Determinants of Obesity in 9 Countries, 2000 - 2011

April 25, 2012

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I. Introduction

Obesity, defined as "abnormal or excessive fat accumulation that may impair health," has been a rising epidemic since 1980, with 1.5 billion obese or overweight adults in 2008 (WHO 2011). The reason that this is such a huge issue is due to the fact that obesity is extremely harmful to a person's health; it is considered the fifth leading risk of global death (65% of the world's population were from countries where overweight and obesity caused more deaths than underweight did). Those who are diagnosed with this disease have an increased likelihood of cardiovascular disease, diabetes, musculoskeletal disorders, and some cancers; according to the World Health Association, each year about "44% of the diabetes burden, 23% of the ischaemic heart disease burden, and between 7% and 41% of certain cancer burdens are attributable to overweight and obesity" (2011). Not only does obesity take a toll on the individual, but it also puts a heavy burden on others such as governments and health care systems, which must dole out provisions to take care of these individuals. Not to mention that those who are afflicted will be unable to work, and thus will bring down the productivity of the economy.

Clearly this pandemic affects the entire world, even if only a small percentage. But is there a link, some common thread, which determines which areas are affected the most? Are all areas of the world subject to becoming obese, or should only certain regions take precautions against this? It is necessary to identify all the determinants of obesity are, and how they affect different regions of the world. By understanding this, we can work to fight this epidemic and create a healthier, more prosperous world.

II. Literature Review

While obesity has seemed to worm its way into all corners of the earth, is this epidemic really a public health problem? Or is it just something that individuals need to work on by themselves? Philip James et al. (2001) do find that this is a world pandemic, yet while the prevalence rates are different in each region, there seems to be a certain pattern for those that are affected. For instance, more women tend to be obese compared to men in most countries. This is not only due to biological reasons, but also due to the domestic role that they play. Since most of their time is spent in the home, they have a higher risk of recurrent eating, causing higher caloric consumption. Another trend that James et al. have noticed is the inverse relationship between obesity and education and socioeconomic status. Due to social circumstances and cultural differences, poorer people tend to be more obese. Processed foods are cheaper and are more widely available providing poor people greater access to these energy-dense food items. Since obesity prevalence rates are continuing to rise, the authors predict that world governments will begin to confront the problem (2001).

Tomas Philipson and Richard Posner (2008), too, find that this problem is something that should be considered a global issue; but not only is it a global one, but an economic one. For one, obesity occurs because individuals must choose between calorie consumption and exertion; this choice is determined by weighing costs and benefits against each other. Also, obesity may cause social and private costs; therefore it needs to be determined whether or not governments should intervene. Again, this issue can be resolved by examining whether or not the benefits of reducing social costs outweigh the costs of doing so (Philipson and Posner, 2008). Since it is a problem concerning these two items, naturally it should be looked into.

Philipson and Posner take note that obesity arose when the world began to switch from an agricultural economy to an industrial one. No longer were people performing manual labor in their every day to day life, and thus were forced to find other means of physical activity. This forced people to make time for exercise, causing an increase in the price of spending calories, so people tended to burn fewer and fewer of them. On top of that, since machinery helped to create food at a faster rate, this reduced the price of consuming calories, allowing people to eat more. Since then, obesity has been rising. Even before this time, there has always been a tradeoff between a person's health and their pleasure and income. By making it easier to earn a better salary and increase their pleasure time, most people gave up their health and allowed themselves to become obese. Also, as more and more people are becoming obese there are fewer stigmas associated with it, and people are not trying as hard to fight it (Philipson and Posner, 2008).

With this rise in obesity, there are many costs that need to be considered. Yes, there are individual ones, especially the burden of diseases, but also the high social cost of public health insurance like Medicare and Medicaid. Due to this, it is clear that a global effort needs to be made to fight this epidemic. However, unlike James et al. (2001), Philipson and Posner do not foresee current intervention, such as education programs, taxation, and regulation on fast food a positive means to reduce obesity; for the most part, it is a voluntary and self-inflicted choice and no matter how much we try, people cannot be forced to eat healthy and exercise more (2008).

On the other hand, while we cannot force people from all regions of the world to act a certain way, perhaps there is a better way to promote a healthier living. In order to do this, though, it needs to be determined if there is a particular reason why certain areas are hit harder than others. In a study done by Jeffrey Sobel and Albert Stunkard reviewed 144 published studies that attempted to ascertain if maybe it could it be related to a person's socioeconomic status (1989)? It appears that among developing nations (women, men, and children) there is a direct relationship between their SES and whether or not they are obese. This could be due to the fact that being on the heavier side means a person is wealthier, because he can afford to eat well, and could be a sign of good health since he obviously does not suffer from malnutrition.

Therefore a person with a higher SES is going to flaunt this and therefore have a higher chance of becoming obese (Sobel and Stunkard, 1989).

On the contrary, in developed countries, the trend is much different. There seems to be a strong inverse correlation between women and their economic status; the higher the SES, the less obese she is. This trend does not, however, continue on to that of men and children who do not seem to follow any sort of pattern whatsoever (Sobel and Stunkard, 1989). This can be attributed to the highly stigmatized view women have of obesity (men and children are pretty neutral on this topic). They view obesity as unattractive and so will take any and all measures to prevent themselves from gaining unnecessary weight. As their SES increases, they have enough money to allow them to exercise more and go on diets. Do the findings of this review prove to be the sole reason for increase in obesity?

In 2007, Lindsay McLaren from the Department of Community Health Sciences at the University of Calgary in Alberta, Canada wanted to update and build on the study done by Sobel and Stunkard. She reviewed 333 published studies which contained 1, 914 associations. While former only examined an overarching measurement of SES seen in the literature they reviewed and divided countries among developed and developing countries (Sobel and Stunkard, 1989), McLaren decided to take it a stop further. She used multiple measures of SES such as education, occupation, assets and material belongings, as well as income, and she created three categories of societal development status, high-to low-Human Development Index (HDI) (McLaren, 2007).Overall, she observed about the same results as did Sobel and Stunkard. As one moves towards a low-HDI, both men and women with higher SESs tend to be more obese. These people tend to value the “bigger is better” mentality compared with those belonging to more developed countries. Those in developed countries tend to view a healthier body as one that is more towards the thinner side. Not to mention the fact that they can afford to purchase healthier, less dense food items, and thus have better diets (McLauren, 2007).

Seeing as how obesity is affecting both developed and developing nations, Kamhon Kan and Wei-Der Tsai from the Institute of Economics in Taipei (2004) wanted to see if people's knowledge of the risk of obesity, meaning the harmful health consequences, affects their tendency to become obese. In their study they assumed that people are rational so therefore obesity has to do with decision making based on a cost-benefit analysis; basically obesity is a choice. They surveyed 4,161 participants about their current lifestyle such as how many years they went to school, how often they meet with their friends, if they were comfortable about their health, how often they watch television, and how often they read the newspaper. By looking into these factors, they were able to see where these people gather their information and if they are receiving the proper knowledge about obesity (Kan and Tsai, 2004).

They were able to discover that while men and women rely on different sources of information, there is somewhat of a correlation between a person's obesity level and they amount of knowledge they have. For women, there was no discernible effect on their BMI; however, there was a rather prominent trend with the men. For those who belonged to the mid-range of BMI distribution and below, they seemed to be more overweight with the more knowledge they knew; they did not believe that these risks would affect those only slightly overweight. Yet as they reached higher levels of weight, and the more they knew of the risks, they made a more conscious effort to lose weight and thus were less obese (Kan and Tsai, 2004). With this information, one can believe that conveying how dangerous even being a little bit overweight is, the obesity level could possibly be lowered.

Looking to help adults fight obesity is only half the battle; children just as susceptible, if not more, than adults. According to Richard Deckelbaum and Christine Williams, in 2001 about 22 million children under the age of five years old were overweight across the United States alone; this is affecting children all over the world. It is particularly important to pay attention to the weight of our rising generation because those that are obese in their youth have a higher likelihood of being obese as an adult. Along with carrying obesity through to their adulthood, obese children may also face numerous comorbidities (diseases or conditions that are associated with a primary disease). These include cardiovascular, orthopedic, psychological and behavioral issues. Once children acquire these additional diseases many of them cannot be cured, and thus they must live with them for the rest of their lives. By understanding the affects of obesity on children in the present as well as the future, society might be able to lower levels of obesity all over the world (Deckelbaum and Williams, 2001).

To see if there was particular reason obesity affects children so much, Patricia Anderson et al. (2011) performed a study on the impact of early elementary school on children's body weight. They took a sample of six years from kindergarten (older starters) and first grade (younger starters) from Early Childhood Longitudinal Study – Kindergarten Cohort of 1998. Younger starters, since they were born before the cutoff date for kindergarten, at the age of six they have had an extra year of schooling than those that were born after the cutoff. If the results revealed that the weight of the younger starters was less than the weight of the older starters, then that would mean school improves weight outcomes. If the results yielded the opposite, however, than it would mean that school was bad for weight outcomes.

At the end of the study, Anderson et al. discovered that there were no harmful effects of school exposure but there are some school systems that are better than others. The effects of the additional year of school on obesity were determined on the environment the children came from prior to the year they entered kindergarten; they were unable to determine this data. If children came from a more regimented environment, such as preschool, where they were unable to snack and were more physically active then further schooling would not have much of an effect on the child's weight or could cause it to increase. If, on the other hand, a child was from an environment where he was allowed to sit inside all day watching television and snacking then school would have a positive effect on his weight and cause him to lose weight. Since these environments could not be determined, no exact effect of schooling on a child's weight could be established; just that it did not cause weight gain (Anderson et al, 2011).

Given the previous studies, it is clear that the world needs to figure out a way in which to lower the levels of obesity. One way that many considered would be a "fat-tax," in which there would be a tax on junk food, and a "thin subsidy," where the revenue from the tax would be used towards healthy foods that one could cook at home. Gideon Yaniv et al. (2009) performed a rational choice model to determine the effects of these two policies. They studied these effects between weight-conscious and nonweight-conscious individuals, as well as the effects between a weight-conscious individual who is physically active and one who is not.

They discovered that for nonweight-conscious people, while the fat tax did reduce the obesity level, the thin subsidy actually caused them to gain weight. The reason for this was because the substitution effect did cause them eat healthier foods; however, due to the income effect they had more money to increase their leisure time and thus had no time to cook. Therefore they were still consuming more than they were expending. For the weight-conscious people, the fat tax might actually increase a person's weight. The substitution effect did allow them to eat healthier foods, but since they are spending more time cooking it takes away from their exercise time; while they are consuming less, they are burning even less calories (Yaniv et al, 2009). What the authors propose instead, is that the revenue earned from the “fat tax” should instead be allowed to subsidize exercise equipment. Therefore, it promotes people take time out of their leisure and uses it to burn calories instead (2009).

While all of the above studies strongly support the idea that obesity is a matter of choice that is not always the case; several other factors need to be taken into account. For one, much of the food items we consume on a daily basis may have certain properties that promote food addiction and overeating. There are skeptics that do not believe this proposal due to the fact that everyone in the world needs to eat in order to survive. So therefore how can something that is necessary for life be considered addictive? Corwin and Grigson (2009) did a study to see if certain food items, those high in fats and sugars, did in fact carry addictive properties The key feature of food addiction is loss of control which leads to eating very frequent and/or larger meals – binge eating. Through biological and neurobiological evidence that they reviewed, under certain conditions food does in fact promote addiction-like states. So while food in and of itself is not addictive, the manner in which food is consumed promotes addiction (Corwin and Grigson, 2009).

Although Corwin and Grigson found that food itself is not addictive, Davis et al (2011) state that fat, sugar, and salt (found in processed foods) do in fact have these properties. For example, sweeteners, such as high fructose corn syrup, have special physiological properties that promote a sense of hunger even when the body does not require energy. There have been studies where rodents were given sugar-enhanced diets which led to a daily increase in food intake (Davis et al, 2011). Davis et al performed their own survey, consisting of 72 obese adult women and men who were 25 to 46 years of age, to assess their clinical comorbidities, psychological risk factors, and abnormal motivation for addictive substances. In the end they discovered that eighteen adults were food addicts, based on the Yale Food Addiction Scale (YFAS), thirteen of which were females and five being males. Also those that reported more binge and emotional eating were more likely to have Binge-Eating Disorder (BED) and severe depression. All in all processed foods do in fact have addictive properties (Davis et al, 2011).

Yet is there another reason why people, both adults and children, tend to lose control when they eat? Goossens et al (2011) believe that the core of "Loss of Control over Eating" (LC), especially in children and adolescents, is due to a disturbed self-image and low self-esteem; they use LC to cope with their negative emotions. In their study, they sought out to find an association between self-esteem, attachment (present parental figures), and LC in preadolescent boys and girls. They used the Eating Disorder Examination Questionnaire to survey 555 third to fifth graders from six elementary schools. The results yielded 482 of the participants reported having LC with a majority of them having lower self-esteem than the NoLC group. There also appeared to be a connection between their attachment to parents and their self-esteem. Those with little attachment tended to have lower self-esteem and thus a higher chance of LC (Goossens et al, 2011). Clearly understanding this phenomenon furthers our knowledge of what leads to obesity.

Even if people have control over their eating habits, there may be a reason why they keep putting on weight. Several studies have shown that in the human body, we have what is called 'gut flora,' especially microbiome, which is the good bacterium in our intestines. This bacterium helps us to efficiently digest most of the calories we ingest. Without this bacterium, humans will tend to have a lower metabolism and thus a greater chance of gaining weight (Bajzer and Seely 2006; Tsai and Coyle, 2009). In our society, we view bacteria as horrible organisms that promote sickness and death, so we do anything in our power to destroy them. The major method of doing so is by taking antibiotics which kill this bacterium. While they kill the bad bacteria, they also tend to kill off the good bacteria such as our 'gut flora.' This fight against germs begins in our early stages of life, before we can even talk, and thus we destroy the good bacteria early on allowing us a greater chance of becoming obese (Murphy, 2011).

Not only are we consuming these antibiotics directly but it is also comes from the livestock that we eat. Many livestock suppliers use antibiotics in their animals in order to fight off any epidemic that might occur, as well as for growth promotion (though recently many have lowered the amount of antibiotics used or governments have banned their use). According to Ternak (2004), many of the drugs that are not utilized are disposed of in the sewage system. Often times the drugs are not broken down well and can seep into the ground water, and thus into our drinking water. So we are inadvertently taking in more antibiotics which continue to destroy our 'gut flora' and thus promote obesity (Ternak, 2004).

No matter how one looks at it, obesity is not something that should not be taken lightly. By looking at all the above studies it has been an issue for many years now and yet obesity levels have continued to rise. Since it affects all corners of the earth, especially those youngest in our population, we need to fight to not only keep our current generation alive, but also the future ones as well. In order to do this, governments need to work together and figure out a way to fight this epidemic.

III. Model and Data Sources

The Data

The model examines the various measures which tend to reflect obesity rates all over the world. These variables were collected from 9 different countries (Australia, France, Germany, Ireland, Japan, Mexico, Republic of Korea, United Kingdom, and the United States) from the year 2000 to the year 2011. These specific countries were chosen because not only do their obesity levels vary percentage-wise (34.6% to 2.7% of population), but so do their socioeconomic status ($38,929 to $6,715 GDP per capita); this diversity allows us to create a better model. The purpose of the study was to see if there is one major reason for the rise in obesity levels which have occurred over the past several years or if it was a combined effect of several factors. While the data is mostly complete, there is some missing data from a few of the countries.

The dependent variable is the level of obesity, measured as a percentage of the countries' overall population. This data was collected from the DataMonitor database, which is an independent company that specializes in data collection and analysis. The percentages from 2000 to 2002 were not found for Germany and Ireland.

The independent variables consisted of GDP per capita, confectionary consumption, alcoholic beverages consumption, non-alcoholic beverages consumption, pharmaceutical expenditures, car consumption, and the antibiotic ban placed on their use on livestock. All variables were chosen as a reflection of the literature that has been reviewed and discussed in the above section.

GDP per capita is an important factor to the level of obesity, because the richer the nation, the more money that can be spent on helping those already inflicted with obesity. This could include bariatric operations, such as gastric bypass surgery which involves shrinking the stomach through stapling. Since this operation is quite pricy (between $18,000 and $35,000), though most insurance companies will aid individuals with their expenses, typically only richer individuals can afford this (Dr. Hutcher, 2010). Not to mention that gym memberships are not cheap, so only those with higher disposable incomes get a chance to exercise more. Money could also be spent on preventive methods; for instance, teaching young children the importance of exercising, as well as learning healthy eating habits. Overall, a higher GDP per capita should allow a country to fight off obesity. This data was collected from the DataMonitor database; data was complete for all countries and all years

Confectionary foods, alcoholic beverage, and non-alcoholic beverage consumption (per capita) measures were meant to reflect the sugar consumption that a country consumes. These measurements were relevant because sugar often times leads to weight gain; sugar is burned off by the body the fastest, leaving the excess fat in the body to be stored in the fat cells. Also, sugar has very addictive properties that may lead to the over consumption of fatty/sugary foods. Thus, the higher the sugar consumption in a country, there should be a higher level of obesity as well. The reason for using alcoholic and non-alcoholic beverages in addition to confectionary foods is because these items also contain sugars that people tend to ignore. Confectionary food consumption consisted of expenditures on sugar confections, chocolate, cereal bars, and gum. Non-alcoholic beverage consumption consisted of expenditures on drinks such as carbonates, juices, tea, coffee, smoothies, etc. Alcoholic beverage consumption consisted of expenditures on alcoholic drinks such as beer, cider, brandy, liqueurs, wine, etc. The data were measured in expenditure per capita from the DataMonitor database; data was complete for all countries and all years.

Another measure that was appropriate to consider in the model was the use of antibiotic use in both individuals and in livestock. Not only do antibiotics kill off the bad bacteria in our bodies, they also tend to kill off the good bacteria (microbiome), especially those that help us digest our food. This measure was represented by pharmaceutical expenditures per capita, so we could assume that the more money spent on pharmaceuticals, more antibiotics would be consumed, and obesity rates would rise. The data was collected from the OECD but unfortunately, the OECD database only held information from the years 2000-2009 for all of the countries. One should also note that pharmaceutical expenditures encompass more than just antibiotic consumption; therefore it may not be a completely accurate measurement of the antibiotic use.

An additional measure of antibiotics is through its use amongst livestock. By consuming livestock that have been treated with high amounts of antibiotics, people can absorb the antibiotic properties, thus furthering the destruction of the microbiome and aiding the rise in obesity levels. If a ban was placed on the use of these antibiotics on livestock, overtime we would be consuming less antibiotics, and thus digest our foods better. The utilization of antibiotics was measured by looking to see if each of the countries had placed a ban on their use during the times being reviewed (2000-2011), zero if there was no ban in a given year, and one if there was a ban put in place. Australia, Japan, Mexico, and the United States did not place bans on their use from 2000-2011, while the EU (France, Germany, Ireland, and the United Kingdom) placed bans in the year 2006. The Republic of Korea did not place a ban on antibiotic use until the year 2011.

I also decided to control for walking, by finding the motor vehicle consumption in each country. Typically, the more a person walks as a form of transportation he is burning off more calories, and thus has a less likelihood of becoming obese. In less developed countries, and in certain areas of the country, motor vehicle transportation is considered a luxury, thus walking is the main form of transportation. Hence, it could be proposed that areas that do not have transportation amenities would have larger rates of obesity. Data was collected from the World Bank as the number of motor vehicles (cars, buses, and freight vehicles) consumed per 1,000 people. The World Bank only had measurements for the years 2008, so that number was kept constant for all years for each country; data was complete.

The Model and Results

Simple Regression

An initial regression was run on the following model:

Obesity level = f(GDP per capita, Confectionary Expenditure, Alcoholic Beverage Expenditure, Non-Alcoholic Beverage Expenditure, Pharmaceutical Expenditure, Car Consumption, Antibiotic Ban)

This initial regression was overall significant, given that the F-statistic, 8.82, had a p-value of 0. Looking at a 1% and 5% significance level, only GDP per capita, confectionary expenditures, alcohol expenditures, pharmaceutical expenditures, and the antibiotic ban turned out to be significant (Exhibit 1). After running a VIF test, it was clear that there is definite multicollinearity (Exhibit 2); this needs to be taken into account while interpreting the results since it could cause the coefficients to be incorrect. Alcoholic beverage consumptions stated that the opposite of what was expected; that an increase in consumption would cause the obesity level to decrease. While the overall model was rather significant, after running a Breusch-Pagan test to check for constant variances, it is clear the model needed to be fixed for heteroskedasticity (Exhibit 3).

Robust Estimation

Due to heteroskedasticity, a robust estimation regression was run; the results can be seen in Exhibit 4. The model turns out to be significant as do most of the variables, except the non-alcoholic beverage and car consumption variables. All coefficients appear to be showing the expected sign, except the alcoholic beverage consumption variable. It appears that with an increase in alcoholic beverage consumption, there will be a decrease in the level of obesity. One would think that the more alcohol a person consumes, the more sugar he is consuming, and therefore the larger the individual.

Logged Regressions

Since the obesity levels were in percentages, to fix for proportionality, I took the natural log of the data set. Upon logging the data set, another regression was done (Exhibit 5). Again, the overall model was rather significant (Prob>F = 0). As for the individual variables, all but the car consumption were significant at the 1% and 5% level. Since I used a fixed number to measure the motor vehicle consumption, it does not truly represent how much walking, or lack thereof, is in each country during the specified years. Plus, in both regressions the variable proved to be vastly insignificant (p-value extremely close to 1). Also, looking at the correlation matrix (Exhibit 6) it is heavily correlated with both GDP per capita and the pharmaceutical expenditures. Due to this collinearity, a slight change in one of the variables could drastically overestimate the change in the obesity level. Thus I chose to drop the variable altogether and see how the model would be changed, if at all.

Without the car consumption variable, the regression that was run proved to be significant yet again and all the variables were significant at the 1% significance level (Exhibit 5). Even so, alcoholic and non-alcoholic beverage consumption yielded unexpected coefficient signs; they have a negative impact on the level of obesity. Pertaining to the alcoholic and non-alcoholic beverages, the reason for these estimates could be because the sugar level content may not be large enough to actually affect a person's weight. Also, drinking extreme amounts of liquid at one time typically 'fills a person up,' causing them to not be hungry so they consume less food items. Looking at the correlation matrix (Exhibit 6), these variables are highly correlated with the confectionary food expenditures. Therefore, these variables may be overstating the consumption of sugars and thus could drastically be affecting the coefficients of the model.

Another explanation for the negative effects alcoholic and non-alcoholic beverages have on obesity levels could be due to the countries that were chosen. Each of these countries all have different cultures; so while it may be appropriate to consume mass quantities of alcohol in France (and therefore spend more money towards these areas), for instance, those in the Republic of Korea may frown upon doing so. At the same time, many French people tend to have a healthier diet, exercise more, and thus will have a lower percentage of obese people.

To see exactly how each variable individually, coupled with confectionary expenditures, affects the model a regression was run with just the alcoholic beverage consumption, and another one with just the non-alcoholic beverage consumption (Exhibit 5). Both regressions have strong F-stats, and therefore are quite significant; as are the variables at the 1% and 5% significance level. These variables are definitely strongly correlated with the confectionary expenditures; by omitting either of the variables, the coefficient for the confectionary expenditures drops, though more so when the alcoholic beverage expenditures were omitted.

Looking only at the results that include the non-alcoholic beverage expenditures (Exhibit 5), one can see that there is a positive relationship between non-alcoholic expenditures and obesity levels, consequently supporting our hypothesis; a 1% increase in these expenditures will cause a 1.15% increase in the obesity levels. This is most likely the case because most people view these beverages, such as juices, as healthy and so tend to consume more of it. However, they do not realize that they are high in sugars, and therefore aid in the accumulation of fat.

Alcoholic beverage expenditures, on the other hand, appear to have a negative effect on the obesity level which contradicts the hypothesis; a 1% increase in these expenditures will cause the obesity level to decrease by 1.15% (Exhibit 5). This can be attributed to the fact that alcohol in and of itself may not promote weight gain. Since it is usually consumed in mass quantities within a short span of time, and the drinker will most likely not be eating simultaneously, he will be expending more calories than consuming. If this process is performed on a daily basis, over time this will add up and he may even lose weight due to malnutrition. Another reason for this is due to the fact that many of the chosen countries belong to the EU; alcohol in these countries is much more expensive than many others. Therefore expenditures many be high in these countries, not necessarily because these countries are drinking more alcohol, but because they are paying more for the alcohol that they are in fact consuming. At the same time, these people tend to be slimmer since they have a healthier lifestyle, thus throwing off the model.

On the other hand, when regressions are run with only the non-alcoholic beverage expenditures, with only alcoholic beverage expenditures, and then the two variables together (all regressions excluding confectionary goods expenditure), the coefficients turn out to be positive (Exhibit 7). As a result, an increase in these expenditures does in fact lead to a higher level of obesity in a country. So then why are the regressions containing the alcoholic beverage and confectionary expenditures the opposite? It appears that there is a particular point in alcohol consumption where it will stop increasing a person's obesity level, and instead lead him towards malnutrition, thus less weight gain. Since there is no way to measure this point exactly, this separation could be the reason for the wrong coefficient sign.

Additionally, after running another Breusch-Pagan test we find that we Fail to Reject Ho, meaning that the variances are constant, thus fixing the heteroskedasticity problem (Exhibit 8).

Logged-Aggregate Regressions

Because all of these expenditures were correlated with one another, and have varying results, I proceeded to aggregate the data to see how that would affect the model; results can be seen in Exhibit 9. By aggregating just the confectionary expenditures and the alcoholic beverage expenditures, it is apparent that the coefficient (lncnftalc) is positive; a 1% increase in the confectionary and alcoholic beverage expenditures will cause a .708% increase in the obesity level. Looking at the aggregation of the confectionary and non-alcoholic beverages expenditures, lncnftnalc has a positive effect on the obesity level; a 1% increase in confectionary and non-alcoholic beverage consumption causes a 1.87% increase in the obesity level. The aggregation of the alcoholic and non-alcoholic expenditures (lnalcnoalc) also has a positive effect on the level of obesity; 1% increase in the level of beverage consumption causes a 1.07% increase in the obesity level. When we aggregate all expenditures, we can see again that the coefficient, lnsugrexp, is positive yet again; a 1% increase in all sugar consumption causes a 1.09% increase in the level of obesity. Therefore we can see that the consumption of sugar, through these measures, does impact obesity in a positive way. Yet when they are viewed individually, alcohol beverage consumption has a negative effect, which must be due to the opposite effects alcohol has on an individual.

Change-in Regression

I performed a Durbin-Watson test, to see if there was any autocorrelation. Due to the format of the data and the way in which the STATA program works, I needed to do individual tests for each country. The results can be viewed in Exhibit 10. The d-statistics for the countries range from about .09 to .58. Since all these values are close to 0, it is clear that positive autocorrelation exists.

Since autocorrelation exists, Dickey-Fuller tests were run on each variable to check for stationarity. Again, due to the workings of the STATA program and the layout of the data, these tests needed to be run for each country individually (Exhibit 11). For each of the countries, the D-F test statistics were larger than the critical values resulting in non-stationarity.

Due to this stationarity problem, the data was transformed again into 'the change in' and another regression was run. Unfortunately, the regression proved not to be significant at the 10% significant level with the F-stat having a p-value of .277 (Exhibit 12). On the other hand, the model still had potential; non-alcoholic beverage expenditure (clnnalcex) and pharmaceutical expenditures (clnpharm) are significant at the 11% significance level.

Yet another Breusch-Pagan test was run again (Exhibit 13) and this time we Reject H_o. Therefore the variances are not constant and we have heteroskedasticity; the model cannot be used.

Regressions: Individual Year

Since stationarity is clearly a huge problem, I attempted to run regressions on each year separately. By doing this, the data would no longer be a time-series and therefore, stationarity would no longer be a problem. However, there were not enough observations in each given year, for these regressions to be significant.

Fixed Effect Model

Since there was not enough data to run regressions for each year, to control for the omitted variables in the panel data I chose to run a fixed effect regression. As can be observed in Exhibit 14, the model is quite significant. However, only pharmaceutical expenditures and the antibiotic ban were significant at the 1% and 5% level, respectively. Both coefficients are positive stating that these measures will cause an increase in the level of obesity. While this may be what is expected for the pharmaceutical expenditure variable, the antibiotic ban was predicted to have a negative effect on the obesity level.

IV. <u>Conclusion</u>

Overall while each of the models has a few drawbacks, they all reveal relatively the same results; all of which was what was predicted. Sugar consumption (as measured the confectionary, alcoholic, and non-alcoholic beverages combined), and the consumption of antibiotics (measured by pharmaceutical expenditures) all have a positive effect on the level of obesity. Also, GDP per capita and the antibiotic ban have a negative effect on the obesity level. Looking closely at the coefficients, it is clear that no one variable has an overwhelming effect on a person's level of obesity; all variables contribute fairly the same. Therefore in an effort to reduce society's overweight problem, we need to make a conscious effort to lead a healthier lifestyle. All nations need to stray away from the processed foods they have become so attached to, as well as the antibiotics that are relied on so heavily. While this may be easy to say, this cannot be done with a simple snap of the fingers. Such a drastic switch is quite costly, so an effort to improve the economies of all nations, and thus their standard of living, is a must. By doing so individuals' health will improve, the need for medicine dies down, and they will be able to afford a healthier diet. If all this can be accomplished, obesity levels will decrease, and the world would be a happier place.

V. **Further Analysis**

In the future I would like to expand upon my analysis in several ways. For one, I would like to gather information on many more countries. It is clear that my data set was rather small, and thus my results may not be truly as explanatory as I had hoped. Another factor that I would like to explore more would be the difference the explanatory variables have among cultures. Since there are so many cultures, individuals' outlook on life may be different, and thus provide different results from what was discovered. In addition, I would also like to take a closer look at the effects of processed foods, especially in regards to fast food. While my study did not lead to a particular variable effecting obesity levels the most, it would be interesting to see if the addition of this variable would change that.

Appendix

Exhibit 1: Simple Regression

Explanatory Variables	Coefficients	t-statistics	Regression Statistics	
gdpcap	-0.0011238	-5.08*	R-Squared	0.4583
cftnryex	0.267367	2.93*	Adj R-squared	0.4064
alcexp	-0.0201346	-3.54*	F(7, 73)	8.82
noalcexp	0.0389395	1.65	Prob > F	0
phrmaexp	0.0204476	2.08+	n	81
carexp	-0.0002347	-0.02		
antbiobn	-8.753797	-2.77*		
Intercept	13.80029	3.61		

*1% significance level, + 5% significance level

Exhibit 2: VIF Test

Variable	VIF	1/VIF
cftnryex	31.8	0.031444
alcexp	13.39	0.074661
noalcexp	13.26	0.075437
carexp	6.67	0.149835
gdpcap	5.82	0.17171
phrmaexp	4.24	0.235632
antbiobn	1.82	0.549704
Mean VIF	11	

Exhibit 3: Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of totoblvl

chi2(1) = 9.30
Prob > chi2 = 0.0023

Exhibit 4: Robust Estimation

Explanatory Variables	Coefficients	t-statistics	Regression Statistics	
gdpcap	-0.0011238	-5.01*	R-squared	0.4583
cftnryex	0.267367	3.85*	F(7, 73)	10.59
alcexp	-0.0201346	-3.96*	Prob > F	0
noalcexp	0.0389395	1.55	n	81
phrmaexp	0.0204476	2.64*		
carexp	-0.0002347	-0.02		
antbiobn	-8.753797	-2.85*		
_cons	13.80029	4.01		

*1% significance level

Exhibit 5: Logged Regressions with Discrete Changes

Explanatory Variables	Coefficients (t-statistics)			
	1	2	3	4
lngdpcap	-2.258735	-2.25876	-2.209335	-2.308905
	(-11.24)*	(-12)*	(-8.32)*	(-11.33)*
lncftex	4.211604	4.211452	0.620909	2.691518
	(-6.91)*	(-9.54)*	(-2.87)*	(-13.59)*
lnalcex	-2.306735	-2.306645		-1.522033
	(-6.33)*	(-8.68)*		(-8.44)*
lnnalcex	-1.457672	-1.457585	1.150954	
	(-3.2)*	(-3.78)*	(-3.39)*	
lnpharm	0.8067846	0.8067307	0.6242101	0.6891078
	(-3.54)*	(-4.7)*	(-2.6)+	(-3.76)*
carexp	-3.14E-07			
	(0)			
antbiobn	-0.3481295	-0.3480989	-0.400906	-0.3138549
	(-2.23)+	(-2.66)*	(-2.18)+	(-2.22)+
Intercept	25.3175	25.31747	11.67852	19.69053
	(-12.84)	(-12.94)	(-7.1)	-14.27
F-Statistic	43.72*	51.71*	23.6*	50.26*
N	81	81	81	81

*1% significance level, + 5% significance level

Exhibit 6: Correlations

	lnoblvl	lngdpcap	lncftex	lnalcex	lnnalcex	lnpharm	carexp	antbiobn
lnoblvl	1							
lngdpcap	-0.0491	1						
lncftex	0.403	0.7711	1					
lnalcex	0.2657	0.6723	**0.941**	1				
lnnalcex	0.4012	**0.8004**	**0.9325**	0.7803	1			
lnpharm	0.0595	**0.8247**	0.6374	0.5588	0.6791	1		
carexp	0.25	**0.8508**	0.7254	0.5626	0.7705	**0.8075**	1	
antbiobn	0.1077	0.1706	0.3601	0.4008	0.2723	0.2862	0.0356	1

Exhibit 7: Logged Regressions without Confectionary Variable

Explanatory Variables	**Coefficient (t-statistic)**		
	1	2	3
lngdpcap	2.04052	-1.171599	-2.06949
	(-7.53)*	(-3.41)*	(-7.45)*
lnalcex		0.6322041	0.072104
		(3.97)*	0.53
lnnalcex	1.953761		1.890184
	(9.66)*		(8)*
lnpharm	0.506785	0.6357994	0.522306
	(2.05)+	(1.88)+	(2.08)*
antbiobn	-0.21596	-0.245083	-0.25104
	-1.2	-0.94	-1.3
Intercept	8.743465	6.444089	8.847672
	(6.48)*	3.57	6.46
F-Statistic	25.06*	4.87*	19.91*
N	81	81	81

*1% significance level, + 5% significance level

Exhibit 8: Heteroskedasticity (Logged Data)

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of lnoblvl

chi2(1) = 0.24
Prob > chi2 = 0.6252

Exhibit 9: Aggregate Logged Regressions

Explanatory Variables	**Coefficient (t-statistics)**			
	1	2	3	4
lngdpcap	-1.27009	-2.16033	-1.5406	-1.5913
	(-3.73)*	(-8.22)*	(-4.71)*	(-4.91)*
lncnftalc	0.708743			
	(4.43)*			
lncnftnalc		1.877779		
		(10.45)*		
lnalcnoalc			1.065964	
			(5.78)*	
lnsugrexp				1.093731
				(6.05)*
lnpharm	0.644783	0.59521	0.646153	0.653036
	(1.95)^	(0.057)+	(2.09)+	(2.14)+
antibiobn	-0.28406	-0.33871	-0.35778	-0.37534
	(-1.11)	(-1.93)*	(-1.51)	(-1.6)
Intercept	6.804563	9.436261	6.837018	7.029697
	(3.82)*	(7.21)^	(4.18)*	(4.34)*
F-Statistic	5.88*	29.18*	9.48*	10.3*
N	81	81	81	81

*1% significance level, + 5% significance level, ^ 10% significance level

Exhibit 10: Durbin-Watson Statistics

Country	Durbin-Watson Statistic
Australia	0.2455169
France	0.1360914
Germany	0.0913092
Ireland	0.1938264
Japan	0.1426703
Mexico	0.2101213
Republic of Korea	0.5824778
United Kingdom	0.4791883
United States	0.2455169

Exhibit 11: Dickey-Fuller (Obesity)

Interpolated Dickey-Fuller		
1% Critical Value	5% Critical Value	10% Critical Value
-3.75	-3.00	-2.63

Country	t-statistic					
	Obesity	GDP per capita	Confectionary	Alcohol	Non-Alcohol	Pharmaceuticals
Australia	-0.431	-2.609	-4.97	-3.443	-0.394	-0.663
France	-1.63	-1.543	-3.858	-2.123	1.475	-2.34
Germany	-1.604	-3.714	-4.085	-3.486	-3.615	-0.554
Ireland	-1.353	-1.78	-1.26	-0.578	-2.051	-4.153
Japan	-3.373	-1.471	2.251	1.188	-1.593	-0.507
Mexico	-5.152	-1.338	-0.115	-0.441	4.103	-1.71
Republic of Korea	-3.004	-0.805	0.973	-1.593	1.335	-3.174
United Kingdom	-2.733	-1.969	-4.746	-1.511	0.421	-3.14
United States	-0.431	-2.609	-4.97	-3.443	-0.394	-0.663

Exhibit 12: Change-in Regression

Explanatory Variables	Coefficients	t-statistics	Regression Statistics	
clngdpcap	0.1965913	0.45	R-Squared	0.106
clncftex	0.1785396	0.19	Adj R-squared	0.0235
clnalcex	-0.6904647	-1.09	F(7, 64)	1.28
clnnalcex	1.233001	1.64*	Prob > F	0.277
clnpharm	0.3444991	1.65*	n	72
antbiobn	-0.0104906	-0.43		
Intercept	-0.0190482	-0.65		

*11% significance level

Exhibit 13: Heteroskedasticity (Change-in)

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of clnoblvl

chi2(1) = 41.79
Prob > chi2 = 0.0000

Exhibit 14: Fixed Effect Regression

Explanatory Variables	Coefficients	t-statistics	Regression Statistics	
lngdpcap	0.1051411	0.32	F(6, 66)	19.17
lncftex	0.0624577	0.18	Prob > F	0
lnalcex	-0.1456993	-0.52	R-squared	0.9954
lnnalcex	-0.2106191	-0.59	Adj R-squared	0.9944
lnpharm	0.3941664	3.57*	n	81
antbiobn	0.06229	2.17+		
_cons	1.019725	0.46		

*1% significance level, + 5% significance level

Bibliography

Anderson, Patricia M. "Is Being in School Better? The Impact of School on Children's BMI When Starting Age Is Endogenous." *Journal of Health Economics* 30 (2011): 977-86. *Elsevier*. Web.

Bajzer, Matej, and Randy J. Seeley. "Physiology: Obesity and Gut Flora." *Nature* 444.7122 (2006): 1009-010. Web.

Corwin, R. L., and P. S. Grigson. "Symposium Overview--Food Addiction: Fact or Fiction?" *Journal of Nutrition* 139.3 (2009): 617-19. Web.

Deckelbaum, Richard J., and Christine L. Williams. "Childhood Obesity: The Health Issue." *Obesity Research* 9.4 (2001): 239S-43S. *Econ Lit*. Web.

Goossens, Lien, Caroline Braet, Guy Bosmans, and Veerle Decaluwé. "Loss of Control over Eating in Pre-adolescent Youth: The Role of Attachment and Self-esteem." *Eating Behaviors* 12 (2011): 289-95. Web.

Hutcher, MD., Neil. "Cost of Weight Loss (Bariatric) Surgery." *What Does Bariatric Weight Loss Surgery Cost?* Ceatus Media Group LLC, Jan. 2012. Web. <bariatricsurgeryguide.com/cost/>.

James, Philip T., Rachel Leach, and Maryam Shayeghi. "The Worldwide Obesity Epidemic." *Obesity Research* 9.4 (2001): 228S-33S. *Econ Lit*. Web.

Kan, Kamhon, and Wei-Der Tsai. "Obesity and Risk Knowledge." *Journal of Health Economics* 23 (2004): 907-34. *Elsevier*. Web.

McLaren, Lindsay. "Socioeconomic Status and Obesity." *Epidemiologic Reviews* 29 (2007): 29-48. *Ebsco Host*. Web.

Murphy, Kate. "In Some Cases, Even Bad Bacteria May Be Good." *The New York Times*. The New York Times Company, 31 Oct. 2011. Web.

Philipson, Tomas J., and Richard A. Posner. "Is the Obesity Epidemic a Public Health Problem? A Review of Zoltan J. Acs and Alan Lyles's Obesity, Business and Public Policy." *Journal of Economic Literature* 46.4 (2008): 974-82. *Econ Lit*. Web.

Sobal, Jeffery, and Albert J. Stunkard. "Socioeconomic Status and Obesity: A Review of the Literature." *Psychological bulletin* 105.2 (1989): 260-75. Web.

Ternak, G. "Antibiotics May Act as Growth/obesity Promoters in Humans as an Inadvertent Result of Antibiotic Pollution?" *Medical Hypotheses* 64.1 (2005): 14-16. Web.

Tsai, Franklin, and Walter J. Coyle. "The Microbiome and Obesity: Is Obesity Linked to Our Gut Flora?" *Current Gastroenterology Reports* 11.4 (2009): 307-13. Web.

WHO. "Obesity and overweight." World Health Organization. Web. <http://www.who.int/mediacentre/factsheets/fs311/en/ > .

Yaniv, Gideon, Odelia Rosin, and Yossef Tobol. "Junk-food, Home Cooking, Physical Activity and Obesity: The Effect of the Fat Tax and the Thin Subsidy." *Journal of Public Economics* (2009): 823-30. *Science Direct*. Web.