The Effects of Government Funded Obesity Prevention Projects on BMI Change

MSc thesis

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Abstract

This study examines the effect of National Institutes of Health (NIH) funded obesity prevention projects on county body mass index (BMI) change, whilst also quantifying the proportion of effective projects in attaining weight loss or weight maintenance (ΔBMI≤0). NIH obesity prevention projects were matched to county BMI data from the Centre of Disease Control (CDC) Behavioural Risk Factor Surveillance System (BRFSS), by means of the cohorts' geographic origin. The effect of 76 projects on county BMI change between 2002-2012 were analysed using a multivariate regression model. Independent variables consisted of different prevention strategies, participant demographics and project specific aspects. BMI increased on average with 0.31% per year in counties were an obesity prevention project was conducted, whereas the average county BMI increased with 0.47% per year from 2002-2012. The proportion of prevention projects that can be related to our measure of effectiveness (ΔBMI ≤ 0) at baseline, 1 year and 3 year after completion are 24.1%, 20.3% and 11.1% respectively. On average projects received a total funding of 1.65 million USD, with an average of 0.55 million USD per year. Significant effects on county BMI change were found for projects conducted through a social meaningful setting (-0.69%), total project time span (+0.44% per year) and the ratio between project cohort size and county population (-0.03% per percentage of cohorts county).

Introduction

The worldwide average of overweight and obese adults aged over 20 in 2008 has reached 35 and 11% respectively (WHO, 2013), as measured via the average number of adult individuals whose body mass index (BMI) exceeds certain thresholds. BMI is calculated according to formula 1, dividing a persons' weight in kilograms by their squared height in meters.

$$Body\ Mass\ Index\ (kg/m^2) = \frac{Weight\ (kg)}{(Height\ (m))^2} \qquad (1)$$

According to the World Health Organization (WHO) a normal BMI ranges between 20-25 kg/m^2, whereas overweight and obesity can be classified by the ranges of 25-30 kg/m^2 and >30 kg/m^2 respectively (WHO, 2013). Increase in BMI is the outcome of a positive energy balance, i.e. consuming more food in relation to calories burned by physical activity (Caballero, 2007). There exists a substantial body of evidence in which obesity and overweight are positively correlated with adverse health effects such as cardiovascular diseases, cancers, diabetes type II and musculoskeletal disorders (A. P. C. S. Collaboration, 2004; P. S. Collaboration, 2009; Ezzati, Lopez, Rodgers, Vander Hoorn, & Murray, 2002; Mathers, Stevens, & Mascarenhas, 2009). The 2012 prevalence of adult obesity in the United States of America has reached more than one third (34.9%) of the adult population, whereas 69.0% can be classified as overweight (CDC, 2013; Ogden, Carroll, Kit, & Flegal, 2014). Obesity and overweight have a negative economic impact through increased healthcare cost (Von Lengerke, Reitmeir, & John, 2006; Wolfenstetter, 2012) and potential loss of national output (McCormick & Stone, 2007). Annual costs attributable to obesity and overweight in the USA are estimated at $148 billion and are projected to increase to $956 billion by 2030 if current trends continue (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008).

Obesity has become an increasing field of research due to its increasing prevalence and adverse health aspects on current society. Organizations conducting an obesity prevention project may apply for a grant from governmental institutes like the National Institutes of Health (NIH). The NIH is the largest source of funding for medical research in the world and is made up of 27 institutes and centres each with a specific research agenda. NIH funding into obesity research amounted to $836 million for the year of 2012 (NIH, 2012).
The process of applying for a grant consists of four stages in which the project is reviewed and assessed by multiple NIH councils and boards. Main review topics consist of the projects significance in addressing an important problem, suitability of the researchers, innovative approach regarding current research, overall strategy, methodologies to accomplish research aim and the contribution of the scientific environment on project success. Organizations which have received a grant need to report their results annually. The actual projects success and effectiveness is not judged by the NIH afterwards, but is only estimated on forehand by the different review groups. Project results may be generated in the form of publications, allowing the assessment of the projects success. These results however only describe the effect on the number of included participants. How the sum of governmental spending on obesity prevention projects actually influences society remains unclear. To the extent of our knowledge their does not exists any literature which describes how the effects of government funded obesity prevention projects transfer to the population of the geographic area in which the project is conducted.

The research objective of this study is to analyse the relationship between county level BMI change in the USA and government funded obesity prevention projects. The effect on county BMI change by total project funding, diverse prevention strategies, cohort sizes, age groups, project duration and other project specific aspects will be evaluated by means of a multivariate regression model. The proportion of projects relating to an effective decrease or maintenance ($\Delta BMI \leq 0$) of county BMI will be quantified at project completion, one year after project completion and three years after project completion.

Combining the government spending, the existing literature gap and negative aspects from the increasing overweight and obesity prevalence make this a relevant and up-to-date research incentive. On the academic level it provides input for the current literature gap on how obesity prevention projects affect the geographic area in which they are conducted. Results from this study provide information inputs on an academic and policy level. By analysing the effect of different preventions strategies and specific project aspects it provides information to policy makers regarding governmental funding into prevention projects, as how current conducted measures influence county BMI change. This information could be used in assessing future projects and the prediction of their effectiveness.

Literature background

Obesity epidemic

The increased prevalence of obesity and overweight among populations focuses on the physiological aspect of accumulating body fat, the creation of a positive energy balance (Caballero, 2007), which can be achieved by increasing energy input through increased consumption and/or decreasing energy output through decreased physical activity. Weight loss focuses on the opposite, the creation of a negative energy balance, which can be achieved by decreasing energy input through decreased consumption and/or increased energy output by means of increased physical activity.

The increased prevalence of overweight and obesity can to a certain extent be explained by changes in the environment. The technological advancement which started in the 1980's facilitated a decreased physical activity at work (Lakdawalla & Philipson, 2002; Mankiw, Forbes, & Rosen, 2004; Philipson, 2001). Other aspects related to technology and transportation have resulted in decreased physical activity during leisure time activities i.e. electronic games, television watching and computers (Hill & Peters, 1998). Lower energy expenditure during work or leisure time can lead to overconsumption when the food intake is not lowered to meet the net balance of energy.

Food price is the second most important factor, after taste, influencing the buying behaviour in consumers (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998). Technological advancement within agriculture provided the ways for producing the constituents of calorie dense foods against lower cost prices, mainly sugars and fats (Drewnowski & Specter, 2004). Between 1985 and 2000 the prices of fruits and vegetables increased by 118%, whereas sugars and sweets only increased by 46% (Putnam, Allshouse, & Kantor, 2002).This difference in price becomes more explicit when energy content is expressed in dollars. Potato chips and soft drinks provide 1200 kcal/$ and 875 kcal/$ respectively. Whereas fresh carrots and orange juice provide 250 kcal/$ and 170 kcal/$ respectively (Drewnowski & Specter, 2004). The increased availability and relative cheaper offering of calorie dense foods stimulates its consumption. Thereby indirectly overconsumption since calorie density is regarded as one of the main influencers in daily energy intake, since people tend to consume a constant volume of food during a meal prepared at home (Rolls & Barnett, 2000).

Obesity prevalence in the United States of America shows a significant correlation with socio-economic status, therefore the burden of this epidemic falls to a great extent on the population with limited resources, racial-ethnic minorities and the poor (Drewnowski & Specter, 2004). This is reflected in the buying behaviour, whereas high income households tend to spent up to 60% more money annually per person on food (Kaufman, MacDonald, Lutz, & Smallwood, 1997). The choices made for their dietary content differs to a great extend compared to low-income households. Greater amounts of high-quality meat, fish, fruit, vegetables and convenience foods were purchased by high-income households (Kaufman et al., 1997). Disposable income is not one of the only influencers in the consumption behaviour. There seems to be a significant correlation between the incidence of obesity and level of education. As one attends more years of education the incidence of obesity decreases (Drewnowski & Specter, 2004; Font, Fabbri, & Gil, 2010). Another important factor within the environment regarding overconsumption is the increasing availability of ways to consume highly palatable and inexpensive calorie dense foods from i.e. vending machines, fast-food restaurants and similar establishments. (Hill & Peters, 1998).

Portion sizes of out-of-home meals have been increasing throughout the years (Ledikwe, Ello-Martin, & Rolls, 2005). The marginal cost pricing i.e. supersized meals at McDonalds results in an increased consumption of food not only during, but also between meals since the percentage of out-of-home has been increasing (Guthrie, Lin, & Frazao, 2002; Young & Nestle, 2002). The previously named factors have facilitated an environment that stimulates overconsumption and promotes physical inactivity. It has led to the formation of an obesogenic environment which can be defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (Lake & Townshend, 2006).

Strategies for obesity prevention projects

The build-up of an obesity prevention program is clearly described by the "Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults" (NHLBI, 1998), which is established by the National obesity Education Initiative of the

National Heart, Lung, and Blood Institute (NHLBI) in cooperation with the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). Prevention programs may apply different strategies for weight loss and maintenance. These strategies focus on dietary therapy, physical activity, behaviour therapy or combining the previously named (NHLBI, 1998). Other strategies applied are pharmacotherapy and weight loss surgery (NHLBI, 1998). The general goal of these programs is either weight loss by decreasing body weight, weight maintenance and/or preventing future weight gain (NHLBI, 1998). In dietary therapy project participants receive individually planned diets with calorie deficit guidelines between 500 to 1000 kcal/day, latter should be an integral part of the project when the focus lies on decreasing bodyweight (NHLBI, 1998). General time span for dietary therapy is on average 6 months in which an attempt is made to decrease bodyweight by approximately 10% (NHLBI, 1998). The rate of weight loss, dependent on the caloric deficit height, generally decreases after a period of six months due to a decreased energy expenditure (NHLBI, 1998). In physical activity therapy a focus lies on increased energy expenditure through exercise. Most weight loss however occurs due to the negative energy balance, hence adjusting caloric intake in relation to calories burned (NHLBI, 1998). Physical activity therapy has the benefit of reducing cardiovascular and diabetes risk relative to dietary therapy on its own. The latter makes sustaining physical activity an important factor in the prevention of regaining weight (NHLBI, 1998). Behaviour therapy strategies focus on providing the mental tools to overcome barriers that may arise in dietary therapy and increased physical activity (NHLBI, 1998). Such therapies may consist of self-monitoring of eating habits and physical activity, stimulus control, problem solving, contingency management, cognitive restructuring and social support (NHLBI, 1998). Combined therapy is made up of the three previously named strategies and is regarded as the most effective therapy of weight loss and weight maintenance (NHLBI, 1998).

Other experimental methods exist for changing people's consumption behaviour and thereby counteracting the obesity epidemic e.g. taxes on unhealthy foods, healthy food subsidizing, anti-obesity advertising, caloric information on menus, limiting volumes of sodas and healthy food advertising (Andreyeva, Chaloupka, & Brownell, 2011; Drewnowski & Darmon, 2005; N.A., P., W., & H.M., 2014). Some of these methods have indicated positive results in changing behaviour. In general only providing nutritional information on its own does not yield the desired effect on consumption behaviour (Galizzi, 2014; N.A. et al., 2014). Experiments which introduced a unhealthy food tax simultaneously with an healthy food subsidy yielded desired results of a decreased consumption for calorie dense foods (Galizzi, 2014). Currently there exists only one meta-analysis analysing the effect of 64 obesity prevention programs on their participants (Stice, Shaw, & Marti, 2006). This research showed that only 21% showed significant intervention effects with regard to weight loss. However, the majority of project participants regained the lost weight in the years after project completion, thereby showing limited long-term effects of weight maintenance (Jeffery et al., 2000).

Materials & Methods

Statistical analysis

In this study the following multivariate linear regression model is used:

$$(2) \qquad Y_i = \beta_{ij} X_{ij} + \mu$$

In this model Y describes the percentage difference in county BMI for project i. β describes the vector related to the independent variable j for project i. X describes the numeric value of independent variable j for project i. μ describes the error term, which captures all other factors that influence Y.

STATA is used to describe the dependant and independent variables with their respective means, standard deviations, median, maximal and minimal values. Subsequently optimal regression models on the basis of adjusted-R^2 are generated by means of the Wilson-leaps-and-bounds algorithm. All generated models are tested on co-linearity and heteroskedasticity by means of the multi-colinearity number and Breusch-Paegan tests.

Dependent variable

County BMI change (%) is defined as the dependent variable in this study and is calculated according to formula 3.

$$\Delta BMI\ (\%) = \frac{avgBMI_{n_{finish}} - avgBMI_{n_{start}}}{avgBMI_{n_{start}}} \times 100\% \qquad (3)$$

In which

(1) $n = year\ (2002, 2003 \ldots .2012)$

(2) $avgBMI_{n_{start}} = \frac{avg\ county\ weight\ (kg)_{n_{start-1}}}{(avg\ county\ height\ (m))^2{}_{n_{start-1}}}$

(3) $avgBMI_{n_{finish}} = \frac{avg\ county\ weight\ (kg)_{n_{finish}}}{(avg\ county\ height\ (m))^2{}_{n_{finish}}}$

Average county BMI values were gathered for start, finish, one and three years after project completion in order to check the robustness of this method. The collection of data after project completion will also provide the necessary data for the weight maintenance effect analysis.

The CDC SMART BRFSS collects data from January till December in each specific year; from this collection the average is calculated. Therefore in order to compute the most accurate starting value one year is subtracted from n_{start} i.e. a project that starts in January 2009 will have the average BMI value for 2008 as start value.In this study we define an effective BMI change by formula 4, either maintaining or decreasing the initial average county BMI.

$$\Delta BMI_{effective} \leq 0 \qquad (4)$$

We opt for this definition because prevention is defined as “the action of stopping something from happening or arising”, hence obesity prevention is aimed on stopping people from gaining body weight. Based upon the number of participants, prevention projects can be expected to have a limited reach into the specific county. It can therefore not be expected that the average county BMI will undergo a similar change as the projects cohort, since significant weight losses are needed to alter the average BMI of a large population.

Independent variables

The independent variables in this study capture aspects of obesity prevention projects which may influence the projects’ effectiveness. Up to current date there is exists no literature on the different aspects of a prevention project and how they affect specifically county BMI. We therefore use the literature on prevention projects and their cohort effect as the base of our choice for entering a variable in our model.

One of the main incentives for this study is the governmental spending on obesity prevention programs. In order to analyse how the grant relates to county BMI change the variable of *grantmln* is introduced. The NIH provides the following statement by president Barack Obama: “To maintain our edge . . . we've got to protect our rigorous peer review system and ensure that we only fund proposals that promise the biggest bang for taxpayer dollars . . . that's what's going to maintain our standards of scientific excellence for years to come." The availability of necessary funds to conduct an obesity prevention project can be regarded as an important factor in its success. Increases in funding may relate to innovative projects with higher societal impact, therefore we speculate that a higher grant would correlate to increased project effectiveness.

In order to achieve weight loss or weight maintenance projects may apply a dietary therapy or physical activity strategy, therefore we introduce the dummy variables *diet* and *PA*. Prevention projects that impose a dietary therapy strategy will get a value of 1 for *diet* and zero otherwise. Prevention projects that impose a physical activity strategy will get a value of 1 for *PA* and zero otherwise. According to literature, dietary therapy is expected to have a higher impact on the cohort relative to physical activity therapy on its own. Low calorie diets have shown to be more effective in attaining weight loss compared to physical activity on its own (NHLBI, 1998).

The manner in which prevention projects transfer information to their participants could be an important factor in facilitating a weight loss effect, since obesity prevention projects focused on only providing information in a didactic manner have shown to be ineffective in changing behaviour (Galizzi, 2014; N.A. et al., 2014). Behavioural therapy is found to be an effective strategy in facilitating weight loss. On average results of such strategies showed a 10 percent decrease in bodyweight over a period of 4 to 12 months (NHLBI, 1998). The intervention approach can be regarded as a behavioural strategy to reinforce a change in the participants’ diet and physical activity habits. Thus, we introduce the dummy variable *intv* taking a value of 1 for intervention projects and zero otherwise. We expect that projects which are intervention projects to show a greater decrease in weight loss compared to non-intervention projects.

The timespan over which a prevention project is conducted may have an effect on project success. Projects conducted over several years will spend relative more time per attendee and therefore provide more opportunity for behavioural change (Rooney & Murray, 1996; Stice & Shaw, 2004). During this period, contact between the participants and practitioners should be done on a frequent basis and in the long-term in order to optimize weight loss and weight maintenance (NHLBI, 1998). A discrepancy exists regarding these literature statements, since according to the meta-analysis done by (Stice et al., 2006) projects should focus on a maximum time span of 4 months. In order to see how the total project timespan relates to county BMI change we introduce the variable *ptime* which describes the total project duration expressed in years. The latter cannot be expressed in months due to lack of such specific information in the publications.

Participants' age may be of influence on project effectiveness since people tend to become more resistant against changes in behaviour as they age (Krosnick & Alwin, 1989). In order to see how differences in adults and non-adults relate to county BMI change we introduce the variables adult and non-adult. Prevention projects focused on adults will get a value of 1 and zero otherwise. Prevention projects focused on non-adults will get a value of 1 and zero otherwise.

Targeting the family by means of enrolling parent and child in the prevention project was found to be an effective measure (Golan, Weizman, Apter, & Fainaru, 1998). The family is regarded to be of main influence for developing the psychosocial environment whilst also being mainly responsible for food purchases and recreational activity (Story, 1999), therefore we introduce the variable *household*. Projects which focus on the parent and child dyad will get a value of 1 for *household* and zero otherwise.

Differences in program effectiveness may arise on the basis of difference in ethnicity i.e. African American vs. Caucasian (S. Kumanyika et al., 1991; Wassertheil-Smoller et al., 1985; Wing & Anglin, 1996). Some obesity prevention programs focus on a specific ethnicity, since behaviours may vary significantly based upon sociocultural influences (NHLBI, 1998). By example, program adherence was found to be lower for African American individuals due to cultural behavioural factors i.e. the social acceptance of having a higher BMI (S. K. Kumanyika & Morssink, 1997). Therefore, targeting a specific group based on sociocultural difference may exert a greater effect on weight loss and/or weight maintenance. We introduce the variable *ethn* which will get a value of 1 for projects focused on African Americans and zero otherwise.

Projects conducted through a social meaningful setting i.e. school, worksite, hospital and primary care could influence project effectiveness. By means of example, projects conducted in school settings may provide great advantages due to their intensive contact with a great majority of children and adolescents in the USA (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2002), whereas projects conducted through worksites provide measures to reach a large proportion of the working adult population *(Clark, Iceland, Palumbo, Posey, & Weismantle, 2003)* The available resources at the specific setting could be used to facilitate a healthy lifestyle, by means of changing the dietary and physical activity habits through changes in policy, cafeteria menus and/or physical environment (Aldana, 2001; Catlin, Simoes, & Brownson, 2003; Dietz & Gortmaker, 2001; Goetzel, Jacobson, Aldana, Vardell, & Yee, 1998). In order to investigate the effect of project setting we introduce the dummy variable *setting*, which will take a value of 1 when a project is conducted through a social meaningful setting and zero otherwise.

An obesity prevention project should reach a considerable number of people in order to decrease the average BMI of a county. Measures for reaching large populations are available for State Health Departments, therefore projects conducted by State Health Departments may be more effective in attaining weight loss or maintenance. We introduce the dummy variable *state* which will get a value of 1 for obesity prevention projects that are conducted on a state level and zero otherwise.

As stated in the literature background, changes in the environment have led to decreases in physical activity and increases in consumption i.e. decreased energy expenditure at the work place, increased availability of calorie dense food and increased portion volumes. On the basis of these changes, prevention projects which try to alter one of these or other factors may be more effective in attaining weight loss or weight maintenance. In order to investigate how changes in the project participant's environment relate to county BMI change we introduce the dummy variable *env* which will get a value of 1 for projects that change a factor in the participants' environment and zero otherwise.

Control variable

In this study we control for the number of participants in the cohort size and the total county population. Reasoning being that the project cohort sizes differ to a great extent and a greater cohort size can be expected to exert a greater effect on a fixed population size i.e. a project with 1000 participants is expected to exert a greater influence on a fixed population relative to 100 participants; the same reasoning can be used for the difference in county population. Therefore we introduce the control variable *nratio*, which is established through dividing the projects cohort by the county population.

Table 1 Descriptive of the dependent and independent variables

Variable name	**Variable Description**
	Dependent variables
dBMI	County BMI change (%)
dBMI1	County BMI change at 1 year after project completion (%)
dBMI3	County BMI change at 3 years after project completion (%)
	Independent variables
grantmln	Received grant expressed in million USD
*diet**	Projects with a dietary therapy strategy
*pa**	Projects with a physical activity strategy
*intv**	Projects which used an intervention approach
ptime	Projects timespan expressed in years
*adult**	Projects conducted with adults
*nonadult**	Projects conducted with non-adults
*household**	Projects conducted with parent and child dyad
*ethn**	Projects conducted among solely African Americans
*setting**	Projects which are conducted through a specific social setting
*state**	projects conducted by a State Health Department
*env**	Projects which facilitated a change in the participants environment
nratio	Project cohort divided by the average county population

*Dummy variable

Data sources & collection

The main sources of data in this study are sourced for the National Institutes of Health and the Centre for Disease Control and prevention. The NIH is the largest source of funding for medical research in the world and is made up of 27 institutes and centres each with a specific research agenda. Project specific data inputs for the independent variables are sourced from the NIH by means of the Research Portfolio Online Reporting Tools (RePORT). The latter allows a set of search options per fiscal year regarding researchers, organization, text search and project details. Data on annual county BMI levels are sourced from the CDC SMART BRFSS, which provides annual prevalence rates in counties for selected conditions and behaviours. The CDC is one of the major operating components of the Department of Health and Human Services in the USA.

At the start of this study an inclusive list of keywords on the topic of obesity prevention and influencing factors was established (Appendix I).Project specific data was collected using the list of keywords of appendix I in the text search option of the NIH RePORTER tool. This search yielded a total of 15,003 unique projects within the wide defined scope of obesity research between the years 2000 and 2013. Project information was exported to Excel for further analysis. The scope of this study lies with projects which aim to decrease bodyweight, maintain current bodyweight or prevent future weight gain. Therefore a list of keywords (presented in appendix II) was used to search among the projects titles. A second text search was conducted among the project abstracts for the presence of prevention or intervention. The latter was done in order to capture projects that might have been eluted from the first search due to a very specific project name i.e. After-school gets moving. The results of both searches were combined and assessed on their aim of either weight loss, weight maintenance or the prevention of future weight gain; this assessment resulted in 337 projects. County BMI data between 2002-2012 is sourced from the CDC SMART BRFSS webpage[1]. Outliers (kg > 300) in these data sets were removed and the average county BMI values were calculated. Outlier removal was done due to the presence of weight inputs of 999kg in the data sets of 2002-2010; reason for this error is unknown. The variables state FIPS, county name, average county BMI, average BMI for the years 2002-2012 were exported to Excel and merged into one data set.

Obesity prevention project analysis

The following section describes how projects were analysed to retrieve the necessary data for the regression analysis. Project information collected from the NIH website consists of project description, details, results, clinical trials and history. The description section provides information on project title, abstract and terms. The details section provides information on project leader, organization, administering institute and funding. The history section provides information on the total received funds per year. The results and clinical trial section provides information on publications that have arisen from each project. Our main interest for this analysis is the project location, needed to match the NIH project data to the CDC county BMI data.

Differences were observed for project time span in the NIH description and published articles. The mentioned timespan in publications was found to be shorter and gives therefore a more precise indication on when the actual prevention project was conducted. Main reason for this could be that the timespan in the project description also takes into account the time needed for data analysis, grant application and/or writing publications.

[1] SMART BRFSS SAS transport formats for the years 2002-2012 were downloaded from the CDC website and imported into STATA

In our analysis, we used the given timespan in the publication as input for start and finish years and used description time span when the publication did not specify an exact duration.

County population inputs for the control variable *npopmln* were sourced from the National Bureau of Economic research (NBER, 2014). Some projects were conducted with participants from multiple counties. Therefore the average of all participating counties in the project was taken as final measure of *npopmln.*

BMI values for the start and finish dates were compiled by means of an array formula on the basis of three criteria, year, state FIPS code and county name. Some projects were conducted with participants from multiple counties. BMI values were computed for every participating county, after which the averages were taken as final measures for start and finish BMI values.

Exclusion criteria

This section describes in a schematic manner how the final number of projects eligible for regression analysis were attained. Projects in the analysis have to adhere to four criteria before they can enter the final database. First, the project should have a focus on weight loss or weight maintenance and be conducted among a certain human population. Second, the project has to provide information on the location from which its participants were recruited. Third, the project has to be conducted between the years 2002-2012 (To match the SMART BRFSS years) . Fourth, the projects county has to be present in the SMART BRFSS database. A county needs at least 500 observations before it can be included in the annual SMART BRFSS database. Figure 2 describes how the previously named criteria result in the final database.

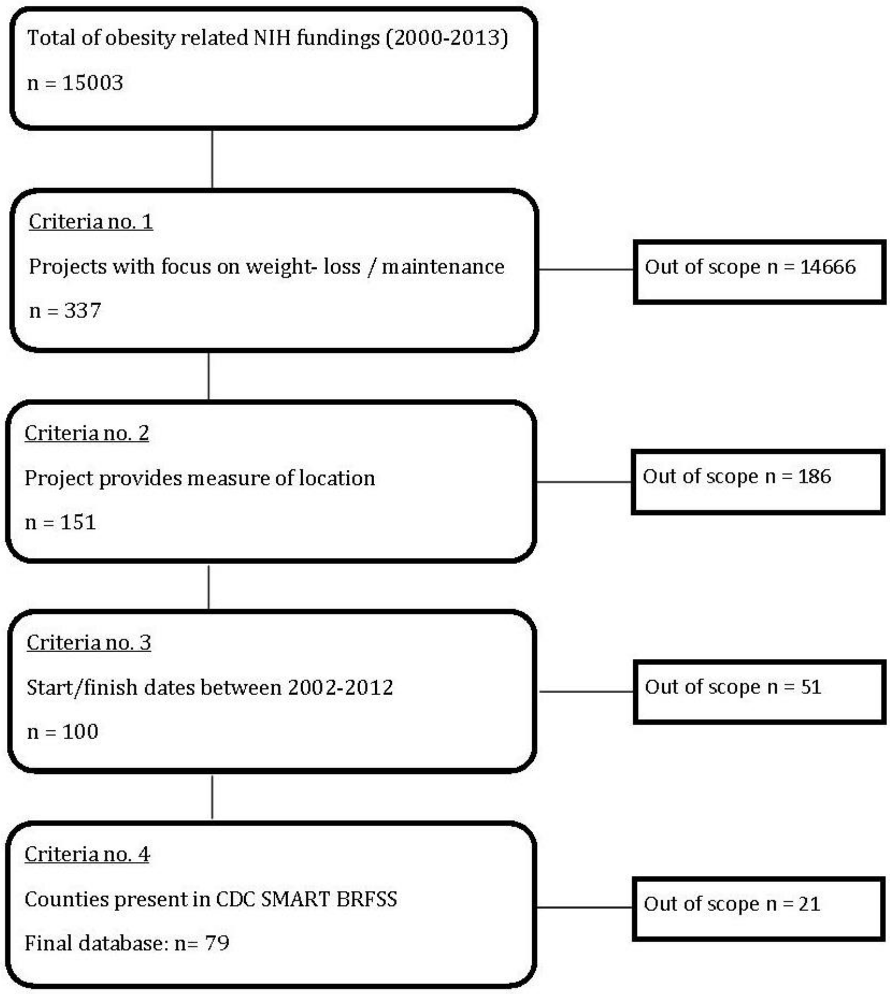

Figure 1 Exclusion tree on the basis of the four criteria

Empirical results & Discussion

Table 2 provides the descriptive statistics of the dependent and independent variables used in this study. BMI increased on average with 0.31% per year in counties were an obesity prevention project was conducted, whereas the average county BMI increased with 0.47% per year from 2002-2012 (appendix IV). The latter shows that on average the county BMI increases with a rate that is 0.16% lower than the USA county average.

Table 2 Descriptive statistics for the dependent and independent variables

Variable Description	Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables						
County BMI change at project completion (%)	*dBMI*	79	0.85	1.41	-2.43	5.54
Annual change in county BMI (*dBMI /ptime*)	*dBMI_year*	79	0.31	0.66	-2.43	2.53
County BMI change at 1 year after project completion (%)	*dBMI1*	63	1.34	1.53	-1.44	5.15
County BMI change at 3 years after project completion (%)	*dBMI2*	45	2.33	1.97	-2.19	6.36
Independent variables						
Received grant expressed in million USD	*grantmln*	79	1.65	1.57	0.03	5.70
Projects timespan expressed in years	*ptime*	79	2.82	1.37	1.00	7.00
Projects with a physical activity therapy strategy	*pa**	76	0.82	0.39	0	1
Projects which used an intervention approach	*intv*	79	0.66	0.48	0	1
Projects with a dietary therapy strategy	*diet**	79	0.79	0.41	0	1
Projects focused on parent and child dyad	*household**	79	0.20	0.40	0	1
Projects conducted with adults	*adult**	79	0.73	0.44	0	1
Projects conducted with non-adults	*nonadult**	79	0.58	0.50	0	1
Projects with a focus on African Americans	*ethn**	79	0.15	0.36	0	1
Projects which are conducted through a specific social setting	*setting**	79	0.61	0.49	0	1
projects conducted by the state health department	*state**	79	0.10	0.30	0	1
Projects which facilitated a change in the participants environment	*env**	79	0.19	0.39	0	1
Ratio of cohort size and average county population	*nratio*	79	0.08	0.23	0	0.73

*Dummy variable

The proportion of prevention projects that can be related to our measure of effectiveness ($\Delta BMI \leq 0$) at baseline, 1 year and 3 year after completion are 24.1% (n=19), 20.3% (n=13) and 11.1% (n=5) respectively. County BMI change shows higher average increases in BMI for 1 and 3 years after project completion compared to baseline. Relating this finding to the decreasing proportion of effective BMI change after project completion, shows a limited effect of weight maintenance. The latter correlates with the literature on direct project participants, which states that the majority of project participants regain the lost weight in the years after projects have been completed (Jeffery et al., 2000). The total sum of funds granted to the 337 projects in our initial database, with a scope of decreasing or maintaining current weight, amounts to 451 million USD for 2000-2012. The total funding of projects in the final database amounted to 130 million USD for 2000-2012. On average projects received a total funding of 1.65 million USD, with an average of 0.55 million USD per year.

Multivariate regression results

Table 3 displays models 1 and 2, which are the result of the initial and optimal regression. The variable *state* was omitted from model 1 due to a variable inflation factor of 5548. The variable *diet* showed the highest correlation (-0.22) with the change in county BMI at baseline. *grantmln* showed the highest correlation with *ptime* (0.66) and *nratio* (0.48),when projects are conducted over a greater time span they consume more resources i.e. time of researchers employed.

Table 3 Initial and optimal regression of county BMI change (%) at project completion

Model 1 Model including all variables at baseline				**Model 2 Optimal model on the basis of adjusted R^2 at baseline**			
Variable Name	**Coefficient**	**Std. Err.**	**P>t**	**Variable Name**	**Coefficient**	**Std. Err.**	**P>t**
nratio	-4.52	2.02	0.03 **	*nratio*	-3.13	0.87	0.001 ***
ptime	0.35	0.17	0.04 **	*ptime*	0.44	0.13	0.001 ***
setting	-0.64	0.38	0.10 *	*setting*	-0.69	0.35	0.05 *
diet	-0.56	0.41	0.17	*diet*	-0.41	0.36	0.26
nonadult	1.48	1.43	0.31	*nonadult*	0.45	0.33	0.17
env	0.22	0.46	0.63	*env*	0.42	0.38	0.28
grantmln	0.11	0.15	0.46				
pa	-0.12	0.46	0.80				
intv	0.05	0.41	0.90				
household	-0.85	1.49	0.57				
adult	1.24	1.47	0.40				
ethn	-0.06	0.49	0.91				
Number of observations	75			Number of observations	76		
R^2	0.25			R^2	0.23		
Adjusted R^2	0.11			Adjusted R^2	0.17		
F-test for overal model significance	1.77 *			F-test for overal model significance	3.52 ***		
Multicollinearity Condition Number	42.1			Multicollinearity Condition Number	9.60		
Breusch-Peagan test for heteroskedasticity	0.23			Breusch-Peagan test for heteroskedasticity	0.20		

level*** .01 significance, ** .05 significance, * .10 significance

When *nratio* increases, a greater proportion of the county population is included in the project. The amount of resources needed to conduct the project therefore also increase, hence greater project costs.

The final amount of observations (n=75) versus the total of independent variables (n=12) in model 1 shows a significant limitation in assessing the effect of each independent variable. The small sample size can be explained by the limited number of projects (n=337) with a focus on either weight loss, weight maintenance or weight gain prevention. Only 150 (44.6%) of the projects published a measure of location. Project publications do not express the origin of their participants in a uniform way. This could be due to confidentiality agreements or the omission of such information in publications. Combining the lack of location data with the timespan criteria of the CDC and NIH data-sets restricts considerably the number of projects entering the final database. The statistical power and thereby the reliability of the regression model prediction decreases to some extent. Rendering it necessary to omit variables from the model by means of establishing an optimal model on the basis of adjusted R^2, which was done by means of the Wilson leaps-and-bound algorithm.

The optimisation has resulted in model 2, which shows to be significant ($p<0.01$) in explaining 17% of the variance in county BMI change. Co-linearity among the independent variables is found acceptable, with a multi-colinearity condition number of 9.60. No significant result was found for the Breusch-Paegan heteroskedasticity test. The variable *nratio* was found significant ($p<0.01$) in explaining the variance in county BMI change at project completion. The coefficient of -3.13 shows that a greater weight loss effect can be expected for conducting the project among a greater proportion of the county's population. Specifically, every percent increase of county proportion included in the project results in a

0.03% decrease of county BMI. The latter is in line with our expectation that projects with a greater reach exert a greater effect on county BMI change. The variable *ptime*, total project timespan, was found significant (p<0.01) in explaining the variance of county BMI change. County BMI was found to increase with 0.44% per year. This result contradicts literature on participants in the projects' cohort, which correlates increasing timespan to greater weight-loss and maintenance effects (Rooney & Murray, 1996; Stice & Shaw, 2004). The setting through which an obesity prevention project is conducted was found significant in explaining the variance in county BMI. A 0.69% decrease in county BMI is observed when a project is conducted through a socially meaningful setting i.e. school, worksite or primary care.

Table 4 describes the regression results for the optimal models at baseline, 1 year and 3 year after project completion, which serves as a robustness check of our model.

Table 4 Robustness checks for 1 (model 3) and 3 (model 4) years after project completion

Model 2 Optimal model on the basis of adjusted R^2 at baseline				Model 3 optimal model on the basis of adjusted R^2 at 1 year after project completion				Model 4 Optimal model on the basis of adjusted R^2 at 3 years after completion			
Variable Name	Coefficient	Std. Err.	P>t	Variable Name	Coefficient	Std. Err.	P>t		Coefficient	Std. Err.	P>t
nratio	-3.13	0.87	0.001 ***	*nratio*	-1.21	2.04	0.56	*nratio*	-1.20	0.71	0.10 *
ptime	0.44	0.13	0.001 ***	*ptime*	0.51	0.14	0.00 ***				
setting	-0.69	0.35	0.05 *								
diet	-0.41	0.36	0.26								
nonadult	0.45	0.33	0.17								
env	0.42	0.38	0.28	*env*	0.67	0.48	0.17	*env*	0.09	0.45	0.84
				adult	-0.47	0.37	0.21	*ethn*	0.05	0.41	0.91
Number of observations	76			Number of observations	63			Number of observations	45		
R^2	0.23			R^2	0.22			R^2	0.04		
Adjusted R^2	0.17			Adjusted R^2	0.17			Adjusted R^2	0.00		
F-test for overal model significance	3.52 ***			F-test for overal model significance	4.20 ***			F-test for overal model significance	1.01		
Multicollinearity Condition Number	9.60			Multicollinearity Condition Number	6.46			Multicollinearity Condition Number	2.03		
Breusch-Peagan test for heteroskedasticity	0.20			Breusch-Peagan test for heteroskedasticity	0.32			Breusch-Peagan test for heteroskedasticity	0.03 **		

level*** .01 significance, ** .05 significance, * .10 significance

Model 3 accounts for the same percentage of variance in BMI change as model 1, however with less significant variables. Model 4 shows a significant effect (p<0.10) for *nratio*, whereas the model itself has no explanatory power. In general table 4 indicates that the variables from model 2 are insufficient in describing the change in county BMI after project completion in a robust way, hence the variables from model 2 only uphold for the time span in which the project is conducted.

Conclusion

This study analyses whether obesity prevention research projects had any effect on the BMI of the county in which they were conducted. Results showed an annual increase in county BMI during project time span of 0.31%. The average county BMI in the USA increased with 0.47% annually for 2002-2012. On the basis of these findings it can be concluded that on average counties which have undergone an obesity prevention project differ to a fair extent from counties which have not, showing a decrease in weight gain of 0.16% per year.

One of the main incentives for this study was to determine the proportion of obesity prevention projects that have been effective in attaining weight loss or weight maintenance. The final database consisted of 79 projects, of which 19 (24.1%) were found to be related to an effective change ($\Delta BMI \leq 0$) in county BMI. Results for one and three years after project completion show that the effective proportion decreases to 20.3 and 11.1% respectively. From these findings it can be concluded that the effect of obesity prevention projects on county BMI dissipate over time, which is in line with the direct participant literature on limited weight loss and weight maintenance effects.

In order to identify project specific aspects that may exert an effect on county BMI a number of independent variables were compiled at the start of this study. The basis for these variables was the existing literature on the obesity epidemic, results of previous prevention projects and the clinical guidelines for establishing an overweight/obesity treatment plan. Multivariate regression of county BMI change at project completion resulted in a significant model ($p<0.01$) explaining 17% of the variance in county BMI change. Main findings regarding the independent variables showed a significant effect in explaining the variance by *nratio*, *ptime* and *setting*. From the finding of *nratio* can be concluded that projects exert a greater effect on the county BMI, when a greater proportion of the county population is included in the project. Increasing the years of project time span was found to increase the county BMI with 0.40% per year, from which can be concluded that it could be beneficiary for future prevention projects to limit the projects' timespan. Projects conducted through a socially meaningful setting such as worksites, schools and primary care were found to decrease county BMI with 0.69%, from which can be concluded that the setting through which the prevention program is communicated exerts a significant effect on the project's success, which could serve as indication for future projects focus.

Another incentive for this study was government spending on obesity research and if the results justified the costs. The total project grant did not affect changes in BMI in a statistically significant way, thereby rendering it necessary to omit this variable from the optimal model. Funding more money into obesity prevention projects will therefore not influence the change in county BMI. However, the grant is an essential part in the execution of a project, since it does show high correlation with project aspects (*nratio* and *ptime*), that exert an effect on county BMI change. Annually the NIH funds close to $830 million per year to obesity research (NIH, 2012). For 2000-2012 a total of 451 million USD was specifically funded to obesity prevention projects (n=337), which amounts to an average of 34.7 million USD per year, whereas the annual costs attributable to obesity and overweight in the USA are predicted at 148 billion USD in 2008 (Wang et al., 2008). Annual costs of obesity prevention projects amount to 0.02% of the annual costs attributable to the obesity epidemic, therefore the possible savings that could be made easily justify the costs of obesity research and could serve as an incentive to increase future funding, since it remains a fact that overweight and obesity are preventable (WHO, 2013).

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Appendixes

Appendix I

Table 5 List of keywords for data collection in NIH RePORTER

obesity
obese
obesity prevention
overweight
overweight prevention
overweighed
weight loss
healthy weight
weight management
weight control
weight gain
bmi
body mass index
bmi change
increased body mass
body composition
overeating
appetite control
increased appetite
body weight
fat percentage
physical activity
dietary restriction
caloric dietary content
calorie dense foods
healthy diet
healthy eating
junk food
fast food
fruits and vegetables
overconsumption
caloric intake

Appendix II

Table 6 List of keywords used in search among project titles

Intervention
Prevention
prevent
Reduce
Reduction
Promote
Promoting
Decrease
decreasing

Appendix III

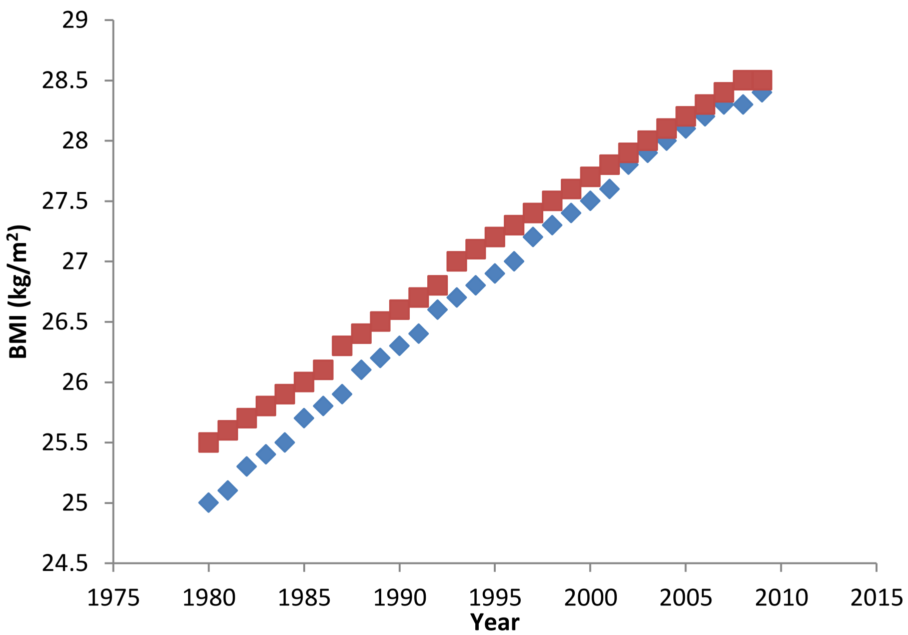

Figure 2 Mean BMI trends USA for female (blue) and male (Red) for 1980-2009 (WHO, 2008a, 2008b)

Trend line formulas

Male: BMI = 0.1079year – 188.03

R^2=0.997

Female: BMI = 0.1203year – 213.18

R^2=0.996

Appendix IV

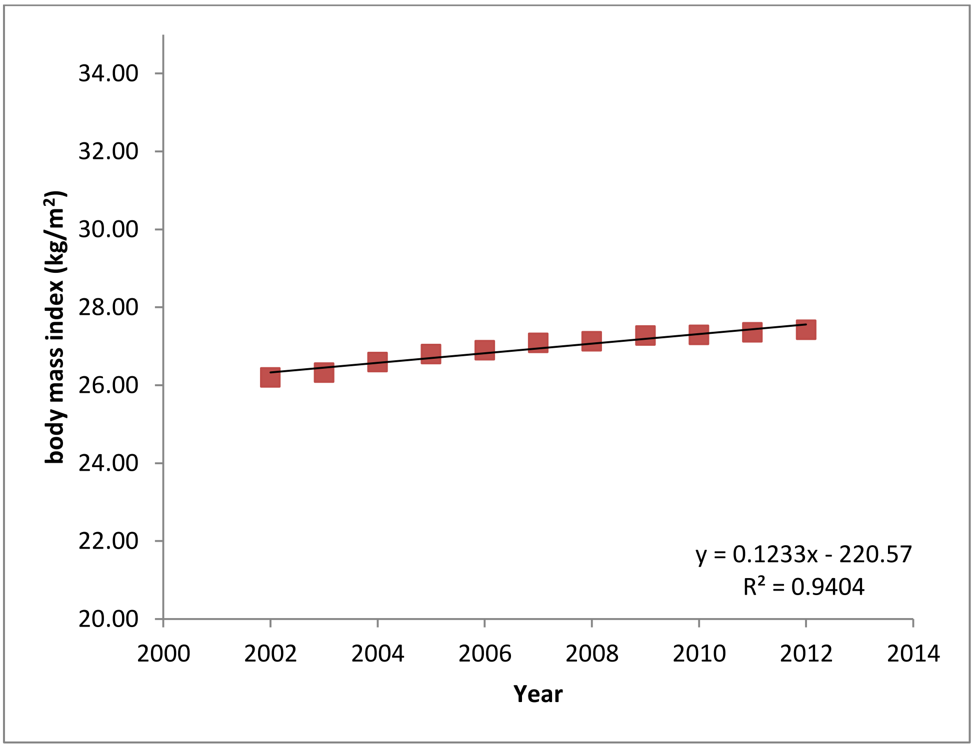

Figure 3 USA average county BMI (kg/m^2) expressed in years for 2002-2012

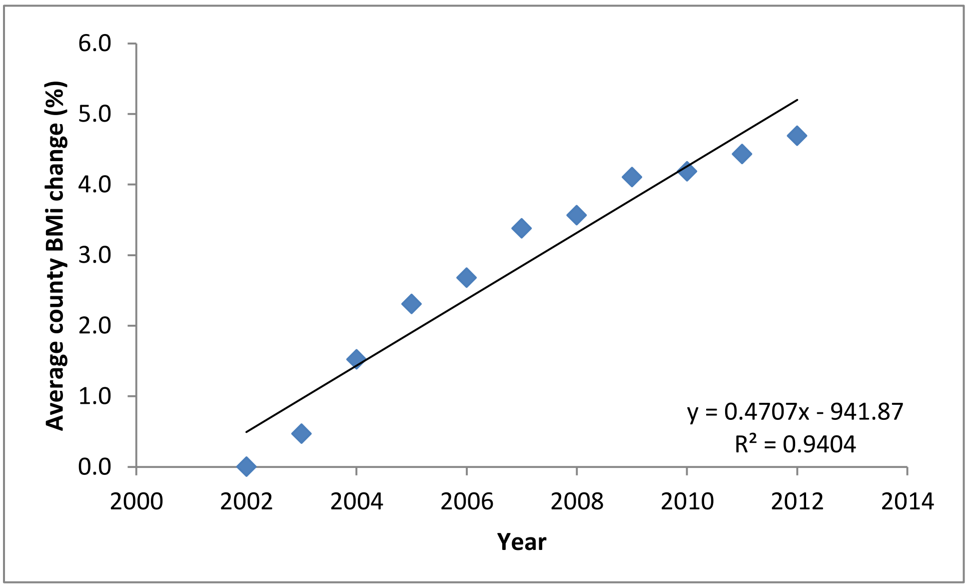

Figure 4 Change in average county BMI expressed in years for 2002-2012