A MICROSIMULATION MODEL: DO OBESE ADOLESCENCE GROW INTO OBESE ADULTS?

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ABSTRACT

Childhood obesity is an important public health problem in the US. According to CDC, in year 2017-2018, about 21% of adolescence aged 12-19 were obese. Reports show that children's obesity is associated with various metabolic complications. Moreover, it has been shown that obese children have a higher chance for growing into obese adults. In this paper we modeled the dynamics of body weight of adolescence (age 10 to 19) as a stochastic Markov model and used microsimulation to quantify the chance of transition to obese adults for children who are in various BMI status (normal weight, overweight, obese) as they grow old, starting at age 10.

INRODUCTION

Childhood obesity is an important public health issue and has reached an epidemic level in the US. The prevalence of childhood obesity has tripled in the US over the past three decades [1]. According to a report by Center for Disease Control and Prevention (CDC) in 2017-2018, about 19% of children and adolescence aged 2-19 and about 21% of adolescence aged 12-19 were obese [1]. Obesity is one of the main risk factors for metabolic complications and hypertension in children and adolescents [3]. There are various reports in the literature that excess body fat increases the chance of various forms of cancers (e.g., breast cancer, colon cancer, kidney cancer, and pancreatic cancers) [4]. Moreover, it has been shown that obese children have a higher chance for growing into obese adults in North America and Europe [5] and are more likely to suffer from cardiovascular and digestive diseases [6]. As reported by Ahmad et al, about 80% of obese adolescents aged 10 to 14 years are at high risk for becoming obese adults [7]. In this paper we quantify the possibility of overweight as well as obese adolescence becoming obese or overweight adults for various ages. To do so, we develop a computational simulation model that characterizes the progression of weight status of adolescence across three body mass index categories (namely, normal weight, overweight, and obese) during their adolescence years (age 10-19). The result of our study makes it possible to estimate the lifetime health and economic consequences associated with prevalence of obesity and overweight during the lifetime of individuals, from childhood, to adolescence, to adulthood.

METHODLOGY

Using TreeAge Pro 2016 (TreeAge Software Inc., Williamstown, Massachusetts, USA), we modeled dynamics of body mass index (BMI) of adolescence (age 10-19) as a stochastic system (Markov Model) that randomly changes among various BMI status (normal weight ($18{\cdot}5 \leq$ BMI < 25), overweight ($25 \leq$ BMI < 30), and obese ($30 \leq$ BMI)) in each year as children grow old. We let children enter the model at age 10 with an initial BMI status. With passing of each one-year time step, everyone will have probabilities of staying in the same BMI state or transitioning to

another BMI state or death. Death is an absorptive state which means once individuals move into this state they leave the model. This will continue till adolescence reach age 20. That is when simulation stops and weight status of individual at the start of age 20 is recorded. The state transition probabilities for adolescents were obtained from the National Longitudinal Survey of Youth (NLSY) [8] and from Coronary Artery Disease Risk Development in Young Adults (CARDIA) [9]. We ran two different scenarios. In the first scenario, we assumed all individuals that enter the model are 10-year-old and obese. In the second scenario, we assumed all individuals that enter the model are 10-year-old and overweight. For each scenario, we defined a simulation experiment in which we sent 1,000 adolescents through the model and then we repeated this experiment 100 times (total of 100,000 trials). Due to stochastic nature of BMI change, each individual in an experiment can have a different BMI trajectory going from age 10 to 19. When individuals reach age 19, the model reports their BMI status at age 19. Thus, we can see what percentage of individuals who started as obese (overweigh) 10-year-old are still obese (overweight) at age 19 as they have gone through their adolescence years. We also changed the initial age of individuals in the simulation model from 10 to 14 and 16 and ran similar scenarios. The simulation results are reported below.

RESULTS AND DISCUSSION

Our preliminary results showed that for 10-yearl-old obese children, about 41% of them stayed obese at age19, about 32 percent of them become overweight and about 27% of them became normal weight. However, for 14-yearl-old obese children, about 66% of them stayed obese at age19, about 25% of them become overweight at age 19, and about 9% of them became normal weight. Moreover, among 16-yearl-old obese children, about 79% of them stayed obese at age19, about 16% of them become overweight at age 19, and about 5% of them became normal weight. As we can see the chance of moving from obese BMI state to normal weight or overweight BMI states decreases as adolescent age increases.

Running the simulation for 10-yearl-old overweight children showed that about 34 percent of them stayed overweight at age19, about 33 percent of them became obese at age19, and about 33% of them became normal weight at age19. However, for 14-yearl-old overweight children, about 34% stayed overweight, about 46% of them became obese, and about 20% of them became normal weight at age 19. Lastly, for 16-yearl-old overweight children, about 37% stayed overweight, about 49% of them became obese, and about 14% of them became normal weight at age 19. Our results show that as overweight adolescent individuals age, they have a higher chance of becoming obese or stay as overweight at age 19.

Lastly, our results also showed that for 10-yearl-old normal weight children, about 36 percent have normal weight at age 19, about 27% became obese at age 19, about 37% of them became overweight at age 19. However, for 14-yearl-old normal weight children, about 35 percent have normal weight at age 19, about 24% became obese at age 19, about 41% of them became overweight at age 19. Moreover, for 16-yearl-old normal weight children, about 34 percent have normal weight at age 19, about 19% became obese at age 19, about 47% of them became overweight at age 19. As discussed, for normal weight children, irrespective of their age, about 35% of them stay as normal weight. However, the percentage of them that become overweight increased from 37% to 47% as they aged.

Our results highlight the importance of introducing health policy interventions earlier in adolescence years, since obese (overweight) adolescence at higher age have a higher chance of becoming obese (overweigh) adults. Similar to other modeling and simulation studies, this study has its own limitations. First, if our data would allow, we would have preferred to put individuals in four BMI categories (normal weight, overweight, obese, and severely obese) to more precisely captures their body weight dynamics. But we thought we may not have enough datapoints in each BMI category. Second, using BMI as a metric for identifying weight status of individuals may lead to underestimation or overestimation of the weight of individuals. As the next step of this study, we plan to calculate probability transition matrix associated with different BMI categories for adults, using the relevant datasets and, consequently, project the body weight dynamics of individuals through their childhood and adulthood.

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