ANALYSIS OF OBESITY MODELLING

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ABSTRACT

Obesity has become very frequent. It increases the risk for developing diabetes type 2, hyperlipidemia and hypertension, and among other also several cardio-vascular diseases. This was the reason it was recognized by World Health Organization as a chronic disease. This means that it should be treated and if possible prevented. Regarding mentioned facts it is not surprising that economic and social burden of this preventable problem is tremendous. In the paper some of recent publications describing modelling results of mentioned problems are analyzed to identify the explanatory power of problem interpretations and the efficacy of proposed control strategies at the level of an individual patient and at the population level. For this also proposed healing strategies and their efficacy were studied. Very promising solution is proposed for closed-loop treatment control of individual integrative treatment. The complexity of problem reduction at the population level asks for further research.

Keywords: overweight, obesity, mathematical modelling, simulation

1. INTRODUCTION

Overweight and obesity have reached pandemic levels. As a consequence it has become clear that excessive fat accumulation may impair health. This was a reason why has World Health Organization (WHO) in 1997 declared obesity being a disease (WHO 2000). This means that such patient's condition needs to be treated and if possible, prevented. Once considered a problem only in high-income countries (North America, Europe), overweight and obesity are now dramatically on the rise also in low- and middle-income countries, particularly in urban settings (WHO 2013, 2014).

WHO uses the gradation of obesity regarding the so called body mass index (BMI) which is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2) (WHO 1995). It provides very useful population-level measure of overweight (25<BMI<30) and obesity (BMI>30) as it is the same for both sexes and for all ages of adults. However, it should be considered as a rough guide because it may not correspond to the same degree of fatness in different individuals. This information is frequently complemented with a waist circumference as it is also in correlation with the accumulation of visceral adipose tissue (VAT) which has additional negative influence to patients' health. Visceral fat is a strong predictor of insulin resistance in obese subjects, but not in normal weight individuals. Unlike subcutaneous fat, increased visceral fat is associated with increased hepatic glucose production and reduced glucose disposal (Carroll et al. 2008). Health is more threatened in the case of higher BMI and if fat accumulation is long lasting. In Slovenia (being an everage country of EU regarding obesity prevalence) for example, arround 55% of population has BMI greater than 25 (Atanasijević-Kunc and Drinovec 2011a).

Increased BMI represents an enlarged risk for developing numerous diseases. First we have to mention diabetes type 2 (D2). This chronic disease has also reached epidemic extensions. Statistical data proves (Atanasijević-Kunc and Drinovec 2011b) that over 85% of D2 patients are also overweight or obese. WHO forecasts that in the next decade the number of people with D2 is going to increase for 50% (WHO 2014). Chronic diseases which are very frequent among obese people are also hyperlipidemia and hypertension.

Obesity increases also the development of cardio-vascular diseases (CVD) (mainly heart disease and stroke). If at the same time patient has also D2, increased cholesterol and increased blood pressure, health is threatened even more as the influences of these diseases are synergistic (Scott et al. 2004). CVD were the leading cause of death in 2012 (WHO 2014).

Among the consequences it is necessary to mention also musculoskeletal disorders, especially osteoarthritis and some cancers (endometrial, breast, and colon) in addition to psychological and social problems.

Pandemic extensions of overweight and obesity which call for corresponding treatment, numerous consequences in the form of chronic diseases and serious health complications which introduce addition expenses show that this situation does not represent a stress only for an individual patient but is also social and economic burden for a wider community which cannot be neglected.

Modelling and simulation have proven to be very useful in analysis, explanation, and prediction also in the field of medicine, pharmacy, and other bio-processes, where the problems connected with obesity are no exception (Atanasijević-Kunc et al. 2008a, Levy et al. 2011). In this sense the following questions are important:

1. How processes connected with obesity development are modelled and what is the informative level of the existing models?
2. What modelling approaches and what sorts of models are used frequently?
3. Can models help in a quantitative prediction of economic burden of overweight and obesity regarding certain community, wider region, country or even a group of countries, like for example European Union?
4. How such problems can be interpreted from the viewpoint of insurance companies, hospitals, but also individual patients and their medical doctors?
5. Can mathematical models help in the explanation what can be done and how these problems can be decreased? Is in solving such problems important to take into account only individual patient, or is more efficient to address a wider community, or perhaps corresponding combination would be the best approach?
6. Is it possible to include also control or regulation principles to improve explanation models' level and the level of problem solving?
7. Can modelling results explain why obesity treatment is so insufficient or is efficient so rarely?

Presented questions have on one side motivated the present work and have on the other also helped in development the criterions which can be used in models' classification and in formulation of some problems which are not solved or are not solved satisfactory. In models' analysis which is presented in the paper the following aspects and criterions are taken into account:

1. Models' message(s)
2. Model classification (static, dynamic, continuous, discrete, hybrid, linear, nonlinear, ...)
3. Model complexity (description specter is very wide, from simple to very complex, which cannot be described in such a way that the reader can repeat the presented experiments, or information is hided because of economic aspects)
4. The level of description or granulation level (mentioned problems can be addressed at the epidemiological level where larger population is observed, but then again the obesity can be presented at the level of individual person or even at the level of some important chemical processes)
5. Are psychological aspects also taken into account?
6. Are addressed also social and/or economic burdens?
7. Are control or regulation mechanisms which influence the disease development and treatment, taken into account (such weakened or even damaged mechanisms are usually important in disease development but are not always described or taken into account through modelling description)?
8. Multi-model problem description and combination of obesity models with the models of other related processes
9. Data analysis on the basis of which the model was developed and their reliability (always important, but not always correspondingly presented).

The paper is organized in the following way. When searching for the solution of this immense trouble it is first important to understand the problem at the level of an individual patient. Some of the crucial modelling results important for understanding dynamic system properties are addressed in the first part of the next section. But for problem reduction it is of crucial importance to take into account also psychological analysis of patient's capabilities, as the efficacy of long-term body mass reduction programs is otherwise incredibility miserable.

In the third section models are first analyzed at the epidemic level due to the fact that obesity was recognized to be a disease when it has reached serious extensions. Such "distant" problem observation can indicate also correlations with other chronic diseases, social processes, and life styles which were rare in the previous centuries. In addition it is shown that epidemic models can be combined with the population models uncovering other processes among which populations' aging is very important. Part of this section is devoted also to the investigation of connections of different-level or multi-model problem descriptions.

In the fourth section the observation is extended to include some of economic, social and health care consequences.

Finally, in the conclusion identified answers to posed questions are summarized and some ideas for future investigations are described.

2. MODELS AT PATIENT'S LEVEL

Biological systems are in general very complex multivariable processes influenced by specific properties of individuals and/or random environmental influences. In such situations *evidence based observations* and *statistical descriptions* are typical starting tools for ordering the information which is at the same time also a basic goal of modelling. Consequently not only the disease descriptions but also the problem interpretations can be adapted through time as realized by (Chang and Christakis 2002). They have observed that through the 20^{th} century obesity shifted in ontological status from being the product of something that individuals *do* to something that they *experience*.

Problem observation through the usage of statistical tools indicated also several important connections among the variables which influence the development of overweight and obese person. Important variables are for example age, body mass, BMI, sex (Jackson et al. 2002), but also environmental or/and social networks

(Christakis and Fowler 2007, El-Sayed et al. 2012, Bruzzone et al. 2012).

2.1. Energy equilibrium

When searching for the main reasons of overweight and obesity and for the main solutions of these problems we have to start with the observation of an individual person as all problems actually start at this level. The relations between eating and drinking or energy intake, physical activity or energy expenditure and weight change have been studied and published extensively (Westerterp et al. 1995, Hall 2006, Chow and Hall 2008, Thomas et al. 2009, Hall 2010a, Hall 2010b, Hall et al. 2011, Hall et al. 2013). Through the last decade one of the most active research group in the field is the one of dr. Kevin Hall from National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, Maryland. They are developing mathematical models of very different complexity describing the problem, but one which should be mentioned explicitly (Hall et al. 2011) is the three compartment continuous nonlinear model consisting of fat mass (fm), lean mass (lm) and extracellular fluid compartments (ecf), each demanding for description first order ordinary differential equation. Inputs to the model are energy intake in the form of carbohydrate, fat, protein intake, the change in sodium, and energy expenditure which is the result of physical activity, thermic effect of feeding and resting metabolic rate (the energy needed to maintain the basic physiological processes). Model parameters are evaluated regarding statistical estimations depending on age and sex of observed person, while initial conditions are for each compartment evaluated from the average regression equations for men and women using the information of body mass, BMI and sex (Jackson et al. 2002). Block diagram of this model is illustrated in Fig. 1.

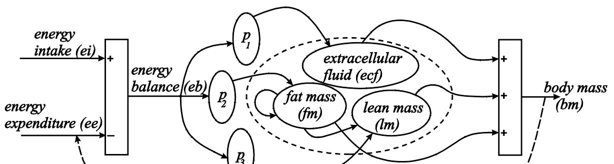

Figure 1: Schematic representation of the three-compartment dynamic model describing body mass changes in an individual person

Basic information of this model is very clear. If energy balance is negative body mass is expected to decrease (genetic and individual properties are not crucial regarding the main system dynamics). To help people understand this better, the authors realized an interactive version of the model available through internet (Hall et al. 2011). The goal is to show that body mass changing is rather slow process and the patient has to persist for longer time to reach new steady state after life style is changed. If energy balance is increased also body mass is going to react correspondingly.

In spite of the fact that basic information is very clear and simple it usually does not work in practice, even in the cases when people are not pleased with their appearance and are at the same time also informed of potential negative risks of obesity. In (Mokdad et al. 2001) it is reported that among the US adults participating in programs for losing or maintaining weight, only 17.5% were following the recommended guidelines for reducing calories and increasing physical activity. As duration of such programs is limited it can be expected that long term efficacy of body mass reduction is essentially worse.

Additional problem, which have to be mentioned and asks for further extensions of presented model (and will be described in the next subsection), is the observation that even after successful dieting process people often regain their body mass which is frequently even higher as before the starvation. It was recognized that repeated starvation episodes influence resting metabolic rate (Astrup, et al. 1999.). This means that described model (see Fig. 1) should be used also in wider time ranges with which it is important to take into account also parameters' time-varying properties (they change with patient's age, body mass) and patient's history which additionally influence metabolic rate.

As mentioned in the Introduction the information of BMI is not the only one when obese patient is examined. An important parameter is also waist circumference (which should be 80cm or less in women and 94cm or less in men (Lean et al. 1995)) because it is also in strong correlation with the accumulation of visceral adipose tissue (VAT) which has additional negative influence to patients' health (Carroll et al. 2008). From this an important question arises: Which factors are contributing to the relative change of visceral versus subcutaneous abdominal fat (SAT) during weight loss? In (Chaston and Dixon 2008) it was reported that there is no convincing evidence that any investigated weight loss intervention selectively targets the reduction of VAT to a greater extent than another. This problem was investigated also by (Hall and Hallgreen 2008). Very interesting result, which can be used to extend the presented model in Fig. 1 to four-compartment model (fm-compartment can split into VAT and SAT compartments), is that changes of VAT mass are allometrically related to changes of total body fat mass (fm) during weight loss, regardless of gender or weight loss intervention and can be described as:

$$\frac{dVAT}{VAT} = k\frac{dfm}{fm} \tag{1}$$

where k=1.3 +- 0.1. Greater weight loss will cause a greater absolute reduction of VAT mass and may thereby result in improved metabolic health. This observation is very important from two additional viewpoints:

- patients should be evaluated as rather successful even if their weight loss is relatively low (this problem will be addressed later again),
- increased VAT in obese patients represents an additional health problem if this condition results in fatty liver (Phillips and Barton 2014) which can be detected for example by the ultra-sound examination.

We have investigated this problem in obese and extreme obese patients but the allometric connection of fatty liver phenomenon with other allometric parameters is still under investigation.

2.2. Psychological influences to problem solution

As indicated in the previous subsection obese people would like to decrease their body mass but are very rarely successful. In general they are not capable to change their life style which is necessary for efficient, long-term and with this also for healthy body mass reduction. Taking into account also psychological processes is therefore of crucial importance for problem reduction at the level of an individual patient.

In very interesting work of (Navarro-Barrientos el al. 2011) it is suggested to extend energy balance description with the behavioral model as schematically presented in Fig. 2. It is developed regarding the extension of the theory of planned behavior (Ajzen and Madden 1986) to dynamic description.

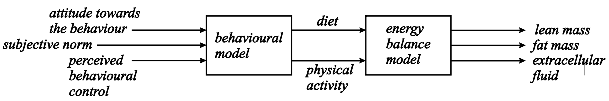

Figure 2: Block diagram of behavioural influence to body mass dynamics as proposed by (Navarro-Barrientos el al. 2011)

For this purpose they have proposed a fluid analogy which mimics the concepts of inventory management in supply chains. The proposed result consists of five reservoirs, where the level of final one – the so called *behavior* is influenced by the *intention* and *PBC* (*perceived behavioral control*), while the *intention* depends on the level of *attitude*, *subjective norm* and *PBC* too. Input variables to these fluid reservoirs are three exogenous variables (strength of beliefs about the outcome x evaluation of the outcome it entering *attitude* reservoir, strength of normative beliefs x motivation to comply is input signal to *subjective norm*, strength of control belief x perceived power of the control factor is input signal to *PBC*) and five endogenous variables, one for each tank representing disturbances. The proposed fifth order dynamic behavioral structure can influence the dieting program as well as physical activity and enable different control strategies.

In (Dong et al. 2013) described structure is extended to closed-loop operation where authors proposed hybrid model predictive control to decrease excessive gestational weight gain.

Different modelling result of dynamic behavioral model as well as precisely defined closed-loop adaptive control approach is described in (Sentočnik et al. 2013) and is schematically presented in Fig. 3. It is suitable for all patients with self-control difficulties. Authors have defined controllability of the patient as one of the crucial properties for the successful integrative patient's treatment. It can be achieved by regular patient's examination by a team of experts. The advantage is simpler and objective estimation of patient's motivation to follow the prescribed behavioral pattern. Patient's efficacy can be evaluated only from body mass changes through treatment period in spite of the fact that also psychological part of treatment, dieting, and physical activity are very important. Medical expert must be capable to adapt treatment to patient's abilities of life style changes so that patient feels he/she is relatively successful. Such satisfaction in general motivates patient to endure in treatment. Proposed approach is very successful and has recently essentially decreased a drop out which is now less than 10%.

Mentioned modelling results also incorporate situations where due to treatment interruptions and as a consequence uncontrollability patient regain the body mass.

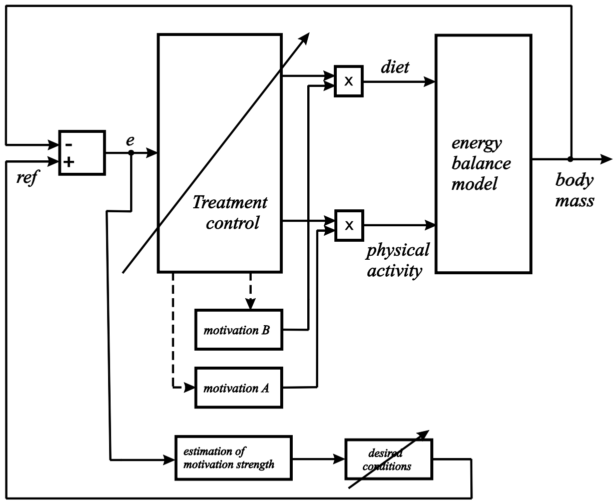

Figure 3: Block diagram of adaptive closed-loop patient control (Sentočnik et al. 2013)

2.3. Other modelling results

A huge number of other results have been published which are important for obesity problem understanding at the level of an individual patient, but cannot be mentioned here due to paper limitation space. We would like to add only two representatives dealing with an important patient state, namely *metabolic syndrome* (MS) which refers to a clustering of specific cardiovascular disease (CVD) risk factors influencing the insulin resistance. The risk factors include obesity, insulin resistance, dyslipidemia, and hypertension and it is known to increase the risk for CVD and D2. MS helps to identify individuals at high risk for both D2 and CVD. Results presented by (Jeong et al. 2014) show that the proposed model can quantify the risk of MS (regarding fasting glucose, waist circumference, HDL-cholesterol, triglycerides and blood pressure) and effectively identify a group of subjects who might be classified into a potential risk group for having MS in the future by the usage of the so called radar charts.

Very interesting contribution on MS is presented in (Angelova 2013) where laboratory animals are used in experimental modelling approach and results statistical evaluation. The advantage of the *animal models* is the opportunity of precise control of diet and motor activity and the opportunity to carry out histological studies of MS, which are difficult to perform in humans.

3. EPIDEMICS MODELLING

For centuries, communicable diseases were the main causes of death around the world. Life expectancy was often limited by uncontrolled epidemics. As a consequence first *epidemic models* have become an important tool for a simplified description of transmission of communicable or infectious diseases through individuals. Epidemic mathematical models of communicable diseases can be divided into *top-down approaches* (Zauner et al. 2012, Miksch 2012) which describe aggregated groups of people or/and patients and are in general simplistic problem descriptions. Typical and often used representatives of this group are different statistical descriptions (among which Markov models are frequently used) and (nonlinear) ordinary differential equations which are organized into the so called *compartment models* (they are actually nonlinear state-space descriptions) which consist of two or more compartments. For example, *SIS-models* consist of those who are susceptible - *S(t)* to the disease and those who have been infected - *I(t)* with the disease and are capable of spreading the disease to those in the susceptible category. In *SIR* and *SIRS-models* additional compartment *R(t)* is used for those individuals who have been infected and then removed from the disease, either due to (temporal) immunization or due to death. Those in this category are not able to transmit the infection to others. The *SEIS-model* takes into consideration the exposed or latent period of the disease, giving an additional compartment, *E(t)*. There are several diseases where an individual is born with a passive immunity from its mother and in such cases compartment *M(t)* is added into model description (*MSIR* or *MSEIR-models*) (Anderson and May 1991).

In contrast to *top-down approaches bottom-up models* describe single individual elements with certain properties in observed environment and from their interactions and evolving processes overall system emerges which is usually of interest. Typical representative from this group are agent-based models (Šalamon, 2011) and sometimes also cellular automata are used.

3.1. Obesity epidemic modelling

With medical research achievements in terms of vaccination, antibiotics and improvement of life conditions, non-communicable diseases (NCDs) started causing major problems in industrialized countries. One of the main reasons, contributing to such situation, is of course obesity. This epidemic was started by the overproduction of food in the United States (Dreifus, 2012). The underlying biological, psychological, and social mechanisms of obesity epidemics have fascinated a broad range of scientific audience.

Here two important questions arise. Is obesity, (partly at least) contagious or not? Is it possible to extend the usage of models describing epidemics of infectious diseases to NCDs? What kinds of adaptations are needed, if any?

As already mentioned, several authors have reported that social networks can represent the possibility of spreading social epidemics (El-Sayed et al. 2012). In (Christakis and Fowler 2007), for example, correlation among social ties and obesity is investigated. It was concluded (on the base of longitudinal statistical study) that a person's chance of becoming obese is increased if he or she has a friend or sibling who has become obese. These effects were not observed among neighbors. Cohen-Cole and Fletcher 2008, on the other hand, presented several doubts of these conclusions. They have realized that presented results may have difficulties in distinguishing social network effects from environmental confounds of weight gain. Though they advise caution in interpreting the available evidence of a social contagion in weight. It is therefore obvious that the variables that may influence increase of body weight in an individual are very problematic to be identified exactly. Sometimes even the main influences to a group of persons is unclear.

Regarding mentioned doubts recently a very interesting paper was published by (Ejima et al. 2013) indicating that a scientific approach to comparatively assessing the control programs has still to be considered. The authors are proposing two forms of *SIR*-models and so answering one of the posed question with *yes*. They have first used the classical form of *SIR-model*, where independent variable is time. Then this form was transformed so that they are observing the spread of this disease regarding patients' age, which enables to present how this chronic disease is developing through life-time. In addition they have taken into account the fact that obesity is caused by both non-contagious as well as by contagious paths. Authors proposed to include into the group *S(t)* all susceptible, in this case they are never-obese, in the group *I(t)* infected, which mean obese, and *R(t)* are recovered or ex-obese. Model parameters were evaluated observing available epidemiological data. As the most important practical finding, they have identified that the optimal choice of intervention programs considerably varies with the so-called transmission coefficient (model parameter) of obesity, β. When β is small, the transmission cannot be maintained by social contagion alone and their model suggests that preventing weight gain among never-obese individuals would be the most effective option. This seems to be expected result as prevention is usually the best solution also from a viewpoint of life quality and economics. When transmission coefficient is large enough to sustain the transmission of obesity through the social path, dietary restriction among obese individuals could potentially be the most effective. Here it is important to point out that in most cases for effective body mass reduction in obese patients specialized integrative treatment is necessary (Sentočnik et al. 2013). But it is very important to accent, that despite the dependence of optimal interventions on β, it should be noted that the transmission potential of obesity in community setting has yet to be explicitly estimated. From Ejima et al. 2013 it is also not explicitly clear how corresponding control actions should be designed.

Problem observation regarding patients' age was proposed also in (Atanasijević-Kunc et al. 2012) where model-combination was developed taking into account also population dynamics and optimal healing dynamics at the individual level. These results, being a mixture of *top-down and bottom-up models* illustrate the effect of population aging which is observed in European countries with which also the relative burden of NCDs is becoming even more unpleasant.

Multi-model or modular problem observation is proposed also in (Glock et al. 2012). In this case three-layer structure is developed starting with a population model, at the second level disease is taken into account which is finally overlaid by economics evaluation. Used modelling approach is System Dynamics and modelling result is therefore in a form of ordinary differential equations.

As realized in (El-Sayed et al. 2012) through past decade the interest is growing in systems approaches of epidemiologic research where social networks analysis and agent-based models (ABMs) are two approaches that seems to be very promising regarding the epidemiologic literature. This methodology was reported also in (Ramirez-Nafarrate and Gutierrez-Garcia 2013) and (Bruzzone et al. 2012) for simulation of obesity epidemic.

Ramirez-Nafarrate and Gutierrez-Garcia observed the prevalence of child obesity. Each agent (child) was characterized with eight parameters (age, gender, weight, height, BMI, weight status category (underweight, healthy weight, overweight, obese), caloric intake, and energy expenditure) while very simplified equation for energy balance was used at each computational cycle. Simulation results suggest that the fraction of overweight and obese children at the end of elementary school can be reduced by moderate physical activity.

The approach of Bruzzone et al. 2012 bases on a very complex modelling result regarding adult population where used data origin from two very different environments, USA and Italy. The authors analyzed the influence of different cultural and social conditions on modelling results. They have taken into account age, gender, social and employment status, education, ethnicity, religion, marital status, and numerous other parameters. Several statistical data evaluations proved (which is in agreement with previously mentioned publications) that it is difficult to estimate in quantitative manner relative influence of each parameter to increased body mass. Developed intelligent agent-based simulator named BACCUS (which is stochastic discrete event simulator) enables to generate a social network including family relationships, friendships, and working relationships. Relative advantage of such modelling result is of course the possibility to extend it to include large scale health care interventions However, modelling presumptions which have been taken into account (for example: children, having an obese parent increases the risk of obesity by 30%; not-married, being single increases the risk of obesity, obese people tend to have obese friends, …) need to be reevaluated and confirmed also by further investigations.

4. ECONOMICS, HEALTHCARE SYSTEMS AND POLICYS

From pandemic extensions of overweight and obesity it is clear that the burden of this chronic disease and detected consequences (social and economic) is enormous and exact evaluation is in reality not possible. Only estimations are available.

Taking into account prevalence of obesity and population distribution in Slovenia and Austria, for example, it can be expected that in average in similar EU countries over € 300 million is needed each year due to obesity in the population of one million people (Atanasijević-Kunc et al. 2012). Similar result was evaluated by (Keaver et al. 2013) regarding the situation in Republic of Ireland where this number was estimated to be in 2009 over € 250 million. With forecasted increasing prevalence of this chronic disease (Ejima et al. 2013, Keaver et al. 2013) the burden is expected to grow at least proportionally.

As pointed out in several mentioned publications the greatest potential lies in prevention. Due to indicated problem complexity no simple solution is available. Behavioral changes cannot be sustained if important drivers of behavior are not considered in correct manner. Therefore a systems-oriented, multilevel framework has to be taken into account as is described for example in (Huang et al. 2009). Most concerning is the situation presented with block-diagram in Fig. 4 illustrating (in simplified manner – for detailed description see (Huang et al. 2009)) the local and global influences to obesity prevalence.

It is clear that no general intervention policy nor mathematical modelling result can be complex enough to resolve this immense trouble. As indicated in (Huang et al. 2009) individual behavior, regarding eating and physical activity are influenced by socio-environmental factors and by powerful biological processes. Behavior change cannot be sustained if these drivers of behavior are not considered in appropriate manner. The solutions need interdisciplinary consideration where mathematical and simulation results can help in evaluation hypotheses addressing part of the whole problem.

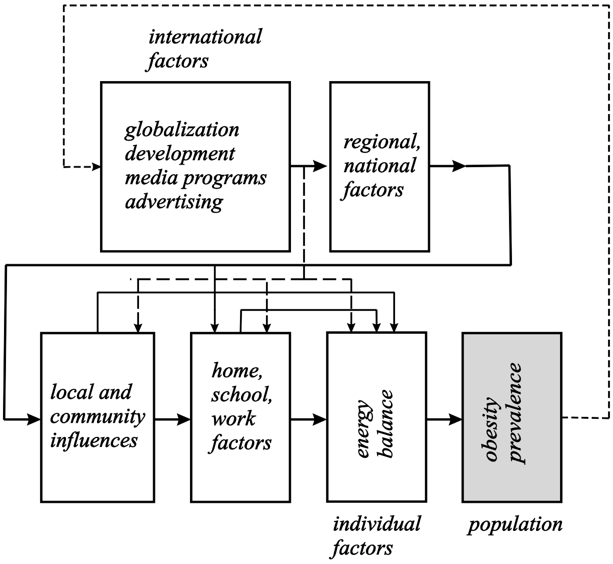

Figure 4: Influences to prevalence of obesity

Similar structure is addressed in (Van Koperen et al. 2013). Authors are describing in qualitative way the logic model used for implementation of strategies to prevent childhood obesity.

Childhood obesity prevention is, as already mentioned, addressed also in (Ramirez-Nafarrate and Gutierrez-Garcia 2013) using agent-based modelling approach advising to increase activity.

When investigating efficient healing and prevention programs an interesting result presented in (Preston et al. 2013) have to be mentioned. Described modelling results suggest that obesity in early adulthood is an important risk factor for mortality above age 50 and therefore an increased attention should be devoted on reducing the incidence of obesity at young adult ages.

5. CONCLUSIONS

In the paper we have analyzed some of recently published works addressing modelling results of obesity and related processes and problems. Main findings are the following:

At the level of an individual (person/patient) energy balance influence is well understood and efficiently described by ordinary differential equations.

Obese patients are rather unsuccessful in long-term body mass reduction due to psychological disturbances which are the result of very complex processes and individual descriptions are to be identified.

In spite of the fact that the nature of mentioned disturbances is complex, very good closed-loop control results can be expected if patient controllability is achieved. For this the integrative treatment must be adapted to patients' capabilities regarding the life style transformation and with this it is expected that the patient increases the treatment time to needed duration.

At the population level several modelling structures developed for contagious diseases were extended to the cases of non-communicable diseases, including obesity. Compartment models indicate that obesity prevention is eventually the most promising solution.

Due to computer technology development also discrete event and agent-based simulation results are very promising.

At the population level general closed-loop approaches are at the moment not possible because of problem complexity as all social, economic and political environment in addition to personal characteristic can influence the prevalence and incidence of disease development. So systematic problem solving asks for interdisciplinary approaches where partial modelling results should contribute to decrease of this preventable burden.

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