University of Alberta

Health Behaviour, Dietary Supplements and Obesity: A Propensity Score Matching Approach

by

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science

in

Agricultural and Resource Economics

Department of Resource Economics and Environmental Sociology

Abstract

Despite significant efforts to inform and educate consumers across North America on healthy eating through “easy to follow” dietary guidelines, diet related non-communicable diseases are on the ascendancy. The objective of this thesis is to use the National Health and Nutrition Examination Survey (NHANES) 2007-2008 data to determine how dietary supplement users may differ from nonusers in body mass index (BMI) outcome and how the extent of dietary supplement intake through its effect on diet quality may affect BMI. Propensity Score Matching was used to account for the possible selection bias and endogeneity of the self-reported dietary supplement intake and treatment outcome variable in the NHANES data. The results suggest that the typical dietary supplement taker is a white female of higher socioeconomic status. Other results show that supplement consumption may be associated with significant lower BMI outcomes. However, we fail to confirm a linear relationship between the number of supplements consumed and BMI. Policy makers should intensify the public education on fruit and vegetable consumption to ensure that people largely meet their nutrient needs from food instead of dietary supplements due to the potential negative effect of overuse of dietary supplements.

Acknowledgments

I wish to express my sincerest gratitude to my supervisor Dr. Sven Anders for all the time he took off his very busy schedule to offer constructive criticism for the improvement of this work. I am also very grateful to the Vitamin Fund of the University of Alberta for offering funding to make this study feasible. Special thanks go to my lecturers, department staff and colleagues at the University of Alberta who made my stay in Edmonton a memorable one.

Also I wish to thank all my family members especially my siblings, parents and in-laws not forgetting my very patient husband and daughter who offered various forms of support and encouragement to see me through the program. Finally, I am grateful to Ms. Mary-Victoria Tanye for her immeasurable support during my last days as a student and for proof reading my work for me.

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CHAPTER ONE

Introduction

1.1 Background

Globally, millions of people are living with the chronic health condition of obesity, typically measured by a person's Body Mass Index (BMI) greater than or equal to 30 kg/m^2. Millions of people may yet experience this debilitating health hazard during their lifetime. According to Loureiro (2004), the highest number of obese and overweight people can be found in the United States of America (64.5%) followed by Mexico, United Kingdom and Australia with prevalence rates as high as 62.3%, 61% and 58.4% respectively. Indeed, trends in obesity and overweight rates particularly across North America are worrying as studies reveal that the prevalence rate increased from 14.5% to 22.5% and 64% in the years 1976-1980, 1988-1994 and 1999-2000, respectively (Loureiro and Nayga Jr, 1999; Schroeter, 2004). The escalating health-care costs of obesity and other related diseases posed significant concerns to health professionals and government agencies alike. Efforts to eradicate or greatly reduce the disease has led to significant investments into research aimed at identifying best strategies to resolve its impact on individuals, economies, and societies as a whole. For instance, the World Health Organization together with the Food and Agriculture Organization have organized workshops and seminars geared at coming up with recommendations on food and disease prevention (WHO/ FAO, 2003).

Numerous studies in various disciplines have documented the importance a healthy diet plays in maintaining a good overall health status (Dickson-Spillmann and Siegrist, 2011; Eikenberry and Smith, 2004; Glanz, Basil, Maibach, Goldberg, and Snyder, 1998; Jeffery and Bisogni, 2009). The emphasis on healthy diets, lifestyles and role of food consumption behaviour as contributing to mitigating diabetes, obesity and other connective diseases has alerted governments to take regulatory actions to curb the problem. Many governments around the world have designed and implemented nutrition programs and guidelines to guide consumers' healthy eating choices based on current nutrition knowledge. In North America (U.S. and Canada) for instance, 'My Plate' and 'Eating well with Canada's Food Guide' represents major government efforts to educate and serve as guidelines for improving consumers' food and dietary choices (Health Canada, 2007; U.S. Department of Agriculture 2011). Proper dietary choices and the recommended consumption of food are envisaged to impact on the general wellbeing and health of people and to resolve the numerous poor diet health issues.

Health problems linked to diet such as obesity, diabetes, high blood pressure, elevated cholesterol levels and other chronic diseases are on the increase (World Health Organization, 2011). The joint WHO/FAO expert consultation on Diet, Nutrition and the Prevention of Chronic Diseases reveals that people have shifted from traditional plant based diets to high-fat, energy-rich diets originating from animal sources (Drewnowski and Darmon, 2005b; Nestle and Jacobson, 2000; WHO/ FAO, 2003). Epidemiological studies have shown that fruits and vegetables (F&V) form part of a good diet and hence, play an important role in the prevention of chronic diseases including certain cancers, cardiovascular disease and obesity (Agudo, 2005; Keen and Zidenberg-Cherr, 1994; Pérez, 2002).

Chronic diseases, especially cancer, diabetes and obesity, are among the leading causes of death in the world. In 2011, between 87-89% of all deaths in Canada and U.S. were attributed to chronic diseases (World Health Organization 2011). Research reveals that many ailments including obesity and other chronic diseases are largely preventable. Their prevention can improve the health of people and also reduce the high costs of health care to the tax payer and to governments. Health care funding in Canada is primarily a public good with an average account for up to 9.7% of GDP (Brown and Suresh, 2004; Canadian Institute for Health Information, 2011; OECD, 2011). The Organization for Economic Cooperation and Development has documented that spending on health care in Canada has grown in real terms by 3.7% per year and on the average from 2000-2009 (OECD, 2011). As a nation Canada has made efforts to find ways of reducing the burden of preventing chronic diseases, particularly, obesity. For instance in 2005, a 300 million dollar initiative dubbed as 'integrated strategy on healthy living and chronic diseases' was launched in Canada to address healthy eating, physical activity and healthy weights (Public Health Agency of Canada, 2005). The anticipated result of this strategy was the reduction of the burden of chronic diseases and their cost in Canada. Yet, in 2009, four years after the prevention strategy, the total health expenditure in Canada hiked to 182.1 billion current dollars (Canadian Institute for Health Information, 2011). Although health care is not a public good in the United States it still accounts for a substantial part of the national economic activity. Between 2000 and 2009, the United States witnessed an annual real growth rate of 4.3% in health care cost (OECD, 2011). In 2010, 17.6% of GDP was used for healthcare funding among OECD countries out of which the United States, with the exception of Netherlands and Norway, spends the most public funds per capita on healthcare. However, the findings of the invaluable role of fruits and vegetables and food consumption behaviours have served as a breakthrough for governments initiatives on obesity reduction specifically and disease prevention in general. The World Health Organization has identified behavioural factors like unhealthy diet, physical inactivity, alcohol, tobacco use, and even more importantly low intake levels of fruits and vegetables, to be among the major risk factors that cause chronic diet-related diseases (Ezzati, Lopez, Rodgers, and Murray, 2004; World Health Organization, 2011). The problem of insufficient intake of fruits and vegetables has been identified as one of the top ten risk factors for global mortality (Mathers, Stevens, and Mascarenhas, 2009). It is estimated that 2.7 million people could be saved globally every year from chronic diseases like obesity if sufficient amounts of micronutrients found in fruits and vegetables were regularly consumed (World Health Organization, 2003).

Many developed countries have declared increasing fruit and vegetable consumption a public health policy goal (Bihan et al., 2010). In Canada, there has been the continuous promotion of healthy lifestyles and nutrition habits for many years (Health Canada, 1997). However, only little has been achieved since many Canadians still fall short of the daily recommended 400g intake of fruits and vegetables. More than 67% of Canadians aged 30 years and over do not attain the daily minimum levels of fruits and vegetables consumption as recommended by *Canada's Food Guide* (Garriguet, 2006). Similarly, in the United States only 40% of Americans are able to meet the recommended daily servings of fruits and vegetables (Guenther, Dodd, Reedy, and Krebs-Smith, 2006). As a result many North Americans are suffering from micro-nutrient deficiencies with implications as far reaching as economic development and productivity, public health care cost and loss in human capital formation (Allen, De Benoist, Dary, and Hurrell, 2006).

The declining consumption of produce in North America which is the main source of micronutrients is partly attributed to the changing socio-demographics and shift to convenience foods (Lisa Mancino, Todd, and Lin, 2009; Stewart, Blisard, and Jolliffe, 2003). Many people who want to improve the micro-nutrient content of their diet resort to taking dietary supplements as a substitute for the consumption of fruits and vegetables (Pole, 2007). Dietary supplements are products containing vitamins, minerals, amino acids, and other nutritional substances that are used to enrich the dietary intake of people. A more formal definition of the term 'dietary supplement' is given in chapter three of the thesis. Dietary supplement use has been on the ascendancy for the past two decades (McNaughton, Mishra, Paul, Prynne, and Wadsworth, 2005). It has been asserted that many people, especially those with little time for home-meal cooking or culinary skills may find dietary supplements to be a convenient substitute to eating fresh fruits and vegetables (Schroeter, Anders, Carlson, and Rickard, 2010). This trend has been helped by the fact that dietary supplements have the potential to improve the micronutrient content of diets poor in nutrients (Vatanparast, Adolphe, and Whiting, 2010). Other studies also suggest that dietary supplements may be used to enhance dietary quality and prevent certain diseases (Chandra, Miller, and Willis, 2005; Pole, 2007; Troppmann, Gray-Donald, and Johns, 2002). The positive effects of dietary supplement intake however, has not been supported by all studies (Mursu, Robien, Harnack, Park, and Jacobs Jr, 2011). Optimal supplement intake levels are a controversial issue among experts and some randomized control trials have revealed that supplementation may not be beneficial after all (Frank, Bendich, and Denniston, 2000). Recent findings by Klein et al. (2011), Mursu et al.(2011), and Wang (2011) suggest that supplement intake may occasionally be unwarranted and may even be detrimental to human health. Given that much of the research evidence on supplement use is inconclusive, it is alarming that most people who take dietary supplements do so without the counsel of a medical professional (Institute of Medicine, 2005). Moreover, the American Academy of Nutrition and Dietetics (formerly called American Association of Dietetics) emphasizes that the best way to promote good health and reduce the probability of certain diseases is to consume a variety of diets. Again, the Academy also recognizes that supplementation may be necessary where there is evidence that specific segments of the population(e.g. at-risk population) need it to meet their nutrient requirements (American Dietetic Association, 2001).

What is actually not clear is whether people are complementing a healthy diet with supplements or replacing a healthy diet with supplements. If dietary supplements are taken to complement an unhealthy diet, then encouraging the use of specific supplements for certain at risk population groups may be needed. However, if supplements replace a healthy diet in the general population, an additional intervention might be needed to encourage the intake of nutrients from food instead of supplements.

1.2 The Economic Problem

Obesity has witnessed over 50% growth in the last three decades (Chou, Grossman, and Saffer, 2004) and it is regarded as a major threat to public health in the United States (Baskin, Ard, Franklin, and Allison, 2005). It is estimated that more than 30% of adults in the United States are obese (Baskin et al., 2005; Ogden, Carroll, Kit, and Flegal, 2012). The rising incidence of obesity has also resulted in an increase in obesity related diseases such as high blood pressure, type-2-diabetes and certain cancers. The impact of rising obesity on the economy of countries with epidemic dimensions of obesity include increasing health care costs, reduced economic output and reduced productivity (Allen et al., 2006; Ludwig, 2009; Rosin, 2008). According to Thorpe, Florence, Howard, and Joski (2004), increases in obesity alone accounted for 12% of the escalation in health expenses between 1987 and 2001 in the U.S. The burden of increasing health expenses is ultimately passed on to tax payers in the form of higher insurance premiums (Rosin, 2008). Some economic studies suggest that people who are obese averagely spend more on prescription drugs than normal weight people and obese women especially face discrimination in the labour market (Averett and Korenman, 1993). Even though genetics appears to play a crucial role in determining an individual's propensity to become obese, some research suggest that changes in genes occur very gradually and can therefore not be made responsible for the escalation in obesity rates across North America (Rashad and Grossman, 2004). Behavioural patterns such as a balanced diet (including a sufficient consumption of fruits and vegetables), physical exercise, and other lifestyle factors can help to reduce the risk and impact of diet-related diseases(WHO/ FAO, 2003). Research shows that most Americans do not meet the recommended intake levels of fruits and vegetables (Guenther et al., 2006) and people appear to increasingly substitute fresh fruits and vegetables for dietary supplements (Pole, 2007). This substitution of fruits and vegetables for dietary supplements is an important area worth investigating due to the rapid growth in the dietary supplement industry in North America.

However, the beneficial effect of dietary supplement intake has not been supported by many studies (Frank et al., 2000) and dietary supplements may or may not have any effect on the dietary quality of people. Many people who take dietary supplements do so without a doctor's advice (Institute of Medicine, 2005). Dietary supplement consumers may therefore rely on information from the producers of supplements. However, consumers may not have access to perfect information on dietary supplements and its potential effect on their health. This information asymmetry problem could lead to serious health consequences on the unassuming consumer due to the possibility of being misled about the efficacy and safety of the supplements (Blendon, DesRoches, Benson, Brodie, and Altman, 2001).

1.3 Research Objectives

The main objective of this thesis is to examine consumer health behaviour, dietary supplements and obesity. Specifically,

- Which factors influence a person's probability of taking dietary supplements?
- Do supplement takers and non-takers differ significantly in terms of key diet-health status outcomes such as in BMI?
- Does the number of supplements consumed impact the principle relationship between supplement consumption and BMI?

1.4 Relevance of the Study

A deeper understanding of the socio-economics of obesity and the factors influencing diet health behaviour are needed in the U.S. There is very little economic research on role of dietary supplements in the consumption of healthy diets in the U.S.(Schroeter, Anders, and Carlson, 2013). To the best of our knowledge, no economic study has used the Propensity Score Matching Approach (PSM) to determine the possible link between dietary supplement intake, food quality and obesity. Dietary Supplement intake per se, does not directly affect BMI but could impact food quality which may in turn influence obesity measured by BMI indicator. Such knowledge creation may help to develop a clearer understanding of the factors that impact dietary supplement intake and lead to a more efficient and effective promotion of healthy food choices and targeted consumer health and lifestyle education. Not only these, it is also important to document if differences exist between supplement takers and non-takers because of the possibility of information asymmetry in the health claims and advertisements of supplements. According to Blendon et al. (2001), it is possible that the public could be misled about the safety of supplements.

Finally, new and reliable empirical results on consumer's diet-health concerns, food behaviour and preferences affecting dietary supplement use patterns will aid in the development of market forecast and recommendations to research, industry and policy decision makers in both the health and food policy fields.

1.5 Organisation of Study

This thesis is organized into seven chapters. Following the introductory chapter, Chapter two presents a review of literature on consumer diet-health behaviour, socio-economic factors affecting food choices, dietary guidelines and obesity. In

Chapter three, the dietary supplement industry in the U.S. is discussed in detail. The fourth Chapter discusses the theoretical model framework for analysing consumer health behavior in the context of food consumption decisions and health. The next chapter is devoted to the dataset used in the empirical analysis. The National Health and Nutrition Examination Survey (NHANES) 2007-2008 is discussed in detail and the variables selected for the empirical model are described. Then in Chapter six, the empirical model results are presented and discussed. The concluding Chapter, summarizes the model results, suggests recommendations for policy actions and identifies limitations of the research.

CHAPTER TWO

Literature Review

2.1 Introduction

The preliminary part of this chapter introduces some of the complexities surrounding food consumption decisions including how socio-demographic and other socio-economic factors could affect food consumption decisions. Apart from that, studies investigating food and health linkages together with how perceptions, attitudes and information affect food consumption are discussed. Finally, an attempt is made to understand obesity and the role of dietary guidelines and other government policies could play in obesity management.

2.2 Dimensions in Consumer Food Behaviour

2.2.1 Complexities in Food Consumption Behaviour

The driving forces behind human food consumption behaviour have been of interest to economists for a long time. They have employed different means ranging from economic experiments, revealed preferences, scanner data, conjoined analysis etc. to bring out the underlying factors of human food consumption. The factors underlying why people eat what they eat may best be described as multifaceted (Jeffery and Bisogni, 2009). Food consumption behaviour is very complex and varied among different groups of people. For instance culture, ethnic origin, country of residence and other socio-demographics could strongly impact what people choose to eat. The review of literature in this section focuses on studies that have looked at how food consumption is affected by socio-demographics, socio-economic, lifestyle, and other factors. These include studies on the consumption of different types of food like fruits and vegetables, meat, eggs, dairy product, fast foods, soda etc.

Pollard, Kirk, and Cade (2002) in their review of literature on the factors affecting fruit and vegetable consumption, came out with nine influencing factors: availability, monetary cost, time constraints, sensory appeal, familiarity, social interactions, personal ideology, media and advertising, and health. According to them availability, monetary cost, and time constraints influence what a person is actually able to buy whilst time constraint, sensory appeal, familiarity, social interactions, personal ideology, media and advertising, and health influence what a person actually chooses to buy and consume. They also cited that socio-demographic and lifestyle factors affect the consumption of fruits and vegetables. For instance, people who were found to have higher education, higher income and higher social status had higher consumption of fruits and vegetables than their counterparts who did not have these credentials. Also women and older adults recorded greater consumption of fruits and vegetables than younger people and males. In a related study by Riediger, Shooshtari, and Moghadasian (2007) on the consumption of fruits and vegetables by adolescents in Canada, they showed that both household education and income independently had significant positive effects on the consumption of fruits and vegetables. According to them, males, older adolescents and adolescents living with only one parent reported significant lower intakes of fruits and vegetables. These associations are not limited to the fruit and vegetable market.

In other food consumption studies, consumption has also been associated with several socio-demographic, lifestyle and religious factors. For example, in the United States, people in households with higher income were found to consume more chicken than those from lower income households (Guenther, Jensen, Batres-Marquez, and Chen, 2005). Also, those from lower income households consumed more processed pork products (Guenther et al., 2005). The same study reported that being female and having a higher educational level was linked to a lower likelihood of consuming beef, pork and chicken. Anders and Mőser (2010) have documented that, other factors like health attributes could affect the consumption of beef. This link between health attributes and food consumption is discussed in more detail in the next section.

In an earlier study on the consumption of different categories of food by Tepper, Choi, and Nayga (1997), whole fat dairy product and egg consumption was positively related to bigger households. People who consumed typical American diets were also found to be more likely to consume eggs and whole fat dairy products than those from other dietary backgrounds. Even though the consumption of fats and oils was more predominant among higher income earners, the relationship between income and fats and oil consumption was negative. Also, income was positively related to beef and cured meat consumption. Additionally, people who had little nutrition knowledge were found to be more likely to consume fast food and younger people were also more likely to take soda. Finally, dietary restraint played a key role in determining the food choice of people in the sample.

Another factor that has been found to affect food decisions of people is information on the nutrient content of the food (nutritional labelling). Two types of nutritional labelling have been cited in the economic literature: mandatory and voluntary labelling. Mandatory labelling is usually enforced by governments to compel producers to provide specific information to consumers. Voluntary labelling however is used by producers to convey other relevant information to consumers. According to Drichoutis, Lazaridis, and Nayga (2005) socio-demographics play a crucial role in nutritional label use which in turn affects the food purchase decisions of people. In an earlier study, nutritional label use was found to be positively associated with larger households, females, whites and older people (Nayga 1996). Older persons were also said to be more likely to consider the nutritional information on the health benefits, fat and cholesterol levels of food before purchase. The reason assigned to the gender difference in nutritional label use was the fact that women are perceived to be more concerned about their diet and health as compared to men.

2.2.2 Food Consumption Behaviour and Health

Consumer food consumption behaviour could be affected by the belief that some food products may be more healthy or helpful than others. It is common knowledge that whole cream milk products contain more fat than skimmed milk and therefore are less healthy in terms of excess fat consumption. Similarly, there is a clear distinction between high calorie products and similar products with lower calories in the grocery shops. For instance, it is very easy to distinguish low sugar content coke or diet coke from the regular brand. These distinctions notwithstanding, many people still consume diets with high calorie content (WHO/ FAO, 2003). The increasing calorific content of diet is said to be one of the major causes of obesity (Rodolfo M. Nayga, 2008).

The amount of nutrients contained in food has been described as a credence attribute because the consumer cannot evaluate it even after consumption (Darby and Karni, 1973). Consumers can only get nutritional information from labelling which is more of a search attribute (Darby and Karni, 1973). Some of these search attributes have been used to study how people react to product consumption in the presence of health information. Socioeconomic indicators have been found to be associated with healthier food behaviour (Cawley and Ruhm, 2012). According to Hearty, McCarthy, Kearney, and Gibney (2007), being female, higher age, higher social status, higher education, non-smoker, lower body-weight and higher physical activity provides a higher probability of healthy eating behaviour. In a study that used market level scanner data to determine the association between various socioeconomic factors and choice of salad dressing, it was observed that people who had lower levels of education, lower income, males and elderly people buy high fat salad dressing without labels (Mathios, 1996). In a related study in the cheese market, Øvrum, Alfnes, Almli, and Rickertsen (2012) performed a choice experiment to determine the effect of being exposed to health information on the consumption of hard cheese. Their results revealed that even though both the experimental and control group had preferences for low-saturated-fat, low-fat and organic cheese over an alternative brand of cheese, being exposed to the health information at the start of the experiment significantly affected the choice for low-fat cheese. Indeed, participants who were privy to the health information at the beginning of the experiment were willing to pay a higher premium price for low-saturated-fat cheese as compared to those in the control group. For instance, the experimental group was willing to pay as much as 1.73 and 2.89 times more for low-saturated-fat cheese and low-fat-cheese respectively. In another study on the consumption of beef in Canada using the Nielsen household and retail-level scanner data, it was discovered that Canadian consumers incorporate fat content and health concerns into their demand for ground meat (Anders and Mőser, 2010) . In the case of extra lean ground beef, they found that retail demand was driven predominantly by health, price and habitual eating routines. They concluded that when given a choice Canadians would rank health over taste.

In conclusion, there is also some research that suggests that the advice of a physician has an effect on the eating behaviour of consumers. Loureiro and Nayga (2007) showed that the advice of a physician had a significantly positive effect on the probability of consuming fewer high fat or high cholesterol diets and fruits and vegetables.

2.2.3 Nutrition, Diet Diversity and Diet Quality

Good nutrition is fundamental to attaining good health. All over the globe, many governments are spending a lot of money in trying to reach out to people on the importance of good nutrition. In North America, there have been dietary guidelines that have been revised over the years to reflect current nutrition knowledge in order to improve the quality of diets consumed over time. It is known that consuming a variety of diets (diet diversity) is crucial to dietary adequacy (Bernstein et al., 2002). However many American consumers make their food choice decisions based on price, taste and convenience instead of health and diet diversity (Glanz et al., 1998). As a result of this and other factors, the diets of most people in America are said to be in need of improvement especially in fruits and vegetables and also for certain segments of the population (Lino, Basiotis, Anand, and Variyam, 1999). Kennedy (2004) used national level data in ten countries to explore the relationship between diet diversity, household food expenditure per capita and household calorie availability per capita. In all ten countries studied, there was a significant positive relationship between diet diversity and household per capita expenditure and per capita calorie availability for both rural and urban areas. Among the American sample, there was a positive relationship between diet quality and the healthy eating index (HEI).

This healthy eating index was developed by the Center for Nutrition Policy and Promotion of the United States to monitor the diets of Americans against the set guide lines (Basiotis, Carlson, Gerrior, Juan, and Lino, 2004; Variyam, Blaylock, Smallwood, and Basiotis, 1998; Variyam and Smith, 2010).

The healthy eating index has gone through transformation from the ten components that reflect the constitution of a healthy diet (Basiotis et al., 2004) to twelve components as contained in the HEI-2005 (Andrea Carlson, Lino, Fungwe, and Guenther, 2009). The components of the HEI are scored and they add-up to 100. A higher score usually represents a diet of higher quality. Since the advent of the HEI, many studies have used it to assess the dietary quality of Americans and elsewhere.

In the years 1999-2000, only 10% of Americans were said to be consuming a good diet as measured by the healthy eating index (Basiotis, Carlson, Gerrior, Juan, and Lino, 2002). The rest of the population either had a diet that needed improvement (74%) or had a bad diet (16%). Socio-demographics have been found to play a vital role in dietary quality. Generally, females, children (<11 years), older persons and non-Hispanic whites have been observed to have higher healthy eating index (Basiotis et al., 2002). People with lower incomes and education have also been identified as those consuming lower quality diets. Similar findings have been reported in Canada and France on diet quality. Drescher and Goddard (2008) analyzed the overall diet quality in Canada and found that higher income, age, female and higher education were positively associated with food diversity. In a large cohort of French adults Drewnowski, Fiddler, Dauchet, Galan, and Hercberg (2009) reported that higher HEI values were related to age, education, physical activity and being a non-smoker. Similar associations were reported on diet quality in the United States using NHANES 2003-2004 (Schroeter et al., 2013). There have been suggestions that higher income and higher educated people have higher quality diets because income and education are interwoven with other factors that result in access to better information on nutrition and thus diet quality (Variyam, Blaylock, and Smallwood, 1998). Indeed, nutrition label use has been found to result in higher diet quality of users as against non-label users (Kim, Nayga, and Capps, 2001)

Apart from the socio-demographics, some studies also suggest that eating certain meals or skipping meals could have a negative effect on diet quality. Carlson et al. (2009) suggest that skipping breakfast and lunch will reduce diet quality by three points per meal. According to Mancino and Kinsey (2008), extending time between meals or eating-out would result in consuming more calories from fats, alcohol and sugars and thus reduce the quality of the diet. A lower quality diet is associated with higher BMI (Duffy, Zizza, and Kinnucan, 2009).

2.2.4 Food Cost and Food Choice Decisions

Economic theory suggests that the price of a good can have an effect on its purchase. The fact that higher cost has been found to be associated with healthier eating may mean that lower income households cannot afford healthier food. According to Drewnowski and Darmon (2005b), the rapid increase in the cost of fruits and vegetables as against other foods from 1985-2000 may in part explain why eating a higher quality diet is still a mirage to the poor. Their study reveals that where as the cost of fresh fruits and vegetables increased by 120% during the fifteen year period stated above, other products such as soft drinks and fats saw a

20% to 40% increase within the same period respectively. This assertion of lack of affordability of good diet by the poor has however not been proven by all studies. Stewart et al. (2003) showed that even though lower income households spend less on the consumption of fruits and vegetables, an increase in their income does not translate into increased consumption of a more healthy diet including increased fruits and vegetables consumption. In a study by Chen, Liu, and Binkley (2012), they sort to find out how income affects the intake of milk and soft drinks. These two categories of food items were chosen because healthier options exist and they were either no price differences between the healthier brands and not so healthy brands or the healthier brands were cheaper. However, their results suggested that there may be other reasons for the rather poor dietary choices of lower income households. Using the 2005-2006 NHANES data they realized that for two identical individuals who only differed by $10,000 in household income, the higher income person consumed 377 fewer calories from milk in a year. Similarly, the higher income persons consumed 2,555 fewer calories from drinking soft drinks per year. They concluded that cost may not be the only factor in explaining the poor dietary choices of poorer households and that the poorer households may be less willing to trade taste for nutrition even in the absence of additional cost.

Finally, Andi, Carlson, and Frazão (2013) have gone further to draw attention to the possibility that a higher quality diet is not necessarily more expensive than a diet of lower quality. According to them, previous studies that have associated higher diet quality to higher cost measured healthy diets by only cost per calorie. Even though they agree that this is one way of assessing a healthy diet, they are of the view that using different metrics will provide a more balanced view on whether healthier diets are more expensive than less healthy diets. They therefore used the cost per calorie, per average portion and per edible gram metrics to determine if healthier diets were indeed more expensive. Their results for the last two metrics show that healthier food costs less. The cost per calorie method however confirmed earlier reports that healthier diets are more expensive. In conclusion, whether healthier diets are more expensive or not actually depend on the method of computation that is employed.

2.2.5 Dietary Guidelines, Food Consumption and Obesity

In the United States, the U.S. Departments for Agriculture (USDA) and Health and Human Services (HHS) jointly develop and update dietary guidelines to help people eat healthy diets and prevent chronic diseases (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). These guidelines are used by the federal government in the development of nutrition education programs. The advent of dietary guidelines in the U.S started in 1980 with 'Nutrition and Your Health: Dietary Guidelines for Americans'. Since then, dietary guidelines are updated and released every five years based on current scientific nutrition knowledge. The main objective of the guidelines is to facilitate and promote good eating habits among individuals in such a way that it becomes a norm for the entire population. The most recent dietary guideline for Americans is that of 2010 which focuses predominantly on how Americans can be healthy in the wake of the rising incidence of obesity and chronic diseases. According to the report, poor diets and physical inactivity are central to the obesity pandemic.

Obesity is defined by the World Health Organization as an abnormal accumulation of fat that may cause damage to health (World Health Organization, 2013). It is usually measured by the Body Mass Index (BMI) of a person and people with a BMI greater than or equal to 30 kg/(body height in meters)^2 are considered obese. Obesity is a global epidemic and a major public health problem in the U.S. Projections indicate that by the year 2030, more than half of Americans will be obese (Finkelstein, Ruhm, and Kosa, 2005). This situation is highly undesired due to the complex nature of trying to mitigate the effects of the burden of the situation on the economy. This is because obesity is found to be associated with several other health conditions such as diabetes, cardiovascular disease, type-2 diabetes and some types of cancer (Allison and Saunders, 2000; Bartrina, 2013; Guarino, 2013; Mokdad et al., 2003; US Surgeon General, 2001). The historical prevalence rates of obesity in the U.S. rose from about 13% in 1959 to 36% in the year 2010 as showed in the table below (Chou et al., 2004; Flegal, Carroll, Kit, and Ogden, 2012).

Table 2.1 Trends in Adult Obesity in the U.S.

Survey	Period	BMI	% Obese
NHES I	1959-1962	24.91	12.73
NHANES I	1971-1975	25.14	13.85
NHANES II	1976-1980	25.16	13.95
NHANES III	1988-1994	26.40	21.62
NHANES 1999	1999-2000	27.85	29.57
NHANES 2009-2010	2009-2010	28.70	35.7

Source: Adapted from (Chou et al., 2004; Flegal et al., 2012)

From the table above, obesity rates in the U.S. have tripled over the last four decades. Even though some people may have a genetic predisposition to obesity, it is said that the soaring statistics on obesity may not be attributed to genes because it takes a long time to alter genes (Koplan and Dietz, 1999; Rashad, Grossman, and Chou, 2005). Other factors that have been linked to the incidence of obesity are dietary (nutritional), environmental and economic factors (Chou et al., 2004; Drewnowski and Darmon, 2005a; Etilé, 2011; Mokdad et al., 2003; World Health Organization, 2013). The consequence of obesity on the economy is enormous. There are direct and in-direct costs to the economy including productivity losses and increasing health care costs (Allen et al., 2006; Ludwig, 2009; Rosin, 2008). Cawley and Meyerhoefer (2012) have estimated that obesity accounted for around $2,741 (in 2005 dollars) of the increase in medical cost between the years 2000-2005 in the U.S. According to them, 20.6% of national spending on medical care was attributable to the cost of treating adult obesity in the U.S within the same period of time. These obesity statistics are alarming and proactive steps need to be taken to mitigate its effects on society. On the nutritional side, people may be able to choose healthier food if they have the right attitude and nutritional information.

The main source of nutritional information is through food labels. Drichoutis, Nayga Jr, and Lazaridis (2011) identify three types of nutritional information that can be found on food packages. They are the nutritional label/fact panels, health claims and nutrition claims (Drichoutis et al., 2011; Hawkes, 2004). The difference between nutritional labels and nutritional claims is that with the former the nutrients that are contained in a food package are listed whereas with the latter, the amount of nutrients present in the food is quantified. Health claims however usually suggest the health benefits of a particular food. Food labels are crucial in informing health conscious consumers about the content of food before consumption. Governments use mandatory labelling to compel companies to disclose food contents to consumers in order to reduce the incidence of market failure due to the lack of information on the part of the consumer. In the U.S. after the government passed the Nutrition Labelling and Education Act (NLEA) in 1990, prepackaged foods were required by law to be labelled before sale. The only exception was with food that is produced in restaurants but with the recent upsurge in the obesity scare, a number of States in the U.S. now require restaurants to provide calorie information on their food (Bassett et al., 2008; Drichoutis et al., 2011; New York City Department of Health and Mental Hygyiene, 2008; Rutkow, Vernick, Hodge, and Teret, 2008). The New York City for instance, is a classical example of a place where such regulation is in force. The Department of Health and Mental Hygiene estimates a reduction in obese individuals by 150,000 over the next five years by this initiative (New York City Department of Health and Mental Hygyiene, 2008). Private companies can also use voluntary labelling to convey all other product information not required by law to consumers. However, there is some evidence to suggest that some consumers have the tendency to trust certification and labelling programs from governments more than those from third parties (Caswell and Mojduszka, 1996). Other regulations that government can use to get people to eat healthy is through tax incentives/penalties. According to Nestle and Jacobson (2000), imposing taxes on high-energy, low–nutrient foods and subsidizing the cost of low-energy, high-nutrient food may shield consumers from unhealthy food.

CHAPTER THREE

The Dietary Supplement Industry

3.1 Introduction

The dietary supplement industry is examined in this section. The chapter is started with the definition of dietary supplements. We then look at the overview of the dietary supplement industry, prevalence and the motivations for dietary supplement use. Following this, the factors associated with dietary supplement use are discussed. The Chapter is concluded with the regulatory environment of dietary supplements in the U.S.

3.2 Definition of Dietary Supplement

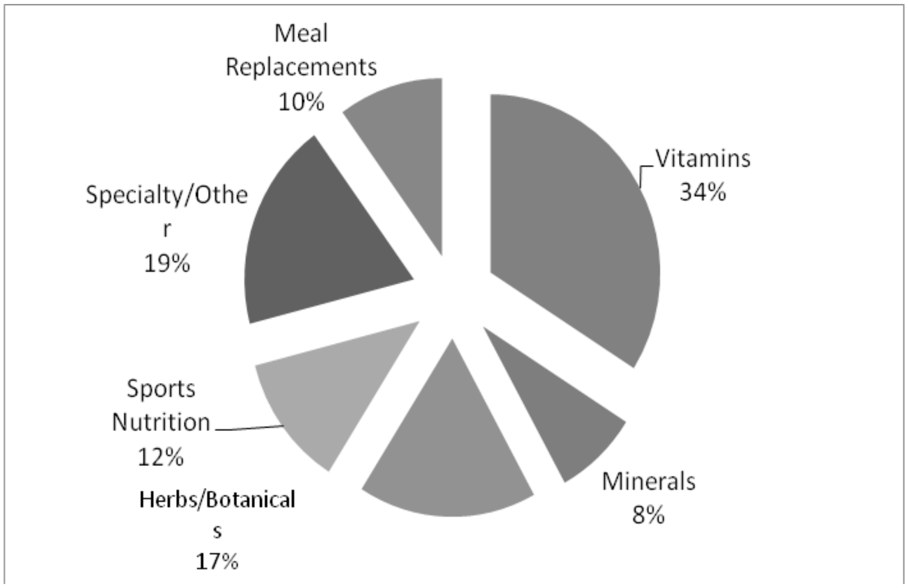
Dietary supplements are described by different names in different countries. For instance, they are also referred to as food supplements, nutritional supplements or natural health products. In some countries, dietary supplements are classified under food (e.g. USA) whilst in others, they are classified under drugs and/or food depending on their composition (e.g. Canada).

In the United States, a legal definition of the term dietary supplement came into being after the passage of the Dietary Supplement Health and Education Act (DSHEA) in 1994 by congress. By this Act, a dietary supplement is defined as any product (other than tobacco) meant to supplement the diet which contains one or more of ingredients such as vitamins, minerals, herbs or other botanicals, amino acids and other dietary substances that are meant to increase the total dietary intake of man and are labelled as dietary supplements (Dietary Supplement Health and Education Act, 1994). In Canada, dietary supplements are classified under natural health products and Health Canada's office of natural health products periodically comes up with new information in the industry. A natural health product according to the natural health product regulations as contained in the amended Food and Drugs Act, 2003 is defined as substances that are used in "the diagnosis, treatment, mitigation or prevention of a disease, disorder or abnormal physical state or its symptoms in humans; restoring or correcting organic functions in humans; or modifying organic functions in humans, such as modifying those functions in a manner that maintains or promotes health" (Food and Drugs Act, 2003). These substances include minerals, vitamins, amino acids, botanicals, essential fatty acids and other derived substances. Other definitions can be found in the European Union and other countries but it is obvious that certain fundamental ingredients (e.g. vitamins, minerals, botanicals, etc.), the oral form of administration (pills, gels, tablets, capsules, syrups, etc) and the fact that supplementation is meant to improve the diet are common in definition throughout the world.

3.3 Overview of the Dietary Supplement Industry

The dietary supplement market has experienced tremendous growth over the years. Much of the growth in the industry has been attributed to the increasing numbers of seniors in society (Mintel Report, 2009). The world's largest consumer is the United States of America which is followed by Western Europe and Japan (McCabe and Fabri, 2012). Dietary supplements are readily available in supermarkets, pharmacies, natural health product stores and on the internet. Global sales of supplements have been estimated between $70 billion and $250 billion (Caballero, 2009). Sales of supplements are said to have experienced an exponential growth over the last few decades. According to Blendon et al. (2001), dietary supplement sales in the USA rose from $8.8 billion in the early 1990's to $15.7 billion in 2000. In recent time, various industry reports from the nutrition business journal (NBJ) show that sale of supplements has increased from $26.9 billion in 2009 to $30 billion in 2011 (Nutrition Business Journal, 2012). Dietary supplements are marketed as vitamins, minerals, botanicals, sports nutrition and others. The figure below shows the composition of consumer sales of various dietary supplements in the United States of America.

Figure 3.1 U.S. Dietary Supplement Sales, 2011



Source: Nutrition Business Journal (2012).

The most widely used form of dietary supplement in the United States is the multivitamin/mineral (Ervin, Wright, and Reed-Gillette, 2004; Foote et al., 2003; Radimer et al., 2004; Rock, 2007). The market share attributable to vitamin/mineral supplements alone is about $12 billion and growth in this segment from 2006-2011 is estimated at 28% (Mintel Report, 2011). Statistics from the Mintel 2011 report indicates that sales growth will be around 3% per year from 2012-2016. Annual growth rates were greatest during the economic recession because people easily turned to supplements as a lower cost alternative to maintaining good health and avoiding sick days (Mintel Report, 2009). The table below shows the total retail sales and forecasts for the sector for a ten year period.

Table 3.1 Aggregate retail sales and forecast of vitamins and minerals in the U.S.

Year	Sales ($ millions)	% annual change	Index 2006 = 100
2006	9,332	n/a	100
2007	9,715	4.1	104
2008	10,579	8.9	113
2009	11,341	7.2	122
2010	11,802	4.1	126
2011 (est.)	11,978	1.5	128
2012 (fore.)	12,322	2.9	132
2013 (fore.)	12,669	2.8	136
2014 (fore.)	13,072	3.2	140
2015 (fore.)	13,492	3.2	145
2016 (fore.)	13,903	3.0	149

Source: Mintel Report (2011).

3.4 Prevalence of Dietary Supplements and Motivations for Supplement Intake in U.S.

According to Timbo, Ross, McCarthy, and Lin (2006), the prevalence of dietary supplement use is on the increase in the U.S. Several studies that have used the National Health and Nutrition Examination Surveys (NHANES) and other nationally representative interviews have confirmed this fact. Rock (2007), reported that the prevalence rate of dietary supplement intake in the USA has transitioned from 23%, 35% to 40 % from the National Health and Nutrition Examination Survey one to three (NHANES I- NHANES III). More recently, more than half of Americans are said to be supplement takers (Bailey et al., 2011; Dickinson, Bonci, Boyon, and Franco, 2012).

The rising prevalence of supplement use is an indication that many more people are joining the league of supplement users. The natural question that arises therefore is: what are the reasons for the consumption of supplements? There are a myriad of reasons underlying the consumption of supplements. Hathcock (2001) identified that people take supplements to enhance their performance, protect their bodies, mitigate the effects of age-related changes and also ensure that their diets are nutritionally balanced. Other people also ingest supplements to protect themselves from certain diseases, for general health and wellness and also to enhance dietary quality (Dickinson et al., 2012; Huang et al., 2006; Troppmann et al., 2002). All these reasons have been summarized and classified as either physical treatment or psychological benefit source (Okleshen Peters, Shelton, and Sharma, 2004). More recent data from Mintel report gives the following reasons cited in Table 3.2 for the intake of dietary supplements.

Table 3.2: Reasons for Dietary Supplement Intake (N=1,522)

Reason Assigned for Supplement Intake	Respondents (%)
To help boost health in general	76
To help ward off illnesses	50
For energy	47
To improve heart health	45
To improve brain function/memory	32
To help with digestion	19
For weight control	14
For cancer prevention	14
To look younger	11
For diabetes prevention	9
As a sleep aid	7
To prepare for pregnancy	7
Some other reason	6

Source: Mintel Report (2011).

3.5 Socio-demographic and Lifestyle Characteristics Associated with Supplement Intake Decisions

Socio-demographic characteristics of people can have an effect on their health behaviour (Ricciuto, Tarasuk, and Yatchew, 2006; Shi, 1998). Research has shown that gender, race, education and household size have an effect on health behavior (Bogue, Coleman, and Sorenson, 2005; Nayga, 1997; Ricciuto et al., 2006). These same socio-demographics and others have been found to influence supplement intake. Supplement users have generally been described to likely be white, educated and female (Bailey et al., 2011; Ervin, Wright, and Kennedy-Stephenson, 1999; Fennell, 2004; Garside, Chan, Buffington, and Dyer, 2005; Harrison, Holt, Pattison, and Elton, 2004; Petrovici and Ritson, 2006; Schroeter et al., 2013; Schroeter et al., 2010).

Another characteristic that has been found to be associated with supplement use is age. According to Petrovici and Ritson (2006), age has an effect on preventive health diet behaviour. The use of supplements is said to increase with age and the records are that, older adults and middle aged people make more use of supplements (Bailey et al., 2011; Balluz, Kieszak, Philen, and Mulinare, 2000; Ervin et al., 1999; Okleshen Peters et al., 2004; van der Horst and Siegrist, 2011). To add to these, household income is another variable that has been found to have an association with supplement use. Generally, higher income households typically use supplements (Ervin et al., 1999; Millen, Dodd, and Subar, 2004; Nayga and Reed, 1999; Schroeter et al., 2010). Not only these, it has been reported that household size has a negative effect on supplement consumption (Nayga and Reed, 1999). This negative relationship has been ascribed to the fact that larger households may not have the wherewithal to buy supplements for all their family members.

Apart from all these socio-demographics, other lifestyle variables have been documented to be associated with supplement use. For instance non-smokers, active people, presence of health condition, special diet and body mass index have a link with supplement consumption. In Nayga and Reed's paper on factors associated with the intake of dietary supplements, being a smoker was found to have a negatively significant relationship with supplement intake. This outcome has been confirmed by Millen et al. (2004) and Reinert, Rohrmann, Becker, and Linseisen (2007). These two sets of authors also found a significant relationship between an active lifestyle and supplement intake (see also Foote et al., 2003; Harrison et al., 2004; Lyle, Mares-Perlman, Klein, Klein, and Greger, 1998; Rock, 2007). Among people who take in alcoholic beverages, those who consume more alcohol have been tagged as less likely to take supplements (Lyle et al., 1998). To add to these, people who take special diet are also more likely to take supplements as compared to their counterparts who neither take special diets nor receive food stamps (Nayga and Reed, 1999). Other health indicators of people like body mass index (BMI), presence of health condition (diabetes or blood pressure) and self rated health have also been documented to impact supplement intake. Whilst most studies reviewed in this thesis suggest that supplement use is inversely related to BMI (Bailey et al., 2011; Foote et al., 2003; Garside et al., 2005; Ishihara, Sobue, Yamamoto, Sasaki, and Tsugane, 2003; Kimmons, Blanck, Tohill, Zhang, and Khan, 2006; Li, Kaaks, Linseisen, and Rohrmann, 2010; Nayga and Reed, 1999; Radimer et al., 2004; Reinert et al., 2007) others have documented that people with obesity (higher BMI) are more likely to use supplements (Pillitteri et al., 2008). People who either have diabetes or high blood pressure have been associated with taking fewer supplements as compared to their counterparts without these health conditions (Harrison et al., 2004; Satia-Abouta et al., 2003). Earlier on, Lyle et al. (1998) had found a similar result between supplement intake and blood pressure but did not find any relationship between diabetes and supplement intake (Lyle et al., 1998). Finally, supplement intake is said to be positively associated with self rated health status (Ervin et al., 1999; Pillitteri et al., 2008) .

All these statistics on the relationship between supplement intake and various indicators give us vital information about consumer health behaviour but it is important to also know if any regulations exist for the industry. The next section discusses the regulatory environment of dietary supplements in the U.S.

3.6 Dietary Supplement Regulation

In the United States, the national agencies responsible for the regulation of dietary supplements are the Food and Drugs Administration (FDA) and the Federal Trade Commission (FTC) (Center for Responsible Nutrition, 2011; Office of Dietary Supplements, 2011). Each of the fifty states also has agencies that oversee the regulation of supplements. A major change took place on the dietary supplement market after the enactment of the Dietary Supplement Health and Education Act (DSHEA) in 1994. Before this Act is examined, the regulatory framework for dietary supplements is first discussed.

The Food and Drugs Administration (FDA) is the national agency responsible for ensuring that the public is provided with the right non-misleading information on food and drugs for good health. Dietary supplements were hitherto treated with all the rigour that other drugs were made to pass through before they are released on to the market. The FDA therefore had the mandate to withdraw any supplement from the market that was thought to be unsafe for human consumption. Under the FDA, supplements were treated as food, drugs or both with the backing of the Food, Drugs and Cosmetic Act (FD&C Act).

Today, the FDA still regulates the dietary supplement industry but with less rigour. The FDA ensures that product information including label claims, packet inserts and other claims meet the set safety standards. Currently, FDA has also established good manufacturing practice regulations specifically for dietary supplements (Institute of Medicine, 2005). These regulations are meant to streamline the manufacture and ensure quality throughout the value chain. The FDA still has the mandate to withdraw any supplement from the market that could cause harm to people (HHS 2009). Their current role can best be described as a post marketing role since manufacturers are no longer required to pass new products through scrutiny by the FDA for safety and effectiveness before marketing (Geil and Shane-McWhorter, 2008). The role of the Federal Trade Commission (FTC) is to ensure that dietary supplement advertisements and promotions are regulated as per the set standards (Hoffman, 2001). The FTC ensures that advertisements are truthful and not misleading to the general public (Federal Trade Commission, 2010). The FTC regulations however came into force after the passage of the Dietary Supplement Health and Education Act (DSHEA).

The DSHEA is the premier official regulation instrument for dietary supplements in the U.S. (Brownie, 2005b). The Act was passed by congress in

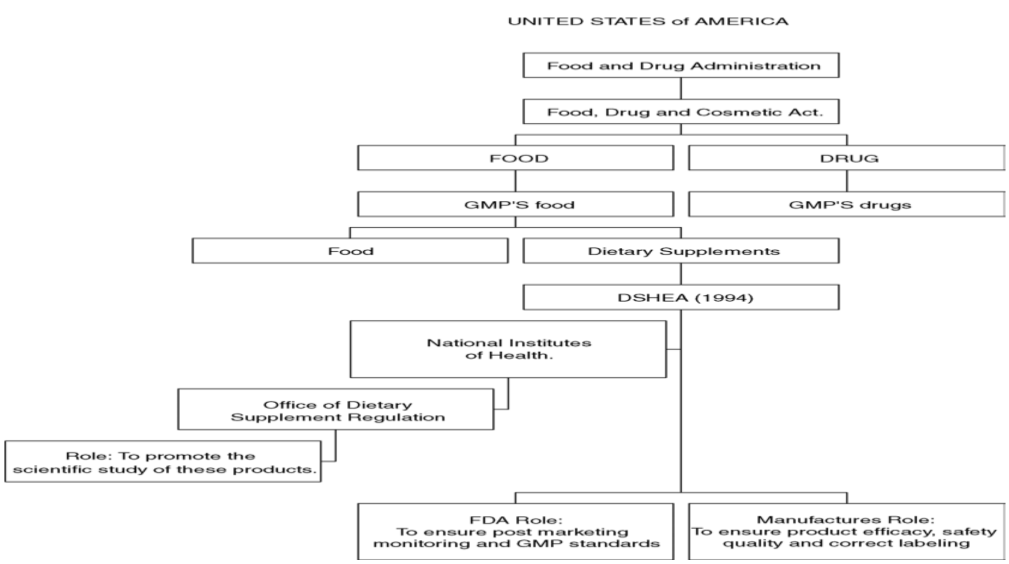
1994 with the main aim of ensuring that the American populace have access to dietary supplements to improve their nutrition without any legal barriers (Dietary Supplement Health and Education Act, 1994). The discussion of this section is based on the DSHEA. The DSHEA redefined dietary supplement as contained in the beginning of this chapter. In section two of the Act, the usefulness of dietary supplements to the citizenry as well as to the economy are outlined. This Act also makes it clear that dietary supplements are neither drugs nor food additives. The DSHEA transferred the authority of ensuring the safety of products to the manufacturer who was required to provide substantial evidence for curative claims.

The DSHEA amended the Nutrition, Labelling, and Education Act to enable claims to be made on supplements. There are five types of claims that are approved by the DSHEA. These are nutritional claims, claims of well-being, health claims, nutrient content claims, and claims that the supplement affects the structure or function of the body. All these claims except the health claims do not need the prior approval of the FDA. Health claims however must be supported by scientific evidence. All these claims must be truthful and carried in a way that would not mislead the general public. Where the FDA has evidence that the regulations underlying claims have been violated, it can institute punitive measures against the manufacturer/supplier and subsequently withdraw the product from the market (Brownie, 2005b).

Under the auspices of the DSHEA, the office of dietary supplements (ODS) which is a subsidiary of the National Institute of Health (NIH) was established. The role of the ODS is to promote studies into the benefits of supplements and explore the potential of supplements as part of efforts to improve healthcare and facilitate access to scientific information on dietary supplement use. The ODS is also mandated to advise the secretary of health and human services on supplement regulation issues, health and safety claims.

The general public also has a role to play in the regulation of supplements in the USA. Under the Dietary Supplement and Non-prescription Drug Consumer Protection Act of 2006, manufacturers and retailers are required to report adverse effects of supplements to the FDA. Individuals also have the right to report adverse effects as a result of supplement intake to the appropriate authority. The figure below gives an overview of the dietary supplement regulatory framework in the U.S.

Figure 3.2 Overview of Dietary Supplement Regulatory Framework in U.S.



Source: Adapted from Brownie (2005b).

CHAPTER FOUR

Methodological Issues in Analysing Consumer Food-Health Behaviour

4.1 Introduction

This chapter is dedicated to a discussion of the methodological issues in studying consumer health behavior in the context of food consumption, dietary choice decisions and health. There is broad literature in this area but measuring and modelling health behaviour from an economic perspective (Glanz et al., 1998; Glanz, Rimer, and Viswanath, 2008; Mancino and Kinsey, 2008). In economics, the empirical causal analysis of the association between food and/or lifestyle choices and their impact on various health outcomes of interest has been plagued by several issues pertaining to model misspecification errors and persistent endogeneity between food, diet and health behaviours (Park and Davis, 2001). For instance do people choose a specific dietary pattern because they want to be healthier or are they of good health because they pursue certain dietary patterns, part of which could be the frequent consumption of (appropriate) dietary supplements? This chapter discusses a basic model framework for measuring consumer utility in the context of health behaviour. Next, econometric issues in analysing health behaviours and their outcomes are discussed. As part of the empirical analysis in this thesis, the propensity score matching method as one methodological approach to address issues of self-selection bias and endogeneity is introduced. This discussion will include a summary of existing studies that have successfully used propensity score matching techniques to analyze questions of similar nature to the objective of this thesis.

4.2 Measuring Consumer Utility and Health Behaviour

Rational consumers will always maximize utility of consumption subject to a budget constraint. The principle rule also extends to the utility that a person derives from the intake of food. In this context, food can be viewed as a consumption good that could impact on a person's health just as other goods perceived to be health enhancing or health diminishing. According to Conner and Norman (2005), people can influence their health status if they choose to adopt behaviours that can enhance their health and do away with those behaviours that may deteriorate their health status over time. One of the researchers to document the principle idea about the linkage between consumption behaviours, utility and health was Grossman (1972).

Building on Becker's model of investment in human capital model, Grossman's seminal work on health capital described and formalizes the process by which people are endowed with a certain stock of health which is said to deteriorate over a person's life time (Grossman, 1972). How fast an individual's health status deteriorates depends, among other things, on investments in health through certain health behaviours. For instance, a balanced diet, one that follows the recommendations of public food and nutrition guidelines, frequent physical exercise and recreation can be considered investments into an individual's health stock. Less favourable activities and consumption choices such as smoking, drinking (alcohol), drug use and poor dietary patterns could accelerate the depletion rate of a person's health stock. Depletion of the stock of health beyond a certain threshold is then associated with the imminent risk of death. An individual's intertemporal utility function based on the above considerations is given by:

$$U= U\ (\Phi_o H_{o,} \ldots \Phi_n H_o, Z_o, \ldots Z_n), \qquad (1)$$

where H_o is the health stock at birth, H_i is the health stock in the time period i, Φ_i is the service flow per unit stock (the number of healthy days at any specified period of time), $h_i = \Phi_n H_o$, is aggregate consumption of health services, and Z_i is a vector of aggregate consumption of other commodities in the period i (Grossman, 1972). In Grossman's model good health is a source of utility as consumption good and an investment good. We can think of good nutrition or eating habits as one of the major contributors to good health. Aided by recommendations and guidelines put out by organizations to ensure that people adhere to set standards for healthy living. The good "good health" can be attained through a variety of ways including nutrition (diet), medical care and other relevant lifestyle choices. In the context of nutrition, the frequent consumption of fresh fruits and vegetables could be thought of an investment in nutritional health. If an individual substitutes or complements fruits and vegetables intake with dietary supplements, the latter would constitute a similar investment in the context of food-health. This is because the individual will derive utility from the consumption of supplements which in the long run may contribute to overall utility derived from good health. Grossman's health production function approach and Becker's human capital theory, which built foundation of many health economic analyses and studies of health behaviour (Fayissa and Gutema, 2005; Kenkel, 1995; Thornton, 2002), will also serve as the theoretical framework and foundation of this thesis research. The health production function of an individual in this thesis is represented as:

$$H = F\,(L, E, S), \tag{2}$$

where H is a measure of health output, L is a vector of lifestyle variables, E stands for education and S is a vector of socioeconomic/socio-demographic variables. We can further break down this model into:

$$h = f\,(l_1, l_2 \ldots l_n, e, s_1, s_2 \ldots s_n). \tag{3}$$

The category of lifestyle factors can then consist of elements that will contribute positively or negatively to health output (h). Smoking, drinking and poor dietary behaviours are assumed to negatively impact health output, whereas active lifestyles, the lack of existing (and/or lifestyle dependent) conditions like elevated blood pressure, diabetes, or overweight/obesity are typically assumed to positively impact health output. One lifestyle factor of interest in this thesis is food-health behaviour and specifically the consumption of dietary supplements. This variable of interest is assumed to not only affect health output, but also assumed to be influenced by the other factors in the above health production function. Socioeconomic factors may in fact play a role in a person's health stock.

For example, being born to rich parents or in a particular part of the world may make a person less/more susceptible to certain health conditions. People born in the developed world commonly have a higher life expectancy at birth as compared to their counterparts born in often poorer developing countries. This means that a person's socioeconomic characteristics may play a vital role in explaining differences in an individual's health stock, depletion or investment rates.

Apart from the health production function approach; other approaches have been developed and used to explain individual's health and food-health behaviours (Duncan, Jones, and Moon, 1996; Glanz et al., 2008; Kim, Nayga Jr, and Capps Jr, 2000; Kim et al., 2001; Nakajima, 2007; Variyam, 2008). Some of the models that have been applied in the literature fall into the category of the social cognitive models. These models aim to explain how people perceive various threats to their health and factors which may (or not) motivate their response mechanisms. Key among social cognition models are the theory of planned behaviour and theory of reasoned action (Ajzen, 1991; Ajzen and Fishbein, 1980), Protection Motivation Theory (PMT) (Rogers, 1983), and the Health Belief Model (Rosenstock, 2005). The theory of planned behaviour or reasoned action suggests that an individual's intention to perform a given behaviour may be predicted by the person's attitudes to the behaviour, his or her underlying subjective norms, and perceived behavioural control. This theory has been widely used in explaining human behaviours in diverse contexts and fields of research spanning from psychology to economics (Beedell and Rehman, 2000; Chintrakarn, 2008; Pufahl and Weiss, 2009; Wilson and Dowlatabadi, 2007).

Applications of these theories specific to questions of supplement intake include a study by Eldridge and Sheehan (1994) that predicted calcium supplement intake intentions by college students. Another study by Conner, Kirk, Cade, and Barrett (2003) examined the factors that predict why women would consume supplements. The theory of planned behaviour has also been employed in studies of fruit and vegetable consumption behaviour (Bogers, Brug, Van Assema, and Dagnelie, 2004; Kothe, 2012). The Kothe (2012) study for example tested the effectiveness of the theory of planned behaviour intervention on fruits and vegetables consumption by young adults. This was done by sending the theory of planned behaviour based emails to participants in order to collect the theory of planned behaviour variables for the baseline and post intervention stages of the research. Results of the study showed that the consumption of fruits and vegetable increased by 0.83 servings per day between the two periods. The protection motivation theory, originally proposed by Rogers (1975), seeks to explain how people view a health threat and how they cope with the threat. This is usually based on the perceived severity of the threat, its chances of happening and the perceived effectiveness of the response (both recommended preventive measures and self-preventive measures).

The Protection Motivation Theory has been used extensively in the medical literature. An example of its application in the area of supplement consumption decisions is Cox, Koster, and Russell (2004). The authors use a PSM framework to predict an individual's intentions behind functional foods and supplements consumption choices. Finally, the Health Belief Model, the most commonly used among this group of models has been used to conceptualize the idea that an individual's health beliefs can make certain health behaviours either attractive or repelling. For example, if a person believes that taking supplements can reduce their risk of future adverse health conditions; this will result in an affinity for supplements. Shaikh, Byrd, and Auinger (2009) used the health belief model as a framework for the study of the link between vitamin/mineral supplement use and nutrition, food security, physical activity and health care access among children and adolescents in the U.S. These social cognition models will not be used in the current study largely due to the secondary nature of the data at hand.

In summary, a suitable theoretical foundation for the study of dietary supplement consumption choices and their impact on individual's health status is Becker's and Grossman's health production function approach. As such this thesis defines dietary supplement consumption as a positive utility shifter that contributes to an individual's health production and thus health stock.

4.3 Issues in Measuring the Impacts of Consumer Food Health Behaviours

Empirical analyses of individual's health behaviour in the context of specific health outcomes is typically complicated by potential problems of endogeneity between key variables of interest and measurement error resulting from self-selection bias, a problem often encountered in consumer survey studies. Hence, the econometric analysis is not straight forward. The use of ordinary least square

(OLS) usually leads to biased results due to potential misspecification errors (Grilli and Rampichini, 2011). A common econometric solution to problems of endogeneity is the use of instrumental variable estimators (IV). However, it is often difficult if not impossible to find suitable instruments in the context of studies in the area of food, diet, and health behaviour (Park and Davis, 2001). In this thesis, the nature of the NHANES data and the specific research questions asked makes it even more difficult to find suitable instruments. For these reasons, common IV approaches are deemed less suitable. Three other econometric techniques suggested by economists for the study of health economic issues plagued by endogeneity and related problems are the difference-in-difference (DID) approach, Heckman-type switching regression models and propensity score matching (PSM).

For example, Variyam (2008) used the difference-in-difference method to analyze if and to what extend nutritional label use affects and/or improves individual's dietary outcomes. He compared the observed dietary outcomes of label users with what would have occurred had they not used the labels. It was possible to do this because data was available for nutrient intake from food that was consumed in the house where consumers are exposed to mandatory labelling and also for that consumed away from the home where they are not exposed to any labelling. Two equations were estimated for the at home scenario and away from home scenario. The difference between the two scenarios was then taken to be the net effect of label use on dietary outcomes. According to him, this process made it possible to remove the potential bias of the effect of labels. Variyam's research result showed that label users had increased consumption of fibre and iron as compared to non-users of labels.

Kim et al. (2000) also examined the effect of label use on the consumption of nutrients and the healthy eating index. The healthy eating index is used to measure the conformance of diet quality to recommended guidelines. To correct for potential problems of self-selection bias as a result of systematic differences between label users and non-users, the authors applied a Heckman-type switching regression model to control for the possible endogeneity in label use decision. The switching regression model consisted of a nutrient intake equation for label users and non-users and a label use decision equation explaining the probability of label usage. The nutrient intake equation was then estimated separately as a second stage conditional on the label use decision model. Full information maximum likelihood estimators were used to estimate the complete model. They found that making use of nutritional labels resulted in decreasing the average consumption of calories from sodium, cholesterol, saturated fats and total fats by 29.58 milligrams, 67.60 milligrams, 2.1% and 6.9% respectively. The daily average intake of fiber was however increased by 7.51 grams.

Propensity Score Matching was used by Drichoutis, Nayga, and Lazaridis (2009) to determine the relationship between nutritional label use and body weight outcomes, measured by individuals' BMI. Their findings suggest that nutritional label use has no statistically significant effect on BMI. The PSM method thereby mimics a randomized control trial or experiment and is so able to overcome the problems associated with endogeneity and self-selection bias. The advantage of using PSM is that it does not restrict the econometrician to assume a specific functional form in the estimation process. Moreover, PSM imposes a “common support” assumption, the estimates are unbiased (Smith and Todd, 2005; Dehejia and Wahba, 1999). This common support assumption means that for any given value, there is a positive probability of being both treated or untreated and therefore each person has an equal chance of selection or participation (Smith and Todd, 2005; Dehejia and Wahba, 1999).

4.4 Propensity Score Matching as the Analytical Method of Choice

The method of propensity score matching was originally developed by Rosenbaum and Rubin in 1983. The rationale behind the propensity score matching approach is to find in a pool of treated and non-treated individuals, the effect of receiving treatment. Since then, PSM has been widely used in evaluating various types of interventions, such as government policies or medical trials (Becker and Ichino, 2002). Currently, the technique enjoys increasing popularity among researchers in diverse fields as well as in economics to empirically analyze situations where the effect and outcome of a specific treatment is of interest (Black and Smith, 2004; Caliendo and Kopeinig, 2008; Drichoutis et al., 2009). In the economics literature PSM has been employed to determine the effects of labour market and training courses on individual’s wage earnings (Dehejia and Wahba, 2002; Heckman, Ichimura, and Todd, 1998; Lechner, 1999; Smith and

Todd, 2005). In health economics and field of food consumption studies, PSM methods have been employed to analyze how consumers that were exposed to a particular treatment (e.g. food label usage) differ from those who reportedly did not receive the same treatment (Abebaw, Fentie, and Kassa (2010); Campbell, Nayga, Park, and Silva (2011); Drichoutis et al. (2009)).

In this thesis, the PSM is chosen as the preferred method due to the existence of two groups within the sample (dietary supplement takers and non-takers). PSM will help account for the possible selection bias in the self-reported dietary supplement intake and possible endogeneity of supplement intake in treatment outcome variable (BMI). Subsequently, individuals who are reported to have taken dietary supplements will be referred to as the treatment group (supplement takers) and those who are reported not to have taken dietary supplements will form the control group (non-takers). The propensity score then describes the conditional probability of taking dietary supplements giving equality in pre-treatment characteristics between both groups. This relationship can formally be expressed as:

$$p(X) \equiv Pr(D = 1|X) = E(D|X), \quad (4)$$

where D represents the intake of supplements (taker = 1, non-taker = 0), and X is a vector of pre-treatment characteristics (e.g. gender). If the health outcomes are Y_{0i} and Y_{1i} for non-takers of supplements and supplement takers respectively, then the treatment effect for an individual ‘i’ can be written as:

$$t_i = Y_{1i} - Y_{0i}. \quad (5)$$

The propensity score can be estimated with any standard probability model. The population average treatment effect (ATE) and the average effect of treatment on the treated (ATT) are the two commonly cited parameters of interest in literature and are given by:

$$\tau ATE = E(\tau) = E[Y (1) - Y (0)] \tag{6}$$

$$\tau ATT = E(\tau |D = 1) = E[Y (1)|D = 1] - E[Y (0)|D = 1] \;. \tag{7}$$

Y(0) and *Y(1)* are the two possible outcomes with and without supplement intake. The parameter that is of interest in this thesis is the average treatment effect on the treated (ATT) because it gives the difference between expected outcome values of supplement takers and non-takers. Estimating the average treatment effect on the treated is only possible under certain assumptions because the counterfactual is not observed. Several assumptions need to hold in order to obtain reliable treatment effects using PSM.

The first assumption is balancing the pre-treatment variables on a given propensity score (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008; A. C. Drichoutis et al., 2009). This means that for a given propensity score, dietary supplement takers and non-takers must have the same distribution of characteristics irrespective of treatment status. This ensures that treatment is random and dietary supplement takers and non-takers are observationally random.

$$D \perp X \mid p(X), \tag{8}$$

where $p(X)$ is the propensity score.

The next assumption is usually referred to as 'unconfoundedness' or 'conditional independence' assumption (CIA) (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008; Rosenbaum and Rubin, 1983)"

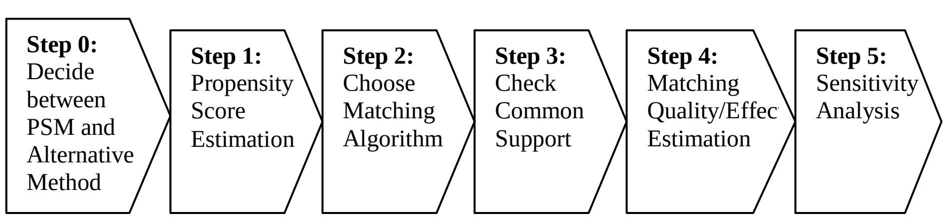
$$Y1,Y0 \perp D \mid p(X). \tag{9}$$

This assumption implies that potential outcomes are not dependent on treatment. In other words, variables that can affect both treatment and potential outcomes concurrently have to be observed by the researcher. Another assumption is that of 'overlap' (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008; A. C. Drichoutis et al., 2009) given as;

$$0 < P(D = 1|X) < 1. \tag{10}$$

This assumption ensures that individuals with the same characteristics *'X'* (e.g. income group/level) are assumed to have an equal chance of falling into the treatment or control group. Once the above assumptions are satisfied, the propensity score of the ATT can then be estimated reliably. The individual steps as part of the PSM estimation approach have been summarized by Caliendo and Kopeinig (2008) and are shown in Figure 4.1.

Figure 4.1 PSM Implementation Steps



Source: Adapted from Caliendo and Kopeinig (2008).

4.5 Model Development

The focus of this thesis is to investigate what determines the propensity of being a dietary supplement consumer and determine whether dietary supplement takers differ from non-takers in BMI. As stated earlier in this chapter, dietary supplements are assumed to contribute to an individual's utility derived from good health and are inputs to the person's health production function. The factors that have been found to be associated with diet-health behaviour and specifically dietary supplement intake decisions, as was discussed in chapter three can be classified as follows: demographics, socio-economics, lifestyle, and health variables. The first empirical PSM model to be estimated can therefore be specified as:

$$SUPPL=F\ (L, S, H), \tag{11}$$

where *SUPPL* is a binary dependent variable used to represent the decision to consume dietary supplements, *L* is a vector of lifestyle variables (e.g. smoking), *S* is a vector of socioeconomic factors (e.g. educational attainment), and *H* is a vector of health related factors (e.g. diabetes, high blood pressure). After the factors assumed to be associated with dietary supplement intake decisions have been determined, the first stage of analysis will be the estimation of the logit model to determine the selection into treatment (dietary supplement intake). After it is assured that the balancing property is achieved, the PSM is then used to estimate the average treatment effect on the treated using the various matching algorithms commonly applied in PSM studies which are briefly described below: Nearest Neighbour, Caliper (Radius), Stratification and Kernel matching algorithms. In the Nearest Neighbour matching algorithm, the nearest propensity score between a treated individual and untreated individual is used to match the treated person to the nearest one in the control group (Caliendo and Kopeinig, 2008; Grilli and Rampichini, 2011; Heinrich, Maffioli, and Vazquez, 2010). This can be done with or without replacement. When the untreated person is used as a "match only once", it is referred to as nearest neighbour matching without replacement otherwise, it is with replacement. Replacement might matter if we want to improve matching quality and decrease bias (Caliendo and Kopeinig, 2008; Grilli and Rampichini, 2011; Heinrich et al., 2010). The caliper (also called radius) matching algorithm is similar to the nearest matching algorithm except that a maximum propensity score distance is imposed. (Caliendo and Kopeinig, 2008; Grilli and Rampichini, 2011; Heinrich et al., 2010). This means that matches are only considered within a certain radius and this eliminates the possibility of matches being too far away and bad matches (Caliendo and Kopeinig, 2008). In stratification matching, the common support of the propensity score is divided into sections called strata and the effect of each strata is computed by taking the average difference in outcome between the treated and control group (Caliendo and Kopeinig, 2008). Finally, kernel matching (local linear matching) unlike the algorithms already discussed is a non-parametric matching algorithm

(Caliendo and Kopeinig, 2008; Heinrich et al., 2010). The key difference between this approach and the others is that in this method, the weighted mean of all the members in the control population is used to construct the counterfactuals. After control group members have been matched to members of the treatment group in terms of the closest propensity score, the average difference in the outcome measure of interest is then computed to represent the Average Treatment Effect on the Treated (ATT) already discussed above.

4.6 Previous Applications of PSM in Consumer Food/Health Behaviour

In this section selected studies that have applied PSM in the food and health economics literature are discussed. Thoa, Thanh, Chuc, and Lindholm (2013) used PSM to estimate the impact of economic growth on health care utilization. They discovered that households that witnessed economic growth during the study period (2003-2007) had access to higher quality healthcare and also spent a smaller proportion of their expenditure on health care as compared to households that witnessed no economic growth. The PSM method was also used in a study by Drichoutis et al. (2009). The authors analyzed the impact of frequent usage of nutritional labeling on individual's body weight outcomes. Their results showed no significant relationship between label use and body weight. In a different study Drichoutis, Lazaridis, and Nayga (2009) used PSM to determine whether the consumption of a Mediterranean diet has a significant, lowering effect on individual's weight and thus obesity levels. Their results showed that the average treatment effect on the treated (eating a Mediterranean diet) had no significant effect on obesity. The authors concluded that there was no association between eating a Mediterranean diet and obesity. Finally, Campbell et al. (2011) employed the PSM method to determine whether the national school lunch program in the U.S. had a positive effect on the dietary outcomes of children who participated in the program. Participating children did not consume lunch of higher quality, but consumed higher food quantities. However, participant and non-participant children had similar dietary overall outcomes.

Even though PSM can be a powerful tool, it is not without limitations. According to Rubin (1997), the propensity score approach only accounts for variations in individual’s observed characteristics and performs better when sample sizes are large. Michalopoulos, Bloom, and Hill (2004) also note that when the treated and non-treated groups are not from the same population, propensity scores do not correct the inherent self-selection bias well due to differences in the exposure to ecological effects. Finally, Guo, Barth, and Gibbons (2006) state that just like randomized control trials, PSM is not the final answer to queries of the effectiveness of a treatment of interest.

CHAPTER FIVE

Data

5.1 Introduction

This chapter is dedicated to the description of the data utilized in this thesis' empirical analysis. The first section presents and discusses the U.S. National Health and Nutrition Examination Survey (NHANES). The chapter continues with a description of those NHANES variables selected and utilized in the empirical analysis. Finally the empirical model specifications are presented.

5.2 The National Health and Nutrition Examination Survey (NHANES)

The U.S. National Health and Nutrition Examination Survey (NHANES) is the primary national survey used to assessing the health and nutritional status of the U.S. populace. The survey is one of the main activities of National Center for Health Statistics (Centers for Disease Control and Prevention, 2011). The survey started in the early 1960's as the national health examination survey and by the 1970's; the nutrition dimension was introduced to make it the national health and nutrition examination survey (NHANES). The nutrition aspect was deemed very important because linkages between diet and disease began to enter the U.S. policy agenda.

The NHANES was initially conducted every four years until 1999 when it became an annual activity. Participants for the NHANES are randomly selected residents of the United States. The survey is comprised of a physical examination, questionnaires and personal interviews. The interviews are used to gather information on demographics, socioeconomic, nutrition and other health related issues like presence of diabetes, hypertension, etc. whilst the physical examination is generally used to conduct laboratory investigations. The data is divided into five sections (demographics, dietary, examination, laboratory and questionnaire) and is stored in files according to the collection method. Table 5.1 below provides an overview of the demographic composition of NHANES for select survey cycles since 2005 (Centers for Disease Control and Prevention, 2013).

Table 5.1 Structure of NHANES Sample for Various Cycles

Ethnicity/Year	2005-06	2007-08	2009-10
Hispanic-Mexican American	2,739	2,064	2,305
Hispanic-Other Hispanic	330	1,147	1,103
Non-Hispanic Black	2,615	2,141	1,903
Non-Hispanic White	3,778	3,969	4,317
Other	488	441	625
Total	9,950	9,762	10,253

Source: Centers for Disease Control and Prevention (2013).

At the time this thesis was initiated, the most recent NHANES data set available was the NHANES 2007-2008 cycle. Data from the various NHANES survey cycles has been used in a number of similar studies focused on individual's health behaviour, consumption choices, other related topics and a multitude of other economic and non-economic research questions (Bailey et al., 2011; Balluz et al., 2000; Ervin et al., 2004; Gahche et al., 2011; Rock, 2007; Schroeter et al., 2013).

For the purpose of the analysis in this thesis, only the adult NHANES participants aged 20 and above were selected, as children typically do not make their own food, diet or health behavioural (e.g. dietary supplement intake) decisions. This selection process resulted in a sample size of 5,125 individuals/ NHANES respondents. From the large pool of NHANES variables, which go far beyond the scope of food and health, the variables selected for the analysis are: socio-economic and demographic variables, lifestyle, food security (initially considered to be part of the socio-economic factors but separated for the purpose of analysis) and health-status variables. As discussed above many of these variables have been cited in previous health-economic literature to affect dietary supplement consumption and individual's health behaviours (Nayga and Reed, 1999; Schroeter et al., 2013). Several variables were re-coded into dummy variables or categorical variables. Socio-economic factors such as age, educational attainment, household income, household size and total number of supplements taken were re-classified into groups in order to account for variations in the sub-groups. The total numbers of dietary supplements taken were also re-categorized into groups to aid in the pair-wise comparison of the effect of number of supplements taken on BMI. Those who took 0, 1 to 5, 6 to 10, 11 to 15, 16 to 20 and 21 to 25 total number of supplements were represented by groups 1 to 6 respectively. Table 5.2 below summarizes all variables used in the subsequent empirical analysis.

Table 5.2 Definition of Variables used in the Analysis

Variables	Description
	Socio-demographics
Male	1=Gender male, 0= female
Married	1=Married or living with partner, 0= otherwise
Divorced	1=Divorced, 0=otherwise
Single	1=Single, 0=otherwise
hsize12	Household size between 1-2 persons=1, 0=others
hsize36	Household size between 3-6 persons=1, 0=others
hsize7	Household size of 7 and above=1, 0=others
hhinc1	Household income between $ 0- $24,9999=1, others=0
hhinc2	Household income between $ 25,000- $54,999=1, others=0
hhinc3	Household income between $ 55,000- $74,999=1, others=0
hhinc4	Household income between $ 75,000- $99,999=1, others=0
hhinc5	Household income between $ 100,000 and above =1, others=0
age1	Age between 20-39=1, 0=others
age2	Age between 40-59=1, others=0
age3	Age 60 and above =1, others=0
Black	Belong to black race=1, others=0
Hispanic	Belong to Hispanic race=1, others=0
White	Belong to white race, others=0
Otherace	Belong to other race other than three above=1, others=0
Somcolege	Attended college =1, others=0
Graduate	College graduate and above=1, others=0
Citizen1	Citizen of USA=1, others=0
	Lifestyle Variables
Suppl	Have you taken any supplements in the past month? 1=yes, 0=No
Nsuppl	Total number of supplements taken 0 = group 1, 1-5=group 2, 6-10=group 3, 11-15=group 4, 16-20=group 5, 21-24=group 6
Vigwork	Involved in vigorous work? 1=yes, 0=No
Vigrecre	Involved in vigorous recreation (eg. exercise) activities? 1=yes, 0=No
Smok100	Have you smoked up to 100 cigarettes in lifetime? 1=yes, 0=No
Drink	Had at least 12 alcohol drinks in 1 year? 1=yes, 0=No

Table 5.2 Continued

Variables	Description
Health Indicator Variable	
BMI	Body mass index (kg/(body height in meters)^2
Bpressure	Have you been told by a health professional that you have high blood pressure? 1=yes, 0=No
Diabetes	Doctor told you have diabetes? 1=yes, 0=No
Food Security Variables	
Nobdiet	Household could not afford balanced meals? 1=(often true, sometimes true), 0= others
Fbank	In last 12 months, did you or any household member receive emergency food from food bank, church, etc? 1=yes, 0=No
Fstamp	Have you or any household member ever received food stamps? 1=yes, 0=No

Source: Adapted from NHANES 2007-2008.

5.3 Profile of NHANES 2007-2008 Respondents

The total number of NHANES respondents who reported to have taken a dietary supplement in the past month was 2,413 individuals, representing 47.1% of 2007/08 NHANES survey participants. The detailed descriptive statistics of the respondents are as displayed in table 5.3 below.

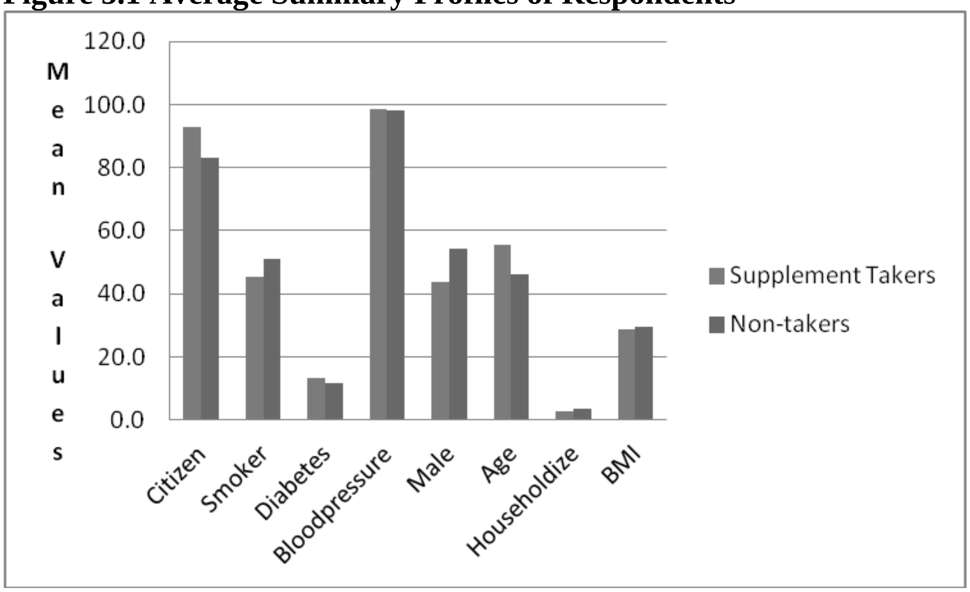
Table 5.3 Descriptive Statistics of Data Used in Analysis

Variable	Mean	Maximum	Minimum	Standard Deviation
Male	0.49	1	0	0.5
Married	0.60	1	0	0.49
Divorced	0.23	1	0	0.424
Single	0.16	1	0	0.37
Hszie12	0.46	1	0	0.498
Hsize36	0.48	1	0	0.50
Hsize7	0.06	1	0	0.228
Hhinc1	0.294	1	0	0.456
Hhinc2	0.304	1	0	0.460
Hhinc3	0.113	1	0	0.316
Hhinc4	0.0894	1	0	0.285
Hhinc5	0.126	1	0	0.332
Age1	0.32	1	0	0.467
Age2	0.32	1	0	0.466
Age3	0.36	1	0	0.480
Black	0.20	1	0	0.403
Hispanic	0.11	1	0	0.312
White	0.48	1	0	0.499
Otherace	0.21	1	0	0.408
Highschool	0.25	1	0	0.431
Graduate	0.19	1	0	0.392
Citizen1	0.87	1	0	0.331
Suppl	0.47	1	0	0.499
Nsuppl	1.15	24	0	2.697
Vigwork	0.19	1	0	0.396
Vigrecre	0.19	1	0	0.396
Smoke100	0.48	1	0	0.50
Drink	0.71	1	0	0.456
BMI	29.01	73.4	14.2	6.701
Bpressure	0.98	1	0	0.126
Diabetes	0.12	1	0	0.330
Nobdiet	0.04	1	0	0.197
Fbank	0.07	1	0	0.259
Fstamp	0.24	1	0	0.424
Wgtcont	0.52	1	0	0.50

Source: Computed from NHANES 2007-2008.

Out of all dietary supplement consumers about 93% consumed between one to five supplements, 6% consumed between six to ten supplements, and the remaining 1% reported consumption of between eleven and the reported maximum of twenty-four supplements per month. Based on a simple descriptive comparison of supplement takers and non-takers, supplement takers were found to be older (55.41 years) than non-takers (46.21 years). A t-test showed that the two means were statistically significant at the 95% confidence interval. Supplement takers also had relatively smaller household sizes and reported lower body mass index. Figure 5.1 graphically contrasts select variable averages of typical dietary supplement consumers as against their non-consumer counterparts.

Figure 5.1 Average Summary Profiles of Respondents



5.4 Empirical Propensity Score Model Specification

The first objective of this thesis, which is to identify the determinants of selection into the treatment group of dietary supplement taker, is achieved by estimating a binary logit model with the dependent variable dietary supplement intake *(SUPPL)*. The independent variables are captured as a vector of lifestyle, socioeconomic and health indicator variables.

As stated earlier in the thesis, dietary supplement intake may contribute to the utility derived from good health and is an input to an individual's health production function. The factors that have been found to be associated with supplement intake as contained in the supplement industry section can be classified as socio-demographic, lifestyle, food security and health considerations. The first empirical model therefore is written as the binary logistic model below:

Suppl = f(male, white, hispanic, otherace, citizen1, hischool, graduate, married, divorced, age2, age3, hsize36, hsize7, hhinc2, hhinc3, hhinc4, hhinc5, wgtcont, drink, smok100, vigrecre, fstamp, diabetes, bpresure)). (12)

This logit model as the first stage of the analysis is used to determine the probability of selection of participants into the treatment group. It is actually our empirical propensity score model. After we ensure that common support is satisfied, we then use the various matching algorithms discussed previously to specifically determine the effect of treatment on the outcomes. The specific questions that were raised are:

- Do dietary supplement takers differ significantly from non-takers in terms BMI?
- Does the number of dietary supplements taken have an effect on body weight outcomes (BMI)?

With respect to determining the effect of the number of supplements taken on BMI, we repeat the propensity score model using several categories in the number of supplements taken (see Table 5.2 for categorization) and then conduct a pair-wise comparison of the categories matching results to determine whether the number of supplements taken stands in a linear relationship with an individual's health outcome measure, BMI.

5.5 Hypotheses

The relationship between dietary supplement intake and BMI is not a causal one. However, dietary supplement intake may have an effect on the overall diet quality of users which may in turn have a visible effect on a diet health outcome indicator such as BMI. It is therefore hypothesized that dietary supplement takers will have a lower BMI than non-takers of dietary supplements. According to some reports, dietary supplement intake could be unnecessary or may even have detrimental effects on the consumers health (Mursu et al., 2011; Wang, 2011). We therefore investigate the relationship between the total number of dietary supplements taken and BMI. We realize that there may be varied effects of the additional health benefits of consuming more dietary supplements as a result of the effect that the impact of dietary supplement consumption could have on nutritional quality. To answer the question of what the relationship between the total number of supplements taken and total health benefits to the individual (reflected in the BMI) may be, we hypothesize that there is a non-linear relationship. We expect individuals to exhibit a trend that shows a declining marginal utility of dietary supplement consumption.

CHAPTER SIX

Results and Discussion

6.1 Introduction

This chapter is used to project and discuss the results obtained from the implementation of the PSM approach based on the U.S. NHANES dataset discussed in the previous chapter. The first part of this chapter is dedicated to the discussion of the results on the probability of selection into treatment (determinants of individual's dietary supplement intake decision). This is followed by the discussion of the results of whether dietary supplement takers differ significantly from non-takers in terms of their BMI outcome measures. Furthermore, the question of how the extent of supplement consumption influences BMI will be answered.

6.2 Selection into Dietary Supplement Intake Group

In table 6.1 below the results of the logit model which is the first stage in the PSM approach is presented. The logit model apart from giving us the idea about who takes supplements is used to determine the best matches between dietary supplement takers and non-takers and to determine the factors that account for the selection into the treatment group. The balancing property was satisfied.

Table 6.1 Determinants of Dietary Supplement Intake

Variables (Y= SUPPL)	Coefficients	Marginal Effect Estimates
Socio-demographic Variables		
Male	-0.541*** (0.0661)	-0.129
White	0.484*** (0.0835)	0.114
Hispanic	0.364*** (0.119)	0.096
Otherace	0.251** (0.104)	0.072
Highschool	-0.0278 (0.0743)	0.075
Graduate	0.426*** (0.0882)	0.199
Married	0.183* (0.0951)	0.049
Divorced	0.147 (0.110)	0.037
Citizen1	0.361*** (0.114)	0.088
Age2	0.554*** (0.0836)	0.146
Age3	1.173*** (0.0955)	0.306
Hsize36	-0.337*** (0.0715)	-0.077
Hsize7	-0.437*** (0.157)	-0.087
Hhinc2	0.190** (0.0774)	*0.034*
Hhinc3	0.279** (0.109)	*0.043*
Hhinc4	0.395*** (0.120)	*0.071*
Hhinc5	0.643*** (0.114)	*0.129*
Lifestyle variables		
Smok100	-0.177*** (0.0663)	-0.039

Table 6.1 Continued

Variables (Y= SUPPL)	Coefficients	Marginal Effect Estimates
Lifestyle Variables		
Vigrecre	0.384***	-0.088
	(0.0837)	
Wgtcont	0.406***	-0.096
	(0.0626)	
Drink	0.0928	-0.021
	(0.0729)	
Food Security Variable		
Fstamp	-0.287***	-0.051
	(0.0806)	
Health Variables		
Diabetes	-0.128	-0.022
	(0.0944)	
Bpressure	-0.235	-0.064
	(0.242)	
Constant	-1.401***	
	(0.289)	
Pseudo R-Squared	0.1174	
Log likelihood	-3172.4882	
Observations	5,125	

Note: Standard errors in parentheses. ***, **, and * indicate significance at the 99%, 95%, and 90% level

From the results, all the socio-demographic variables with the exception of *DIVORCED*, *HISCHOOL* and *HHINC3* are significant at explaining the probability of selection into treatment group. Among the socio-demographics, *MARRIED*, *Hsize7* and *HHINC4* are significant at 5% whereas *HHINC2* is significant at 10%; all others are significant at 1%.

The socio-demographic factors that could negatively affect the propensity of taking dietary supplements are being male and household size. According to the results below, males are probably 54% less likely to take dietary supplements as compared to their female counterparts. This finding is similar to what has been earlier documented in previous studies (Bailey et al., 2011; Fennell, 2004; Rodolfo M Nayga and Reed, 1999). This negative relationship has been generally attributed to the belief that females are generally more concerned about diet behaviour and weight (BMI) in particular. Whereas households that are composed of three to six people are 34% less likely to be taking dietary supplements, their counterparts who have seven or more household members have an even lower probability (44%) of consuming dietary supplements when both groups are compared to households that have a maximum of two members. This is also similar to what previous researchers have said about the effect of household size on consumer diet behaviour. It is said that larger households may not have the means to buy dietary supplements for all its members and hence the negative relationship (Nayga and Reed, 1999). The other socio-demographic factors that could positively affect the probability of taking dietary supplements are being white, higher education, being married, higher age, higher household income and being a citizen of the United States of America. These results are consistent with what previous researchers have documented (Bailey et al., 2011; Ervin et al., 1999; Fennell, 2004; Garside et al., 2005; Petrovici and Ritson, 2006). These factors that seem to have a positive influence on the propensity of taking dietary supplements are usually characteristic of people with higher socioeconomic status. All the races under consideration in this thesis have a greater propensity to consume supplements as compared to people who are black. For instance, whites, Hispanics and all other races that responded to the questionnaire have a higher propensity of consuming supplements by 48%, 37% and 25% respectively. When married and divorced people were compared to single people, those who were married were 19% more likely to take supplements. Higher level of education seems to consistently pay off as indicated by the results. Respondents who were graduates had the highest propensity (43%) of taking dietary supplements. This result may be attributed to fact that higher educated people may be better informed and in better position to take charge of the diet health. Finally, people in the highest income group have the greatest propensity (64%) to take dietary supplements when they are compared to people in the lowest income bracket. The reason behind this observation could be because those with higher incomes may be better resourced financially to buy dietary supplements.

The lifestyle variables that are significant at explaining the propensity to consume dietary supplements are smoking, weight control and vigorous recreation (*SMOK100, WGTCONT and VIGRECRE*). According to the results, people who smoke cigarette are probably 18% less likely to take dietary supplements as compared to those who do not smoke. This negative relationship between smoking and supplement intake has been reported in previous work (Brownie, 2005a; Harrison et al., 2004; Ishihara et al., 2003; Li et al., 2010; Nayga and Reed, 1999; Schroeter et al., 2013). This negative relationship may be ascribed to the belief that smokers are less concerned about their health (Nayga and Reed, 1999). People who had been asked to control their weight and those involved in vigorous recreation (physical exercise) had a positive propensity to take dietary supplements. Those who had been asked to control their weight were 38% more likely to be on dietary supplements as compared to those who were not told to do same. This is similar to what was documented by Nayga and Reed (1999). This finding is important because previous research suggests that people who are on weight control could be on special diets that may not be rich in all nutrients and may need supplementation (Kolasa, Lackey, and Poehlman, 1996). In this thesis, those who are involved in vigorous activities (eg. physical exercise) were found to be 38% more likely to take supplements as compared to those who were not. This result is also consistent with what has been reported in the literature (Foote et al., 2003; Harrison et al., 2004; Li et al., 2010; Lyle et al., 1998; Nayga and Reed, 1999; Reinert et al., 2007; Rock, 2007). Unlike the finding in Lyle et al., (1998) drinking alcohol did not have a statistical significant effect on the propensity of consuming dietary supplements. This may be due to the way the question was asked in the NHANES survey. A drinker was classified as a person who consumed only twelve alcoholic drinks in the whole year.

The only food security variable that was found to be significant at explaining the propensity of taking dietary supplements was receipt of food stamps *(FSTAMP).* Food stamp recipients were 29% less likely to take supplements as compared to those who were not on food stamps. This result may suggest that those who may need supplements are not the ones taking them. This is because food stamp recipients may be food insecure and may not be eating meals that are balanced in all the required nutrients. The result is however not surprising because Nayga and Reed (1999) had discovered a similar relationship.

When we move to the health indicator variables, the results are not significant. There are mixed reports in the literature regarding the presence of a health condition like diabetes or hypertension (blood pressure) and supplement intake. While some of the papers that were reviewed reported that there is a negative relationship between supplement intake and diabetes/blood pressure (Harrison et al., 2004; Satia-Abouta et al., 2003), others concluded that there was no association between supplement intake and a health condition (Balluz et al., 2000; Lyle et al., 1998). The results of this study are therefore aligned to the findings of the latter.

In conclusion, several lifestyle, health and demographic variables play an important role in determining who is likely to be in the dietary supplements treatment group. It may therefore be very important to factor in these characteristics in formulating policy for the dietary supplement industry.

6.3 Do Dietary Supplement Takers Differ From Non-Takers in BMI?

The main objective of this thesis was to analyze whether people who regularly consume dietary supplements as a general positive health behaviour and investment in their health status may benefit from having a better food and diet-related health outcomes, measured by their (lower) BMI. A PSM model was employed to estimate the extent to which supplement takers and non-takers differ in weight outcomes. Table 6.2 presents the results of different matching algorithms for the comparison of NHANES respondents in dietary supplement treatment and control groups.

Table 6.2 Matching Algorithms showing if Supplements takers and non-takers differ in BMI

Matching Algorithm	**Coefficient**	**Standard Error**
Nearest Neighbour Matching	-0.864***	0.207
Radius Matching (r=0.1)	-0.830***	0.210
Radius Matching (r= 0.001)	-0.830***	0.194
Kernel Matching	-0.864***	0.192
Stratification Matching	-0.833***	0.220

Note: ***, **, and * indicate significance at the 99%, 95%, and 90% level

From the results in table 6.2 above, the initial hypothesis proposed that supplement takers may differ from non-takers in terms of their BMI is clearly upheld. Across the select matching algorithms, supplement takers seem to have a lower body mass index of about 1 kg/(body height in m)^2. This similarity in outcome across all the matching algorithms is worth noting because even though asymptotically all algorithms should produce similar results, other studies found inconclusive results (Drichoutis et al., 2009). The nearest neighbour matching and kernel matching both produced the same result of a lower body mass index of 0.9 kg/(body height in meters)^2 while the radius matching and kernel matching also produced a lower BMI of 0.8 kg/(body height in meters)^2. This difference in BMI between dietary supplement takers and non-takers may be significant in moving a person from one weight classification to another (obese, overweight, underweight or normal weight). For instance, a person with a BMI of 29.9 kg/(body height in meters)^2 is classified as overweight but another with a BMI of 30 kg/(body height in meters)^2 is obese. This observation with recent data is a good sign because there is some earlier research that suggests that people who are obese/overweight are less likely to take supplements (Kimmons et al., 2006). Balluz et al. (2000) noted that those who are overweight or obese may have a greater tendency to take supplements because they may be making weight loss attempts (on diet). The negative relationship between supplement intake and BMI in this study is not a new finding. Many researchers to date have drawn this conclusion (Bailey et al., 2011; Foote et al., 2003; Garside et al., 2005; Ishihara et al., 2003; Li et al., 2010; Nayga and Reed, 1999; Radimer et al., 2004; Reinert et al., 2007)

Dietary supplement intake through its possible effect on the diet quality could be seen as the factor responsible for the difference in body mass index between dietary supplement takers and non-takers of dietary supplements. This is because the propensity score method matched all the individuals in the sample based on pre-treatment characteristics as was described in the methodology section.

6.4 Effect of the Extent of Dietary Supplement Intake on BMI

This part of the thesis is quite novel and a literature review did not find any previous studies on the relationship between the actual number of supplements that are taken by an individual and BMI. It was hypothesized there is a nonlinear relationship between the number of dietary supplements taken and BMI. Table 6.3 below gives the summary of the results of the various matching algorithms.

Table 6.3 Effect of Total number of Supplements on BMI

Treatment	**Nearest Neighbour**	**Radius r=0.1**	**Radius r=0.001**	**Kernel**	**Stratification**
1 vs. 2	-0.956*** (0.212)	-0.948*** (0.198)	-0.948*** (0.171)	-0.955*** (0.204)	-0.901*** (0.201)
1 vs. 3	-1.552*** (0.259)	-1.564*** (0.285)	-1.564*** (0.280)	-1.552*** (0.281)	-0.108 (0.637)
1 vs. 4	-1.557*** (0.280)	-1.564*** (0.294)	-1.564*** (0.264)	-1.557*** (0.257)	-0.978* (0.567)
1 vs. 5	-1.558*** (0.293)	-1.565*** (0.284)	-1.565*** (0.257)	-1.565*** (0.251)	
2 vs. 3	-0.096 (0.261)	-0.021 (0.276)	-0.021 (0.276)	-0.096 (0.271)	-0.180 (0.234)
2 vs. 4	-0.030 (0.282)	-0.034 (0.272)	-0.034 (0.265)	-0.030 (0.290)	1.411*** (0.464)
2 vs. 5	-0.025 (0.289)	-0.034 (0.302)	-0.034 (0.259)	-0.034 (0.259)	
3 vs. 4	1.871** (0.797)	1.940** (0.789)	1.940** (0.755)	1.871** (0.771)	3.412*** (0.954)
3 vs. 5	2.068*** (0.786)	1.956** (0.856)	1.957** (0.838)	1.956** (0.779)	

Note: Standard errors in parentheses. ***, **, and * indicate significance at the 99%, 95%, and 90% level.

As depicted by the results above, taking any number of supplements as compared to not taking supplements at all may result in a lower BMI of approximately between 1 to 2 kg/(body height in meters)^2. This is the outcome displayed by the pair-wise comparison between treatment 1 (not taking supplements at all) and treatments 2 (1-5 supplements), 3 (6-10 supplements), 4 (11-15 supplements) and 5 (16-20). The last treatment group was omitted from this analysis due to very few observations (only three people in the sample consumed between 21 to 24 supplements). Just like the finding in section 6.3 above, people who took between one to five supplements in total seemed to have a significantly lower BMI of approximately 1 kg/(body height in meters)^2 than those who did not take any supplements at all. Apart from the stratification matching algorithm which was not significant in the second treatment group, results from all the other matching algorithms show that people who took between six to ten dietary supplements had a lower body mass index of approximately 2 kg/(body height in meters)^2 as compared to their counterparts who were not on dietary supplements at all. These results were also significant at 1%. A similar trend is observed for the third and fourth treatment groups. Here the results suggest an anticipated, negative effect on BMI of 2 kg/(body height in meters)^2 for people who consumed 11 and 20 dietary supplements within the month.

The pair-wise comparison between the second and third treatment groups showed no significant effect on body mass index. It could be inferred from this results that increasing consumption of dietary supplements follows the rule of diminishing marginal returns or benefits. In other words, there may be no additional benefit from consuming more than a certain number of supplements (in this case 5). This finding is logical because a look at the nutritional fact sheets on many supplement containers reveals that supplements tend to contain similar nutrients like vitamins A, C, D, E etc. and some minerals. Therefore, if a consumer takes different supplements, there may be the tendency of exceeding the recommended daily intake allowance for specific nutrients. In the pair-wise comparison between the third and fourth group, only the stratification matching algorithm is significant at the 1% level, but shows a positive. According to this result, people who took between eleven and fifteen supplements had a body mass index that was 1.4 units greater than those who took fewer dietary supplements. The situation begins to worsen further when even more numbers of dietary supplements are taken as depicted by treatments 3 vs. 5 In these latter comparisons, NHANES participants who consumed between eleven and fifteen supplements, or sixteen to twenty supplements seemed worse-off in terms of BMI by approximately 2 kg/(body height in meters)^2 as compared to those who took between 6 and 10 supplements. This is similar to the findings of Frank et al. (2000), Mursu et al. (2011) and Wang (2011) where supplementation was found to have detrimental effects on the health of consumers.

In conclusion, there are mixed effects of the number of supplements taken on body mass index. While taking any amount of dietary supplements appears to be better than not taking any at all, there appears to be a threshold after which increasing the number of dietary supplements taken could adversely affect consumer health by increasing the body mass index and posing other health threats that may be associated with overweight and obesity. People should therefore be cautious about the extent to which they consume different dietary supplements at the same time because of the imminent danger of exceeding recommended daily nutrient intake levels and especially when they do so without the counsel of a medical professional.

CHAPTER SEVEN

Summary, Policy Implications, Recommendations and Limitations

7.1 Summary

The increasing incidence of obesity across North America is a source of concern to many stakeholders like the government, non-governmental organizations, the World Health Organization etc. Governments as well as health professionals, and consumer groups are concerned about the rising healthcare costs that are directly related to lifestyle and food-intake related diseases. This thesis adds to the discussion on the role dietary supplements could play in meeting some of the micro-nutrient needs of diets of people in the U.S. majority of who are thought of as not consuming the recommended amounts of fruit and vegetables which is the main source of most micro-nutrients. Due to the inadequate consumption of fruits and vegetables by the vast majority (60%) of Americans (Guenther et al., 2006), many see dietary supplements as the next best and convenient alternative to meet their nutritional needs (Pole, 2007; Schroeter et al., 2010). However, dietary supplement takers are at the mercy of marketing companies who try to project their products in the positive light. As a result, there is a tendency of information asymmetry which could result in some health repercussions to the consumer.

The main objective of this thesis was to determine if dietary supplement takers differ from non-takers in BMI. This was achieved by using the PSM approach to account for a possible selection bias and endogeneity between the self reported dietary supplement intake and BMI in the NHANES data set. It was envisaged that the number of supplements taken by an individual could also affect BMI and so the next objective was to determine if a linear relationship exists between dietary supplement intake and BMI.

The objectives of the thesis were achieved through a two step estimation procedure. The first stage was a logit model (propensity score estimation) which was used to determine the selection into the treatment group. After it was ensured that the balancing property was satisfied, the various matching algorithms were then used to account for any differences left between dietary supplement takers and non-takers. The results reveal that several socio-demographic, lifestyle, food security and health variables significantly affect NHANES participant's probability of regularly consuming at least one dietary supplement per month. Moreover, the profile of the average dietary supplement consumer in the U.S. was found to be white, highly educated, of higher household income and of higher overall health status (e.g. non-smoker, non-drinker, etc.). The results found in this analysis largely conformed to previous studies in the area of consumer food-health and dietary behaviour studies (Bailey et al., 2011; Ervin et al., 1999; Fennell, 2004; Nayga and Reed, 1999; Schroeter et al., 2013). Drinking was reported to have a negative effect on supplement intake by Lyle et al. (1998) but in this thesis, no significant relationship was discovered between drinking and dietary supplement intake. More results reveal that dietary supplement takers have a significantly lower BMI of about 1 kg/(body height in meters)2 than non-takers of dietary supplements across various matching algorithms. The results on the effect of total number of supplements taken on BMI however show that increasing the number of supplements taken may not always positively affect the diet quality of the consumer as reflected in increased BMI. Therefore dietary supplement intake may not be the panacea to mitigating the incidence of obesity. People should be very cautious about the extent of supplementation because taking too many supplements could have implications of higher BMI and ultimately obesity and other linked conditions.

In conclusion, it seems that dietary supplements through its possible effect on diet quality may play an important role in helping people maintain a relatively lower BMI. Even though dietary supplements seem to work, they work for the wrong people. People who may really need dietary supplements to improve their diets like those in the lower socio-economic bracket (low income, food insecure, black, etc) are those in most need of supplementing their diet. Sadly it seems they are the ones who are not taking the supplements. From all indications, those

taking the supplements may already be healthy and may even not be in need of dietary supplements. Like the American Academy of Nutrition and Dietetics (formally called American Dietetic Association) stand point, it may be better to acquire the needed nutrients from food instead if there is really no need to take dietary supplements (American Dietetic Association, 2001).

7.2 Policy Implications and Recommendations

From the results of the study, dietary supplement takers belong to the higher socio-economic class. These people usually have better diet and health outcomes than the more vulnerable in society but are also the ones who also use dietary supplements. Health policy on consumption, especially with regards to fruits and vegetables and dietary supplement intake, should be rebranded to target specific segments of society. This is to ensure that those in need of improved diet get the message rightly. Policy makers should therefore find new ways of sending campaign messages to make healthy eating more appealing to the more vulnerable group of people who may be in most need of dietary supplements because they may not get all the required nutrients from food alone. If not, the people in the higher socio-economic class who may likely get all their micro-nutrient needs from food will continue to take dietary supplements. Even though there is some evidence in this report to suggest that dietary supplements may work, it is not possible to make any strong recommendation in support of dietary supplement intake due to the complex nature of fully understanding the dynamics involved in peoples diet-health behaviour. For instance, the efficacy of supplementation may just be as good as adherence.

Policy makers should also require dietary supplement producers and marketers to be more frank with consumers on the possible detrimental effects that over supplementation could have on the health status (measured by BMI) of an individual. If possible, warnings should be placed on the labels of dietary supplements about the likely consequences of over utilization of supplements or a combination of supplements. Additionally, stringent punitive measures should be implemented against producers who deviate from the laid down production and marketing procedures in the dietary supplement industry. In order to prevent the adverse effects of excess consumption of dietary supplements, the education on intake of fruits and vegetables should be intensified and vigorously promoted to the at risk populations. The intention is to encourage them to increase consumption in order to meet their required daily amounts of micro-nutrients largely from food. For this to happen, policy makers, supplement producers and marketers must adopt a supportive approach to healing, and the benefits of good nutrition which encompasses the maximum consumption of fruits and vegetables cannot be understated. Finally, consumers should be encouraged to seek medical/nutritional guidance before initiating the consumption of any type or combination of dietary supplements.

7.3 Limitations

Research of this nature should be multidisciplinary in order to capture the different things that could affect the propensity of taking dietary supplements and BMI. This is because dietary supplement intake is not causally linked to BMI and a lot of other factors that could potentially affect the likelihood of taking supplements or BMI for that matter are beyond the scope of this paper. Therefore, the results of this thesis is not sufficient for us to conclude that those who want to improve their BMI or lose weight should resort to taking dietary supplements because several other factors are beyond the scope of this study. Apart from this, the only diet-health indicator used in this thesis was dietary supplement intake. The healthy eating index could have improved the findings but this index was not available for the NHANES 2007-2008 at the time of the thesis. The results therefore come with limitations.

Also, the study was limited to the adult population aged twenty and above in the U.S. on the premise that younger people do not typically make their diet/supplement decisions. It is possible that some of these people excluded from the sample do make their own decisions. Not only these, the propensity score matching method employed only uses observed covariates to do matching and there is a possibility that there could still be some form of unobserved heterogeneity in the data. To add to these, it may be important to incorporate the exact number of nutrients in each supplement or type of dietary supplement taken in future analysis as this could affect the results of the relationship between the total number of supplements taken and BMI. It may also be good to have information on the expenditure on dietary supplements but this is lacking in the current data. Information on expenditure may assist in answering some of the questions on why those in the lower socio-economic bracket do not take dietary supplements. Finally, future research should look at modeling sub-populations to answer the question of whether dietary supplements could benefit all or particular groups.

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