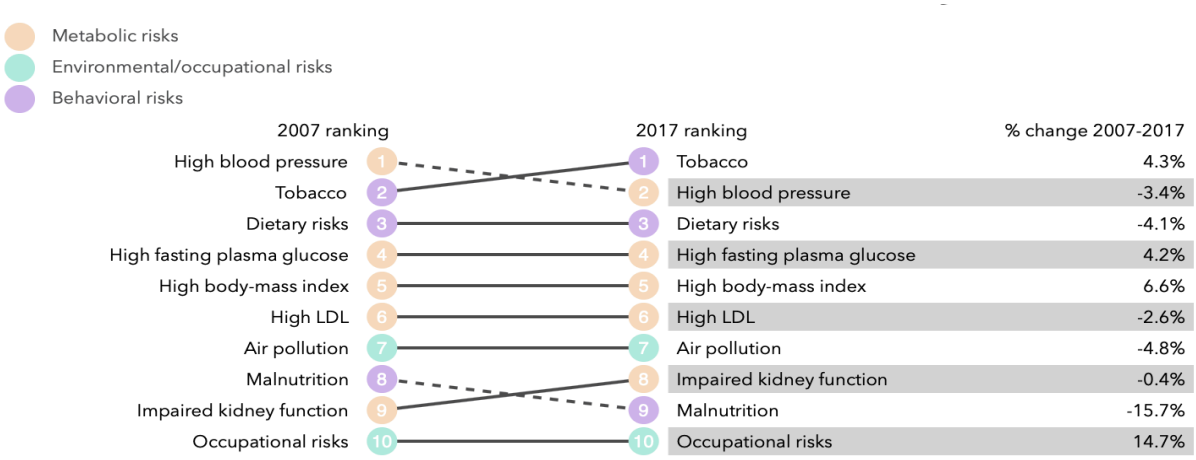
Figure 4. Average daily calorie intake (kcal) in North Macedonia by gender and monthly income, 2015



(Source: Adjusted from IPH, Food Consumption Study, 2015)

Figure 5. Top 10 risk factors contributing to DALYs in North Macedonia in 2017, and percent change 2007-2017, all ages, rank

What risk factors drive the most death and disability combined?



(Source: IHME, 2020)

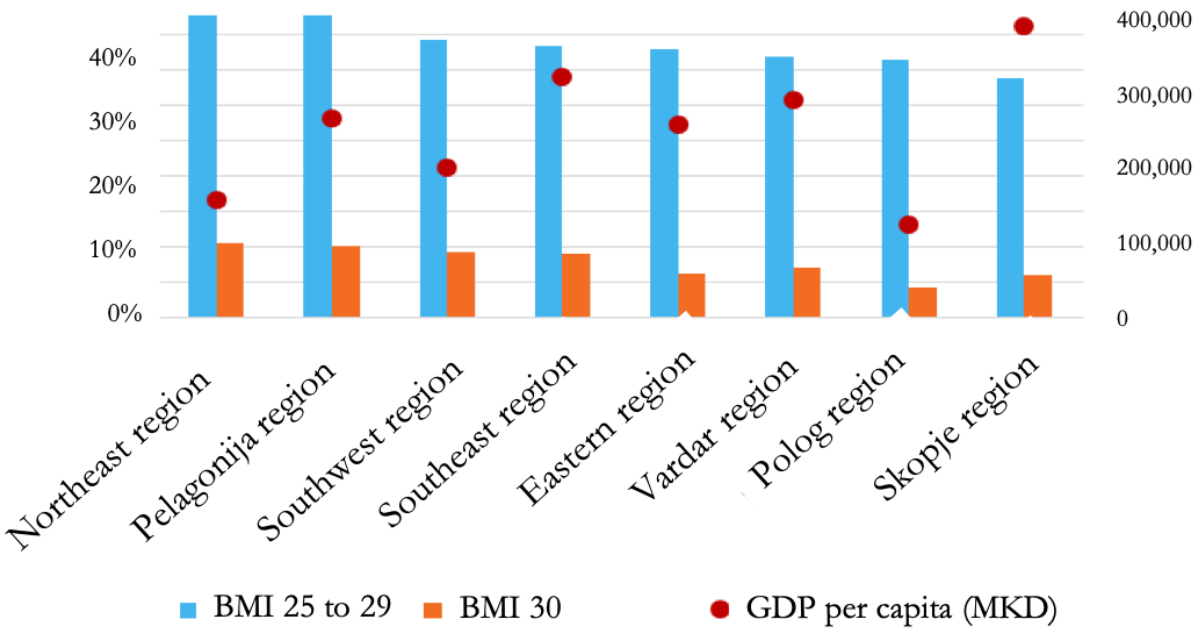
Physical activity

Physical activity represents significant part of the process of health maintenance and improvement, and has proven health benefits if practiced with recommended frequency and intensity (Oja et al, 2017). Although not too many studies have been undertaken in the country to specifically assess physical activity, the first food consumption survey undertaken in 2015 showed that over half of respondents (50.6%) reported no physical activity, and additional 41.1% reported having moderate physical activity of less than the recommended 150 minutes per week (Spiroski, 2016).

Overweight and obesity

Overweight[1] and obesity[2] are factors behind many chronic diseases. According to the Health Insurance Fund (HIF) data from the diabetes screening of the target population aged 35-55 years carried out in 2016, 38% of examined patients were overweight (body mass index (BMI) between 25-29), and 7% were obese (BMI of 30 and more).

Figure 6. Overweight and per capita GDP by regions, 2016



(Source: Unpublished report on Social determinants of health (HIFM and SSO))

An unpublished results of a social determinants of health study conducted in 2017, showed that in North Macedonia in 2016 at regional level, there was a moderate negative correlation between obesity and economic development of the region (-0.44); namely the Skopje Region with the highest per capita GDP had the lowest rate of overweight persons, and the Northeastern Region with the second lowest per capita GDP had the highest percentage of overweight persons (Figure 6).

1 According to the WHO definition, overweight person is one having Body Mass Index of over 25 (https://www.who.int/topics/obesity/en/, accessed 10 February 2020)

2 According to the WHO definition, an obese person is one having BMI of 30 and over (https://www.who.int/topics/obesity/en/, accessed 10 February 2020)

National commitments for child wellbeing in global agendas: nutrition and obesity

The 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development (UN, 2015), adopted by world leaders in September 2015 at an historic UN Summit, universally apply to all, and countries have to mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. SDGs recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection, and that providing support throughout the entire life, starting from early childhood is crucial.

While the SDGs are not legally binding, governments are expected to take ownership and establish national frameworks for the achievement of the 17 Goals. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, which will require quality, accessible and timely data collection. Regional follow-up and review will be based on national-level analyses and contribute to follow-up and review at the global level.

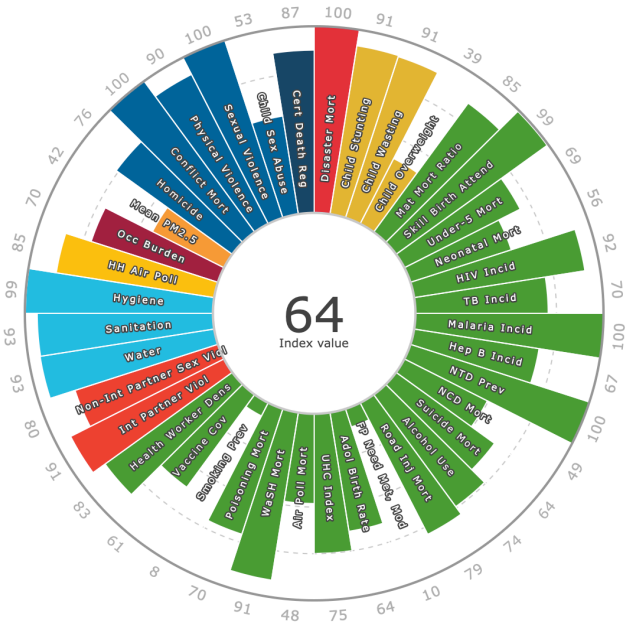
Nutrition is one of the key issues that could help achieve the SDGs. Nutrition represents many things is people's lives: a process by which individuals achieve their physical and mental growth potential; a characteristic of the quality of an individual's diet in relation to their nutrient needs; and a benchmark or metric against which the effectiveness of numerous development goals are assessed. It is also, not least, a fundamental right of all of humanity. Without good nutrition, the mind and body cannot function well. When that happens, the foundations of economic, social and cultural life are undermined (UN Standing Committee on Nutrition, 2014).

While 'nutrition' appears to be associated with SDG 2 ('End hunger, achieve food security and improved nutrition, and promote sustainable agriculture' as currently proposed), in reality nutrition is interwoven with all 17 SDGs. The nutritional status of children was recognized as a key indicator of poverty and hunger within the MDGs. That was an important step in acknowledging that national policies and programmes which improve nutrition have a role to play in development beyond the resolution of individual nutrient deficiencies. But nutrition also has relevance beyond poverty reduction and the removal of hunger; it plays a part in strengthening development mechanisms and instruments such as economic growth strategies, health sector reform, improved governance, and even human rights (UN Standing Committee on Nutrition, 2004). In other words, nutrition offers a lens through which to consider how actions taken to address one or more SDGs would translate into improved child growth, and how these would support attainment of other individual goals.

Nutrition could contribute to achievement of other SDGs. For example, as health outcomes and nutritional status are inextricably linked, the ability to learn and the nutrition of a child are mutually supportive. Undernutrition acts as a drag on education: compounding the negative effects of many other characteristics of poverty, it is associated with delayed school enrolment, impaired concentration, more schooling lost to illness, and drop-out before completion (Jukes, 2007). Children who are more affected by stunting early in their life have poorer test scores on cognitive assessments and activity level (Alderman, Hoddinott & Kinsey, 2006). The education of girls in particular has been shown to have direct links to improved nutrition of their children (Smith and Haddad, 2015), as well as indirect impacts via later marriage (when their bodies are ready for childbirth), reduced child mortality rates even controlling for income of the household (Wang et al., 2016), reduced fertility rates, and enhanced earnings of adult women. Good nutrition provides for good students, and access to education and learning generates improvements in caring practices, dietary choices and nutrition outcomes (Alderman, Hoddinott & Kinsey, 2006). As a result, the benefits of good nutrition for education require that actions to promote good nutrition be taken long before schooling begins.

North Macedonia too, is committed to delivery towards achievement of the SDGs. Below is the assessment of the health-related SDGs achievement of the country in 2017 (Figure 7).

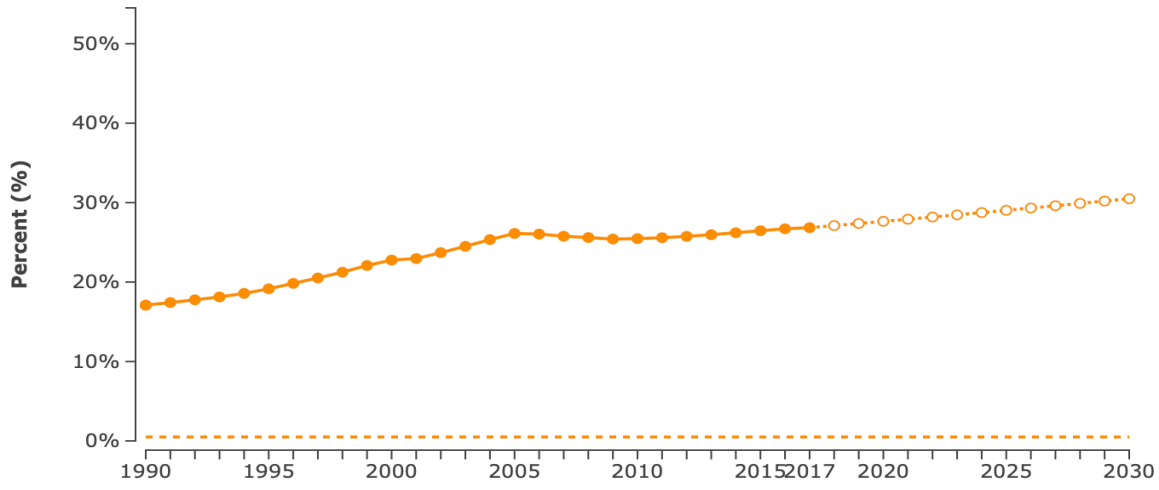
Figure 7. North Macedonia's status with health-related SDGs in 2017



(Source: IHME, 2020)

According to the data presented above, the country is lagging behind with the delivery on the reduction of child obesity; the prevalence of overweight among children aged 2 to 4 years (indicator 2.2.b),[3] in 2017 was 26.8%, with SDG index of 39.0/100. If the country continues with the current pace of activities, according to the Institute for Health Metrics and Evaluation (IHME) projections, it would not only be unable to achieve this SDG target for its youngest population, but its SDG index would additionally worsen, as the prevalence of child overweight would increase to 30.5% (20.5%-41.3%)(Figure 8).

Figure 8. Prevalence of child overweight, North Macedonia, 1990-2017 and projections to 2030



(Source: IHME 2020)

3 Related to Target 2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

Literature review

Childhood obesity is a well-recognized epidemic in high income countries. Though it was once considered isolated to developed nations, obesity is now on the rise in middle and low income countries. Childhood obesity has implications on health and is highly stigmatised in some areas of the world. In a systematic review published in Nature, of 5 studies which looked at the association between overweight and obesity on premature mortality, 4 found significant increased risk of premature mortality. Within the same systematic review it was also found that child obesity was significantly associated with increased risk of cardio metabolic morbidity (i.e. diabetes, hypertension, ischaemic heart disease and stroke) as well as increased risk of later disability pension, asthma, and polycystic ovary syndrome (Reilly & Kelly, 2011). These conclusions were also supported in yet another systematic review which linked childhood obesity and type 2 diabetes, hypertension and coronary heart disease in 39 large studies (Park et al., 2012). Many later in life complications are result of a high percentage of obese children ending up as obese later on in adulthood with an average of 40% (though upwards of 80%) of overweight and obese children becoming or remaining obese and overweight as adults (Bridger, 2009; Deshmukh-Taskar et al., 2006; Serdula et al., 1993). Obesity is further perpetuated within a family. Having at least one obese parent increased the risk of a child being obese by age 7 significantly. The risk was even higher when both parents were obese (Reilly, 2005).

The factors that play into obesity are manifold. Environmental factors, lifestyle preference and cultural environment are all contributory (Sahoo et al., 2015). While it is understood that weight is managed through the balance of caloric intake and calories burned during activity, the situation surrounding obesity is far more complex. Environmental barriers such as fewer spaces to walk around and increased utilization of cars and other transport systems have reduced physical activity. At the same time the availability of cheap high sugar/calorically dense foods further make a healthy choice a difficult one. These environmental and structural barriers impact dietary intake, physical activity, and sedentary behaviour (Davison & Birch, 2001).

Genetics also contribute as some are more predisposed to genes which alter how one understands fullness and therefore increases caloric consumption. Some studies find 20-40% of obesity is heritable or at the very least perpetuated by family environment (Anderson & Butcher, 2006). Though differentiating what is genetic verses environmental is difficult and many believe that while there is a genetic propensity, alterations in the environment would make significant changes in altering healthy habits. Thus government and social policies could make substantial changes. Taxing unhealthy foods, reducing access to such foods, increasing green spaces for activity, and creating work environments that reduce sedentary behaviour are all meaningful actions when it comes to tackling obesity (Republic of Ireland, Department of Health and Children, 2005).

Childhood obesity in North Macedonia

At the current moment it is hard to understand the full picture of childhood obesity in North Macedonia as there exist very few English published studies in North Macedonia. Some things are known such as the rates in North Macedonia of overweight and obese children are comparable, over 30% overweight or obese, to other international contexts. As a country in transition there has been remarkable modernization with the construction of many factories and consequently increased urbanisation, particularly in Skopje. While traditionally there is a strong agrarian foothold in which plentiful amounts of fresh fruit and vegetables are produced at reasonable prices, new lifestyles in North Macedonia are characterized by an increase in availability of energy dense and nutrient poor food. Lack of regulatory policies allowing uncontrolled and strong marketing schemes by the food industry and lower levels of education have been blamed for the rise in child obesity and consequently hypertension and metabolic syndrome. Many schools also lack school kitchens where food could be prepared under nutritional guidelines (Tasic, Danilovski & Gucev, 2016). North Macedonia also has few resources to develop public services related to physical activity and nutrition policies (Starc & Klincarov, 2016).

Important factors in determining which children in North Macedonia are more susceptible to being obese or overweight can be generally broken down into socioeconomic status, geography, gender and national identity. In North Macedonia, there is a significant positive relationship between socioeconomic status and obesity. Pupils from a high socioeconomic status were 46% more likely to be overweight or obese compared to low socioeconomic pupils. Urbanisation also plays a substantial role in North Macedonia as children living in urban areas were 40% more likely to be overweight or obese than those in rural areas. Differences also existed by gender as boys were 23% more likely to be overweight and obese compared to girls. One of the most vital periods in which overweightness and obesity occurred was in the 10th year of age (Gontarev & Kalac, 2014). Further compared to other countries in the region, such as Slovenia, North Macedonian children are far less active (Gontarev, 2008; Sember et al., 2016). At the turn of the 21st century, the trend of excess weight and faster growth among North Macedonian children in North Macedonia resembled the patterns of less industrialised countries, whereby higher socioeconomic status were more likely to put on excess weight. Prevalence of both obesity and severe obesity among children in North Macedonia is high compared to most of the European countries participating in the Childhood Obesity Surveillance Initiative (Wijnhoven et al., 2014; Spinelli et al., 2019). In comparison the pattern of weight and growth for migrant Albanian minority children showed slower growth patterns and were predominantly normal weight (Knai et al., 2012). At the end of the weight scale are the Roma children who were more likely to be classified as undernourished (Spiroski et al., 2011).

Further to the above, there is a trend of increasing overweight and obesity prevalence (Spiroski et al., 2014). According to the Health Behaviour of School Children survey 2011, overweight is recorded among 33%, 26% and 24% of children at age 11, 13 and 15 respectively (Kjostarova-Unkovska & Georgievska-Nanevska, 2013).

Consequences of obesity/cost of obesity

As evidenced by the international literature, obesity is one of the main risk factors for developing diabetes in adolescence/early adulthood as well as a range of other non-communicable diseases (e.g. cardiovascular disease etc). The increase of the burden of the NCDs inadvertently have a tremendous impact on the overall cost of the national healthcare system. In the context of diabetes (the disease most closely related to obesity), the literature identifies three main costs: direct, indirect and intangible. Direct medical costs include resources used to treat the disease (thus included outpatient care, inpatient care, medications, medical devices and long term care) (Seuring, Archangelidi & Suhrcke, 2015). Indirect costs include lost productivity caused by morbidity, disability, and premature mortality. Intangible costs refer to the reduced quality of life for people with diabetes brought about by stress, pain, and anxiety.

The direct cost of diabetes varies significantly among countries. According to a study by the American Diabetes Association, the largest components of the direct costs in the USA are: (a) hospital inpatient care (43%); (b) prescription medications to treat diabetes (18%); (c) anti-diabetic agents and supplies (12%); (d) physician office visits (9%); and (e) nursing facility stays (8%) (American Diabetes Association). Similarly, diabetes carries significant costs in the UK as well. According to a recent study, direct costs equate to around 9.8 billion GBP, with 8.8 billion pounds spent on type-2 diabetes mellitus alone (Diabetes UK, 2014).

The international literature stipulates a few transmission mechanisms though which indirect costs are incurred: (i) increased absenteeism (days missed from work due to ill health or hospitalization); (ii) presenteeism (reduced productivity whilst at work); (iii) inability to work due to long term diabetes related disability; (iv) premature death; (v) reduced productivity from those not part of the labour market (Lewin Group, 2010).

The cost associated with inability to work due to long term diabetes related disability is high in some of the OECD countries. A study in Australia for instance, argues that 38% of people with diabetes over the age of 45 years are not in employment, thus further exacerbating the overall productivity loss (Schofield et al, 2010).

Some part of the costs are also related to the reduced productivity of those in the labour force. A study in the US has calculated this portion of the total costs, though acknowledging that this is an underdeveloped area of research (American Diabetes Association, 2013). Overall, the international literature finds that presenteeism accounts for roughly 11% of the total combined (direct and indirect) cost of diabetes (American Diabetes Association, 2013). Absenteeism is also considered to further increase the total indirect costs due to diabetes. Various sources could be used in assessing this element of the indirect costs. A study in the UK has used data on diabetes-related sickness absence to estimate the total costs due to absenteeism.

Indirect costs are not specifically related to preventing or managing diabetes, but are associated with costs that impact on society and productivity. In the United States, loss of work and increased absenteeism accounts for 5 billion USD, reduced productivity while at work costs society about 20.8 billion USD, and reduced productivity for those who are not in the workforce account for 2.7 billion USD in indirect costs; 21.6 billion USD was lost due to the inability to work because of diabetes and 18 billion USD was lost because of early mortality (American Diabetes Association, 2013). In the UK reduced productivity at work due to death or poor health is estimated at 9 billion GBP (Hex et al., 2012).

Diabetes lowers an individual's quality of life in many ways, including their physical and social functioning and their perceived physical and mental well-being. With a value of 1 representing the health-related quality of life without illness and 0 representing death, people with type 2 diabetes had a value of 0.77 in the population of the United Kingdom prospective diabetes study (Clarke, Gray, & Holman, 2002).

Aims of the study

Against the above-elaborated background, the aims of this study are manifold:

I. To take stock of the available secondary data on child/adolescent obesity in North Macedonia, whilst identifying any gaps that should be filled with a subsequent data gathering exercise;

II. Based on the available secondary data, to develop an econometric model that would test the association between obesity and some of the most widely associated NCDs (e.g. diabetes, cardiovascular disease etc);

III. Based on (ii) above, to develop a costing model that would account for both, direct and indirect costs associated with the obesity related NCDs. In doing this analysis we aimed to rely on both, survey data and administrative records.

Methodology

As described earlier, the current study was structured as an analytical exercise based on available secondary data on obesity and overweight in children and adolescents, including nutrition and physical activity habits and status, epidemiology and healthcare utilisation, and household income.

As a first step, the study team developed an inventory of available data that was considered useful for the analysis and development of the econometric model (Appendix 1).

After initial assessment of the available data, the team decided to use most recent datasets, so as to ensure as much as possible accuracy of results to the current situation. The data and methods of analysis are described separately for each dataset, in the next section.

Data and methods used in the analysis

European Union Statistics on Income and Living Conditions (EU-SILC)

The European Union Statistics on Income and Living Conditions (EU-SILC) data has information on BMI status for all respondents (including adolescents over the age of 16 years). In addition, the survey has a rich set of questions which could allow us to further study the link between adolescents' overweight/obesity and household based characteristics (e.g. urban/rural, household income, parental characteristics etc).

Hence, the purpose of this exercise is two-fold: (i) to derive the rate of overweight/obesity among adolescents; and (ii) to conduct an analytical exercise on the main household's characteristics that are correlated with the probability of being overweight or obese as an adolescent.

If we assume a linear model, the likelihood of being overweight/obese could be analysed by regressing the relevant dependent variable (yi) on a vector of k socio-demographic indicator variables (xk). This set of socio-demographic variables would include the standard correlates (age, ethnicity, level of education, place of residence, socio-economic status etc.). The equation of the model would be as follows:

$$yi^* = \alpha + \Sigma kxki + \varepsilon i \,, \quad with\ i = 1,\ldots N \tag{1}$$

Assuming that yi* in equation (1) is a latent variable, the logit model is written as:

$$y_i = \begin{cases} 1 \ if \ \ y_i^* > 0 \\ 0, otherwise \end{cases} \tag{2}$$

All of the modelling exercises above have been conducted on the available datasets using the usually applied software (STATA 14, StataCorp, TX, USA).

Data for the link between individual and household level variables and adolescent overweight/obesity

In order to gauge the link between individual and household level variables (e.g. socio-economic standing), we relied on the EU Survey on Income and Living Conditions (EU-SILC). It is a nationally representative survey, containing information on various indicators, from completion of schooling to employment, type of employment and earnings. Occasionally, the EU-SILC survey features the so-called 'modules' and for the purpose of this exercise we rely on the module on health.

Inter alia, the module on health contains information on height and weight, which was subsequently used in order to derive a person's BMI status. Based on the BMI status, two dummy variables were created: (I) overweight, for individuals that have BMI higher than 25; and (ii) obese for individuals with BMI higher than 30. Given that in our sample, we also have individuals ages less than 19 years of age, we used the appropriate reference scale provided by WHO.[4]

In terms of analytical work, we first started by deriving the share of individuals that are overweight or obese. Given that EU-SILC data includes individuals over the age of 16, we couldn't specifically comment on the rate of child obesity. Nevertheless, the sample has sufficient number of respondents in the 17-24 years age cohort, which allowed us to specifically analyse some of the individual and household related correlates to adolescent overweight and obesity.

In distilling the individual and household level variables, we were guided by both, what was available in the survey and what the literature dictates as the meaningful correlates of obesity. As expected, we have included variables for gender and age (in ten year brackets). In addition, we have also included a variable if the person was currently in school or not (relevant for those in the 17 to 24 years cohort). Level of schooling completed was used as a proxy for socio-economic status. In that respect, we have created a few categories: completed pre-primary (which also includes no schooling at all), completed primary, completed lower secondary, completed upper secondary and completed tertiary education. Subjective health assessment could sometimes also be used as a correlate of obesity and in that respect we have created three variables capturing the level of a person's self-assessed health status: good/very good, fair and bad/very bad. Obesity could sometime lead to a chronic illness, so we have also created a dummy for whether or not a person has a chronic illness.

Obviously, a person's lifestyle (e.g. type of food consumes and physical activity has a bearing on the overall health and BMI). In order to gauge this aspect of one's life, we have created variables capturing: consumption of fruits and vegetables at least once a day and whether the person was physically active.

The literature also suggests that there is a rural-urban disparity in probability of being overweight/obese. Since EU-SILC data doesn't contain information on rural/urban status we used the variable capturing density of population: densely populated region, intermediate and thinly populated one.

Finally, socio-economic standing (e.g. income, poverty), as suggested by the literature, has an impact of one's overall health as well as BMI status. In order to capture this aspect, we used two measures for socio-economic standing. The first one is a subjective measure, i.e. ability to pay bills and make ends meet: (i) with great difficulty; (ii) with difficulty; (iii) with some difficulty; (iv) fairly easily; and (v) easily. As a robustness check, we have coupled this with an objective measure of income per household member divided in a few categories: from 0 to 5,000 North Macedonian denars (MKD) per person per month, from 5,001 to 10,000 MKD per person per month, from 10,001 to 15,000 MKD per person per month, from 15,001 to 20,000 MKD per person per month, from 20,001 to 25,000 MKD and finally over 25,000 MKD per person per month.

4 Available at: https://www.who.int/growthref/who2007_bmi_for_age/en/

In doing the analysis we proceeded two-fold: (i) first we presented the descriptive statistics; and (ii) we run the standard logit models on correlated of overweight and obesity. As indicated above, we conducted the analysis on the 17-24 years sub sample (the analysis on the entire sample is presented in the appendix of the report).

Micronutrient survey

Similarly to the case above, we have also relied on a non-representative micronutrients survey in order to: (i) estimate the overall rate of obesity among younger children and infants; and (ii) to try and establish a link between the rate of overweight/obesity among very young children and some household characteristics.

The micronutrient survey was conducted in 2011 among 1,526 children aged 6 to 59 months (IPH, 2012). While the survey consists of set of questions on the types of food consumed by the under-5 children, it also has information on their height and weight, which was used in order to derive the BMI index and, based on it, to derive variables capturing overweight and obesity among children under the age of 5 years. Relevant thresholds provided by the WHO[5] were used in deriving the overweight/obesity variables.

In addition, the survey has information on family characteristics (e.g. family income) which was used in order to assess the correlation between household based characteristics and the probability of being overweight/obese.

Childhood Obesity Surveillance Initiative (COSI)

COSI runs regularly in North Macedonia in 3-year interval since 2010. The last survey was administered in 2019 in a total sample of 3,214 school children aged between 82 and 154 months in selected schools/municipalities in North Macedonia.[6] It is important to note that the survey is not representative of the various schools/municipalities. Nevertheless, the survey is useful in allowing to study the so-called 'school environment' and how it is correlates with the overall overweight/obesity among children.

The survey has three components. The first one collects information on individual children demographic characteristics: age, gender, height and weight. The height and weight of children were used in constructing the standard BMI (body mass index), which in turn was used in order to define two variables: (i) overweight (if the child was overweight or obese); and (ii) obese (if the child was obese). It is important to note that in defining the children who were overweight or obese we relied on the standard WHO BMI for age, applied separately on girls and boys.[7] After that, we have summarized the rate of overweight/obesity both, on rural/urban characteristics as well as by municipality. The results section below provide a further snapshot of the main findings from the analysis.

The second part of the survey consist of a set of questions on the school environment. For example, it is asked if there are sport classes at school level, if the school has a cafeteria or canteen etc. A full set of questions and how they were asked are provided in the Appendix of this report. Based on the available questions we have created the following variables: the school has a playground (and if children use it), if the school has an indoor gym (and if children use it), if the school organizes sport activities (and if at least half of pupils show up to these sporty events), if non-sugary drinks could be bought around school premises, if fresh fruits and vegetables could be bought around school premises, if unhealthy snacks (chocolate, crisps, ice cream and the likes) could be bought around the school premised, if the school has vending machines, if school has a canteen/cafeteria and finally, if advertisement of foods rich in calories but poor in nutrients is allowed on school premises.

In addition to previous COSI rounds in North Macedonia, the 2019 COSI survey also has a third component, module on family data that includes household and individual characteristics. In order to analyse the link between individual/household

5 Available at: https://www.who.int/childgrowth/standards/bmi_for_age/en/ (accessed: 18 February 2020)
6 There are two caveats in order here: (i) while the sample frame for COSI 2019 is similar to the ones from the previous years (e.g. 2016), there is some information on certain schools (e.g. in the region of Strumica) missing; (ii) in the analysis we are missing some children as their age was not provided (or the date of the execution of the survey was not provided which prevented us from computing the age of the child).
7 Available at: https://www.who.int/childgrowth/standards/bmi_for_age/en/ (accessed: 18 February 2020)

characteristics, we relied on the standard logit model as described in the section on EU-SILC analysis above.

We have coupled the individual/household level characteristics with an analysis of the link between school characteristics and the rate of overweight/obesity. The variables created as well as the overall rate of overweight/obesity by school were used in a standard ordinary least squares (OLS) procedure. More specifically:

$$Rate\_overweight_i = \alpha + \beta \Sigma\, school\_characteristics_i + \varepsilon_i \quad (3)$$

Whereby, rate_overweight is the share of overweight children by school, while Σ school characteristics is the battery of independent variables that capture the school characteristics (as specified above).

Outpatient visits

In addition to the exercises above, we have also obtained access for the total amount of outpatient visits in the country (via the so-called 'Moj termin'). The aim of this exercise was to determine the age of onset of diabetes, both type 1 and type 2, as the disease which is most closely correlated with obesity. Knowing this information was considered useful so as to determine the demographic group (e.g. children, pre-adolescents, adolescents) which warranted further focus of the analysis.

Cost of obesity

There are a few methods of calculating the economic burden of a disease or a condition. One of the most applied one is the cost of illness methodologies. According to it, the overall burden of disease is calculated by taking into account: (i) the direct cost of illness (e.g. cost associated with outpatient visits, inpatient stays or medicines); and (ii) indirect costs of illness (e.g. productivity loss due to the disease, loss of life etc).

Cost-of-illness studies estimate both the quantity of resources (in monetary terms) used to treat a disease and the negative economic consequences of illness, measured as lost productivity to society or to a specific sector. Thus, cost-of-illness aims to determine and measure the costs associated with a particular disease, focusing on direct, indirect and intangible aspects. They essentially represent a useful first step in assessing the economic burden of ill health in general and of chronic disease in particular, with most studies suggesting that the burden is substantial. Cost-of-illness studies can also provide the foundation for subsequent economic evaluations and cost-effectiveness analyses of specific interventions or policy measures (Hodgson, 1994). Therefore, measuring the cost of specific diseases is of particular interest, as cost-of-illness –along with economic evaluation- is a method that can potentially indicate the priorities in health policy agenda and serve as an additional tool for resource allocation decisions (Rice et al., 1985). In general, it is widely acknowledged that such studies are particularly useful for policy design and decision making (Byford et al., 2000).

According to the existing literature, there are two main approaches for costing and illness and/or its complications: (a) prevalence-based approach, and (b) incidence-based approach (Hodgson and Meiners, 1984; Byford et al., 2000). In particular, prevalence-based studies aims to estimate the cost for a specific time period (usually a year), and they thus rely on the number of hospitalisations attributed to the disease in a year. Prevalence-based studies are particularly useful for budget impact analyses, cost control, and they are largely used for estimating the costs of chronic diseases (Shaya et al., 2002). On the contrary, incidence-based approach focuses on calculating the lifetime costs of cases, which were first diagnosed in a specific year (Byford et al., 2000). Such studies generally require precise information about the epidemiology of the disease (Shaya et al., 2002). The cost illness is the most widely used approach and it consists of three components: (a) direct costs, (b) indirect costs, and (c) intangible costs (Figure 9).

Total costs =
Direct costs + Indirect costs + Intangible costs

Direct costs

These are the costs of medical care in relation to prevention, diagnosis and treatment of disease. They include costs such as ambulances, inpatient or outpatient care, rehabilitation, community health services and medication. Of the cost components, this is the most straight forward measurement. The data for this section of the cost estimation could come from both, macro sources (national administrative patient data, hospital/outpatient national level data) as well as micro data sources (health expenditure surveys, health utilization surveys). We also advise the use of nationally administrative data in the case of North Macedonia, whenever such data becomes available. Relying on administrative data in estimating the direct cost of a chronic diseases has both advantages and disadvantages. In general, administrative data normally allow for: (a) measuring the cost and draw conclusions based on a large and well-defined population, (b) estimating the cost impact of comorbidities (Elixhauser et al., 1998; Riley, 2009). Moreover, high-quality administrative data can provide reliable data on transaction costs and fees.

Indirect costs

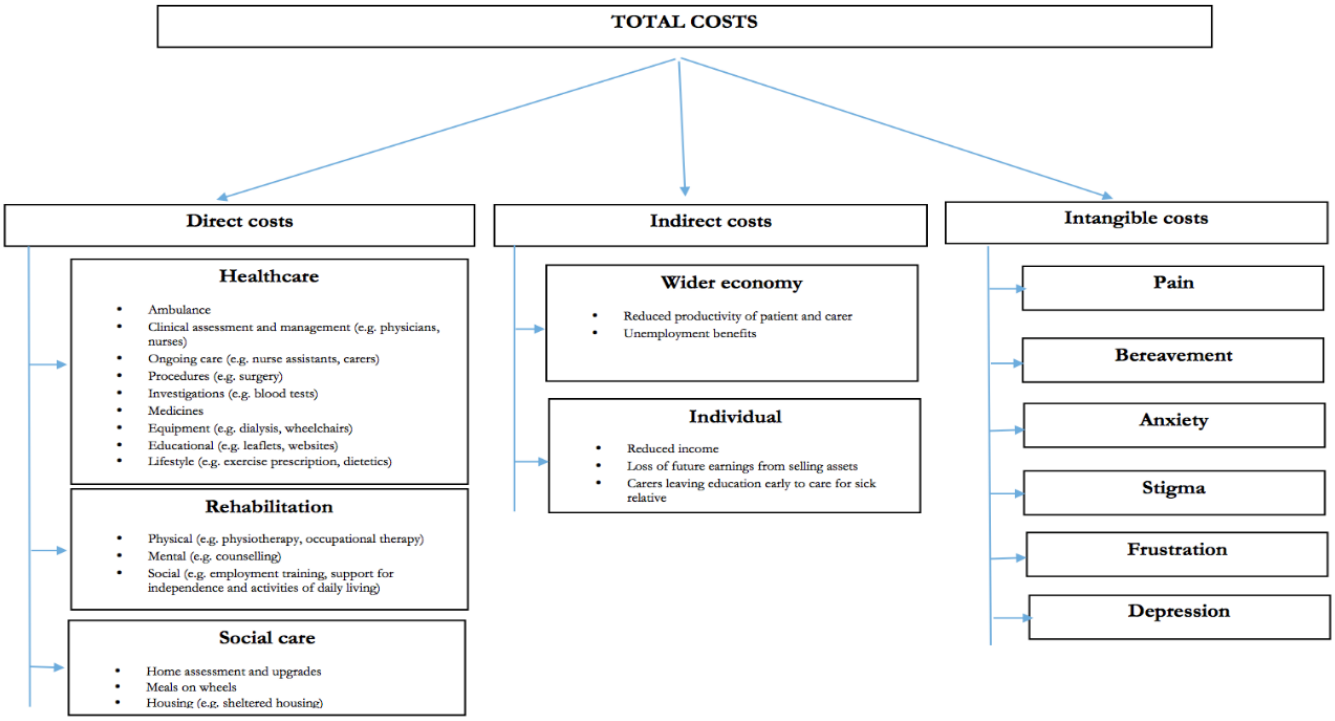
The loss of human resources caused by morbidity or premature death reflect indirect costs. The literature suggests mainly two channels through which indirect costs effectuate themselves: (a) wider macro economy (increased unemployment benefits, reduced productivity of both, patient and carer); and (b) individual level (reduced income, loss of future

earnings from selling assets etc.). Most of the indirect costs could be analysed from using micro-level data (labour force surveys, which ideally, would measure, employment status, wages as well as health status proxied by an existence of a chronic illness). This type of survey could allow for a proper assessment of both, probability of working among chronic patients as well as earnings/chronic disease nexus. In addition, the indirect costs for children/adolescents include costs related to dropping out of school/university as a results of a chronic disease – this is even more important given that the bulk of the human capital is created during adolescent/university years. Hence and in order to complement the indirect costs above, the potential survey should also include information on school/university drop out (and/or missing school/university days) as a result of an obesity related chronic illness.

Intangible costs

These costs capture the psychological dimensions of illness including, among other, pain, bereavement, anxiety and suffering. This cost category is typically hardest to measure, though it could have indirect impact on some of indirect costs, for example, participation in the labour market and/or earnings.

Figure 9. Schematic diagram of total costs of illness structure



As we can see from the above, conducting standard methodology for estimating the burden of obesity related NCDs is data exigent and requires resources that could not be located in the case of North Macedonia. While we acknowledge this as a limitation of this work (which we further elaborate on in the limitation section of the report), our set of recommendations also include some recommendations related to data gathering/generating that would facilitate a costing analysis in the near future. Figure 11 captures the break-down of costs as well as some of the data needed to estimate the total costs associated with the burden of an NCD.

In principle such methodology could also be applied in the case of North Macedonia, however, one of the drawbacks of this methodological approach is that it is exigent in terms of data needs. Given the shortcomings in terms of data availability in North Macedonia, we have used a much more simplified approach with the data that is available. It is important to note that in estimating the cost of overweight/obesity we did

so by estimating the costs of the two most common diseases associated with overweight/obesity. We have relied on the estimates obtained through the Global Burden of Disease (IHME, 2020). The study has provided the estimates for the YLLs (years of life lost) due to various diseases, thus including diabetes and cardio-vascular diseases. The YLLs estimates are available for various age groups (e.g 0-4, 5-9, 10-14 etc).

In estimating the total macroeconomic cost, we have summed up the YYLs for diabetes and cardio-vascular diseases for the age groups 0-24 and have multiplied it by the total GDP per capita following the formula:

$$\textit{Total cost} = (\Sigma\ \textit{YLL}_{\textit{diabetes}} + \Sigma\ \textit{YLL}_{\textit{cardio-vascular diseases}}) * \textit{GDP per capita} \quad (4)$$

The data for GDP per capita is obtained from the World Development Indicators. It is important to note that, given GDP per capita data constraints, calculations for total macroeconomic cost are based on actual data up until 2017. From 2018 until 2030, linear trend has been used in extrapolating the projections.

Results

EU-SILC 2017

Descriptive statistics

Table 2 captures the information for the respondents in the age group 17 to 24 years. Given that most of the individuals are younger, the share of those being overweight or obese should be smaller. Indeed, as evidenced by Table 2 about 26% of individuals in this age group are overweight, while only about 3% are obese. Furthermore, the sample is roughly equally split between men and women. Over half of the respondents (56%) are currently in school, which is another reason why the share of those with completed secondary and tertiary education is small (59% for upper secondary and only 3% for tertiary). Almost the entire sample (98%) are in good or very good health and only 1% of the respondents have stated that they suffer from a chronic illness. In addition, just over half (59%) of respondents are physically active. Finally, in terms of socio-economic characteristics, 61% can make ends meet with great difficulty or with difficulty (only 12% have stated that they can make ends meet easily or very easily). The results of the descriptive statistics for the entire sample are presented in the Appendix 3, Table 13.

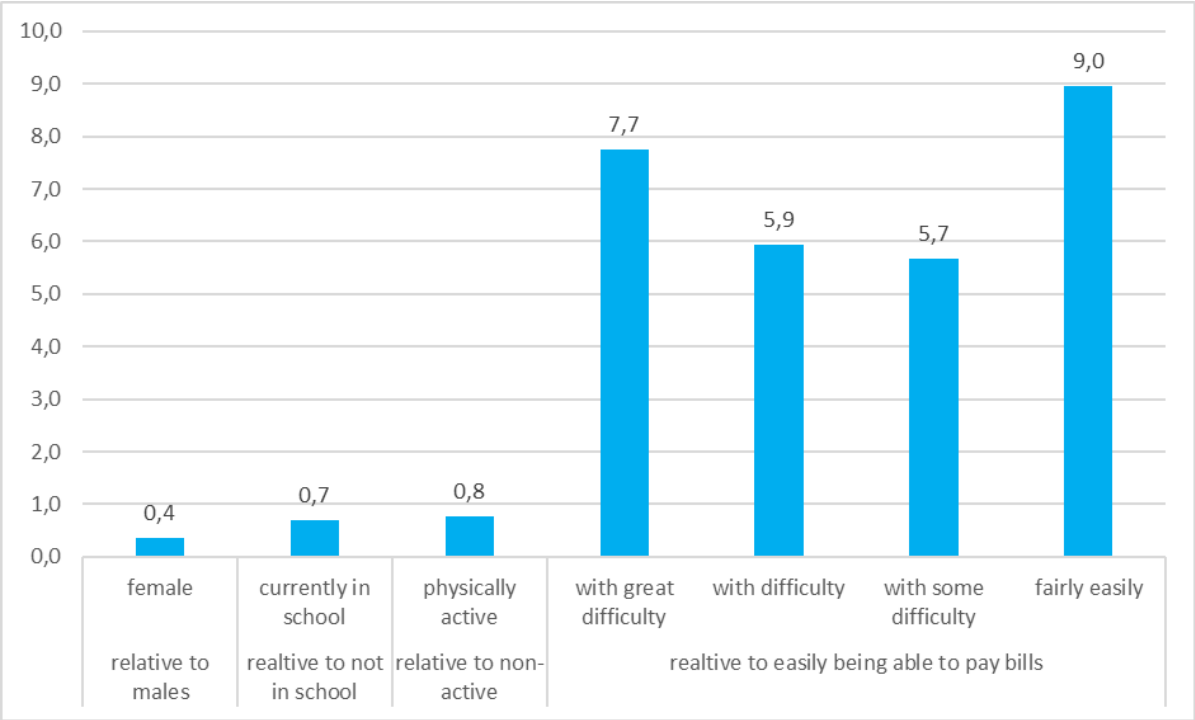
Table 2. Descriptive statistics for respondents age 17 and 24 years, EU-SILC 2017

	No. obs	Mean	Std Dev	Min	Max
overweight	1,539	0.26	0.44	0	1
obese	1,526	0.03	0.17	0	1
female	1,539	0.47	0.50	0	1
Currently in school	1,526	0.56	0.50	0	1
completed pre-primary	1,528	0.01	0.09	0	1
completed primary	1,528	0.01	0.11	0	1
completed lower secondary	1,528	0.36	0.48	0	1
completed upper secondary	1,528	0.59	0.49	0	1
completed tertiary	1,528	0.03	0.18	0	1
good and very good health	1,526	0.98	0.14	0	1
fair health	1,526	0.01	0.10	0	1
bad and very bad health	1,526	0.01	0.10	0	1
chronic illness	1,526	0.01	0.11	0	1
consuming fruit at least once per day	1,524	0.50	0.50	0	1
consuming vegetables at least once per day	1,524	0.50	0.50	0	1
physically active	1,525	0.59	0.49	0	1
populated densely	1,539	0.28	0.45	0	1
populated intermediate	1,539	0.43	0.50	0	1
populated thinly	1,539	0.28	0.45	0	1
with great difficulty	1,539	0.34	0.47	0	1
with difficulty	1,539	0.27	0.44	0	1
with some difficulty	1,539	0.27	0.44	0	1
fairly easily	1,539	0.10	0.30	0	1
very easily	1,539	0.02	0.14	0	1

Logit models

In presenting the findings from the logit models we proceed in the following way. Firs, and so as to make it easier for the reader, we present the results of the statistically significant variables only in a bar chart format – each bar representing the odds ratios relative to the base category. The entire set of tables, including the level of statistical significance and the 95% confidence interval is added as a technical appendix at the end of the study. It is important to note that we focus on the results for the sub-sample of young/adolescents (17-24 years of age), whilst the results for the entire sample are included in the technical appendix of the study (with a short commentary in the main text).

Figure 10. Odds ratios of likelihood of being overweight, statistically significant variables only, 17-24 years sub-sample



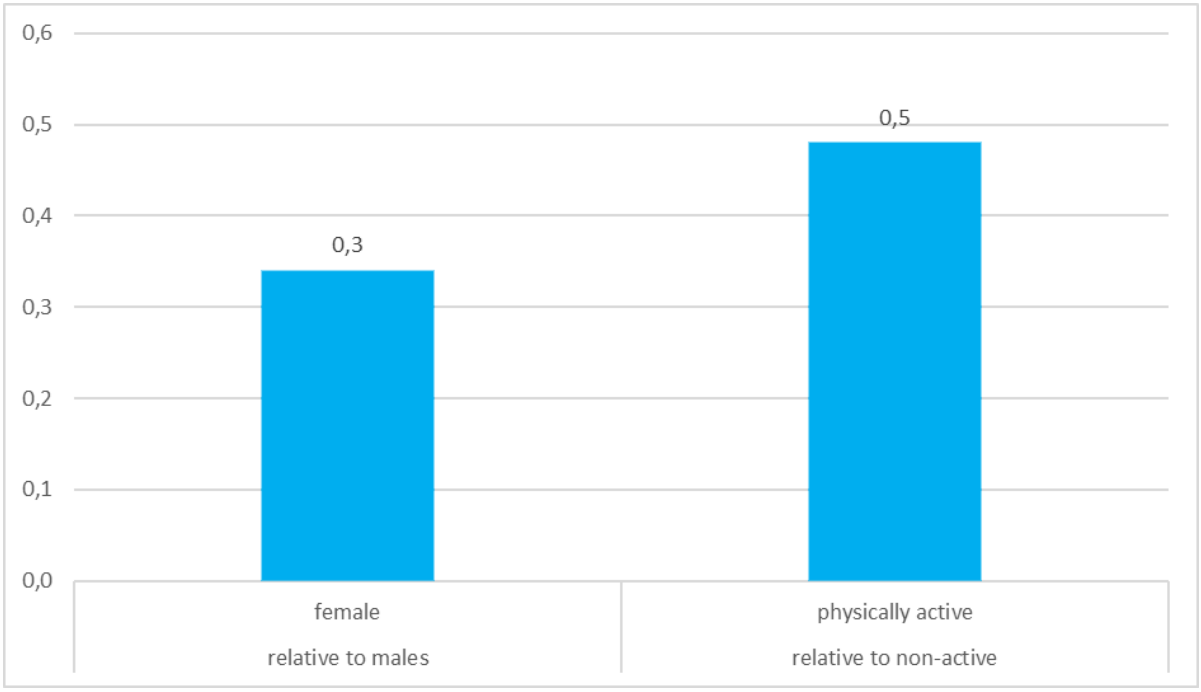
Note: The red line denotes the odds ratio of 1; values above it suggest positive correlation between the variables of interest and the dependent variable; values below 1 suggest negative correlation.

Figure 10 captures the odds ratios of the statistically significant correlates of being overweight for those aged 17-24. The first finding is related to gender and as expected, girls are much less likely to be overweight relative to boys. Second, we also find, as expected a robust link between physical activity and the probability of being overweight. More specifically, we find that adolescents that are physically active are 0.7 times less likely to be overweight compared to those that aren't. Similarly, those that are currently in school are less likely to be overweight relative to those that are not in school. Finally, our main finding relates to the socio-economic status. When using the subjective measure for socio-economic status, we find that those in the lower socio-economic strata are more likely to be overweight, relative to adolescents from more affluent households. In that respect we could state that, when it comes to this age group, the county has started to make its epidemiological transition in that overweight is much more pronounces in the lower socio-economic levels (similar to what we see in most of the high income countries). It is important to note that we find statistical significance of the socio-economic standing variable only when considering the subjective measure of socio-economic status (the results using objective

measure of socio-economic standing do not yield statistically significant results). A full set of results are reported in the Appendix 3, Table 14 (likelihood of being overweight for the age group 17-24 using subjective measure of socio-economic standing) and Table 15 (likelihood of being overweight for the age group 17-24 using objective measure of socio-economic standing).

As a robustness check, we have also conducted this exercise on the entire sample of respondents (all ages). The objective of this exercise is to establish if indeed, the main findings from the literature in the region and globally, are also applicable in North Macedonian context. The results of the logit models on correlates of overweight when using the entire sample and a subjective measure of socio-economic status are presented in Appendix 3, Table 16 and Appendix 3, Table 17 when using an objective measure for socio-economic status. There are a few findings that stem from this table. First, we find evidence that females are less likely to be overweight compared to males. Second, in terms of age, we find a non-linear link between age and likelihood of being overweight with the transition happening between the age of 36 and 45. More specifically, those that are younger and those over the age of 75 are much less likely to be overweight, compared to those in the mid-age categories (40s, 50s, 60s). Third, and most importantly, we also find that education is a significant determinant of the likelihood of being overweight with the likelihood being higher for those with lower level of education. For example those with primary education are 1.5 times more likely to be overweight relative to those with tertiary education. We ascribe this finding to two things: (i) first one is a socio-economic status (i.e. those with higher level of education eat better food, could exercise etc, which reduces their likelihood of being overweight); and (ii) there is a significant level of awareness of the ills associated with overweight and obesity, particularly among those that are better educated. We also find that those with a chronic illness are 1.2 times more likely to be overweight. Finally, we do not find statistically significant link between the subjective measure of socio-economic standing and overweight, possibly also influenced by the findings related to the level of education.

Figure 11. Odds ratios of likelihood of being obese, statistically significant variables only, 17-24 years sub-sample



Similarly to the exercise above, we have then repeated the logit models using being obese as a dependent variable, for the sub-sample of those aged 17-24. The results for the statistically significant variables are presented in Figure 11. There are mainly two important findings and both of them fall within the scope of individual characteristics. First, similarly to the analytical exercise on correlates of being overweight, we find that females are less likely to be obese, relative to males. Second, and very similarly to the results on the overweight exercise, we find that those that are physically active are roughly 0.5 times less likely to be obese relative to those that are not physically active, ceteris paribus. The full set of results when using subjective variable for socio-economic standing are presented in Appendix 3, Table 18 and in Appendix 3, Table 19 when using objective measure of socio-economic standing.

Finally, in the Appendix 3, Table 20 and Table 21 depict the results of the logit models on correlates for obesity for the entire sample and the findings are similar to the ones on the correlates of overweight.

COSI 2019 family data

The 2019 COSI survey also has a module on family data that includes household and individual characteristics, which allow us to replicate some of the EU-SILC data results. The results of the logit model of child overweight are reported in Table 3. There are a few findings that stem from the analysis. First, overweight increases with age, in that older children (in terms of number of months) have 1.05 higher likelihood of being overweight relative to younger ones. Second and consistent with the literature, we find a robust link between urbanicity and childhood overweight. More specifically, children from urban settings are 1.7 times more likely to be overweight relative to the rural ones (Table 3). Finally, we also found some evidence that overweight is more likely in the lower socio-economic classes, although the results are insignificant.

Table 3. Individual and household characteristics and overweight children, logit model

Overweight	Odds Ratio	Std. Err.	P>z	95% confidence interval	
age	1.058492	0.02497	0.016	1.010666	1.108582
male	1.069601	0.189624	0.704	0.755643	1.514004
urban	1.704482	0.429881	0.034	1.039714	2.794286
active at school	0.837024	0.151012	0.324	0.587717	1.192087
five or more fruits and vegetables per day	0.974913	0.213193	0.908	0.635077	1.4966
EARNINGS (RELATIVE TO NO DIFFICULTIES)					
little difficulties in making ends meet	0.852259	0.1634	0.404	0.585293	1.240992
medium difficulties in making ends meet	0.680086	0.220029	0.233	0.360723	1.282193
serious difficulties in making ends meet	1.491484	0.866332	0.491	0.477745	4.656303
constant	0.002692	0.006033	0.008	3.33E-05	0.21765

Similar results emerge when the exercise is repeated while using obesity as a dependent variable and the results are reported in Table 4 below. More specifically we find a positive link between age and the probability of being obese and also we find a link between gender and the probability of being obese. More specifically, males are 1.5 times more likely to be obese relative to females. Finally, we find that children living in urban areas have much higher odds of being obese, relative to those in rural areas (the odds ratios being 2.4).

Table 4. Individual and household characteristics and obese children, logit model, COSI 2019

Obese	Odds Ratio	Std. Err.	P>z	95% confidence interval	
age	1.073868	0.030169	0.011	1.016335	1.134657
male	1.54428	0.339857	0.048	1.003224	2.377137
urban	2.398438	0.884318	0.018	1.164355	4.940508
active at school	0.896666	0.200564	0.626	0.57841	1.390034
five or more fruits and vegetables per day	0.890518	0.242465	0.670	0.522254	1.518459
ЗАРАБОТУВАЧКА (СПОРЕДЕНО СО НЕМА ТЕШКОТИИ)					
little difficulties in making ends meet	0.9224	0.213044	0.727	0.58657	1.450502
medium difficulties in making ends meet	0.82958	0.329944	0.639	0.380465	1.808847
serious difficulties in making ends meet	0.691708	0.513475	0.620	0.161455	2.963432
constant	0.000134	0.00036	0.001	7.05E-07	0.025573

Micronutrient survey

The results from the micronutrient survey indicate similar prevalence of overweight and obesity on the sub-set of children aged 0 to 5. We found an overall rate of overweight of 38.4%; and an overall rate of obesity of 18.2%. These numbers are in line with the overall findings from the COSI 2016 survey on a set of older children. The results are also in line with what has previously been published on the overall childhood obesity in North Macedonia (Gontarev & Kalac, 2014; Gontarev, 2008; Spiroski et al., 2014).[8]

8 Unfortunately, the analysis on the correlates of overweight/obesity did not yield statistically significant results.

COSI 2019 school data

Table 5 and Table 6). We first start with the share of overweight children, regressed on the number of school characteristics. There are two important results that stem from this analysis: (i) first the share of children who are obese is negatively correlated with the possibility of children to use the indoor gym outside of school hours; and (ii) the share of children who are overweight or obese is positively correlated with the availability of advertisements of food that are rich in calories but poor in nutrients. In addition, the results are consistent when obesity is used as a dependent variable.

These two results are also consistent with the findings from the EU-SILC survey in that we find a negative link between exercise and overweight/obesity. More importantly, there are some useful policy implications that stem from this analysis. First, school authorities should promote physical exercise, particularly outside of school hours and second, they should also try to curb the advertising which is allowed around school premises.

Table 5. School characteristics and overweight children, COSI 2019

(N=62, R2=0.22)

	coeff.	stan. error	p value
kids_use_playground	-0.06414	0.090963	0.484
kids_use_gym	-0.09782	0.055474	0.084
sport	0.038851	0.049443	0.436
nosugar	0.034472	0.081678	0.675
sugar	-0.01977	0.07548	0.794
fruits	-0.06195	0.055968	0.274
snacks	-0.11	0.074208	0.144
cafeteria	0.004757	0.060314	0.937
vending	0.053077	0.047015	0.264
advertising	0.144837	0.046783	0.003

Table 6. School characteristics and obese children, COSI 2019

(N=58; R2=0.126)

	coeff.	stan. error	p value
kids_use_playground	-0.05163	0.080073	0.522
kids_use_gym	-0.07578	0.03524	0.037
sport	0.026401	0.033822	0.439
nosugar	0.050284	0.055776	0.372
sugar	-0.00758	0.069296	0.913
fruits	-0.05916	0.047773	0.222
snacks	-0.01926	0.067421	0.776
cafeteria	-0.01582	0.048371	0.745
vending	0.008314	0.03525	0.815
advertising	0.050775	0.028649	0.083

Outpatient visits

The results of the analysis are summarized in Table 7. There are a few findings that stem from this first pass at the data. First, as expected, there is a segment of the very young population, where diabetes 1 appears from very early age. For example, ICD-10 diagnosis E10 (type 1 diabetes) is the 134th most common diagnosis for outpatient visits for children age 1. It sporadically appears (though never in the top 50 diagnosis) for children and adolescents up to age 20. Second, type 2 diabetes (E11) is not very common in children – in fact it does not appear as a reason for an outpatient visit up until the age of 15. Even then, it never reaches the top 100 reasons for an outpatient visits. Nevertheless, this analysis help us distil that mid to late adolescence is the age when diabetes type 2 occurs for the very first time and hence our focus should be on this age group. Hence, our decision to further analyse the EU-SILC data.

It is important to note that diabetes type 2 progressively reaches the top reasons for an outpatient visit and from age 40 onwards is constantly listed as the top 5 diagnosis/reason for an outpatient visit (Appendix 5, Table 25).

Table 7. Prevalence of ICD-10 diagnoses E10 and E11 by age from 0 to 20 years, Moj termin, 2017

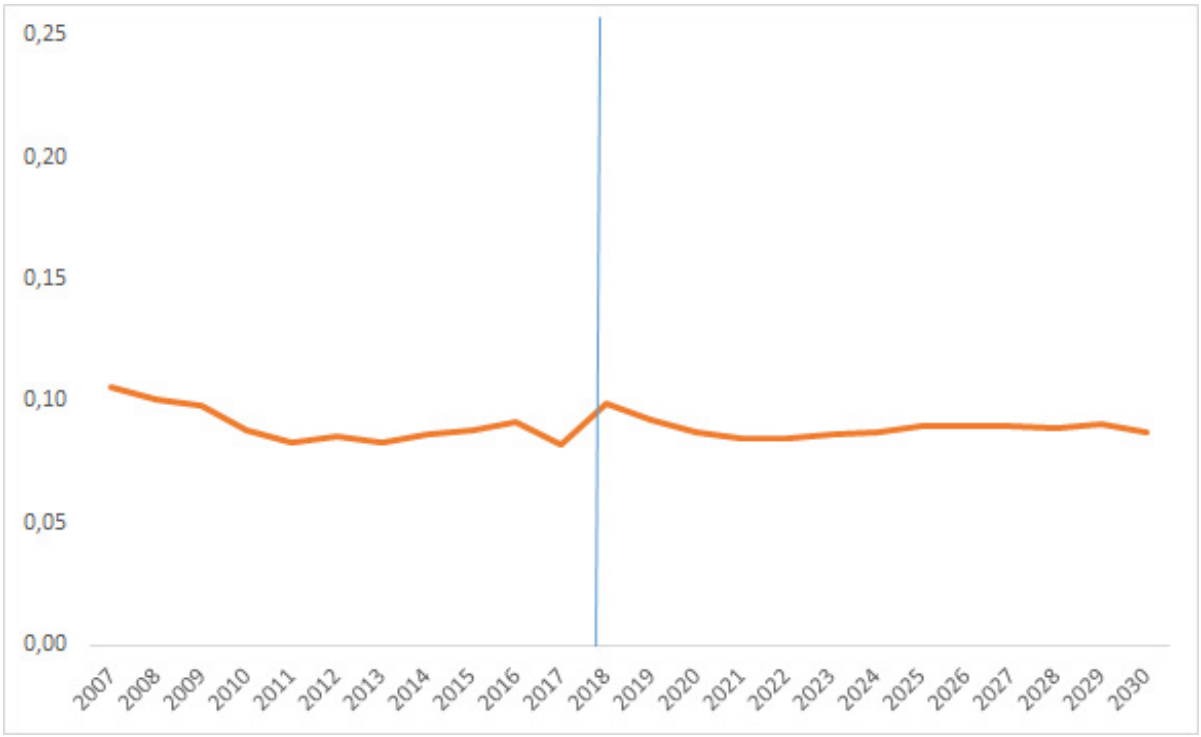
Age (years)	E10 (diabetes, type 1)	E11 (diabetes, type 2)
0	none	none
1	134th	none
2	none	none
3	none	none
4	none	none
5	51st	none
6	48th	none
7	140th	none
8	none	none
9	66th	none
10	none	none
11	38th	none
12	123rd	none
13	101st	none
14	177th	none
15	96th	111th
16	none	none
17	218th	219th
18	45th	148th
19	129th	none
20	91st	165th

Overall macroeconomic cost associated with obesity in North Macedonia

In order to estimate the overall burden of overweight/obesity as explained in the methodology section, we used a much more simplified approach based on data from the Global Burden of Disease (IHME, 2020) and World Development Indicators (World Bank, 2020). Our study took the data on YLL (years of life lost) as a result of the two diseases most commonly associated with overweight/obesity (diabetes and cardiovascular diseases) and scaled those up, using data on GDP per capita, in order to estimate the overall burden of overweight/obesity. As indicated above, the exercise was repeated twice, first only on the age group 0-24 years and then to the entire population. We have conducted the exercise for North Macedonia initially, but have also provided a comparative analysis using data from the rest of the region as well.

There are a few findings that stem from the analysis. For 2017, the total YLL attributed to cardiovascular diseases and diabetes amounted to 1714. As expected, when we only take into account the age group 0-24 years, the overall cost associated with obesity related diseases is small – roughly 0.10% of GDP (or roughly 8.5 million EUR). In addition, as Figure 12 illustrates, the cost has been fairly stable over the last ten years and hence, given the linear extrapolation trend, is expected to be so in the next ten years.

Figure 12. Cost of obesity-related diseases (diabetes and CVDs) as a share of GDP, North Macedonia, age group 0-24 years



In order to compare North Macedonia with the countries in the region, we have conducted a similar exercise for the region (i.e. Western Balkans as well as Slovenia, Croatia, Bulgaria and Romania). The exercise was conducted in a similar fashion in that we have aggregated the YLL for the most common NCDs associated with overweight/obesity (diabetes and cardiovascular disease) for the age group 0-24 years. The total YLL is then scaled up using GDP per capita (as specified in the methodology section in the earlier part of the document) and expressed both, as a share of GDP and in absolute numbers (for a quick comparison, we express the numbers in millions of EUR). The results are captured in Table 8 below.

There are a few findings emerging from the table. First, as a share of GDP, the overall burden of the obesity-related diseases is comparable (albeit smaller) to the case of North Macedonia. Only in Albania, we see a fairly higher number (potentially impacted by both, the overall GDP as well as the GDP per capita). Second, we complement these findings with the total burden in absolute terms (millions of EUR). While the numbers follow population patterns (i.e. the burden is higher for the more populous countries (e.g. Bulgaria, Romania)) there are couple of additional observations. For example, in North Macedonia the overall burden of NCDs related to overweight/obesity of those aged 0-24 equates to roughly 8.5 million EUR, which is similar to the case of Bosnia & Herzegovina (with twice as many inhabitants as North Macedonia) and only slightly smaller compared to the case of Serbia (which is four times more populous than North Macedonia).

The consequences of overweight/obesity do not only pose burden now, but they are also very likely have an impact on all stages in an individual's life. Behavioural patterns and attitudes associated with overweight and obesity are usually formed during childhood/adolescent years and as such, they could have longer term economic burden. In order to show this (and given the data limitations elaborated above), we have also calculated the economic burden of the two NCDs above for the entire population.

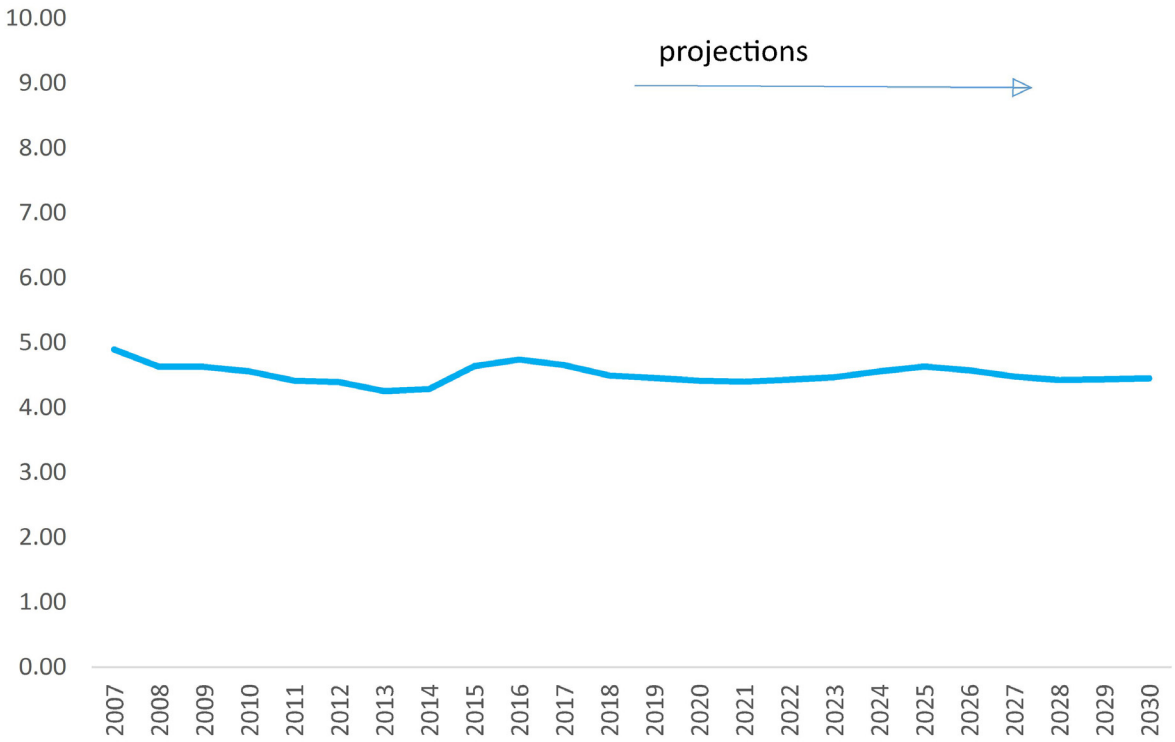
Table 8. Total economic cost of NCDs associated with obesity (age groups 0-24) as a share of GDP and in million EUR, 2017

	% of GDP	in million EUR
North Macedonia	0.10	8.5
Albania	0.16	19.8
Montenegro	0.04	1.7
Bosnia	0.05	7.5
Bulgaria	0.05	25.0
Croatia	0.01	6.7
Slovenia	0.01	3.4
Romania	0.03	47.1
Serbia	0.03	11.5

Note: underlying data taken from the GBD (YLL) and WDI (GDP per capita)

As Figure 13 suggests, the overall cost of obesity-related diseases (both direct and indirect) is roughly 5% of GDP (482 million EUR or roughly 241 EUR per person per year). Much of this cost could easily be avoided by preventing obesity from early age, educating the public of the dangers of poor nutrition and obesity and the benefits of physical exercise – something that we further discuss on the policy recommendations section of this report.

Figure 13. Cost of obesity-related diseases (diabetes and CVDs) as a share of GDP, North Macedonia, all ages



Limitations of the study

There are some limitations associated with our research endeavours. First limitation pertains to data availability. While a number of datasets were identified, not all could be retrieved for the study, mainly due to their unpublished status. The study is devoid of insights from the most recent Health Behaviour of School Children (HBSC) study 2018 and the UNICEF Multi-indicator Cluster Survey (MICS) 2019, and these datasets might be considered for any future exploratory exercise or follow up assessments in this subject.

Secondly, the completeness of available data posed some limitations to the study. While ideally dataset should be for the same year, due to availability of some indicators only for a particular year (e.g. BMI in EU-SILC survey available only for 2017 and in COSI for 2016 and 2019), the analysis had to be performed across the available years. This, however, was not considered as too big a limitation, given that analysed parameters have slow pace of change over time (e.g. income, eating habits, BMI, etc.). In addition, since health data in EU-SILC is modular (i.e. collected once every several years), it was not possible to establish trends over time, even though EU-SILC data is available on annual basis.

Thirdly, the caveat on results interpretation is noteworthy. While the results of both COSI 2016 and 2019 point to two particular policy relevant conclusions: (i) type of physical activity; and (ii) type of food consumed, it is important to note that this exercise only establishes a correlation, not a causal link. Moreover, as stated in the methodology section above, the exercise is conducted on a non-representative sample of children and schools, so this could also have a bearing on the overall final findings.

One of the biggest limitations of the study is the inability to provide a proper estimate of the losses associated with overweight/obesity. Indeed, as indicated in the inception report, we have planned to estimate the standard metrics associated with NCDs (e.g. DALY, premature mortality, years of life loss). There are many obstacles that we have encountered in the way which prevented us from doing so and which forced us to rely on the GBD (Global Burden of Disease) estimates. The model for estimating the burden of disease presented in the methodology section provides a flavour of how data exigent the process is, but, nevertheless, it also provides an incentives to the authorities to start collecting the necessary data for such exercise to be conducted in the near future. Simply put, our current study is exploratory in nature and as such, it 'stitched' together all available datasets (on individual, household or school level) in order to provide, as analytically as possible, an explanation of the universe of correlates of child/adolescent overweight/obesity and the burden of related NCDs.

Discussion

The value of the current study and how it relates to the existing findings in the area of child/adolescent overweight/obesity in North Macedonia

As further discussed in the introduction of this report, the main objective of this study was manifold: (i) first to map out the existing data sources that could be used in devising an econometric model on correlates of child overweight and obesity in North Macedonia; (ii) to use the identified sources in order to devise appropriate econometric model that would take into account the entire universe of correlates/ determinants of child overweight obesity (on individual level, on household level as well as on wider school/macro level). In addition, and to the extent possible, this study also provides an initial estimate of the overall burden of overweight/obesity by estimating the cost of the most common non-communicable diseases associated with overweight and obesity (e.g. diabetes and cardiovascular diseases).

There are a few findings that stem from this very first attempt to conduct a systematic study on overweight/obesity in North Macedonia. First, based on the data from EU-SILC survey, we find that level of physical activity is associated with lower likelihood of being overweight/obese. This is in line with what the existing literature has suggested. For example, the literature has already suggested that North Macedonian children are much less active compared to children in Slovenia, which could be one of the explanatory factors for the higher rates of overweight/obesity in the country (see for example Gontarev, 2008; Sember et al., 2016). Second, based on the COSI 2019 dataset we also confirm the existing finding on the link between urbanization and overweight and obesity. More specifically, we find that urban children are 1.7 times more likely to be overweight/obese relative to rural children. This finding is confirmed when we look at some of the school level characteristics. More specifically, based on the COSI 2019 dataset we find that the share of children who are overweight/obese is lower in schools where children are allowed to use the sports gymnasium during and outside of school hours.

Third and most importantly however, we found interesting evidence that some of the epidemiological transition in North Macedonia has already happened in that the socio-economic status and overweight/obesity relationship resembles the relationship registered in high income countries. More specifically, based on the EU-SILC data we found that adolescents from the lower socio-economic groups are more likely to be overweight/obese relative to those from the higher socio-economic groups. While the findings are derived based on subjective measure of socio-economic status, they are comparable to the results derived on more objective measures of socio-economic status (i.e. income). More importantly, we found similar patterns based on the COSI 2019 dataset, although the results lack statistical significance.

Finally, in our study we also find that additional school based characteristics are also important for child/adolescent overweight/obesity. Based on the COSI 2019 data, we found that the share of children who are overweight/obese is higher in schools where the advertising of foods rich in calories but poor with nutrients is allowed. While we caution against direct causal link in this case, the established correlational pattern could create the basis for important policy recommendations.

Finally, we found that the overall burden of the NCDs associated with overweight/obesity to be small, when considering only the age group of children/adolescence. This is understandable,

given the progression and development of NCDs. The results are comparable across the countries in the region. However, once the entire population is taken into account, we notice a fairly large burden of diabetes and cardiovascular diseases (going up to 5% of GDP) indicating that the authorities should start sending the right message since childhood/adolescence. In other words, knowing about and reducing the risks of becoming overweight/obese in adolescence, could significantly curb the overall burden that NCDs pose in medium to long run.

Policies and interventions for addressing the issue

The results of our study complement the conclusions of previous studies undertaken in the country, confirming the necessity for paying particular attention to growing levels of overweight and obesity in children (Spiroski, 2016). Previous studies also confirm that situation with overweight and obesity in North Macedonian population does not differ much comparing to most of the countries in the European region of the WHO, suggesting the need for addressing the associated risk factors, such as nutrition and physical activity through adoption and enforcement of policies and interventions that have proven results from elsewhere.

In 2017, WHO gathered and published an overview of 'best buys' and other recommended interventions for the prevention and control of noncommunicable diseases (WHO, 2017), which specifically lists proven interventions and measures aimed at health promotion and prevention of early onset of a disease. Among those are reducing unhealthy diets and physical inactivity, as well as appropriate management of CVDs and diabetes, offering variety of effective interventions (Table 9).

Table 9. WHO Best buys for prevention and control of NCDs

Objective 3. Reducing modifiable risk factors for noncommunicable disease and underlying social determinants through creation of health-promoting environments	
Reduce unhealthy diet	• Eliminate industrial trans-fats through the development of legislation to ban their use in the food chain • Reduce sugar consumption through effective taxation on sugar-sweetened beverages • Limiting portion and package size to reduce energy intake and the risk of overweight/obesity • Implement nutrition education and counselling in different settings (for example, in preschools, schools, workplaces and hospitals) to increase the intake of fruits and vegetables • Implement nutrition labelling to reduce total energy intake (kcal), sugars, sodium and fats • Implement mass media campaign on healthy diets, including social marketing to reduce the intake of total fat, saturated fats, sugars and salt, and promote the intake of fruits and vegetables
Reduce physical inactivity	• Implement community wide public education and awareness campaign for physical activity which includes a mass media campaign combined with other community based education, motivational and environmental programmes aimed at supporting behavioural change of physical activity levels • Implement whole-of-school programme that includes quality physical education, availability of adequate facilities and programs to support physical activity for all children
Objective 4. Strengthen and orient health systems to address the prevention and control of noncommunicable diseases and the underlying social determinants through people-centred primary health care and universal health coverage	
Manage diabetes	• Lifestyle interventions for preventing type 2 diabetes

For the first time in North Macedonia, some documents and legislative acts in nutrition area have been adopted. Several documents and legislative acts in nutrition area have been adopted the country. Among them, the boldest are the adoption of the Food Based Dietary Guidelines[9] and the Rulebooks on meal standards in primary school settings.[10] Several other documents have been drafted, like the Action plan for nutrition 2016-2025 and Action plan for NCDs prevention 2016-2025, but are still not adopted by the Government as a formal documents. Several documents and legislative acts in nutrition area have been adopted the country. Among them, the boldest are the adoption of the Food Based Dietary Guidelines[11] and the Rulebooks on meal standards in primary school settings.[12] Several other documents have been drafted, like the Action plan for nutrition 2016-2025 and Action plan for NCDs prevention 2016-2025, but are still not adopted by the Government as a formal documents. However, it is clear that the country already made the commitment and has drafted evidence-based policies for investing into reducing overweight and obesity from early years of life of its population. This commitment is further strengthened by a recent conclusion of the Initial conference of the Working group for health sector,[13] for development and endorsement of a comprehensive health strategy 2020-2030, that has to go beyond the health sector itself and consider 'both investments in health and health as an investment'.

The current study is the first attempt for assessing overweight and obesity in children, and future research should be directed at evaluation of implementation and impact of the adopted documents, providing not only information on their impact, but also providing evidence for shaping the policies towards the overall goal of reducing overweight and obesity in children, and ensuring their healthy start of life and health and wellbeing during the entire lifespan.

9 Food Based Dietary Guidelines, available at: http://iph.mk/wp-content/uploads/2014/11/nasoki_ishrana-2014.pdf, accessed: 22 March 2020

10 Rulebook on the standards of nutrition and meals in primary schools, available at: http://www.mon.gov.mk/index.php/2014-07-23-14-03-24/vesti-i-nastani/2386-standardi-i-alatki-za-pravilna-ishrana-vo-osnovnite-uchilishta, accessed:22 March 2020.

11 Food Based Dietary Guidelines, available at: http://iph.mk/wp-content/uploads/2014/11/nasoki_ishrana-2014.pdf, accessed: 22 March 2020

12 Rulebook on the standards of nutrition and meals in primary schools, available at: http://www.mon.gov.mk/index.php/2014-07-23-14-03-24/vesti-i-nastani/2386-standardi-i-alatki-za-pravilna-ishrana-vo-osnovnite-uchilishta, accessed:22 March 2020.

13 Initial conference of the Working Group for Health, Government of the Republic of North Macedonia, 28 February 2020.

Recommendations

There are a few recommendations that stem from this very first attempt to study the main correlates of child/adolescent overweight/obesity and the related cost. We have grouped the recommendations in terms of two broad groups: (i) policy recommendations stemming from the review of existing policies and stemming directly from our results; and (ii) recommendations on generation of data sources that will help fill in the gaps/limitations of the existing work and help provide further rigorous evidence on the main drivers of childhood/adolescent overweight/obesity.

Recommendations stemming from the data work and from the review of existing policies

There are few recommendations that stem from the results of our study:

i. First, the authorities should strengthen their message of the need for physical activity among children and adolescents. As further evidenced by our results, we find a strong negative link between physical activity and being overweight/obese;

ii. Second, we also find that urban children tend to have higher likelihood relative to rural ones. Hence, and building on (i) reinforcing the message of physical activity (and overall behaviours) among urban children and adolescents could further reduce the rate of overweight and obesity particularly among urban youth;

iii. We also find a negative link between socio-economic status and overweight obesity in that the lower ranked socio-economic groups tend to be associated with higher rates of overweight and obesity. Coupling the findings from this study with a more qualitative approach on the type of food consumed by the lower socio-economic groups could also help generate further policy recommendations that will be specifically geared towards this segment of the population;

iv. The authorities should also review the availability and marketing of foods in schools settings and in the school environments. Promoting message of healthier lifestyles could further convince schoolchildren in the importance of proper and healthy diet.

v. Along the same lines, the school authorities should review their policies on physical activity classes and policies on sports gymnasiums opening and closing times. As evidenced in our study, a more liberal working hours could help children in being more physically active. Obviously, this would require additional health and safety measures, the need for additional supervision staff etc. In any case, reinforcing these policies could further propel the physical activity of children as elaborated in point (i) above.

Recommendations on the generation of new data and evidence

There is, however, so much we could do with the existing data which is usually a one-off survey and/or fractured among different surveys (some of them not nationally representative). Hence, and in order to further understand the drivers of overweight/obesity in a causal manner we also propose generating further evidence by the way of collecting longitudinal/panel data on children which will be followed over a certain period of time (a few years). By applying appropriate econometric techniques (e.g. propensity score matching and the likes) one could, in that case, establish a causal link between some of the main correlates (e.g. socio-economic status or physical activity) on one hand and overweight/obesity on the other. In addition, longitudinal/panel data could also help in studying the effectiveness of a particular nutrition/health policy.

References

1. WHO Regional Office for Europe (2019). European Health for All Database (http://data.euro.who.int/hfadb/ пристапено на 10 февруари 2020.

2. Milevska-Kostova, N, Chichevalieva, S., Ponce, N. A., & Winkelmann, J. (2017). The former Yugoslav Republic of Macedonia: Health System Review. *Health systems in transition*, 19(3), 1–160.

3. MoH (2018). Programme for insulin, glucagon, insulin needles, glucose test strips, and education on the treatment and control of diabetes for 2019 [in Macedonian: Програма за обезбедување инсулин, глукагон, инсулински игли, ленти за мерење шеќер и едукација за третман и контрола на дијабетесот за 2019 година], Скопје, Министерство за здравство, достапно на: http://zdravstvo.gov.mk/wp-content/uploads/2019/08/Programa-za-insulin-za-2019.pdf, пристапено на 10 февруари 2020.

4. Ball, K., Mishra, G. D., Crawford, D. (2003) .Social factors and obesity: an investigation of the role of health behaviours. *International Journal of Obesity*, 27(3), 394–403.

5. Whitehead M and Dahlgren G. (2006). *European strategies for tackling social inequities in health: Levelling up Part 2*. Copenhagen: WHO Regional office for Europe.

6. Institute for Public Health (2015). *Study on Population Nutrition in RM*, Skopje: Institute for Public Health.

7. Oja, P., Kelly, P., Pedisic, Z., Titze, S., Bauman, A., Foster, C., ... & Stamatakis, E. (2017). Associations of specific types of sports and exercise with all-cause and cardiovascular-disease mortality: a cohort study of 80,306 *British adults. British Journal of Sports Medicine* 51(10):812-817.

8. Spiroski I (2016). Public Health Nutrition- state, policies and challenges. *Arch Pub Health* 8(1):20–27. [македонски]

9. IPH (2012). *Macedonia National Nutrition Survey 2011*, Skopje: Institute for Public Health, достапно на: https://www.unicef.org/northmacedonia/media/2971/file/MK_2011_NutritionSurvey_ENG.pdf, пристапено на 18 февруари 2020.

10. UN (2015). 2030 *Agenda for Sustainable Development*, достапно на: http://www.un.org/sustainabledevelopment/development-agenda/, пристапено на 18 февруари 2020.

11. UN Standing Committee on Nutrition (2014). *Nutrition and the Post-2015 Sustainable Development Goals: A Technical Note*, достапно на: https://www.unscn.org/files/Publications/Briefs_on_Nutrition/Final_Nutrition%20and_the_SDGs.pdf, пристапено на 1 февруари 2020.

12. UN Standing Committee on Nutrition (2004). Nutrition and the Millennium Development Goals. *SCN News No. 28*. Geneva, Switzerland.

13. WHO (2006). WHO Child *Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. Geneva: World Health Organisation.

14. WHO (2014). *Comprehensive implementation plan on maternal, infant and young child nutrition*, достапно на: http://www.who.int/nutrition/publications/CIP_document/en/, http://apps.who.int/iris/bitstream/10665/113048/1/WHO_NMH_NHD_14.1_eng.pdf?ua=1, пристапено на 1 февруари 2020.

15. UNICEF/WHO/The World Bank (2014). *Joint Child Malnutrition Estimates: Levels & Trends in Child Malnutrition* (updated September 2014). New York, NY: UNICEF.

16. Black R, Victora C, Walker S, Bhutta Z, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, Uauy R, and the Maternal and Child Nutrition Study Group (2013). Maternal and child undernutrition and прекумерна тежина in low-income and middle-income countries. *The Lancet*, 382 (9890): 427–51.

17. Jukes, M. (2007). Impact of early childhood health and nutrition on access to education in developing countries. *Paediatrics and Child Health*, 17(12), 485–91.

18. Alderman H, Hoddinott J and Kinsey B. (2006). Long term consequences of early childhood malnutrition, *Oxford Economic Papers* 58(3):450–74.

19. Smith, L. C., & Haddad, L. (2015). Reducing child undernutrition: past drivers and priorities for the post-MDG era. *World Development*, 68, 180–204.

20. Wang, H., Bhutta, Z. A., Coates, M. M., Coggeshall, M., Dandona, L., Diallo, K., ... & Hay, S. I. (2016). Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, 388(10053), 1725–74.

21. WHO (2013). Is it true that lack of iodine really causes brain damage? WHO Health Topics Q&A, updated May 2013. http://www.who.int/features/qa/17/en/, пристапено на 12 февруари 2020.

22. IHME (2020). Health-related SDGs Viz Hub, достапно на: https://vizhub.healthdata.org/sdg/, пристапено на 18 февруари 2020.

23. Reilly JJ, Kelly J. (2011). Long-term impact of прекумерна тежина and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *International Journal of Obesity (London)* 35(7):891–8.

24. Park MH, Falconer C, Viner RM, Kinra S. (2012) The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obesity Reviews* 13(11):985-1000

25. Bridger T. (2009). Childhood obesity and cardiovascular disease. *Paediatrics & Child Health*. 14(3):177–82.

26. Deshmukh-Taskar P, Nicklas, T. A., Morales, M., Yang, S. J., Zakeri, I., & Berenson, G. S. (2006) Tracking of overweight status from childhood to young adulthood: The Bogalusa Heart Study, *European Journal of Clinical Nutrition* 60:48–57.

27. Serdula MK, Ivery D, Coates RJ, Freedman, D. S., Williamson, D. F., & Byers, T. (1993). Do obese children become obese adults? A review of the literature, *Preventive Medicine*, 22(2), 167–77.

28. Reilly JJ. (2005). Early life risk factors for obesity in childhood: cohort study. *BMJ* 333:1357

29. Sahoo K, Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of Family Medicine and Primary Care* 4(2):187-92.

30. Davison KK and Birch LL. (2001). Childhood прекумерна тежина: A contextual model and recommendations for future research. *Obesity Reviews* 2:159–71.

31. Anderson PM, Butcher KE. (2006). Childhood obesity: Trends and potential causes. *The future of children* 16:19–45.

32. Dublin: Department of Health and Children (2005). Department of Health and Children. Obesity: The policy challenges: The report of the national taskforce on obesity.

33. Tasic V, Danilovski D, Gucev Z. (2016) The Child Health Care System of Macedonia. *J Pediatr.* 177s:s127-s137.

34. Starc G and Klincarov I. (2016). Growth and nutritional status of migrant and minority children: The case of Macedonian and Albanian children in Slovenia and Macedonia. *Anthropological Notebooks* 22(3):109-123.

35. Gontarev S and Kalac R. (2014). Association between Obesity and Socioeconomic Factors in Macedonian Children and Adolescents. *Advances in Life Sciences and Health*, 1(1):55-63.

36. Gontarev, S. (2008). The influence of some, environment, psycho-social and demographic factors on physical activity among Students between the ages of 15 and 18. [необјавена докторска дисертација]. *Skopje: Ss. Cyril and Methodius University in Skopje, Faculty of Physical Education, Sport and Health*.

37. Sember V, Starc G, Jurak G, Golobič M, Kovač M, Pavletič Samardžija P, Morrison SA. (2016). Results From the Republic of Slovenia's 2016 Report Card on Physical Activity for Children and Youth. *Journal of Physical Activity and Health*, 13(11): S256–S64.

38. Wijnhoven TMA, van Raaij JMA, Spinelli A, Starc G, Hassapidou M, Spiroski I et al (2014). WHO European childhood obesity surveillance initiative: body mass index and level of прекумерна тежина among 6–9-year-old children from school year 2007/2008 to school year 2009/2010. *BMC Public Health* 14(1):806.

39. Spinelli A, Buoncristiano M, Kovacs VA, Yngve A, Spiroski I, Obreja G, et al. (2019). Prevalence of severe obesity among primary school children in 21 European countries.*Obesity Facts* 12(2):244–58.

40. Knai C, Lobstein T, Darmon N, Rutter H, McKee M. (2012). Socioeconomic patterning of childhood overweight status in Europe. *International Journal of Environmental Research and Public Health* 9(4):1472–89.

41. Spiroski I, Dimitrovska Z, Gjorgjev D, Mikik V, Efremova-Stefanoska V, Naunova-Spiroska D et al. (2011). Nutritional Status and Growth Parameters of School-Age Roma Children in the Republic of Macedonia. *Cent Eur J Public Health.* 19(2):102-107.

42. Spiroski I, Gjorgjev D, Kochubovski M, Kendrovski V, Ristovska G, Dimovska M. (2014). Comparative study about the nutritional status of school-aged children in the Republic of Macedonia in the period 2010-2013, Arch Pub Health 6(1):5-10 [Macedonian].

43. Kjostarova-Unkovsla L. and Georgievska-Nanevska E. (2013). Health as quality of life: social inequalities among youth in the Republic of Macedonia. Health Behaviour in School Aged Children Study (HBSC): report 2013. Skopje: Centre for psychosocial and crisis action – Malinska, XXVI, pp.174. [Macedonian: Ќостарова-Унковска Л., Георгиевска-Наневска Е., уред. (2013). Здравјето како квалитет на животот: социјални нееднаквости меѓу младите во Република Северна Македонија. Студија за однесувањата поврзани со здравјето кај децата на училишна возраст (HBSC): извештај 2013. Скопје, Центар за психосоцијална и кризна акција - Малинска, XXIV, 174 стр]

44. Seuring T., Archangelidi O., Suhrcke, M. (2015), The economic costs of type 2 diabetes : a global systematic review. *Pharmacoeconomics*, 33(8):811–31.

45. Diabetes UK (2014). *The cost of diabetes*, достапно на: https://www.diabetes.org.uk/Documents/Diabetes%20UK%20Cost%20of%20Diabetes%20Report.pdf, пристапено на 20 јануари 2016.

46. Lewin Group (2010). *The economics of diabetes in the US* [Research conducted by the Lewin Group and commissioned by Novo Nordisk through its Changing Diabetes® leadership initiative].

47. Schofield D, Percival R, Passey M, Shrestha R, Callander E, Kelly S. (2010). The financial vulnerability of individuals with diabetes, *British Journal of Diabetes & Vascular Disease*, 10(6):300–4.

48. American Diabetes Association. (2013). Economic costs of diabetes in the US in 2012. *Diabetes care* 36(4):1033–46.

49. Hex N., Barlett C., Wright D., Taylor M., Varley D. (2012). Estimating the current and future costs of type 1 and type 2 diabetes in the UK, including direct health costs and indirect societal and productivity costs, *Diabetic Medicine* 29(7):855–62.

50. Clarke, P., Gray, A., & Holman, R. (2002). Estimating utility values for health states of type 2 diabetic patients using the EQ-5D (UKPDS 62). *Medical Decision Making* 22(4):340–9.

51. Hodgson T.A. (1994), Costs of illness in cost-effectiveness analysis: a review of the methodology, Pharmacoeconomics, 6, 536-52.

52. Rice D.R., Hodgson T.A., Kopstein A.N., (1985), The economic costs of illness: a replication and update, Health Care Financing Review, 7, 61-80.

53. Byford S., Torgerson D.J., Raftery J. (2000), Cost of illness studies, BMJ, 320, 1335.

54. Hodgson T.A., Meiners M.R. (1982), Cost-of-illness methodology, a guide to current practices and procedures, 60, 429-62.

55. Shaya F.T., Mullins C.D., Wong W. (2002), Incidence versus prevalence modelling in pharmacoeconomics, Expert Review of Pharmacoeconomics and Outcomes Research, 2, 435-42.

56. Riley G.F. (2009), Administrative and claims records as sources of health care cost data, 47, S51-S55.

57. Elixhauser A., Steiner C., Harris D.B., Coffey R. (1998), Comorbidity measures for use with administrative data, Medical Care, 36, 8-27.

58. World Bank (2020). World Development Indicators Datacatalog, достапно на: https://datacatalog.worldbank.org/dataset/world-development-indicators, accessed: 20 February 2020.

59. WHO (2017). Best buys' and other recommended interventions for the prevention and control of noncommunicable diseases [Appendix 3 of the Global action plan for the prevention and control of noncommunicable diseases 2013-2020], Geneva: World Health Organisation, достапно на: https://www.who.int/ncds/management/WHO_Appendix_BestBuys.pdf, пристапено на 20 февруари 2020.

Appendix 1

Repository of available secondary data relevant for the study

Table 10. Available secondary datasets with obesity-related measures

Source (and owner)	Description (periodicity, size, data type)
Household consumption survey (State Statistical Office)	Periodicity: annual Sample size: approx. 5000 households Latest available year: 2017 Available data: health expenditures, out-of-pocket (not disaggregated)
European Union Statistics on Income and Living Conditions (EU-SILC) (State Statistical Office)	Periodicity: annual Sample size: approx. 12000 respondents (age 16+) Latest available year: 2017 Available data: income, BMI
Data on anthropometric status of children (Institute of Public Health	Periodicity: annual (collected through CPH) Sample size: approx. 1000 children in 5th grade in primary school and 1st year in high school Latest available year: 2017 Available data: anthropometric, BMI
COSI (Institute of Public Health)	Periodicity: every three years (2010, 2013, 2016, 2019) Sample size: approx. 3000 children in 2nd grade (7 years) Latest available year: 2019 (to include socio-economic parameters) Available data: physical activity, family self-reported socio-economic status
HBSC (National HBSC counterpart)	Periodicity: not defined Sample size: approx. 3800 children (11,13,15 years) Latest available year: 2010 (2016?) Available data: self-reported health status, self-reported risk-taking behaviour (smoking, drinking, drugs, physical activity)
MICS (UNICEF)	Periodicity: not defined Sample size: approx. 4700 households Latest available year: 2011 Available data: malnutrition, child anthropometry, BMI
UNICEF Nutrition Survey (UNICEF)	Periodicity: not defined Sample size: approx. 3000 households (with focus on non-pregnant women 15-49 years of age and children 6-59 months) Latest available year: 2011 Available data: macronutrient and micronutrient status, nutrition habits
Patient records (Health Insurance Fund and/ or Directorate of e-Health)	Periodicity: regular administrative data Sample size: disease-specific Latest available year: 2018 Available data: inpatient admissions and outpatient visits for obesity related illnesses (diabetes and cardiovascular).

Appendix 2

Creating variables from available datasets

Table 11. Creating variables based on the questions from the COSI 2016 and COSI 2019 datasets

Question	Answering options	Final variable created
Are the children allowed to use the playground when they are not at school?	Yes No	Dummy variable 0-1
Are the children allowed to use the school gymnasium when they are not at school	Yes No	Dummy variable 0-1
Does your school organize, at least once a week, some sport or a physical activity for the children when they are not at school	Yes, for all school grades Only for some school grades No	Dummy variable 0- 1(1 if the respondent said: yes for all school grades)
Do teaching activities in your school include education connected to nutrition, especially as a special subject, or integrated with other subjects?	Yes No	Dummy variable 0-1
Around your school could children buy the following drinks?	Water (free, for purchase, not available) Tea (free, for purchase, not available) 100% fruit juice without added sugar (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the drinks listed, either free or for purchase).
Around your school could children buy the following drinks?	Fruit juices or other non-carbonated drinks with added sugar (free, for purchase, not available) Carbonated non-alcoholic drinks with added sugar (free, for purchase, not available) Aromatized milk with added sugar (free, for purchase, not available) Hot drinks (cacao, tea, latte) (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the drinks listed, either free or for purchase).
Around your school could children buy the following drinks?	Other drinks with sweeteners (which are not sugar) (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the drinks listed, either free or for purchase).
Around your school could children buy the following food?	Fresh fruits (free, for purchase, not available) Vegetables (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the food listed, either free or for purchase).
Around your school could children buy the following food?	Sweet snacks (e.g. chocolate, bonbons, lollypops, cakes, cereal bars, biscuits) (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the food listed, either free or for purchase).

Question	Answering options	Final variable created
Around your school could children buy the following food?	Ice cream (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the food listed, either free or for purchase).
Around your school could children buy the following food?	Savoury snacks (e.g. crisps, popcorn, savoury biscuits etc) (free, for purchase, not available)	Dummy variable 0-1 (1 if the school has any of the food listed, either free or for purchase).
Does your school have a canteen	Yes No	Dummy variable 0-1
Does your school have a cafeteria where pupils can buy food and drinks?	Yes No	Dummy variable 0-1
Does your school have vending machines where pupils can buy food and drinks (other than water, fruits and vegetables)?	Yes No	Dummy variable 0-1
Does your school prohibit advertising food which is calorific but poor with nutrients (e.g. cakes, pasties, bonbons, sweetened carbonated and non-carbonated drinks, sweets and savoury snacks) which could compromise the promotion of healthy and balanced nutrition?	Yes No	Dummy variable 0-1

Table 12. Creating variables based on the questions from the Micronutrient survey

Question	Answering options	Final variable created
Which ethnic community does the household head belong to?	North Macedonian Albanian Turk Serbian Roma	Categorical variable for the answering options
What is the average household income (including pensions in social transfers)?	None Less than 5,500 MKD 5,501 – 8,000 MKD 8,001-13,000 MKD 13,001-18,000 MKD Over 18,000 MKD	Categorical variable based on the categories in the answering options. X`

Appendix 3

Supplementary tables of EU-SILC 2017 dataset analysis

Table 13. Descriptive statistics for the entire sample, EU-SILC 2017

	No. obs	mean	Std Dev	Min	Max
overweight	12,542	0.57	0.50	0	1
obese	12,518	0.11	0.31	0	1
female	12,542	0.51	0.50	0	1
17 to 24	12,542	0.12	0.33	0	1
25 to 35	12,542	0.15	0.36	0	1
36 to 45	12,542	0.15	0.35	0	1
46 to 55	12,542	0.17	0.38	0	1
56 to 65	12,542	0.19	0.39	0	1
66 to 75	12,542	0.14	0.34	0	1
age_over_75	12,542	0.08	0.27	0	1
Currently in school	12,518	0.08	0.27	0	1
completed pre-primary	12,521	0.03	0.16	0	1
completed primary	12,521	0.08	0.26	0	1
completed lower secondary	12,521	0.30	0.46	0	1
completed upper secondary	12,521	0.46	0.50	0	1
completed tertiary	12,521	0.14	0.35	0	1
good and very good health	12,512	0.70	0.46	0	1
fair health	12,512	0.19	0.39	0	1
bad and very bad health	12,512	0.11	0.31	0	1
chronic illness	12,402	0.20	0.40	0	1
consuming fruit at least once per day	12,507	0.49	0.50	0	1
consuming vegetables at least once per day	12,507	0.54	0.50	0	1
physically active	12,516	0.41	0.49	0	1
populated densely	12,542	0.27	0.45	0	1
populated intermediate	12,542	0.46	0.50	0	1
populated thinly	12,542	0.26	0.44	0	1
with great difficulty	12,542	0.29	0.45	0	1
with difficulty	12,542	0.27	0.44	0	1
with some difficulty	12,542	0.28	0.45	0	1
fairly easily	12,542	0.13	0.33	0	1
very easily	12,542	0.03	0.18	0	1

Table 14. Logit model, correlates of overweight, subjective socio-economic standing, EU-SILC 2017, age group 17-24 years

(N=1,524)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.35771	0.055149	0.000	0.264423	0.483908
(relative to not in school)					
Currently in school	0.68617	0.10844	0.017	0.503398	0.935304
(relative to completed tertiary)					
completed pre-primary	0.377735	0.379731	0.333	0.052661	2.709487
completed primary	0.720883	0.535924	0.66	0.167903	3.09507
completed lower secondary	0.453779	0.184233	0.052	0.204766	1.005609
completed upper secondary	0.745327	0.281239	0.436	0.35576	1.561478
(relative to bad and very bad health)					
good and very good health	0.260978	0.22668	0.122	0.047563	1.431989
fair health	0.210708	0.233799	0.160	0.023944	1.854226
(relative to not having a chronic illness					
chronic illness	0.676748	0.537265	0.623	0.142779	3.207666
consuming fruit at least once per day	0.914781	0.197603	0.680	0.59903	1.396966
consuming vegetables at least once per day	0.924782	0.198459	0.716	0.607256	1.40834
physically active	0.776091	0.116596	0.092	0.57814	1.04182
(relative to populated thinly)					
populated densely	1.18529	0.225338	0.371	0.816584	1.720475
populated intermediate	1.293642	0.218723	0.128	0.928746	1.801903
(relative to easily being able to afford paying bills)					
with great difficulty	7.745846	5.551241	0.004	1.901234	31.55747
with difficulty	5.946333	4.269453	0.013	1.455756	24.28901
with some difficulty	5.671608	4.070379	0.016	1.389374	23.15226
fairly easily	8.955752	6.554599	0.003	2.133628	37.59113
_cons	1.141193	0.230222	0.513	0.768493	1.694645
Log pseudolikelihood	-113,113				

Table 15. Logit model, correlates of overweight, objective socio-economic standing, EU-SILC 2017, age group 17-24

(N=1,516)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.357542	0.054968	0	0.264524	0.48327
(relative to not in school)					
currently in school	0.664992	0.104322	0.009	0.488969	0.904379
(relative to completed tertiary)					
completed pre-primary	0.463051	0.464294	0.443	0.064885	3.304566
completed primary	0.8134	0.605913	0.782	0.1889	3.502486
completed lower secondary	0.484455	0.196395	0.074	0.218868	1.072323
completed upper secondary	0.742876	0.281243	0.432	0.353723	1.560161
(relative to bad and very bad health)					
good and very good health	0.259967	0.219142	0.11	0.049818	1.356584
fair health	0.187733	0.206392	0.128	0.021764	1.619372
(relative to not having a chronic illness)					
chronic illness	0.69788	0.558554	0.653	0.145384	3.350014
consuming fruit at least once per day	0.886277	0.194328	0.582	0.576676	1.362094
consuming vegetables at least once per day	0.94586	0.207413	0.8	0.61542	1.453725
physically active	0.785058	0.11714	0.105	0.585993	1.051746
(relative to populated thinly)					
populated densely	1.19679	0.227347	0.344	0.824747	1.736663
populated intermediate	1.291701	0.218909	0.131	0.926628	1.800604
(relative to over 25,000 per person per month)					
income per person per month 0 to 5,000	1.148103	0.711216	0.824	0.340947	3.86612
income per person per month 5,001 to 10,000	1.170519	0.718668	0.798	0.351369	3.899364
income per person per month 10,001 to 15,000	1.452073	0.907066	0.55	0.426844	4.939788
income per person per month 15,001 to 20,000	1.05077	0.700518	0.941	0.28447	3.881317
income per person per month 20,001 to 25,000					
Log pseudolikelihood	-113723				

Table 16. Logit models, correlates of overweight, subjective measure of income, EU-SILC 2017, entire sample

(N=12,384)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.442171	0.021206	0.000	0.402502	0.48575
(relative to over 75)					
17 to 24	0.316435	0.044917	0.000	0.239585	0.417936
25 to 35	0.594081	0.070464	0.000	0.470853	0.74956
36 to 45	0.95628	0.112381	0.704	0.759544	1.203974
46 to 55	1.528552	0.174726	0.000	1.221746	1.912404
56 to 65	1.772614	0.19828	0.000	1.423642	2.207127
66 to 75	1.594782	0.177402	0.000	1.282374	1.983299
(relative to not in school)					
Currently in school	0.600525	0.070137	0.000	0.477658	0.754996
(relative to completed tertiary)					
completed pre-primary	1.57502	0.269273	0.008	1.126577	2.20197
completed primary	1.552551	0.185571	0.000	1.228302	1.962397
completed lower secondary	1.549277	0.12319	0.000	1.325704	1.810556
completed upper secondary	1.253343	0.086337	0.001	1.095052	1.434515
(relative to bad and very bad health)					
good and very good health	1.378705	0.153899	0.004	1.107784	1.715882
fair health	1.244546	0.127569	0.033	1.01803	1.521463
(relative to not having a chronic illness					
chronic illness	1.240984	0.106895	0.012	1.048204	1.469219
consuming fruit at least once per day	0.981695	0.066652	0.786	0.859378	1.121421
consuming vegetables at least once per day	0.997544	0.067408	0.971	0.873802	1.13881
physically active	0.95254	0.046436	0.319	0.86574	1.048044
(relative to populated thinly)					
populated densely	0.808701	0.051717	0.001	0.713433	0.91669
populated intermediate	0.944878	0.053441	0.316	0.845732	1.055646
(relative to easily being able to afford paying bills)					
with great difficulty	1.202913	0.159638	0.164	0.927409	1.56026
with difficulty	0.946202	0.12569	0.677	0.729312	1.227593
with some difficulty	1.190543	0.156442	0.184	0.920224	1.540268
fairly easily	1.211723	0.168566	0.167	0.922551	1.591535
_cons	1.141193	0.230222	0.513	0.768493	1.694645
Log pseudolikelihood	-1048890.6				

Table 17. Logit models, correlates of overweight, objective measure of income, EU-SILC 2017, entire sample

(N=12,380)

	odds ratios	standard error	*p* value	95% confidence interval	
(relative to over 75)	0.440194	0.021095	0.000	0.400731	0.483543
17 to 24					
25 to 35	0.338348	0.048542	0.000	0.255413	0.448213
36 to 45	0.61924	0.073855	0.000	0.49016	0.782311
46 to 55	0.996997	0.11732	0.980	0.791644	1.255618
56 to 65	1.593107	0.18332	0.000	1.271442	1.996151
66 to 75	1.829391	0.204918	0.000	1.46879	2.278522
66 до 75	1.630782	0.180959	0.000	1.312028	2.026977
(relative to not in school)					
Currently in school	0.594898	0.069369	0.000	0.473356	0.747649
(relative to completed tertiary)					
completed pre-primary	1.701945	0.29375	0.002	1.213476	2.38704
completed primary	1.665041	0.202686	0.000	1.311619	2.113694
completed lower secondary	1.61867	0.132357	0.000	1.378975	1.900029
completed upper secondary	1.257989	0.088063	0.001	1.096706	1.442991
(relative to bad and very bad health)					
good and very good health	1.383057	0.15414	0.004	1.111666	1.720702
fair health	1.2281	0.125999	0.045	1.004392	1.501636
(relative to not having a chronic illness					
chronic illness	1.246663	0.107253	0.010	1.053219	1.475637
consuming fruit at least once per day	0.977311	0.066715	0.737	0.854922	1.117222
consuming vegetables at least once per day	0.989243	0.067091	0.873	0.866112	1.129879
physically active	0.954468	0.046388	0.338	0.867746	1.049857
(relative to populated thinly)					
populated densely	0.797781	0.050945	0.000	0.703928	0.904148
populated intermediate	0.951464	0.05385	0.379	0.851563	1.063084
(relative to over 25,000 per person per month)					
income per person per month 0 to 5,000	1.436862	0.355728	0.143	0.884464	2.334262
income per person per month 5,001 to 10,000	1.322913	0.328455	0.260	0.813193	2.152132
income per person per month 10,001 to 15,000	1.35571	0.334742	0.218	0.835592	2.199576
income per person per month 15,001 to 20,000	1.022252	0.268027	0.933	0.611476	1.708979
income per person per month 20,001 to 25,000	1.141193	0.230222	0.513	0.768493	1.694645
Log pseudolikelihood	-1048852				

Table 18. Logit model, correlates of obesity, subjective socio-economic standing, EU-SILC 2017, age group 17-24

(N=1,475)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.34559	0.154285	0.017	0.144063	0.829029
(relative to not in school)					
Currently in school	0.620342	0.25077	0.238	0.28089	1.370013
(relative to completed tertiary)					
completed pre-primary	6.401362	10.4299	0.255	0.262657	156.0112
completed primary	1.697317	2.105295	0.670	0.149266	19.30032
completed lower secondary	0.628638	0.674565	0.665	0.076738	5.149795
completed upper secondary	1.277755	1.366316	0.819	0.157127	10.39072
(relative to bad and very bad health)					
good and very good health	0.036392	0.041164	0.003	0.003964	0.33406
fair health					
(relative to not having a chronic illness)					
chronic illness	0.039201	0.069198	0.067	0.001233	1.24689
consuming fruit at least once per day	1.059371	0.691337	0.930	0.294823	3.806581
consuming vegetables at least once per day	1.366245	0.877721	0.627	0.387872	4.812475
physically active	0.484375	0.176476	0.047	0.237168	0.989252
(relative to populated thinly)					
populated densely	1.31432	0.594489	0.546	0.541612	3.189434
populated intermediate	0.879623	0.387471	0.771	0.370976	2.085679
(relative to easily being able to afford paying bills)					
with great difficulty	2.602867	1.850641	0.178	0.646021	10.48714
with difficulty	2.851403	1.940017	0.124	0.751492	10.81914
with some difficulty	1.116581	0.884391	0.889	0.236425	5.27335
failry easily					
_cons	1.141193	0.230222	0.513	0.768493	1.694645
Log pseudolikelihood	-26156				

Table 19. Logit model, correlates of obesity, objective socio-economic standing, EU-SILC 2017, age group 17-24

(N=1,499)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.369093	0.165643	0.026	0.153155	0.889492
(relative to not in school)					
currently in school	0.527359	0.203982	0.098	0.247094	1.125513
(relative to completed tertiary)					
completed pre-primary	18.43072	32.1831	0.095	0.601455	564.7831
completed primary	3.981099	5.316202	0.301	0.290631	54.53355
completed lower secondary	1.17489	1.375883	0.891	0.118353	11.66318
completed upper secondary	1.883573	2.155844	0.58	0.199866	17.75111
(relative to bad and very bad health)					
good and very good health	0.042569	0.048216	0.005	0.004624	0.391938
fair health					
(relative to not having a chronic illness)					
chronic illness	0.035497	0.061089	0.052	0.001217	1.035293
consuming fruit at least once per day	1.100914	0.733812	0.885	0.298117	4.06556
consuming vegetables at least once per day	1.232941	0.784956	0.742	0.354015	4.294008
physically active	0.442961	0.166864	0.031	0.211698	0.926859
(relative to populated thinly)					
populated densely	1.19679	0.227347	0.344	0.824747	1.736663
populated intermediate	1.291701	0.218909	0.131	0.926628	1.800604
(relative to over 25,000 per person per month)					
income per person per month 0 to 5,000	0.12654	0.112816	0.02	0.022047	0.726293
income per person per month 5,001 to 10,000	0.283225	0.237879	0.133	0.054602	1.469103
income per person per month 10,001 to 15,000	0.189849	0.169016	0.062	0.03316	1.086939
income per person per month 15,001 to 20,000	0.237742	0.258952	0.187	0.028117	2.010237
income per person per month 20,001 to 25,000					
Log pseudolikelihood	-26200.9				

Table 20. Logit models, correlates of obesity, subjective income measure, EU-SILC 2017, entire sample

(N=12,384)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.796141	0.056446	0.001	0.692852	0.914829
(relative to over 75)					
17 to 24	0.761537	0.19986	0.299	0.455302	1.273746
25 to 35	1.18447	0.230207	0.384	0.809262	1.733641
36 to 45	1.801883	0.319499	0.001	1.272908	2.550683
46 to 55	2.052479	0.347307	0.000	1.473141	2.859653
56 to 65	2.34091	0.372304	0.000	1.713988	3.197141
66 to 75	2.182495	0.343915	0.000	1.602588	2.972244
(relative to not in school)					
Currently in school	0.39489	0.121079	0.002	0.216514	0.720221
(relative to completed tertiary)					
completed pre-primary	1.801844	0.449244	0.018	1.10533	2.937261
completed primary	1.874187	0.325965	0.000	1.332813	2.635462
completed lower secondary	1.614924	0.216244	0.000	1.242147	2.099574
completed upper secondary	1.529745	0.186571	0.000	1.204494	1.942824
(relative to bad and very bad health)					
good and very good health	0.486724	0.066902	0.000	0.371776	0.637212
fair health	0.678666	0.082725	0.001	0.534441	0.861811
(relative to not having a chronic illness					
chronic illness	1.136878	0.122563	0.234	0.920341	1.404362
consuming fruit at least once per day	1.263565	0.14299	0.039	1.012214	1.57733
consuming vegetables at least once per day	1.052499	0.117651	0.647	0.845419	1.310301
physically active	0.987631	0.075366	0.870	0.850432	1.146963
(relative to populated thinly)					
populated densely	0.979365	0.097751	0.835	0.805351	1.190978
populated intermediate	1.007872	0.087577	0.928	0.850046	1.195002
(relative to easily being able to afford paying bills)					
with great difficulty	1.436862	0.355728	0.143	0.884464	2.334262
with difficulty	1.322913	0.328455	0.260	0.813193	2.152132
with some difficulty	1.35571	0.334742	0.218	0.835592	2.199576
fairly easily	1.022252	0.268027	0.933	0.611476	1.708979
_cons	1.141193	0.230222	0.513	0.768493	1.694645
Log pseudolikelihood	-530,112				

Table 21. Logit models, correlates of obesity, objective income measure, EU-SILC 2017, entire sample

(N=12,380)

	odds ratios	standard error	*p* value	95% confidence interval	
female	0.791396	0.056494	0.001	0.688068	0.910242
(relative to over 75)					
17 to 24	0.802221	0.214835	0.411	0.474615	1.355958
25 to 35	1.213014	0.238536	0.326	0.825049	1.783414
36 to 45	1.89122	0.338922	0.000	1.331066	2.687102
46 to 55	2.092539	0.360099	0.000	1.493458	2.931934
56 to 65	2.402586	0.384266	0.000	1.756058	3.287146
66 to 75	2.205026	0.347553	0.000	1.619006	3.003163
(relative to not in school)					
Currently in school	0.382944	0.117334	0.002	0.210052	0.69814
(relative to completed tertiary)					
completed pre-primary	1.878467	0.475683	0.013	1.143548	3.085693
completed primary	1.94799	0.346273	0.000	1.374922	2.759914
completed lower secondary	1.633491	0.220509	0.000	1.25375	2.128251
completed upper secondary	1.537682	0.186319	0.000	1.212628	1.949869
(relative to bad and very bad health)					
good and very good health	0.468173	0.064147	0.000	0.357913	0.612399
fair health	0.666142	0.080954	0.001	0.524957	0.845299
(relative to not having a chronic illness					
chronic illness	1.113829	0.119586	0.315	0.902464	1.374698
consuming fruit at least once per day	1.261135	0.143753	0.042	1.008639	1.57684
consuming vegetables at least once per day	1.044022	0.117364	0.702	0.837571	1.301361
physically active	1.000185	0.076383	0.998	0.861144	1.161677
(relative to populated thinly)					
populated densely	1.007877	0.100838	0.937	0.828409	1.226225
populated intermediate	1.026935	0.089323	0.760	0.865976	1.217812
(relative to over 25,000 per person per month)					
income per person per month 0 to 5,000	0.791439	0.185442	0.318	0.500003	1.252743
income per person per month 5,001 to 10,000	0.929658	0.208515	0.745	0.59897	1.442915
income per person per month 10,001 to 15,000	0.877355	0.198957	0.564	0.562535	1.368363
income per person per month 15,001 to 20,000	0.741053	0.182376	0.223	0.457473	1.20042
income per person per month 20,001 to 25,000	0.546178	0.163617	0.043	0.303628	0.982487
Log pseudolikelihood	-528808				

Appendix 4

Results of COSI 2016 dataset analysis

Methodology

The WHO European Childhood Obesity Surveillance Initiative (COSI) survey was administered in 2016 in a total sample of 3,573 school children aged between 82 and 154 months in selected schools/municipalities in North Macedonia. As this is period survey, the same structure and methodology was used, with exception to the self-reported socio-economic status questionnaire, which was introduced in the COSI 2019 survey.

COSI 2016 Results

Overall, it appears that roughly a third (32.7%) of children in our sample are overweight, while 15% are obese. This is comparable to data on adolescents that have previously been released by WHO[14]. As expected, the share of overweight and obese children is higher in the urban areas (34.36%) compared to rural areas (28.21%). Similar disparity exists vis-à-vis child obesity (16.89% in urban areas vs. 13.03% in rural areas). Further disaggregation of data reveals that the share of children that are overweight/obese is highest in Strumica and Bitola.

The results of the analytical exercise are further elaborated in the tables below (Table 22, Table 23 and Table 24). We first start with the share of overweight children, regressed on the number of school characteristics. While the results are as expected in terms of magnitude and sign, they are non-significant. There are a few reasons for this findings: (i) the small number of schools in the sample (N=78); (ii) the somewhat not so large variation of the dependent variable across schools/school characteristics etc. It is important to state that the results are consistent when the exercise is repeated when using the share of obese children as a dependent variable (Table 23).

Table 22. School characteristics and overweight children, COSI 2016

(N=78)

	coeff.	std. error	*p* value
kids_use_playground	4.600398	3.099866	0.142
kids_use_gym	3.418105	3.227653	0.293
sport	-1.29525	3.270456	0.693
sugar	3.258613	4.287616	0.450
nosugardrinks	-5.24137	4.114591	0.207
other_sugary	-1.44605	4.444551	0.746
vending	0.04525	3.69475	0.990
prohibit_ad	-0.09828	2.950472	0.974
cafeteria	3.24766	2.87751	0.263
canteen	0.597355	3.200502	0.853

14 Available at: http://www.euro.who.int/__data/assets/pdf_file/0015/243330/The-former-Yugoslav-Republic-of-North Macedonia-WHO-Country-Profile.pdf?ua=1

Табела 23. Карактеристики на училиштето и деца со дебелина, COSI 2016

(N=78)

	coeff.	std. error	*p* value
kids_use_playground	4.69131	2.159491	0.033
kids_use_gym	-0.78053	2.248512	0.730
sport	-1.03992	2.278331	0.650
sugar	2.725505	2.986925	0.365
nosugardrinks	-1.94755	2.866389	0.499
other_sugary	0.391309	3.096252	0.900
vending	-0.23002	2.573911	0.929
prohibit_ad	-1.41259	2.055417	0.494
cafeteria	0.762684	2.004589	0.705
canteen	0.64948	2.229598	0.772

Table 24. School characteristics and obese children, COSI 2016, rural only

(N=29)

	coeff.	std. error	*p* value
kids_use_playground	8.193624	4.064511	0.059
kids_use_gym	2.748512	3.952441	0.496
sport	-9.4243	5.037714	0.078
sugar	12.99268	5.922287	0.042
nosugardrinks	-2.41492	5.385501	0.659
other_sugary	-3.0763	5.592597	0.589
vending	4.034763	8.664091	0.647
prohibit_ad	-1.53554	3.965127	0.703
cafeteria	-3.0937	4.793306	0.527
canteen	3.472022	6.103148	0.576

Interesting results emerge when we re-run the analysis on two separate sub-samples: rural and urban. In particular, the results on the determinants of share of obese children in rural areas is worth further description. As evidenced by Table 24, we find that availability of sport classes is negatively associated with the share of obese children. By the same token, we also find that availability of sugary drinks around schools is positively associated with the share of children that are obese. While interesting, these results failed to emerge on the urban sub-sample, most likely given the lower variation of the share of obesity among the selected urban schools.

Appendix 5

Supplementary table of outpatient visits dataset analysis

Table 25. Ranking of most prevalent ICD-10 diagnoses by age groups and prevalence, Moj termin, 2017

rank	Age (years) 0 to 5		age 6 to 10		age 11 to 20		age 21 to 30	
1	tonsillitis	17.2	tonsillitis	20.4	tonsillitis	14.2	tonsillitis	8.2
2	acute pharyngitis	10.4	acute pharyngitis	8.3	acute pharyngitis	6.2	general examination	4.8
3	acute bronchitis	7.7	acute bronchitis	6.9	general examination	5.0	acute pharyngitis	3.2
4	general examination	7.4	general examination	4.6	acute sinusitis	3.3	cystitis	2.7
5	common cold	6.3	common cold	3.7	acute bronchitis	3.3	gastritis	2.7
			Case count by age group:		216 non-insulin dependent DM		55 non-insulin dependent DM	

rank	age 31 to 40		age 41 to 50		age 51 to 60		age 61 to 70	
1	tonsillitis	5.6	primary hypertension	12.5	primary hypertension	21.2	primary hypertension	27.0
2	primary hypertension	4.5	anxiety disorders	3.3	non-insulin dependent DM	6.1	non-insulin dependent DM	7.5
3	general examination	4.3	general examination	3.3	lipoprotein metabolism	3.6	hyperplasia of prostate	3.4
4	anxiety disorders	3.7	tonsillitis	3.3	anxiety disorders	2.5	lipoprotein metabolism	3.0
5	gastritis	2.6	non-insulin dependent DM	3.2	dorsalgia	2.1	health services other circums.	2.5
	27 non-insulin dependent DM							

rank	age 71 to 80		age 81 to 90		age 91 to 100	
1	primary hypertension	29.2	primary hypertension	30.0	primary hypertension	26.6
2	non-insulin dependent DM	6.7	xhyperplasia of prostate	4.6	cardiomyopathy	6.7
3	hyperplasia of prostate	4.3	non-insulin dependent DM	4.6	vascular dementia	5.9
4	health services other circums.	2.6	cardiomyopath	3.6	xhyperplasia of prostate	5.1
5	other COPD	2.2	vascular dementia	2.7	non-insulin dependent DM	3.3

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