

THESES OF DOCTORAL DISSERTATION

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**The socio-economic burden of obesity, some ways, and impasses
of its prevention**

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1. INTRODUCTION AND OBJECTIVES

The prevalence of obesity and its co-morbidities is increasing monotonically all over the world. Obesity, and its adverse consequences, like morbidity, mortality, and obesity-related diseases, cause a considerable burden to society in general and the social security system, in particular, e.g. in form of enhancing costs of the health care system. Results of the National Nutrition Status Survey in 2014 have proven, that nearly two-thirds of the Hungarian population is overweight or obese, 28.2% of the male and 31.5% of the female population are suffering from obesity in Hungary (Erdei et al, 2017). The social costs of obesity and overweight are well characterized by calculations of Iski and Rurik (2014) who have proven, that 11.6% of the National Health Insurance Fund (207 billion HUF) had been spent on medical treatment of obesity-related diseases. This was 0.73% of the Hungarian GDP. Obesity is a general problem in Hungary, but overweight and obesity do not only affect the Hungarian adult population.

An increasing proportion of the Hungarian population is the Roma population, the Roma minorities are an endangered national minority. The Roma population suffers from disadvantaged living conditions, food insecurity, high-risk health-related behaviors, discrimination, and stigmatization. Roma is at a higher risk of certain health conditions, the Roma population is characterized by poor health and short life expectancy. Among the Roma population, one of the consequences of low food security and a disadvantaged socio-demographic situation is inadequate nutrition, which in many cases has a high prevalence of obesity and diseases attributable to obesity (European Commission, 2014). However considerable efforts and resources had been allocated in development and research of efficiency of interventions, aiming at prevention and decreasing of obesity, there are relatively few pieces of evidence-based information of efficiency of prevention and intervention programs.

An important, vulnerable group in society is the children. Overweight and obesity in the case of children in first childhood (kindergarten) and school-age is a global problem too, being in the focus of public attention and international research. The prevalence of overweight is 13.4% and obesity is 6.6% in the case of children and young people in the age bracket 3-18 years (Jakab et al, 2018). There is a positive correlation between childhood obesity and adulthood, obesity-related morbidity, and mortality. School catering systems have a key role

in the formation of nutritional behavior and eating habits of children. An important goal of high-level regulation (37/2014. (IV. 30.) EMMI) of food supply systems in children-related institutions (kindergartens, schools) has been the modification of the activity of these nutritional systems, aiming at the enhancement of quality and nutritional value of foods, served to the children, laying down the foundations of the healthy nutritional behavior in adulthood. The difficulty of modification of these systems is well demonstrated by the fact, that as a consequence of the considerable social pressure the Ministry had had to modify this regulation considerably.

In a summary it can be stated, that during the last decades the overweight and obesity have got unprecedented importance in health policy, political and economic decision making as well as in everyday life. Decreasing the prevalence and incidence of obesity, and obesity-related diseases became an important topic of politics and national strategies. From point of view of the food industry, it is a question of vital importance to understand the causes and consequences of obesity, because this will determine the main directions of product development and the economic environment of food-related regulations.

In the framework of my Ph.D. thesis, I analyzed the three most important socio-economic aspects of obesity and the possibilities of its prevention.

The aim of my work was threefold:

1. Determination of current and prognostic burden of obesity in case of Hungarian adult population, quantification of macro-economic consequences of obesity and their prognosis for the next one hundred years (three-generation period).
2. Determination of prevalence of obesity, current and prognostic burden of obesity in case of Hungarian Roma population. Guided by this goal, preparation of a forecast for the prevalence of obesity and its burden in case of Roma population, and estimation of efficiency of intervention programs, different in intensity; preparation of quantitative models to a comparative analysis of different type intervention programs, based on changes in nutritional status and prevalence of co-morbidities of obesity.
3. An in-depth analysis of an actual government-level project aiming at the prevention of childhood obesity: the investigation of socio-economic causes, leading to introduction and modification of 37/2014. (IV. 30.) Ministerial Decree on the nutritional standards of public catering.

Based on these considerations, I have formulated the research hypotheses as follows:

H₁: Based on the system dynamics method a more robust and flexible model can be constructed, than the algorithms, generally applied for analysis and prediction of the burden of obesity.

H₂: Combining the system dynamics approach with the Solow model of economic growth it can be proven, that obesity causes considerable health and economic burden in Hungary, the importance of which will be increasing, hindrance the economic development.

H₃: The prevalence and incidence of obesity and obesity-related diseases in the Roma minority are an especially severe epidemiologic problem. In the lack of complex, high-intensity obesity prevention and intervention programs, parallel with the increasing number and average age of this segment of the population, obesity and obesity-related diseases will be one of the main causes of deteriorating health conditions of the Roma population.

H₄: The importance of prevention is increasing in general, and in childhood in particular. An important part of these efforts is the reform of school catering in Hungary, but this must be based on a wide-range social consensus and concentrated efforts of different stakeholders.

2. MATERIALS AND METHODS

In line with the three research directions, I have applied three quantitative methods to determine the burden and consequences of obesity in Hungary, taking into account the time and scope, as well as the available material and intellectual resources.

2.1. Application of system dynamics analysis for forecasting of the social burden of obesity in Hungary

I divided the methodological part of system dynamics analysis into two sections: first, I present the methods I used to estimate the expected prevalence of overweight and obesity as well as the burden of obesity measured in years of life lost in the Hungarian adult population. In the second phase of my investigation, I described the methods of estimation of the macro-economic burden of obesity in Hungary. In my study, I have considered the Hungarian adult population as a system. The time window of investigations was 100 years. I have considered the five-year age cohorts of the sub-system and I have supposed that each member of a given cohort can be divided into three categories, according to his nutritional status: normal, overweight, and obese. One part of each category will exit due to death, another part of the cohort will go into the $n+1$ cohort. The matrix of transition will determine, the probability of getting from one nutritional category to another. In this way, for each cohort transition nine transitional probabilities should be determined (e.g. from normal to normal, from normal to obese, and from normal to overweight). For the operationalization of my model, I have applied the following type of data and data sources (Table 1).

Table 1. Type of data and data sources applied to the operationalization of the model for the Hungarian population

Type of data	Data sources
Demographic variables	The input data of demographic variables (size and age of the population) had been based on Official Statistical Yearbooks of the Hungarian Central Statistical Office (2011).
The fertility rate of the Hungarian population	To estimate future changes in the number of newborn male children I have applied the data source of the World Population Prospects study of the United Nations (UN, 2019).

Nutritional status of the Hungarian population	The current nutritional status of different cohorts has been estimated based on the Hungarian Diet and Nutritional Status Survey (Erdei et al, 2017).
Death ratio	The death ratio in different cohort groups has been determined based on the Global Burden of Disease (GDB) database (Keating, 2018). The GBD system incorporates both the prevalence of different diseases or risk factors and the relative harm they cause.
Base units of investigations	I have applied a discrete-time approach, that's why I had to determine the base units of investigations.
Transition probabilities	The ideal way of determination of transition probabilities from one arbitrary nutritional status into another would be the analysis of individual life histories, but this type of statistical data collection does not exist in Hungary. Thus, we have had to apply the transitional probabilities of the Dynamo-HIA database.

The burden of obesity by Solow-Swam Model

The Total Factor Productivity is a function of numerous factors, but with a considerable simplification, it can be approximated as a variable, determined by two basic resources of production: capital and living labour. All diseases have a negative effect on capital accumulation, size, and performance of productivity of labour force. At the same time, the pharmaceutical costs demand resources, which could be used in another field of economy. From this follows, that the health interventions can exercise a positive effect on the production of value-added by increasing the number of material resources, allocated for augmented reproduction. In a summary, it can be stated, that the obesity-related co-diseases exercise a negative effect on economic development: on one hand, by decreasing the labour forces, on another hand by demanding additional financial resources for medication. From this follows, that prevention and intervention programs could have a positive effect on economic development by decreasing losses in labour force and increasing the material resources of production. A dynamic model of these processes is depicted in Figure 1.

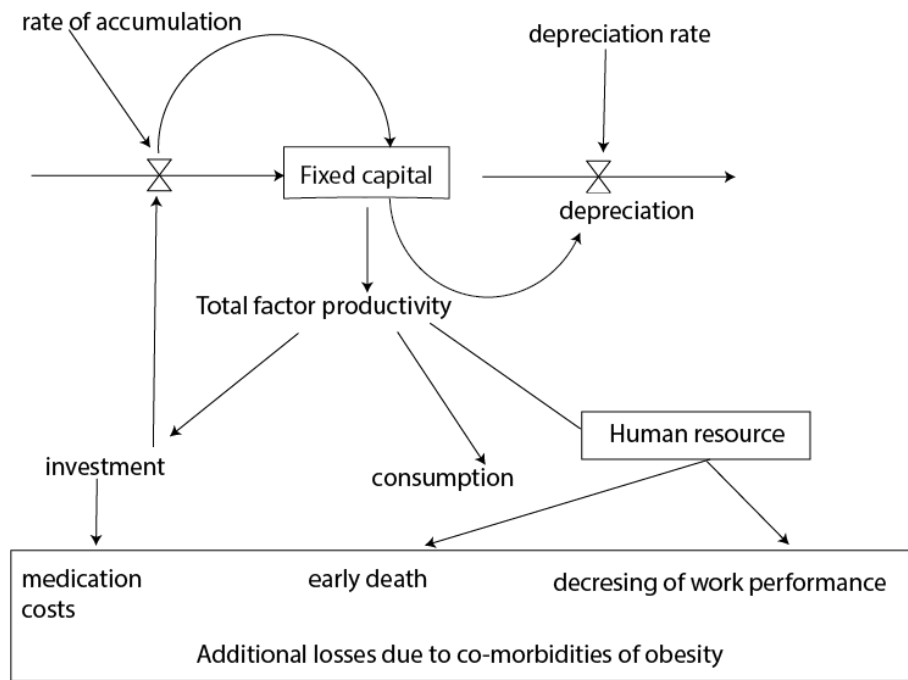


Figure 1. Application of Solow-Swan model to the determination of burden of obesity

Another factor of productivity loss due to co-morbidities of obesity is the adverse economic consequence of years lived with diseases. The Global Burden of Diseases database gives data on YLD values of different diseases, attributable to obesity by different age categories. These values are determined as a difference of statistical life expectancy of different cohorts and the years lived without the disease. Then the “crude” years, lived with the disease are corrugated with weights, expressing the effect of disease on the life quality of the patient. We have supposed, that (1) the weights, applied for comparison of the severity of different diseases are applicable to express the difference in workability of workers, living with or without the given disease; (2) we have supposed, that these disability weights will be constant from the onset of the disease up to the end of life.

2.2. Estimation of present and future social burden of obesity in case of Hungarian Roma population

The Health Impact Assessment (HIA) concept is rapidly gaining importance in policymaking. This is an umbrella concept of different procedures, methods, and tools to promote the objective comparison and evaluation of different intervention and/or prevention programs on the health of the population or a targeted segment of it. The DyNamic Modelling for Health Impact Assessment (DYNAMO-HIA) is a high-level, sophisticated tool for the

quantification of user-specified policy interventions. The DYNAMO-HIA has been designed to model a closed real-life population (Lhachimi et al, 2012). The closed population means, that we do not take into consideration the effects of the in-and outbound migration. This population is stratified by sex and age in one-year age categories.

The mathematical theory behind the model is the Markovian approach of multistate models. The basic assumption of the model is that the change of the state of a given person of the population depends only on current characteristics (age, sex, risk factors, and health status). This multi-state model is implemented as a partial micro-simulation, combining a stochastic micro-simulation to project risk-factor behavior with a deterministic macro approach for the disease life table. A high number of risk-factor biographies are simulated. Based on transition probabilities between different risk categories (e.g. from normal to obese nutritional status), corresponding to the age and sex category (e.g. 25-years old man) the risk-factor status of every simulated individual is updated for each year of simulation horizon. In the macro module, a separate disease life history is constructed for each risk-/factor biographies.

I have applied the DYNAMO-HIA software to estimate the current and future burden of obesity in the Roma population. For the operationalization of my model, I have applied the following type of data and data sources (Table 2).

Table 2. Type of data and data sources applied to the operationalization of the model for the Hungarian Roma population

Type of data	Data source
Demographic characteristic of Roma population in Hungary	Hungarian Central Statistic Office: National census in 2011.
Nutritional status of Hungarian Roma population	The nutritional status of the Roma population was surveyed based on primary data collection. The ethnicity of the participants was assessed by self-declaration.
Estimation of obesity and obesity-related disease	DYNAMO-HIA software
Transition probabilities between nutritional status	DYNAMO-HIA software
Obesity intervention programs	Based on literature search: the selection of „best practice” intervention

The goal of HIA is to compare the presumed efficiency of different policies/interventions/prevention programs on the future health status of the populations. This means, that we choose one epidemiologic status, which is called a reference scenario, and on-base of results, obtained for prediction of the health status of the population (or a part of it) in

the future, we compare the reference scenario with results of the intervention. To quantify the potential effects of various obesity prevention programs we have compared two systems of models (scenarios) by DYNAMO-HIA software. In the case of the first model system, we had been modeling the effects of a hypothetical intervention, focusing just on one influencing factor of food consumption: television (TV), radio, and newspapers advertising of food and beverages high in fat, sugar, and salt. In the first model intervention, we have supposed the decreasing (limitation) of promotion of foods high in fat-, sugar- and salt in different media: radio, newspapers, and TVs.

In another model intervention, we have supposed that there will be a complex project, aiming at total lifestyle-change of the Roma population (increased physical activity, radical changes in food consumption, behavioral therapy). We have supposed that this project will have different components. The basic pillars of this project could be as follows: 60-90 minutes of moderate-intensive aerobic physical activity each week (or equivalent), promotional programs for the re-formation of food consumption, based on latest nutritional recommendations (e.g. Smart PlateTM, developed lately by the Hungarian Association of Dieticians, adapted to specific needs of different age groups), (c) specific project for modification of nutritional habits of Roma population (e.g. projects for enhancement of nutrition literacy).

We have modeled the effects of prevention/intervention programs, focussing on different age brackets. These age categories were as follows: early childhood: 5 years age, prepuberty: 11 years age, middle age: 40 years age; elder: 62 years). All these age brackets have been chosen based on careful analysis of literature. It has been proven, that these age categories offer the possibility of an efficient intervention because they coincide are with the change in lifestyle or the socio-economic status of individuals (Weihrauch-Blüher et al, 2018; Kjøllesdal et al, 2019; Zamboni and Mazzali, 2012).

2.3. The MACTOR method

The fundamental theoretical paradigms of the analysis were institutional economic theory, principle-agent theory, and the concept of strategic planning (Dacin et al, 2002). According to the basic theory of the so-called “French school of strategy,” the different social systems can be considered as a playground in which different groups of participants (the actors) take part with the purpose of making their specific interests prevail. In the opinion of (Godet, 1991), if one can adequately simplify the actors and the most characteristic features of their systems of interests and strategies, then it is possible to analyze the chances of different actors

realizing their goals. The method of the systematic analysis of social bargaining can be described by using the MACTOR model. One of the key concepts of the model is that actors may influence other actors in terms of their potential to put pressure on other actors directly or indirectly to affect their behavior. The influence of one actor (A) on another actor (C) is the sum of the direct and indirect influences of actor A on actor C.

Series of preliminary interviews were conducted to determine the set of relevant actors and interests. The interviews were carried out in 2015 and 2016. This preliminary phase of interviews aimed to outline the most important stakeholder groups and the set of potential objectives of the stakeholders. As a result of these preliminary investigations, a robust and relatively well-manageable set of actors and goals could be identified. In setting up a pool of experts a specific procedure was followed. In this phase, we pursued the following logic. We considered experts to be people (1) who have direct “field” experiences in catering functions as parents or teachers; (2) people whose job directly involves a catering business with relatively long experience in the practice of SCS and whose existence directly depends on this enterprise; (3) independent experts, preferably those who have been especially active in professional social debates concerning the catering regulations in the printed and electronic media; (4) experts who have been actively involved in the preparation and enforcement of the new regulatory framework of the SCS. Due to time and financial constraints 33 expert interviews were carried out, all of them face-to-face. Additionally, we interviewed 26 parents and 13 teachers.

Based on unstructured interviews, the key actors of the catering system were determined. In the next phase, the intensity of mutual direct influences was characterized using a rectangular matrix offering a good overview of the MACTOR method. The cells of the matrix – by definition – reflect the intensity of the influence of any actor in a row on any actor in a column. The intensity of the direct influence by one actor on another was measured on a 0-4 scale ranging from no influence to absolute influence.

The importance of different goals from the point of view of each actor was expressed by the Matrix of Actor-Objective. This was the so-called 1MAO matrix. Each cell of the matrix contained the attitude of a given actor towards a given goal in the form of a positive, 0, or negative sign. In the second phase, the 2MAO matrix is determined, which contains the intensity of these attitudes determined from the point of view of different actors and quantified on a -4 ...+4 scale, where -4 denotes the high importance and total negation of the given goal, and +4 denotes the high importance and total support.

3. RESULTS AND DISCUSSION

3.1. Expected prevalence of overweight and obesity and macroeconomic burden of obesity in Hungary

The most important changes in nutritional status in the case of women are in the age categories 46-50 years and 71-75 years. In the 71-75 age cohort, the number of overweight women will be 120 thousand and the number of obese will be 100 thousand. In the second part of the forecasting period, more than two-thirds of women will be in the overweight and obese category (Figure 2).

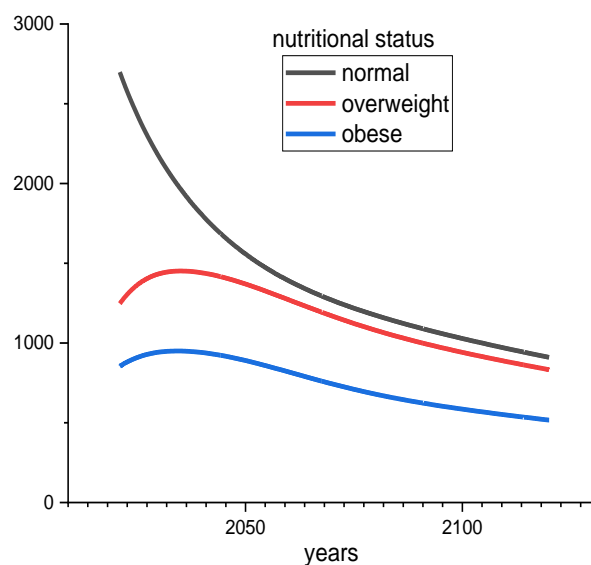


Figure 2. The dynamics of changes of the female population according to different nutritional status

I have proven, that currently the number of life years, lost due to obesity is nearly 80 thousand years, and in the middle of thirties of our century will be more than 90 thousand. The highest level of life years loss will be in middle age and the elderly in the case of women (Figure 3).

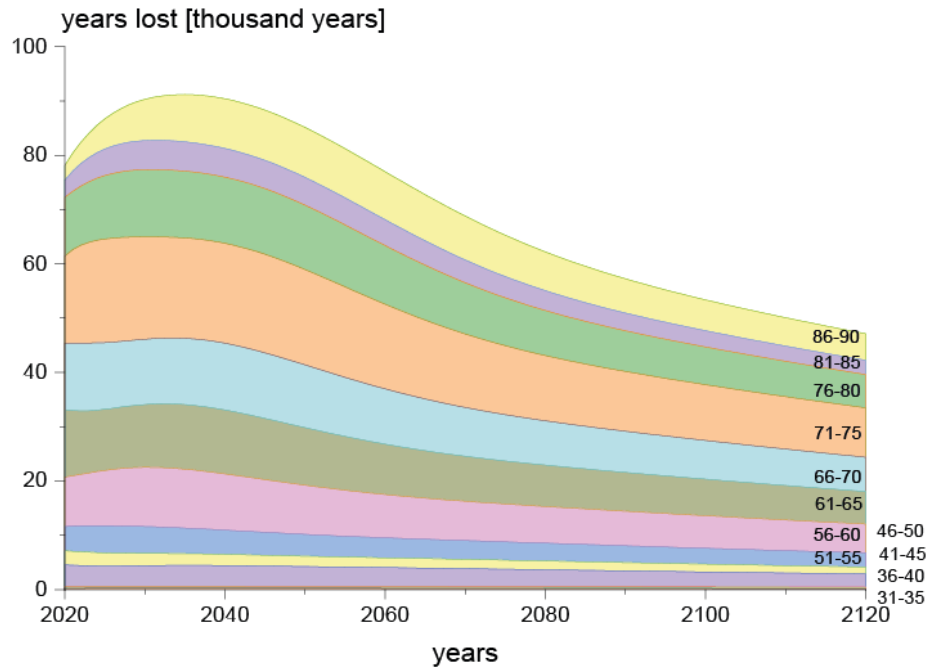


Figure 3. Structure of loss in life years according to different age brackets

In the male population, the most important changes in nutritional status will be in 31-35-year cohorts, and 71-75 years cohorts. At 31-35 years cohorts, the number of obese citizens will be 45-50 thousand, but the share of the obese population will be significantly higher in the case of all cohorts (Figure 4). E.g. share of overweight and obese men in this cohort will be 67%.

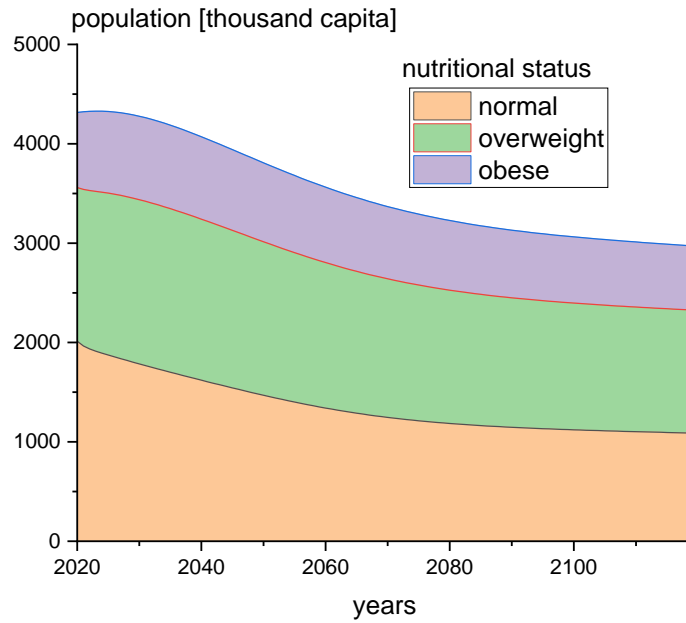


Figure 4. The change of male population in different nutritional status in next one hundred years

In the case of the male population, the number of years lost due to the co-morbidity of obesity will be 50 thousand years. The largest losses of life years are expected in the 55-60 and 71-75 age groups (Figure 5).

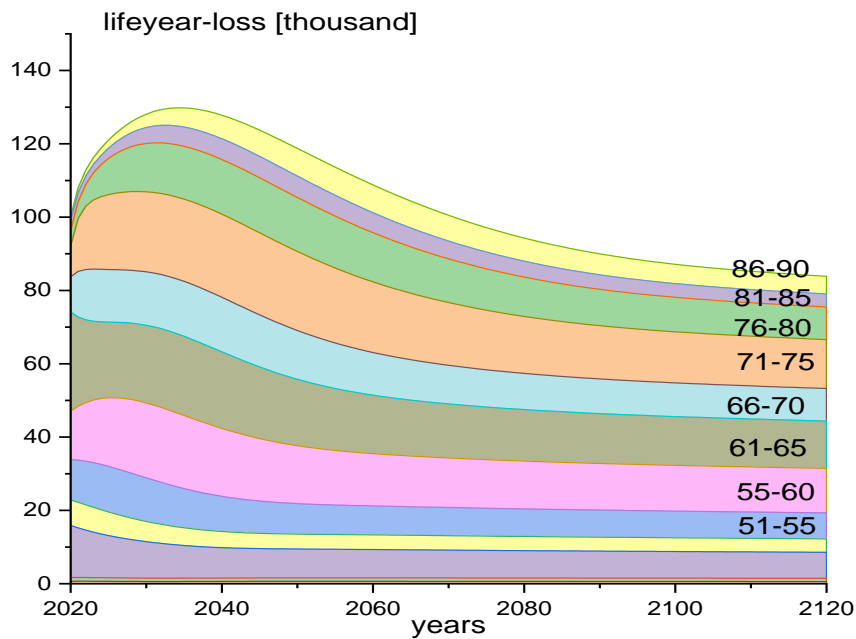


Figure 5. Forecasted life year-loss due to obesity-related death at different age brackets

Analyzing the burden of obesity from point of view of economic development it can be stated, that the losses in the working-age population due to premature death will be relatively low. At the same time the productivity losses, due to co-morbidities of obesity will gain in importance. The highest increase in absolute as well as relative terms can be expected in the case of medication costs. After one hundred years the difference between the obesity-free scenario, and the baseline scenario, calculated based on my system-dynamics model will be 0.8 % of the GDP in each year (Figure 6).

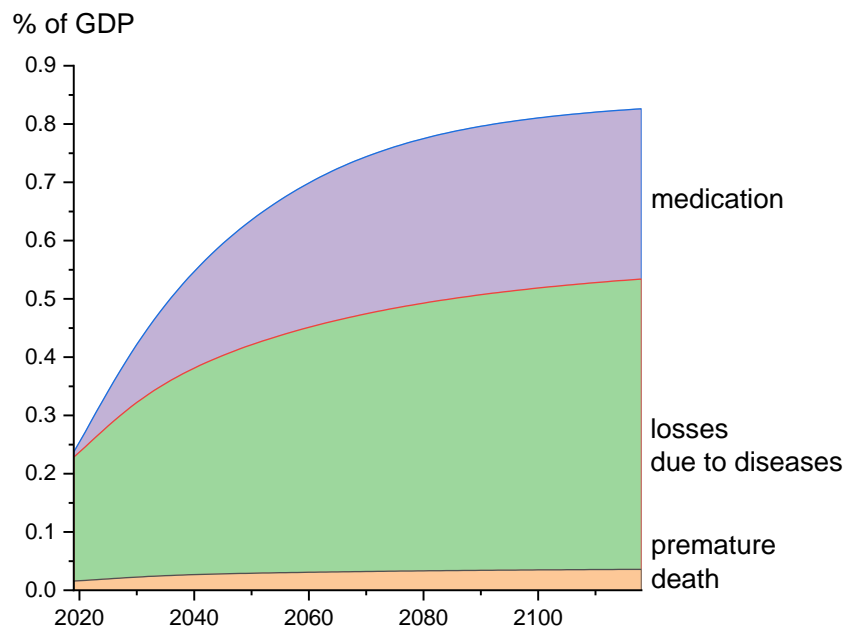


Figure 6. The burden of obesity to Hungarian economy as a % of GDP

By on econometric models, it can be proven, that obesity will cause considerable economic losses, due to decreasing working-age population as a consequence of premature death and losses by co-morbidities of overweight and obesity. The gap between obesity-free development trajectory and the current development path (baseline scenario) will be continuously increasing. Currently, this difference is ca. 0.2%, but this value will increase up to 0.6% at the beginning of the middle of the century. This will be circa 10% of the current share of health-related costs within the Hungarian GDP.

3.2. Obesity in Hungarian Roma population: present and future

Based on BMI values 50.8% of men and 40.6% of women can be considered as overweight or obese in the age bracket 18-35 years. In the case of the Roma population, every second man

(56.4%) and every third woman (37.3%) can be categorized as overweight, nearly one-third of the man and women population is obese (Figure 7).

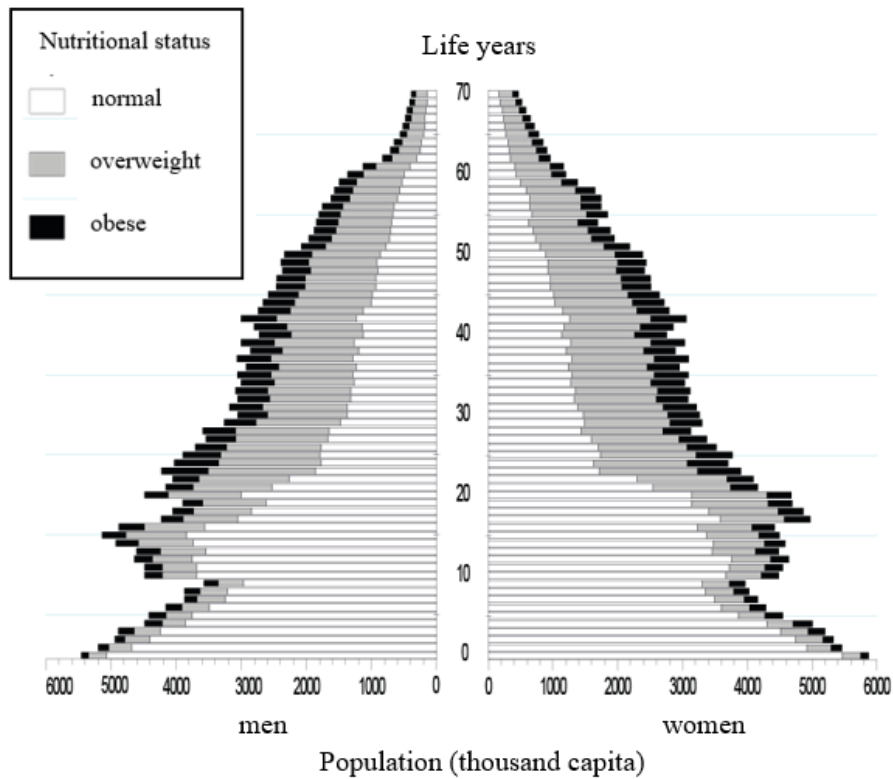


Figure 7. Nutritional status of Roma population in 2019

The expected prevalence of overweight and obesity in 2070 will be 21.000 in the case of women and 17.000 in the case of men. The prevalence of overweight or obesity was generally higher among women than among men in all age brackets. The prevalence of obesity-related diseases is rising, the number of diseases attributable to obesity is increasing from six thousand to twenty-six thousand in the case of women and nearly from six thousand to more than seventeen thousand in the case of men over the next half-century (Figure 8). The rate of ischemic heart disease in obese men will almost six times higher than the current prevalence value, and in women will more than three times higher compared to the current prevalence value. The rate of cerebrovascular disease will be three times higher as at present. For the Roma population as a whole, co-morbidities of obesity reduce life expectancy by 0.2 years in men and 0.66 years in women.

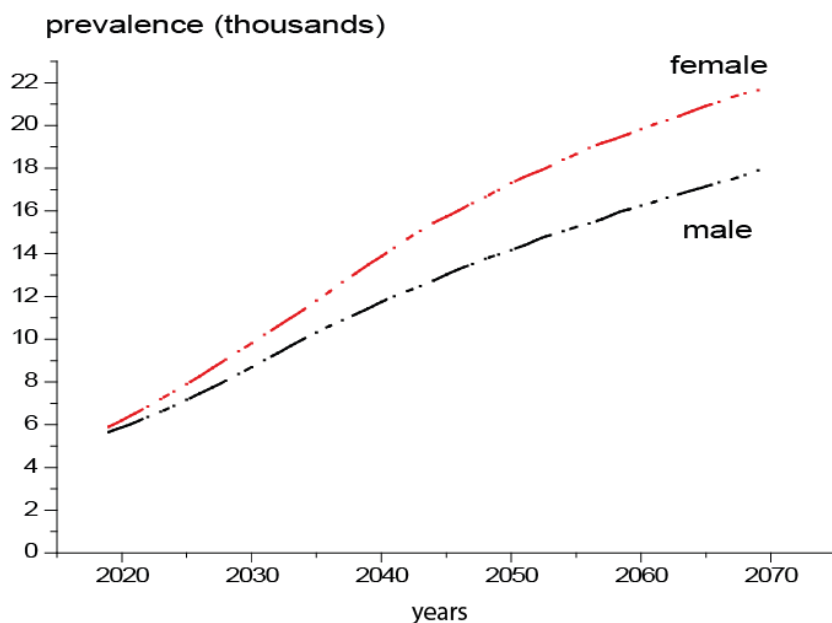


Figure 8. Expected prevalence of co-morbidities of obesity in Roma population in the next 50 years

We could register the co-morbidities of obesity in more than 300 cases in 2019. Two third of these cases are diabetes mellitus followed by ischaemic heart disease and stroke. Diabetes mellitus, as well as ischemic heart disease and cerebrovascular disease, are responsible for more than ninety percent of all major diseases attributable to obesity (Table 3).

Table 3. The additional disease burden, caused by obesity in the case of the Hungarian Roma population, in 2019

Disease	Men	Women	Total
Ischaemic heart disease	44	31	75
Stroke	14	11	25
Diabetes mellitus	101	94	195
Lung cancer	7	3	10
Bowel and rectal cancer	3	1	4
COPD	5	1	6
Breast cancer		4	4
Total	174	145	319

Prevalence of obesity in case of intervention program, focusing just on one factor

Analyzing the results of modeling the effect of this intervention by different age groups, it can be seen, that the effect of intervention at age-brackets 4-5 years and 11-12 years can be considered as moderate, because the additional number of the population, categorized as normal from point of view of nutritional status will increase just by two percent point both in case of boys and girls. The most important change can be proven in the case of the 60+ population, here the share of obese women will be decreasing by eight percent point.

Results of modeling of effects of a complex prevention program

As a result of the intervention, the number of overweight persons will decrease by 0.12% in the case of boys and 0.04% in girls by 2070. In the case of middle-aged citizens, the prevalence of overweight will be decreasing by 0.31% in the case of males and by 0.22% in the case of the female population. The most efficient period of intervention is the elder age. At this age, the number of overweight people will decrease by 0.37% in the case of men and 0.42% in the case of women. Considering the number of obese persons, it can be stated, that the prevention programs, focusing on middle age and elder generations are more efficient than the preventions and interventions in early childhood or prepuberty. Prevention programs, focusing on the middle-aged population offer moderate results: the prevalence of obesity will decrease by 0.42% in the case of men and 0.35% in the case of women (Figure 9).

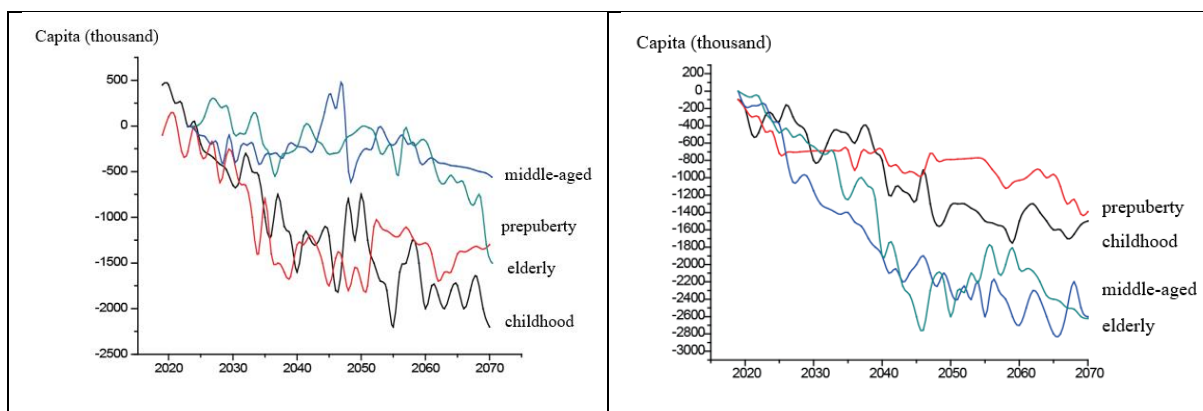


Figure 9. Effects of a complex prevention program for overweight (left side) and obesity (right side)

The prevalence of obesity and the comorbidities of obesity will increase considerably in the Roma population, parallel with the augmentation of the frequency of obesity. Our results have proven, that obesity is and will be an extremely important problem for the Roma

population because the multiply disadvantaged groups are especially prone to this epidemiologic phenomenon. complex intervention programs, based on a comprehensive transformation of lifestyle and food consumption patterns can present perceptible outcomes primarily among the middle-aged and the elderly. The survey results drawing attention to the fact that reducing the burden of obesity in the Roma population caused by obesity is only to be achieved as a complex, all-councils act that requires resources much greater than what is available now.

3.3. Uphill fight: the reform of Hungarian school catering system

The matrix of the direct influences of actors is shown in Table 4. The matrix highlights the considerable influence of the government on the behavior of catering service providers and the SCS in general because the government has a considerable influence on the monetary resources for school catering. Local authorities can exercise an important influence on catering service providers because they can select the SCS provider for different schools in the framework of the public procurement procedure.

Table 4. The matrix of direct influences on actors measured on a 0-4 scale (0 – no direct influence, 4 – very strong influence)

	Government	Local authorities	Parents	Children	Catering service managers	Catering service providers	Teachers
Government	0	3	1	0	1	4	2
Local authorities	1	0	1	0	1	4	0
Parents	1	3	0	3	0	0	2
Children	0	0	2	0	0	0	1
Catering service managers	0	0	0	2	0	0	1
Catering service providers	1	1	0	0	3	0	0
Teachers	1	2	2	3	1	1	0

The health of children is a generally accepted goal for all participants, but this goal is relatively more distant in time, which means it is difficult to translate into operative actions. Local authorities are in direct connection with the population so the taste of food is especially

important for them. The children’s acceptance of food is important for the parents, too, because in this way they can reduce their household expenditure on feeding their children. A well-fed child can be managed easily so the taste and acceptance of food are important for teachers, as well. It should be highlighted that the goal of minimization of expenditure on health promotion is quite an important question for the majority of actors. We have found that school feeding was important for parents. It can be assessed as a positive point, that – at least on the verbal level – the healthiness of school feeding was evaluated as a question of great importance. The interest relation of the different actors is summarized in Table 5.

Table 5. The actors’ interest relations were measured on a -4...+4 scale.

Interpretation: -4 the objective is against the vital interest/jeopardizes the existence of the actor, 4 the objective is a vital interest of the actor

	good taste of the meal (TASTE)	the healthiness of the food (HEALTH)	Healthy children (HEALTHYCHI)	Vote maximization (VOTE)	the feeling of being sated (SATED)	minimization of expenditure on health promotion (CPOSTMIN)	the simplicity of food preparation (SIMPLE)
Government	1	3	4	4	3	3	0
Local authorities	2	1	4	4	3	4	0
Parents	4	3	4	0	2	3	0
Child	4	1	4	0	2	0	0
Catering service managers	3	0	0	0	2	4	4
Catering service providers	3	0	0	0	2	2	4
Teachers	3	1	3	0	3	1	0

Analysis of actors’ positions and strategies

Analyzing the map of influences and dependencies between actors (Figure 10) it can be seen that the government has a relatively favorable bargaining position because it has a relatively high level of influence and a low level of dependence. The direct socio-economic environment of children’s food consumption is the following: the triangle of teachers, local authorities and parents have roughly the same position, namely a relatively high level of influence and a low level of dependence. The two key actors of the SCS system, the children

and the catering service managers, have an extremely low level of influence, which – especially in the case of the children – is accompanied by high dependence. In other words, the two critical actors of the systems, namely the actual service providers and the children have the least possibility to influence the operation of the system.

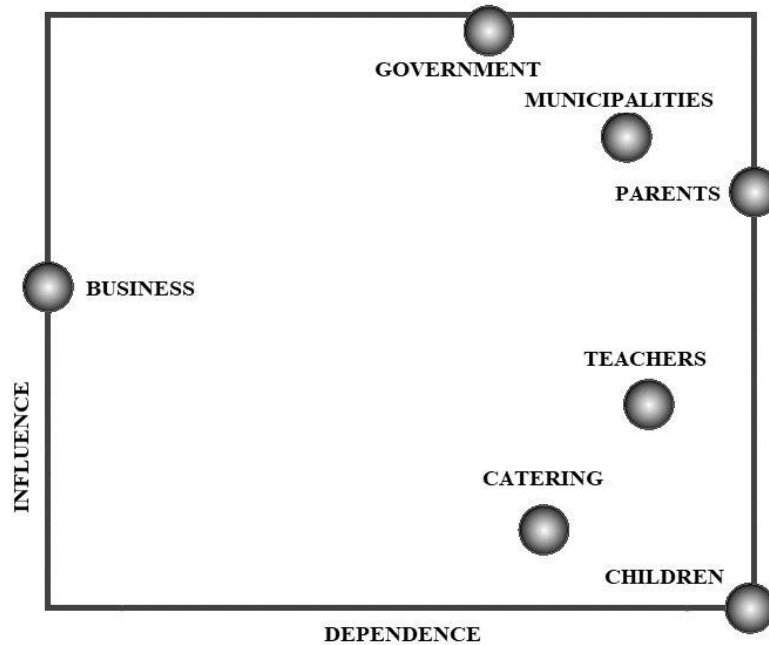


Figure 10. The influence-dependence relations of actors

In general, it can be stated that the MACTOR method has been an efficient tool to uncover the direct and indirect force relations and motivations of different actors. It is a contradiction that while all Hungarian governmental programs have highlighted the importance of prevention in the healthcare system, obesity among the young population groups has been increasing in the last few decades (Tóth et al, 2014). My results have proven the importance of a complex, holistic approach, and application of system theory. Analyzing the bargaining position of different actors my results highlight the importance of children, because they play a central role, and are capable to influence their parents and the pedagogic staff. From this follows, that there is a need to mobilize considerable resources to better understand the food consumption behavior of children.

4. RECOMMENDATIONS

Obesity will cause considerable economic losses in Hungary at a macroeconomic level, due to decreasing of the working-age population as a consequence of premature death and losses by co-morbidities of overweight and obesity. On another hand, the pharmaceutical cost of obesity will demand further material resources. Obesity should be considered as a factor of considerable importance to the performance of the national economy in Hungary. The gap between the obesity-free development trajectory and the current development path will be continuously increasing, currently, this difference is ca. 0.2%. This value is one and a half times more than the total sum of state support to sport and reconstruction and development of sport-related facilities of the Hungarian state budget for 2019. Thus, the importance of obesity prevention and intervention programs in Hungary will be gaining to prevent the development of obesity. Methods, intensity, and focus groups of these prevention and intervention programs should be determined on careful analysis of international and Hungarian experiences and in-depth mathematical optimization.

The results of our research conducted in the Roma population proved that the prevalence of overweight and obesity in the Roma population (minority ethnic group) is equal to the prevalence of overweight and obesity in the Hungarian population. The rapidly increasing number of Roma population and the prevalence of obesity is an increasing challenge of Hungarian health care systems, which highlight the importance of evidence-based prevention and intervention programs. Regarding intervention programs, only the complex obesity intervention programs, based on a comprehensive transformation of lifestyle and food consumption patterns can present perceptible outcomes primarily among the middle-aged and the elderly. The results of the research draw attention to the fact that the normalization of the nutritional status and the reduction of co-morbidities of obesity among the Roma population requires complex, race-specific intervention.

My results regarding school catering as an obesity prevention program among children have proven the importance of a complex, holistic approach, and application of system theory. It can be stated that before drawing up the regulations related to school catering, the situation of the various actors involved in the catering and their system of interests must be taken into account. Children play a central role in school catering because they can indirectly influence parents and teachers. It follows that significant resources need to be mobilized to understand children's eating behaviors and to develop interventions to change behaviors. Initiators and implementers of changes in school meals may benefit from collaborations with parents to

increase acceptance of school meals and food consumption. Developing and adopting healthy child nutrition requires a complex nutrition education program and ongoing dialogue between teachers, parents, and school nutrition professionals, and the government. The requirements of school catering standards carrying important messages to students about healthy eating and are an effective way to change the eating behavior of new generations.

5. NEW SCIENTIFIC RESULTS

1. I have proven, that – based on system dynamics modeling – it is possible to construct a more transparent, traceable, simpler, more robust, and reliable risk analysis system than the current methods, based on Markov chains and micro simulations.
2. I have been the first to quantify the long-range burden of obesity in Hungary, based on a complex system dynamic and econometric model. My results have proven, that the burden of obesity will be increasing rather rapidly in the next decades. Obesity, as a socio-economic problem decreases the economic development by 0.2% currently, and this will increase to 0.7% at the beginning of next century.
3. I have carried out an in-depth analysis to uncover the current and future situation in the case of the Roma minority in Hungary. I have proven, that currently, nearly 20% of the Roma population can be characterized as obese. The co-morbidities of obesity will be increasing from 6 thousand to 26 thousand among women and 6 to 17 thousand in the case of men. These diseases will decrease the life expectancy of men by 0.2 years, and women by 0.66 years.
4. My calculations highlight, that the short-range interventions, focussing on just one factor of obesity won't be able to decrease the rate of obesity in a significant way.
5. The targeted projects, focussing on different factors of obesity, and concentration the middle-aged and elder generations will be able to significantly decrease the burden of obesity. A complex obesity prevention program can offer a 0.42 % reduction of obesity in the case of men and a 0.35% decrease in the case of women.
6. I have carried over an in-depth analysis of attempts, aiming at the improvement of the public catering system. My results have proven the importance of a complex, holistic approach, and application of system theory. Analyzing the bargaining position of different actors my results highlight the importance of children in the school catering system, because they play a central role, and are capable to influence their parents and the pedagogic staff.
7. There is a need to mobilize considerable resources to better understand the food consumption behavior of children. The school should better integrate the parents as well as their organizations into the school food policy and catering system. This could contribute to the better acceptance of reform steps with the vision of education of new generations of consumers.

References

1. Dacin, M., Goodstein, J., & Richard Scott, W. (2002). Institutional theory and institutional change: Introduction to the special research forum. *Academy of management journal*, 45(1), 45-56.
2. Erdei, G., Kovács, V. A., Bakacs, M., & Martos, É. (2017). Országos Táplálkozás és Tápláltsági Állapot Vizsgálat 2014. I. A magyar felnőtt lakosság tápláltsági állapota. *Orvosi Hetilap*, 158(14), 533-540.
3. European Commission. (2014). Roma health report: Health status of the Roma population.
4. Godet, M. (1991). Actors' moves and strategies: The mactor method: An air transport case study. *Futures*, 23(6), 605-622.
5. Iski, G., & Rurik, I. (2014). Becslések a túlsúly és az elhízás hazai gazdasági terheiről| The estimated economic burden of overweight and obesity in Hungary. *Orvosi Hetilap*, 155(35), 1406-1412
6. Jakab, A. E., Hidvegi, E. V., Illyes, M., Cziraki, A., & Bereczki, C. (2018). Prevalence of Overweight and Obesity in Hungarian Children and Adolescents. *Annals of Nutrition and Metabolism*, 72(4), 259-264.
7. Keating, C. (2018). The genesis of the Global Burden of Disease study. *The Lancet*, 391(10137), 2316-2317.
8. Hungarian Central Statistical Office (2011). The national census in 2011. – 9. Nemzetiségi data.
9. Lhachimi, S. K., Nusselder, W. J., Smit, H. A., Van Baal, P., Baili, P., Bennett, K., Fernández, E., Kulik, M. C., Lobstein, T., & Pomerleau, J. (2012). DYNAMO-HIA—a dynamic modeling tool for generic health impact assessments. *PloS one*, 7(5), e33317.
10. United Nations (2019). World Population Prospects. <https://population.un.org/wpp/>
11. Tóth, G., Molnár, P., & Suskovic, C. (2014). Trends in Body Mass Index in School-age children in Central-Europe. *Hum. Biol. Rev.*, 3, 167-174.
12. World Health Organization (2020). Obesity and overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
13. 37/2014. (IV. 30.) EMMI Decree on Nutritional Regulations in Public Catering

AUTHOR'S PUBLICATIONS RELATED TO THE TOPIC

Articles

1. **Kiss, A.**, Fritz, P., Lakner, Z., & Soós, S. (2020). Linking the dimensions of policy-related research on obesity: a hybrid mapping with multicluster topics and interdisciplinarity maps. *Scientometrics*, 122(1), 159-213.
2. **Kiss, A.**, Andó, R., Fritz, P., & Lakner, Z. (2020). Current and future burden of obesity at the Hungarian Roma population II. [Az elhízás jelenlegi és prognosztizált betegségterhe a magyarországi romák körében II.] *Orvosi Hetilap*, 161(27), 1137-1145.
3. **Kiss, A.**, Andó, R., Fritz, P., & Lakner, Z. (2019). [Current and future burden of obesity at the Hungarian Roma population I. Az elhízás jelenlegi és prognosztizált betegségterhe a magyarországi romák körében I.] *Orvosi Hetilap*, 160(28), 1097-1104.
4. **Kiss, A.**, Popp, J., Oláh, J., & Lakner, Z. (2019). The reform of school catering in Hungary: Anatomy of a health-education attempt. *Nutrients*, 11(4), 716.

Conference- presentations

1. **Kiss, A.**, Lakner, Z. (2018). Application of system dynamics for determination of burden, costs, and efficiency of prevention programs, presented at 12th International European Forum on System Dynamics and Innovation in Food Networks, Innsbruck-Igls, 2018. Austria.
2. Ignits, D., Lakner, Z., **Kiss, A.** (2017). Csoportos intervención alapuló primer prevenciós program óvodáskorú gyermekek körében. A Magyar Elhízástudományi Társaság XXV. Jubileumi Kongresszusa, Budapest, 2017. Magyarország.