Obesity & Overweight Epidemic: An Innovative Approach to Understanding & Addressing Obesity In The Kingdom Of Saudi Arabia

by

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Dedication

I dedicate this work to my beloved country, Saudi Arabia. To both the leadership and people.

I would also like to dedicate this thesis to my loved ones. To my amazing father and best friend Haytham Al-Tayyar and my lovely mother and #1 love in this world (tied for first place with my dad) the one and only Sahar Achrafieh who have both provided me with all the love, care, affection and support a son can ask for. Without you I would not be where I am today. I love you both so much! To my dear brother Mohammad H. Al-Tayyar and your wife Zein Attar and the little angels, your daughters Jawaher and Loulwah (unconditional love), you are and will always be my pillar of support and best friend. I will continue to drive you crazy with my apparent chaos but I will remain comforted by the fact that you will always be there for me as I will always be there for you. Thank you for being the most amazing brother a person can ask for, I am blessed to have you in my life. To my one and only loving sister Haifa Al-Tayyar also known as supermom and the best sister in the world, I love you with all my heart. Without your love and support and kindness I would not be the man I am today. You are my sweetheart and one of the kindest, smartest and most capable young woman I know. I am lucky to have you in my life; I will always be there for you. To Fahad Bubshait my dear brother in law, your title has been changed to brother a long time ago. You are an amazing father to your kids and husband to my sister and son to my parents. Your support, care and love are unparalleled. To the three little angels: Yasmin, Fouad and Haya. You're never ending and unconditional love for me keeps me going. I dedicate this work to my grandfathers Dr. Ahmad Al Tayyar and Zuhair Achrafieh may God rest your souls. I was greatly inspired by both and blessed to have learned from them. To my grandmothers, thank you for keeping my grandfathers in check. I know it was probably a tough job.

To my future wife (still pending) and future kids (hoping to be blessed by having you). I look forward to you reading this work in the near future.

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Thesis Supervisor: Anthony Sinskey
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ABSTRACT

Obesity and overweight are complex global issues that have been and continue to be a significant problem that needs to be addressed. Understanding obesity and overweight are fundamental to finding practical and sustainable solutions.

Innovation has different meanings to different people and can be applied in many different sectors in varying forms and at different levels. Innovation in healthcare is no longer a luxury but rather a necessity. In this thesis, we review some concepts of interest to healthcare innovation briefly and also examine the topic of obesity and overweight from a global perspective and with a focus on the Kingdom of Saudi Arabia. We review global obesity and overweight and then focus on obesity and overweight in the Kingdom of Saudi Arabia. We also reflect on the work of Prof. Clayton Christensen "Jobs to be Done Theory" and how it can help address innovation in the healthcare system and in particular applying it to the general

concept of tackling obesity. The thesis highlights a critical understanding of obesity based mostly on the work of Jason Fung, MD in his recent book titled "The Obesity Code: Unlocking the Secrets of Weight Loss." A novel integrated solution for tackling obesity in the Kingdom of Saudi Arabia will be proposed incorporating insights from the research material on both innovation and obesity with the utilization of concepts gained from the System Design and Management program at MIT. The concept of innovation in the healthcare setting is shown to be instrumental in creating an opportunity for higher quality, cheaper and faster delivery of health services heavily dependent on the work of Prof. Clayton Christensen. Also, we highlight the need for an innovative integrated solution at different levels of the system including the individual level and institute level and finally the national levels. We believe there is a genuine need to approach innovation in the healthcare setting at the different establishments within the healthcare system and the importance of cross-pollinated innovation teams.

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Table of Contents

Contents

Tables

Table of Figures

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Chapter 1 Introduction

Thesis Organization

We begin by giving an overview regarding both overweight and obesity, starting with the definitions and explaining how categorization can occur utilizing the Body Mass Index.

We then listed some of the associated medical conditions and adverse health effects associated with obesity.

Next, we touched on the prevalence of obesity globally and emphasized the increasing trend of childhood obesity. We highlight the association between childhood obesity and increased risk of future obesity.

We then clearly demonstrate the trend of increasing prevalence of obesity and overweight.

Next, we list and tackle possible causes and some complex influencers to the development of obesity. We listed many potential causes but focused on the diet since we believe it is a critical contributor to the obesity epidemic.

We then highlighted the important concepts of "proximate" vs. "ultimate" causes of understanding obesity and similar medical conditions.

Next, we shifted our focus to understand more about overweight and obesity in Saudi Arabia. We highlighted the significance, prevalence, and the potential economic burden.

We then describe and elaborate on the "Caloric Imbalance Theory" and highlight some of its deficiencies.

Chapter 6 highlights the role of exercise and expands on the concept of "Body Set Weight."

Chapter 7 then shifts our minds to understanding obesity through the "Hormonal Theory of Obesity." We also introduce diabesity and then shed some more light on sugar and artificial sweeteners. We then touch on some evidence for protective factors and then dismiss a few myths related to diet.

In Chapter 8, we introduce innovation and define what we mean by it. We then infuse the "Jobs to be Done Theory" and introduce disruptive business models which have been mentioned in the work of Prof. Christensen.

Finally, in Chapter 9, we present our recommendations for tackling obesity and our logic behind them.

Overview

Obesity is a complex problem

"We frequently try and solve complex, ill-defined problems by searching for simplistic solutions to the already incorrectly or poorly defined problems" (Christensen, Grossman, & Hwang, 2009).

"Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health" ("WHO | Obesity," 2014).

Body Mass Index (BMI) is used as a crude population measure of obesity. BMI is calculated by dividing an individual's weight (in Kilograms) by the square of their height (in meters). We will elaborate a bit further on BMI in Chapter 2.

There are a few interesting facts obtained from the World Health Organization Fact Sheet on obesity:

- *"Worldwide obesity has more than doubled between 1980 and 2014"*
- *"In 2014, more than 1.9 billion adults, 18 years and older, were overweight. Of these over 600million were obese."*
- *"In 2014, approximately 41 million children under the age of 5 were overweight or obese."*

("WHO | Obesity and overweight," 2016)

To address the issue of overweight and obesity, we need to clearly define, understand and categorize the problem. We could then address the issue utilizing innovation concepts and a system approach. Our solution or group of solutions must be "competitive, responsive and consumer driven with clear metrics of value per currency spent" (Christensen, 1997).

Obesity and diabetes have always been topics of great interest to public health professionals worldwide. We believe in the importance of addressing them, not only at the individual level but also at the community and national levels. We will highlight the importance of addressing obesity in Saudi Arabia.

Overweight and obesity appear to be a significant problem globally. Saudi Arabia, unfortunately, is not an exception. We hope to show the magnitude of the issue for the Kingdom of Saudi Arabia. As we can see from Figure 1 the prevalence of overweight and obesity as of 2014 in Saudi Arabia was approximately 69.4 percent.

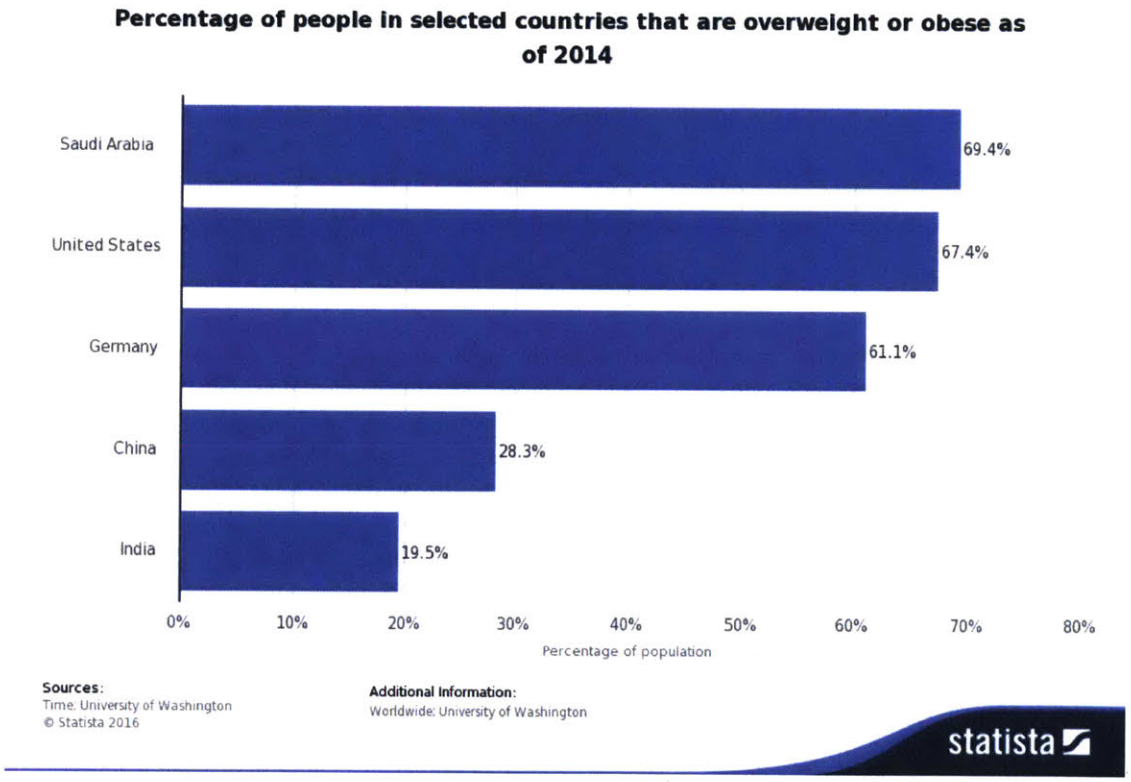


Figure 1: ***Percentage of people in selected countries that are overweight or obese as of 2014*** (Time, n.d.)

In Saudi Arabia, the increase in obesity prevalence over the years was documented from as far back as early 1970's. The increasing prevalence of obesity over time and the trend towards a continued rise is alarming since obesity contributes to the

individual, community and national medical challenges. Obesity is a chronic disease and an independent risk factor for other chronic non-communicable diseases such as diabetes mellitus type 2, heart disease, stroke, hypertension, dyslipidemia, obstructive sleep apnea, cancer (multiple types), and gout, atrial fibrillation, venous thrombosis (clots), dementia, osteoarthritis, kidney disease, skin changes and psychosocial issues. Obesity is a complex multifactorial disease. It is interlinked with other conditions and results in significant morbidity and mortality burden as a stand-alone entity and as a risk factor for other chronic non-communicable diseases such as cardiovascular disease, osteoarthritis and multiple types of cancer that have been associated with obesity.

The effects of the obesity epidemic are not limited to health but also pose an economic burden on the system, as it is associated with significant direct and indirect costs related to obesity and the complications and medical conditions associated with obesity.

If overweight and obesity are not tackled appropriately and aggressively in a timely manner, this will ultimately result in a significant burden on the individual, community, and ultimately the country.

When we look into the cause of obesity, we quickly realize that "Obesity is the result of a multitude of factors, and therefore no single solution is likely to be effective in tackling it."(*Overcoming obesity: An initial economic analysis*, 2014)

A range of interventions at different levels of the defined system will likely be necessary. The interventions need to be systematic and complementary to one another. Time and effort will be required to address the epidemic of overweight and obesity.

Motivation for Thesis

The motivation for this thesis is as follows:

1. Discuss obesity and overweight from a global perspective and a focus on the problem in the Kingdom of Saudi Arabia demonstrating the prevalence of obesity and overweight in addition to some of the adverse effects associated with being overweight or obese.

2. Supporting the shift from the "Caloric Imbalance Theory" to the "Hormonal Theory of Obesity." Keeping in mind that although we think the hormonal theory better assists us in understanding obesity when compared to caloric imbalance theory, it is not complete and further research is required.

3. Provide a high-level innovative and integrated approach to tackling obesity and overweight in the Kingdom of Saudi Arabia. Utilizing innovation concepts such as the "Jobs to Be Done Theory" to the problem of obesity and incorporating some general tools and principles learned from System Design and Management. At Massachusetts Institute of Technology (MIT).

With that in mind, we hope to answer the following research questions:

1. What do we know about obesity globally and in Saudi Arabia?
2. What innovative approaches can we pursue in hopes of putting a dent in the increasing prevalence of obesity and overweight in Saudi Arabia?

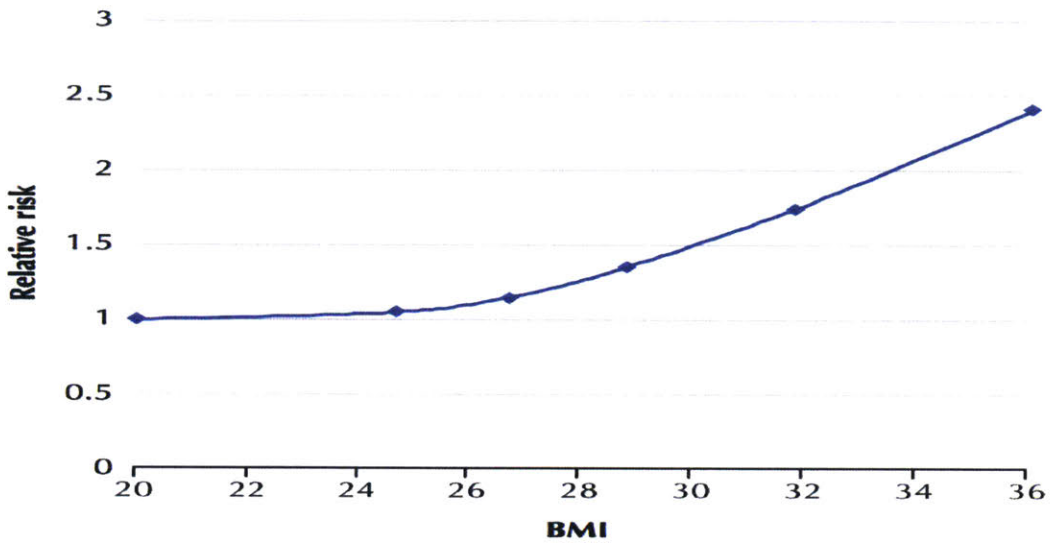
Chapter 2 Overweight & Obesity

Definition of Overweight & Obesity

According to the Centers for Disease Control and Prevention, overweight and obesity are terms used to describe when the weight of the individual is higher than what is considered a healthy weight for a given height ("Defining Adult Overweight and Obesity | Overweight & Obesity | CDC," n.d.).

Obesity is commonly defined regarding a person's body mass index; the body mass index (BMI) is commonly used as a screening tool for overweight and obesity. Body Mass Index (BMI) is calculated as a person's weight in kilograms divided by the square of their height in meters ("Defining Adult Overweight and Obesity | Overweight & Obesity | CDC," n.d.).

Obesity is a complex chronic disease of which prevalence has been continuously on the rise across the full spectrum of the population including children, adolescents, adults and the elderly. It is a global epidemic. Obesity is associated with a significant increase in the risk of mortality (death) as demonstrated in Figure 2



Note: This figure is based on data from a study of female nurses in the United States. Studies for all adults imply a similar relationship between BMI and risk of mortality in men.

Figure 2: The relationship between body weight, by BMI, and relative risk of mortality (Manson et al., 1995)

Categorization According to Body Mass Index (BMI)

Body Mass Index (BMI) classification is used to screen for overweight and obesity. Individuals can be sub-classified according to the calculated BMI, as adopted by the National Heart, Lung, and Blood Institute ("Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health." 1998) and the World Health Organization (WHO Consultation on Obesity (1997: Geneva, Diseases, & World Health Organization. Programme of Nutrition, 1998), and affirmed in the American Heart Association (AHA)/American College of Cardiology (ACC)/The Obesity Society (TOS) Guidelines (Jensen et al., 2014) to the following categories for adults:

Normal weight – BMI ≥18.5 to 24.9 kg/m2

Overweight – BMI ≥25 to 29.9 kg/m2

Obesity – BMI of ≥30 kg/m2

Severe obesity – BMI ≥40 kg/m2 (or ≥35 kg/m2 in the presence of comorbidities)

Refer to Figure 3 for details on sub-classification in adults and youth.

Weight categories for adults and youth

Category	Adults (18 years and older)[1]	Youth (2 to 18 yrs) CDC, AAP, IOM, ES, IOTF[2,3]
Underweight	BMI <18.5	BMI <5th percentile for age
Normal weight	BMI 18.5-24.9	BMI ≥5th to <85th percentile
Overweight	BMI 25-29.9	BMI ≥85th to <95th percentile
Obesity	BMI ≥30	BMI ≥95th percentile
Severe obesity	BMI ≥35 (class II obesity)	BMI ≥120 percent of the 95th percentile, or a BMI ≥35 (whichever is lower)*[4,5]
	BMI ≥40 (class III obesity)	BMI ≥140 percent of the 95th percentile, or a BMI ≥40 (whichever is lower)[5]

AAP: American Academy of Pediatrics; IOM: Institute of Medicine; ES: Endocrine society; CDC: Centers for Disease Control; IOTF: International obesity task force; BMI: body mass index.

* In children, several definitions of severe obesity have been used. The most widely accepted is BMI ≥120 percent of the 95th percentile, or a BMI ≥35 (whichever is lower).[3] This corresponds to approximately the 99th percentile, or BMI Z-score ≥2.33 (ie, 2.33 standard deviations above the mean).

References:

1. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. Obes Res 1998; 6 Suppl 2:51S.*
2. *Barlow SE, Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics 2007; 120 Suppl 4:S164.*
3. *Wang Y. Cross-national comparison of childhood obesity: the epidemic and the relationship between obesity and socioeconomic status. Int J Epidemiol 2001; 30:1129.*
4. *Kelly AS, Barlow SE, Rao G, et al. Severe Obesity in Children and Adolescents: Identification, Associated Health Risks, and Treatment Approaches: A Scientific Statement From the American Heart Association. Circulation 2013.*
5. *Skinner AC, Skelton JA. Prevalence and Trends in Obesity and Severe Obesity Among Children in the United States, 1999-2012. JAMA Pediatr 2014.*

Graphic 78725 Version 10.0

Figure 3: Weight categories for adults and youth. Adapted from ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

These cutoffs underestimate risk in the Asian and South Asian population yet they apply well to Caucasian, Hispanic, and Black individuals. Thus, in the WHO and National Institutes of Health (NIH) guidelines for Asians, overweight is a BMI between 23 and 24.9 kg/m2 and obesity a BMI >25 kg/m2.

Medical Conditions & Negative Effects Associated With Obesity

Obesity is associated with and increases the risk of a multitude of disorders/events as follows:

- Diabetes mellitus type 2
- Heart disease
- Stroke
- Hypertension
- Dyslipidemia
- Obstructive Sleep apnea
- Cancer (Higher death rates: Colon, Rectum, Prostate, Uterus, Cervical, Ovarian, Breast, Esophagus, Liver, Pancreas, Multiple Myeloma, Non Hodgkin Lymphoma, Kidney)
- Gout
- Atrial fibrillation
- Venous thrombosis (clots in veins)
- Dementia
- Osteoarthritis (May be directly related to the trauma associated with excess body weight. More frequently in non-weight-bearing joints, suggesting that there are components of the obesity syndrome that alter cartilage and bone metabolism independent of weight bearing.)
- Kidney disease
- Skin changes
- Psychosocial issues
- Abdominal Hernias

- Accidents
- Complications during pregnancy
- Complications with surgical procedures
- Decreased longevity and quality of life
- Fertility issues
- Gallbladder and liver disease

Examples of Global Prevalence of Obesity

Whether countries are rich or poor, it appears that over the past 50 years, obesity and overweight in children have increased across a wide range of countries worldwide as we can see from Figure 4

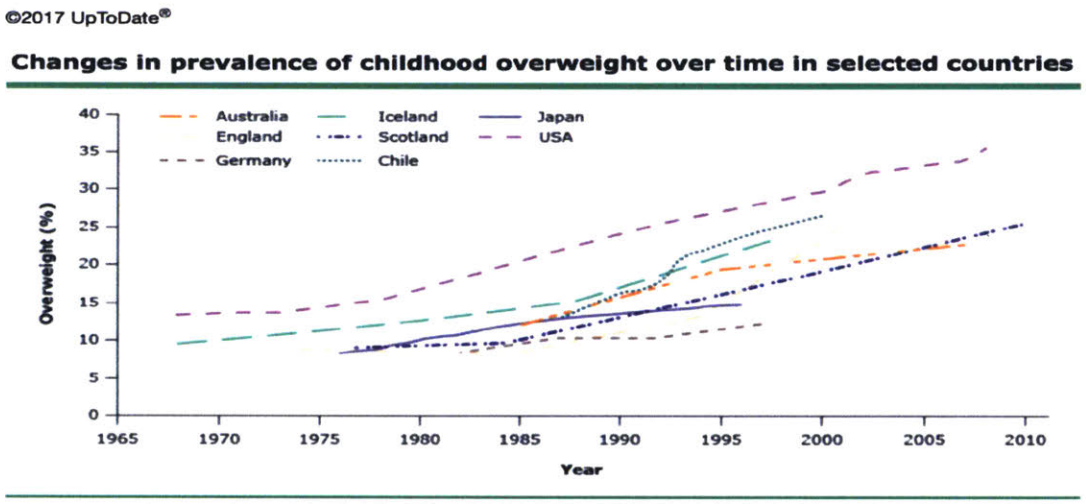


Figure 4: Changes in prevalence of childhood overweight over time in selected countries. Source: Adapted from ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

A history of childhood obesity is a risk factor for obesity in adulthood. Between 1976-1980 and 2013-2014, the prevalence of obesity among school-aged children (6 to 11 years) and adolescents (12 to 19 years) in the United States dramatically

increased from 6.5 to 19.6 percent in children, and from 5.0 to 20.6 percent in adolescents (Ogden et al., 2016).By referring to Figure 5 , Figure 6 , Figure 7 , Figure 8 we can see that the prevalence of childhood overweight which is a predictor and risk factor for overweight and obesity in adulthood, has been on the rise in several countries.

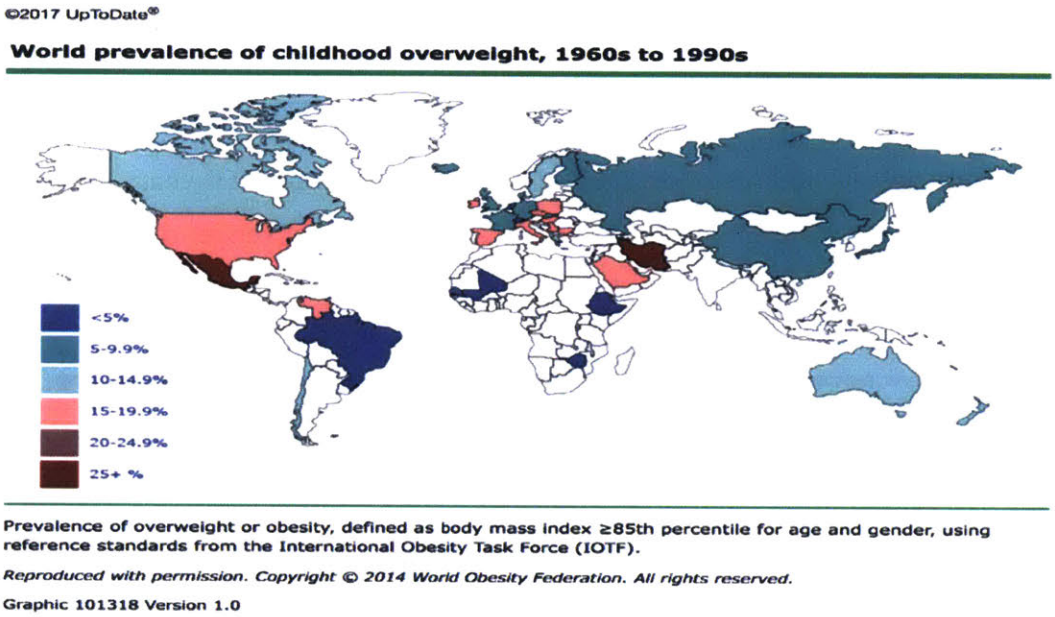


Figure 5 ***World prevalence of childhood overweight, 1960s to 1990s. Adapted from*** ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

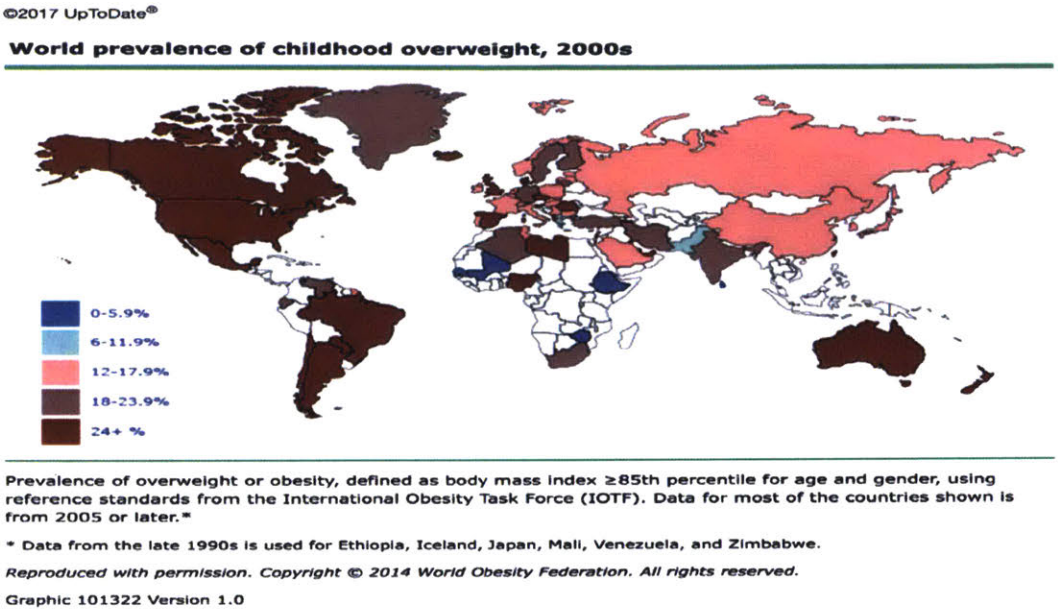


Figure 6 World prevalence of childhood overweight, 2000s. Adapted from ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

By comparing both Figure 5 and Figure 6 we can see that the prevalence of overweight is on the rise globally.

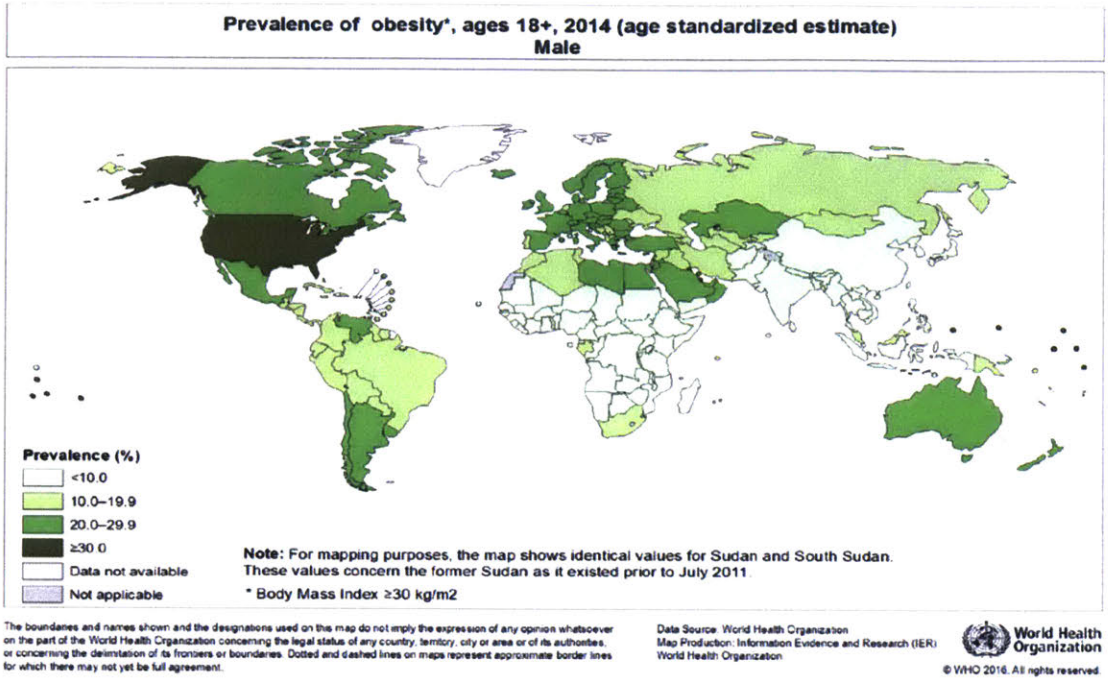


Figure 7 Prevalence of obesity, ages 18+, 2014 (age standardized estimate) for males. Adapted from ("WHO | Obesity and overweight," 2016)

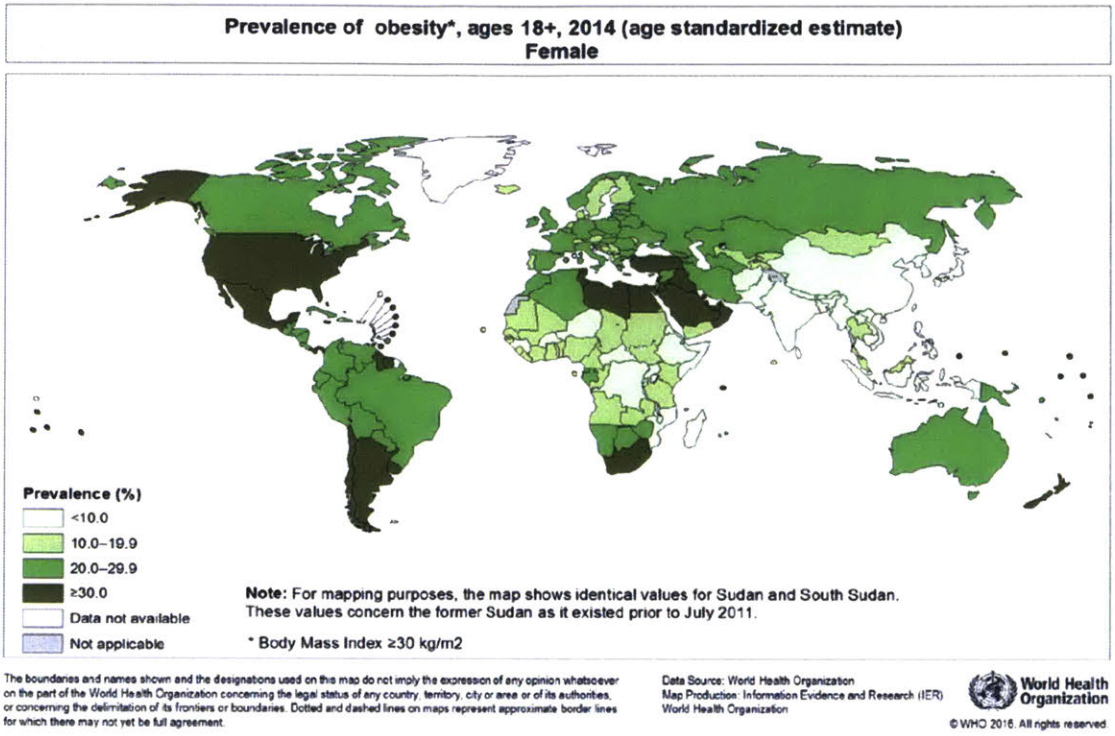


Figure 8 Prevalence of obesity, ages 18+, 2014 (age standardized estimate) for females adapted from ("WHO | Obesity and overweight," 2016)

Similarly by referring to both Figure 7 and Figure 8 above, we note that the prevalence of obesity is significant for both male and females 18 years of age and older as documented for 2014.

We note that obesity has been on the rise since the 1970s (Fung, 2016). From 1976 to 1996, the average fat intake decreased from 45 percent of calories to 35 percent. Butter consumption dropped 38 percent. Animal protein decreased 13 percent. Egg consumption fell 18 percent. Sugars and grain consumption increased (Fung, 2016). Rates of obesity dramatically increased, starting in 1977 as shown in Figure 8. The increase in obesity happens to parallel the move toward a low-fat, high-carbohydrate diet (Fung, 2016).

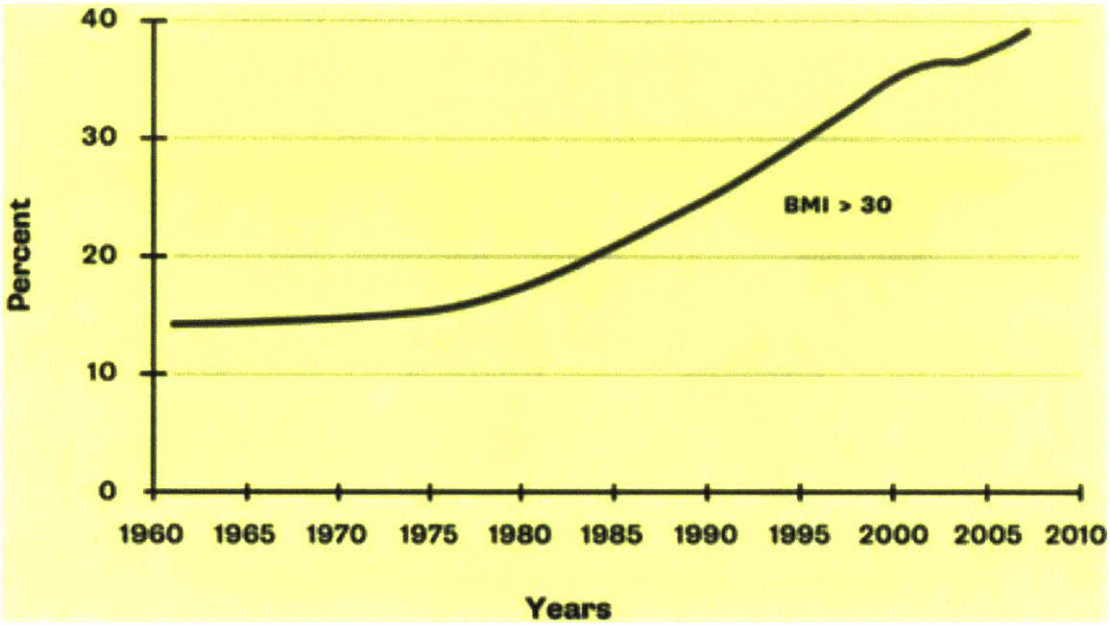


Figure 9 Increase in obese and extremely obese United States adults aged 20-74 adapted from (Fung, 2016)

"Habits have changed considerably since the 1970s including adoption of a low-fat, high-carbohydrate diet, increased number of eating opportunities per day, more meals eating out, more fast-food restaurants, more time spent in cars and vehicles, increased popularity of videos games, increased use of computers, increase in dietary sugar, increased use of high-fructose corn syrup and increased portion sizes. Any or all of these factors may contribute to the obesogenic environment." (Fung, 2016)

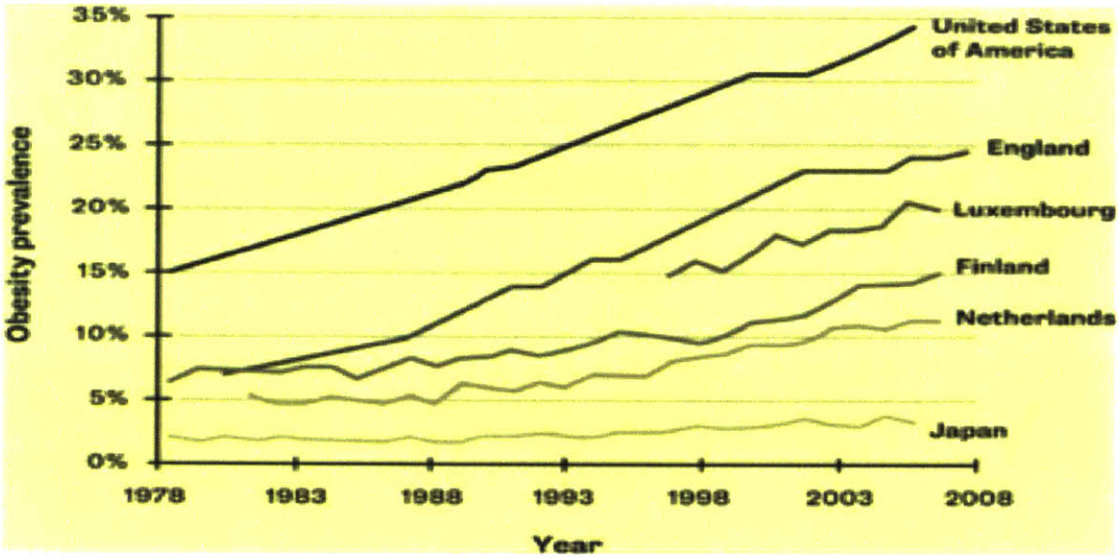


Figure 10 The increasing worldwide prevalence of obesity adapted from (Fung, 2016)

Obesity, as we stated earlier, is a global epidemic. We can see from Figure 10 it has been on the rise since early 1970's in several countries (Fung, 2016). Further subdivisions of specific population categorization according to age, gender and ethnicity will not be tackled in this paper in deep detail.

The aim of this section was to shed some light on the extent of the issue and the fact that it is a global issue.

Etiology of Obesity and the Complex Influencers

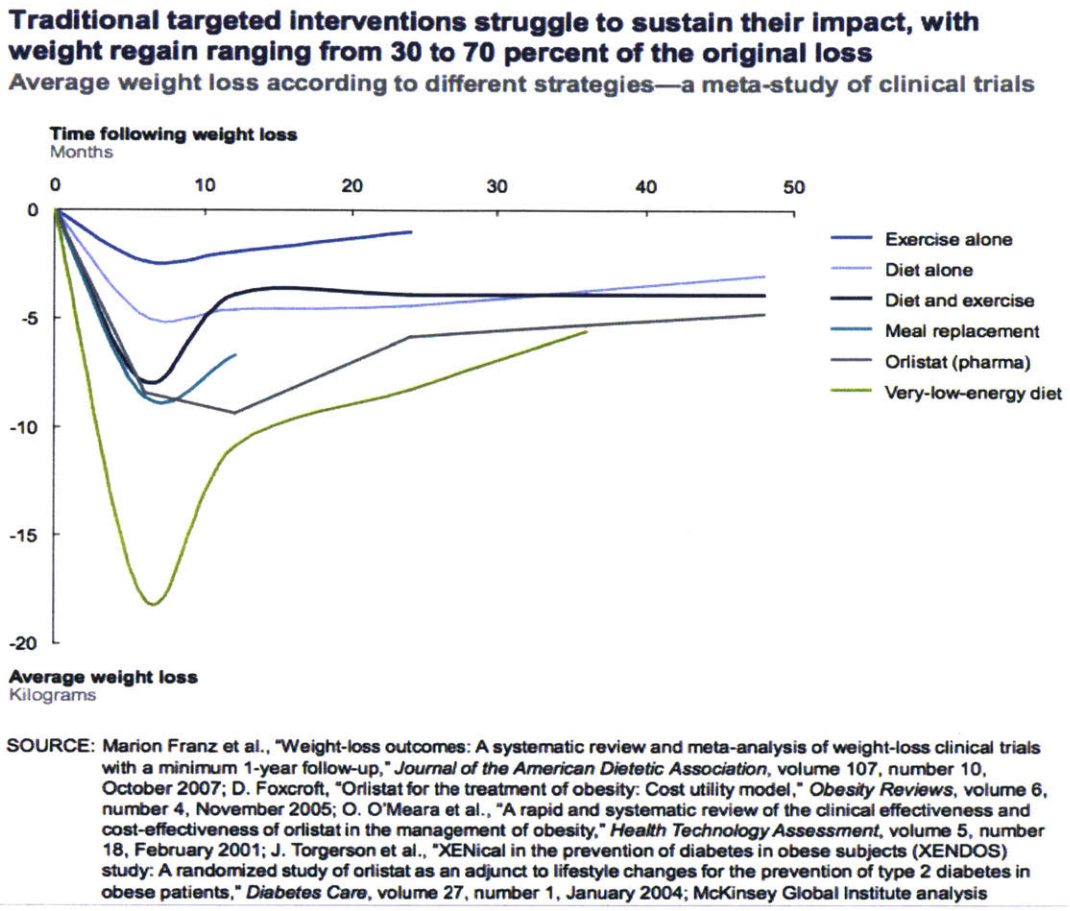


*Figure 11 Adapted from (*Overcoming obesity: An initial economic analysis*, 2014)*

As we can see from the Figure 11, traditional targeted interventions, struggle to have a sustained impact on weight. Regain of weight ranges from 30 to 70 percent of the original loss (*Overcoming obesity: An initial economic analysis*, 2014). This helps us better appreciate the complexity of solving the issue of obesity. It seems that all intervention thus far might vary in efficacy in the short term but ultimately converge again in the long term resulting in regaining part of the weight lost or all of it (*Overcoming obesity: An initial economic analysis*, 2014).

To address a problem, one must first clearly define the problem that needs to be addressed. When we consider finding a solution, we must first begin with the single

most critical question regarding obesity or any other disease: "What causes it?" (Fung, 2016).

To the best of our current knowledge, approximately 70% of obesity is influenced by genetics, and 30% is attributed to environmental causes. "One article reported that studies of twins confirmed a strong genetic influence, regardless of the force of the environment" (Froguel & Blakemore, 2008).

Obesity's rising prevalence over the last thirty years cannot be explained by genetic changes at the population level (Fung, 2016). "The more likely drivers of obesity worldwide have been global changes in food and physical activity environments" (Finucane et al., 2011). We believe that our diet has contributed significantly to the increase in overweight and obesity prevalence when compared to other potential causes. There are multiple factors that have been considered as contributors to, or causes of, obesity and overweight. The following diagram shown in Figure 12 will attempt to highlight some of these and the section that follows will give a brief discussion about each.

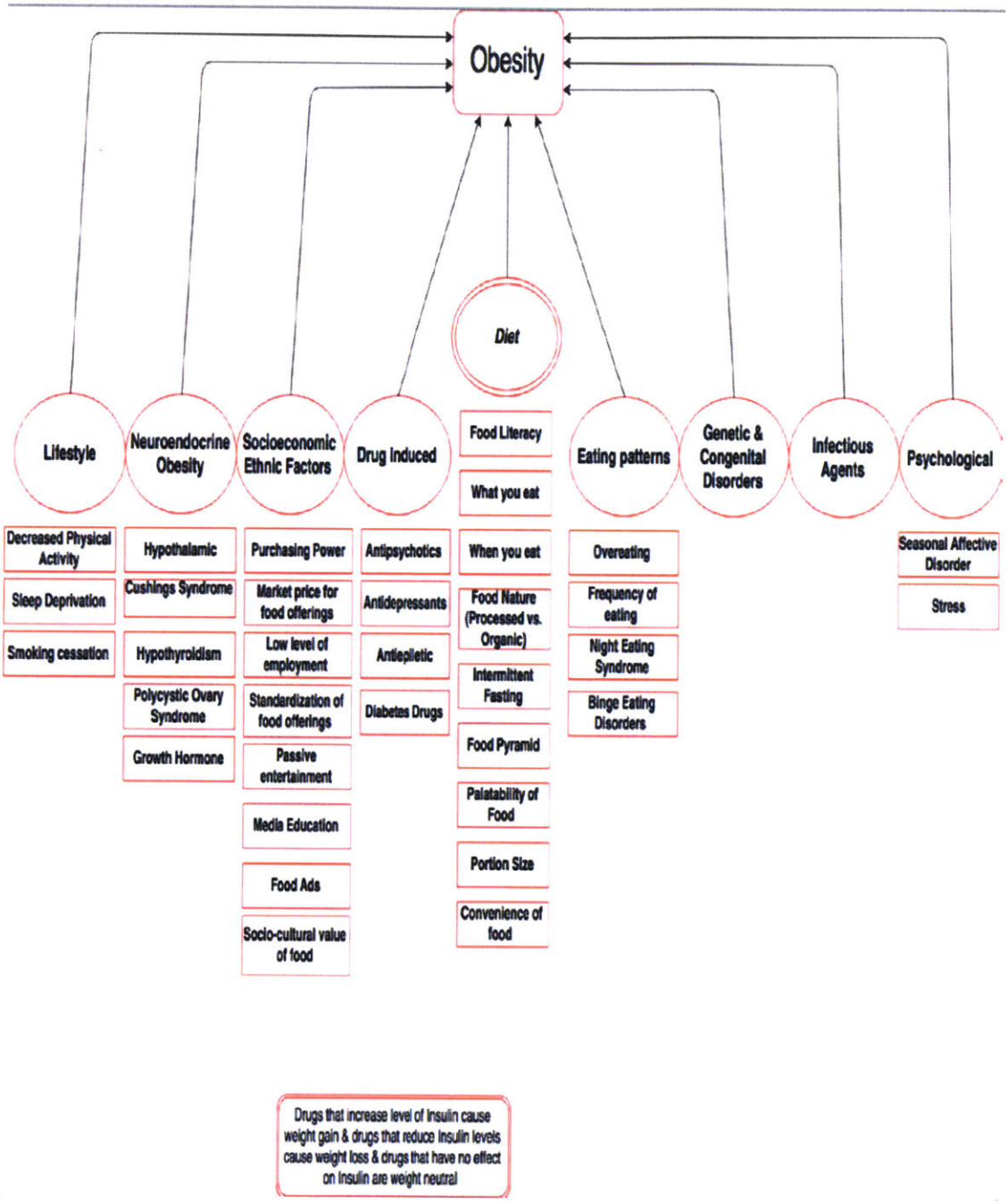


Figure 12 Etiology of Obesity – image created by Ahmed Al Tayyar,MD. Adapted in part from ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

Lifestyle

A sedentary lifestyle might promote weight gain. A 23 percent increase in obesity was noted with prolonged Television watching in addition to an increase in the risk of diabetes by 14 percent (Hu, Li, Colditz, Willett, & Manson, 2003).

Neuroendocrine

There are several neuroendocrine disorders that might be associated with obesity.

- Hypothalamic obesity
- Cushing's syndrome
- Hypothyroidism
- Polycystic ovarian Syndrome
    - 50% of women with this disease are obese
- Growth hormone
    - Growth hormone deficiency in adults is associated with an increase in abdominal and visceral fat.

Socio-economic Ethnic

It appears that obesity is more prevalent in the lower socioeconomic groups. However it is not limited to the lower socioeconomic groups. The exact reason for this is not known, however it most likely is multifactorial and involves nutrition education, living area and access to healthy food choices and potentially access to parks and sidewalks. Ethnicity might also play a role. We see differences in tendency towards obesity in different ethnic backgrounds.

Drug Induced

Weight gain can be a side effect of multiple drugs, including psychoactive drugs, antidepressants, antiepileptic drugs, diabetes drugs, and hormones to name a few in addition to some other drugs that include cyproheptadine (an antihistamine), beta-blockers, and glucocorticoids.

Smoking cessation is associated with an average weight gain of 4 to 5 Kg but can be higher.

Diet

The main takeaway from this section is that we have to focus on the following:

- What we eat?
    - Macronutrient categories and Micronutrients
- When we eat?
    - Frequency of food consumption and time of consumption
- Processed food vs. Organic
- Protective factors
- Fasting
    - Fed state vs. Fasting state

All foods can be divided into macronutrient and micronutrients. The three primary macronutrients are carbohydrates, proteins and fats. Several thoughts regarding an imbalance within the macronutrients or between the macro and micronutrients have been considered as potential factors contributing to accumulation of weight and obesity.

It was believed that dietary fat was related to heart disease. John Yudkin (1910–1995) who was a prominent British nutritionist studied diet and heart disease, yet "he did not find a relationship between dietary fat and heart disease. He believed that the main culprit of both obesity and heart disease was sugar" (Fung, 2016). "Scientific debate went on in a back and forth manner about whether the culprit was dietary fat or sugar yet this issue was seemingly settled in 1977, not by scientific debate but by governmental decree." It appears that "George McGovern, then chairman of the United States Senate Select Committee on Nutrition and Human Needs, convened a tribunal, and after several days of deliberation, it was decided that henceforth, dietary fat was guilty as charged" (Fung, 2016) we learned however

that fat is not our enemy. We will elaborate more on this and hopefully better understand overweight and obesity.

"Nutrient poor, energy-dense foods are highly palatable, widely available, inexpensive, served in large portions, inadequately labeled, and heavily marketed, all of which promote overconsumption. Environmental changes have also encouraged more sedentary behaviors in occupational, recreational, transportation and household settings. In addition, cultural, social, and economic factors contribute to obesity" (T. Gill, 2014).

When people are surrounded by temptation, a good portion of them will find it difficult to resist an "abundance of inexpensive, palatable and energy dense foods" that can be obtained with minimal effort. I.e. convenience (T. Gill, 2014).

As an example of the trends in food portion increase over time we refer to Figure 13 to help illustrate:

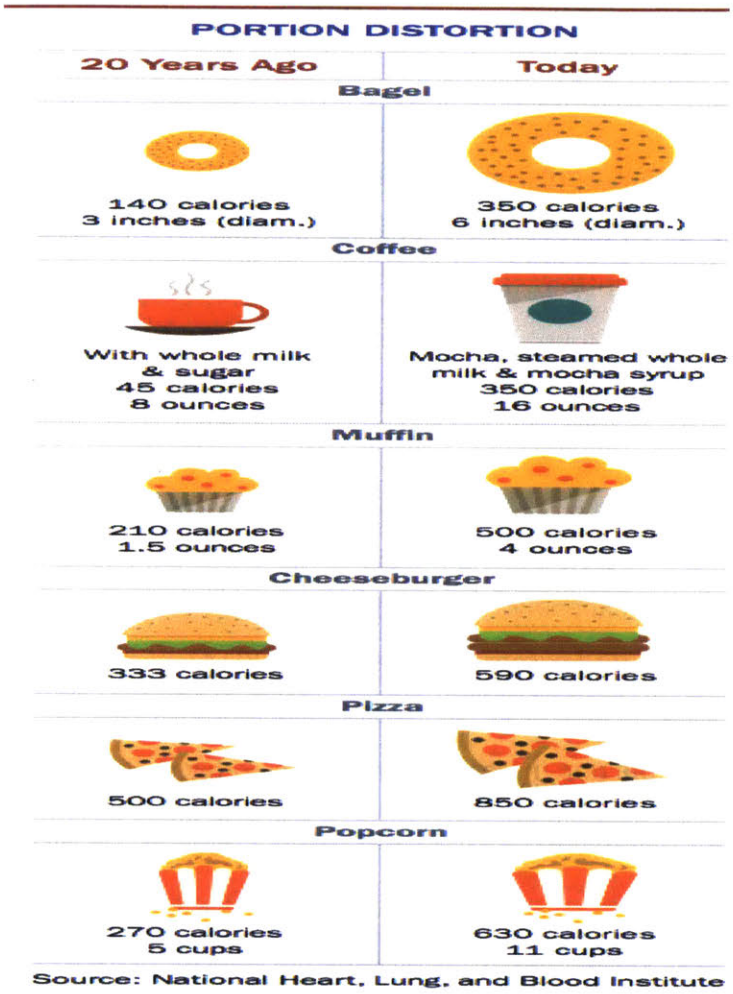


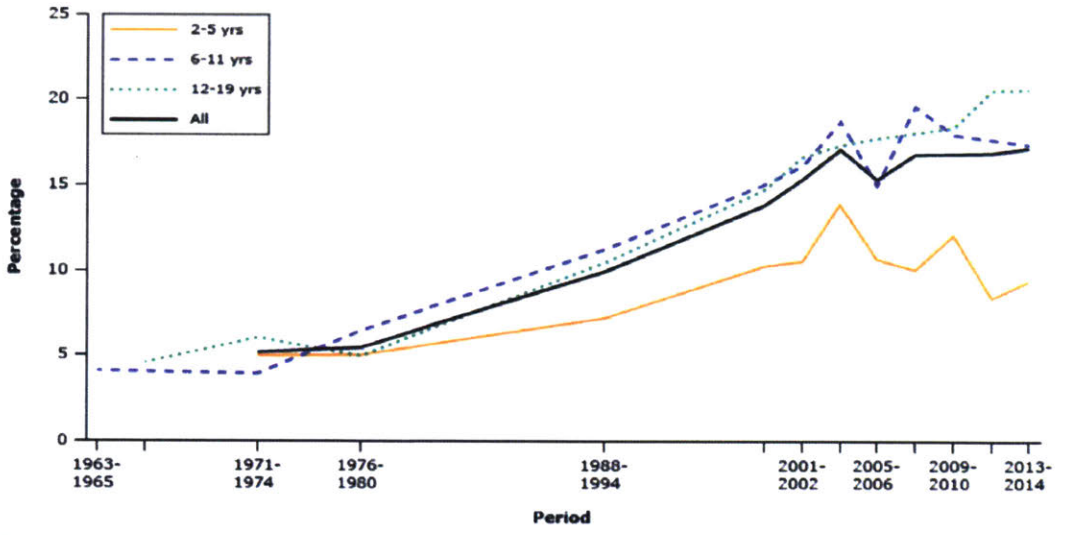
Figure 13 Graphic representing portion distortion (1996 and 2016) *Source: National Heart, Lung, and Blood Institute*

The prevalence of obesity does not appear to have been influenced by the general recommendation of a low-fat, reduced-calorie diet as the treatment of choice for obesity over the past thirty years (Fung, 2016). Obesity continued to rise. "Those who followed a reduced caloric intake diet ultimately failed to sustain a meaningful weight loss" (Fung, 2016). The prevailing Caloric Imbalance theory of obesity does not seem to explain the obesity epidemic well enough worldwide. "The approach to sustained long-term weight loss has been a failure thus far" (Fung, 2016).

In 1989, Dr. Staffan Lindeberg studied the residents of Kitava (Fung, 2016). A place of interest, since a traditional diet, was mainly consumed by the inhabitants. "Their diet mainly consisted of starchy vegetables, including yam, sweet potato, taro, and cassava. An estimated 69 percent of calories were derived from carbohydrates, and less than 1 percent of the calories came from processed Western foods" (Lindeberg, Eliasson, Lindahl, & Ahrén, 1999). Despite this high carbohydrate intake, insulin levels were very low among the Kitavans. Virtually no obesity resulted. In addition, insulin levels of the Kitavans were well below the 5th percentile of the Swedes (Lindeberg et al., 1999).

Japanese natives, of Okinawa Island, eat a diet that is nearly 85 percent unrefined carbohydrates. "They are one of the longest-lived peoples in the world, with more than triple the rate (compared to nearby Japan) of people living past 100 years"(Fung, 2016). The previously mentioned examples shed a bit more light on the story of obesity. They help us see that it is not that carbohydrates are bad, but rather the evil possibly lies within the processing. The refined carbohydrates contribute to obesity rather than the unrefined carbs. This is not the full picture. (Fung, 2016)

The prevalence of childhood obesity in all age categories increased from 1977 to 2000(Fung, 2016). This increase in obesity prevalence paralleled the consumption of sugar from 1977 to 2000(Fung, 2016). Diabetes seemed to be on the rise following the prevalence of obesity but with a time lag of approximately ten years. (Fung, 2016)



Data from the United States Health and Nutrition Examination Surveys (NHANES). Obesity is defined as a body mass index (BMI) ≥95th percentile for age and gender. This figure does not distinguish between groups with mild versus severe obesity.

Fryar CD, Carroll MD, and Ogden CL. Prevalence of Overweight and Obesity Among Children and Adolescents Aged 2–19 Years: United States, 1963–1965 Through 2013–2014. Health E-Stats July 2016. Available at:
http://www.cdc.gov/nchs/data/hestat/obesity_child_13_14/obesity_child_13_14.htm

Figure 14 Trends in obesity among children and adolescents aged 2-19 years, by age: United States, 1963-1965 through 2013-2014. Adapted from ("Evidence-Based Clinical Decision Support at the Point of Care | UpToDate," n.d.)

"The Pima Indians of the American Southwest have the highest rates of diabetes and obesity in North America. An estimated 50 percent of Pima adults are obese, and of those, 95 percent have diabetes (Krosnick, 2000). When the Pima replaced traditional, unrefined foods with highly refined sugar and flour, they became obese."(Fung, 2016)

Furthermore, the Australian Romp and Chomp study mentioned ran from 2004 to 2008 (de Silva-Sanigorski et al., 2010). Twelve thousand children aged zero to five years were targeted in the study. Daycare centers were divided into two groups. The intervention group received the Romp and Chomp educational initiative while the other group would continue their usual programs. The study's two principal nutritional objectives were very specific and targeted. The first objective was, "significantly decrease consumption of high-sugar drinks and promote the

consumption of water and milk." The second objective was, "significantly decrease consumption of energy-dense snacks and increase consumption of fruit and vegetables." Like other programs, it attempted to increase exercise and get the families of the children to be more involved. The results demonstrated that "Both the 2 and 3.5-year-old children showed significantly better weight reduction compared to the control group. The prevalence of obesity was reduced by 2 percent to 3 percent". (Fung, 2016)

"Daily consumption of sugar-sweetened drinks not only carries a significant risk of weight gain, but also increases the risk of developing diabetes by 83 percent compared to drinking less than one sugar-sweetened drink per month (Schulze et al., 2004)." (Fung, 2016)

There are several diet-related issues that we will touch on further throughout different parts of the thesis. However, the high-level takeaways from our research and readings are the following:

1. The dietary choices we make are important for weight control.
2. Fed state to Fasting state balance of time is critical (Fung, 2016).
3. Intermittent fasting is an essential tool for weight control and weight loss (Fung, 2016).
    a. Fasting the holy month of Ramadan and the Prophet Mohammad's - Peace Be Upon Him- advised to fast Monday and Thursday, i.e., 2 days per week is supported by science) however, we need to remind ourselves of the need for proper fasting and break of fast behavior and food consumption methods since the majority do this incorrectly.
4. Avoid processed food (Fung, 2016)
5. Avoid added salt.
6. Avoid added sugar (Fung, 2016).
7. Not all-dietary fat is the enemy but rather the saturated fats (Fung, 2016).

8. Protective factors should be considered such as (olive oil, fiber, vinegar, water, fruits and vegetables, super food, whole grains, etc.)(Fung, 2016).

There are many other pearls dispersed throughout the paper, and it is important to remember that this is not an all-inclusive list. Diet in our opinion is one of the most important factors to consider. We will discuss the hormonal theory and the caloric imbalance theory briefly in other sections of the paper to shed more light on this topic.

Infectious Agents

Some animal models demonstrating obesity have been associated with adenovirus infections. There is very little evidence to support this in humans thus far. From another perspective, the gut micro-biomes were believed to affect weight through poorly understood mechanisms such as low-grade inflammation or altered gut permeability (T. Gill, 2014). We will not dive into this further as we believe this is beyond the scope of this paper and the research to date is not helpful from a public health point of view.

Psychological

Seasonal Affective Disorder (SAD) is one condition that has been linked to weight gain. This condition refers to a form of depression that occurs during the winter season in people living in the far north. Treatment can be through exposure to light or via certain medication (T. P. Gill, 2015).

Genetic

One of the strongest predictors of a child's weight status is the weight status of their parents. Overweight parents are more likely to have overweight children. Genetic factors influence obesity in two ways. First, there are genes that are primary factors in the development of obesity such as leptin deficiency. Second, there are

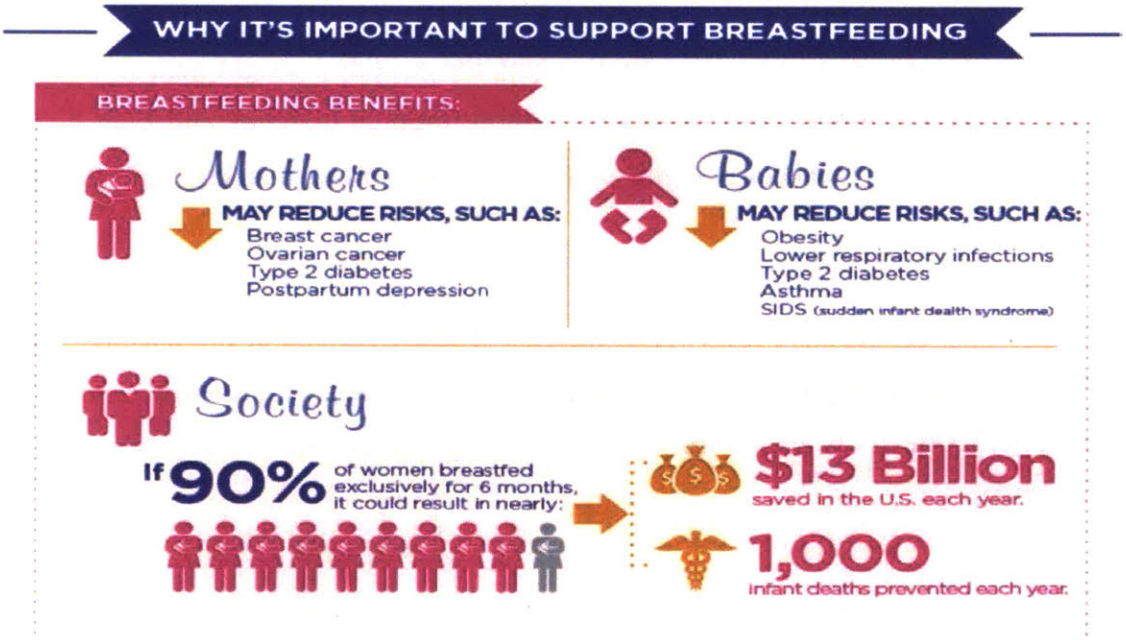
susceptibility genes on which environmental factors act to cause obesity (T. P. Gill, 2015).

Breastfeeding

It appears that breastfeeding has a protective effect when compared to formula feeding with relation to the risk of overweight development (T. P. Gill, 2015).

Exclusive breastfeeding for a minimum of six months is associated with a reduced level of obesity later in childhood as concluded by some reviews. A meta-analysis of 17 studies of breastfeeding duration found that each additional month infants were breastfed was associated with a 4% lower risk of later-life obesity (T. P. Gill, 2015).

"Breastfeeding, in general, is shown to be associated later in a child's life with decreased risk of overweight, decreased blood cholesterol and blood pressure, and a reduced risk of developing type 2 diabetes"(Plagemann & Harder, 2005).



Source: National WIC Association

Figure 15 Why it's important to support breastfeeding? Source: National WIC Association

Pregnancy

Good nutrition during pregnancy is essential for fetal growth and development in addition to the health and wellbeing of the mother and the ease of delivery.

High body mass index (BMI) pre-pregnancy and excessive weight gain during the gestational period are considered risk factors for childhood obesity. In addition, diabetic mothers infants have a higher risk of being overweight as both children and adults (Baptiste-Roberts, Nicholson, Wang, & Brancati, 2012), as do children whose mothers smoked during pregnancy (Oken, Levitan, & Gillman, 2008).

"The mothers' nutritional or hormonal profile during pregnancy is probably an important determinant of metabolic programming. There is evidence that an individual's predisposition to obesity is influenced for the long term by both nutritional and environmental elements of exposure during critical development periods" (Ozanne, 2015).

For women categorized to be of normal weight, the expected weight gain is 11.5kg to 16.0 kg during pregnancy. The risk of both gestational diabetes and high birth weight child are increased if weight gain is in excess of the expected. (T. P. Gill, 2015).

There is a two to threefold increase in the risk of obesity if one of the parents was obese and up to 15-fold if both parents are obese (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Obesity is also more prevalent among low-income populations (Eagle et al., 2012).

Poor Sleep

Insulin levels are affected by the lack of adequate sleep. Therefore, the lack of adequate sleep is considered a factor in the risk of weight gain and the development

of obesity. When sleep is limited to 5 or 6 hours per night, the risk of weight gain is increased by more than 50 percent (Cappuccio et al., 2008). It was also noted that when sleep was limited to 4 hours, insulin sensitivity was reduced by 40 percent (Spiegel, Knutson, Leproult, Tasali, & Van Cauter, 2005).Both the Wisconsin Sleep Cohort Study and the Quebec Family study demonstrated that short sleep duration was linked to higher body weight, decreased leptin and increased ghrelin (Taheri, Lin, Austin, Young, & Mignot, 2004). In another study by Kawakmi , the risk of developing diabetes mellitus type 2 was increased with shortened sleep duration (Kawakami, Takatsuka, & Shimizu, 2004). These studies were highlighted by Dr. Jason Fung in his book "The Obesity Code: Unlocking the secrets of weight loss".

Chapter 3 Concept of "Proximate" Vs. "Ultimate" Causes

To better understand obesity as a problem one must consider an important concept that has been learned from reading the work of Dr. Jason Fung. This concept is focused on understanding the difference between "proximate cause" and "ultimate cause."(Fung, 2016)

Dr.Jason Fung explains this in the following manner:
"The proximate cause is immediately responsible, whereas the ultimate cause is what started the chain of events." (Fung, 2016)

To better understand this concept, let us look at the following example as highlighted by Dr. Jason Fung. "Why is the room hot?" Proximate cause, in this scenario is that "heat energy coming in is greater than the heat energy exiting" and the solution can be seen as "turn on the fans to increase the amount of heat leaving" However, when we consider the ultimate cause we realize that "the thermostat is set too high" and therefore the solution becomes "turn down the thermostat". The ultimate cause must be addressed rather than just focusing on the proximate cause." (Fung, 2016)

In the next chapter, we will have a brief overview on overweight and obesity in Saudi Arabia.

Chapter 4 Overweight & Obesity in Saudi Arabia

Prevalence

As we can see from *figure 1*, it appears that as of 2014 approximately 69.4% of the people in Saudi Arabia are overweight or obese. This statistic includes both obesity and overweight together. This is an alarmingly high percentage of the population and cause for significant public health concerns. As we have mentioned earlier in this paper, overweight and obesity are associated with a significant number of comorbidities and increase mortality risk.

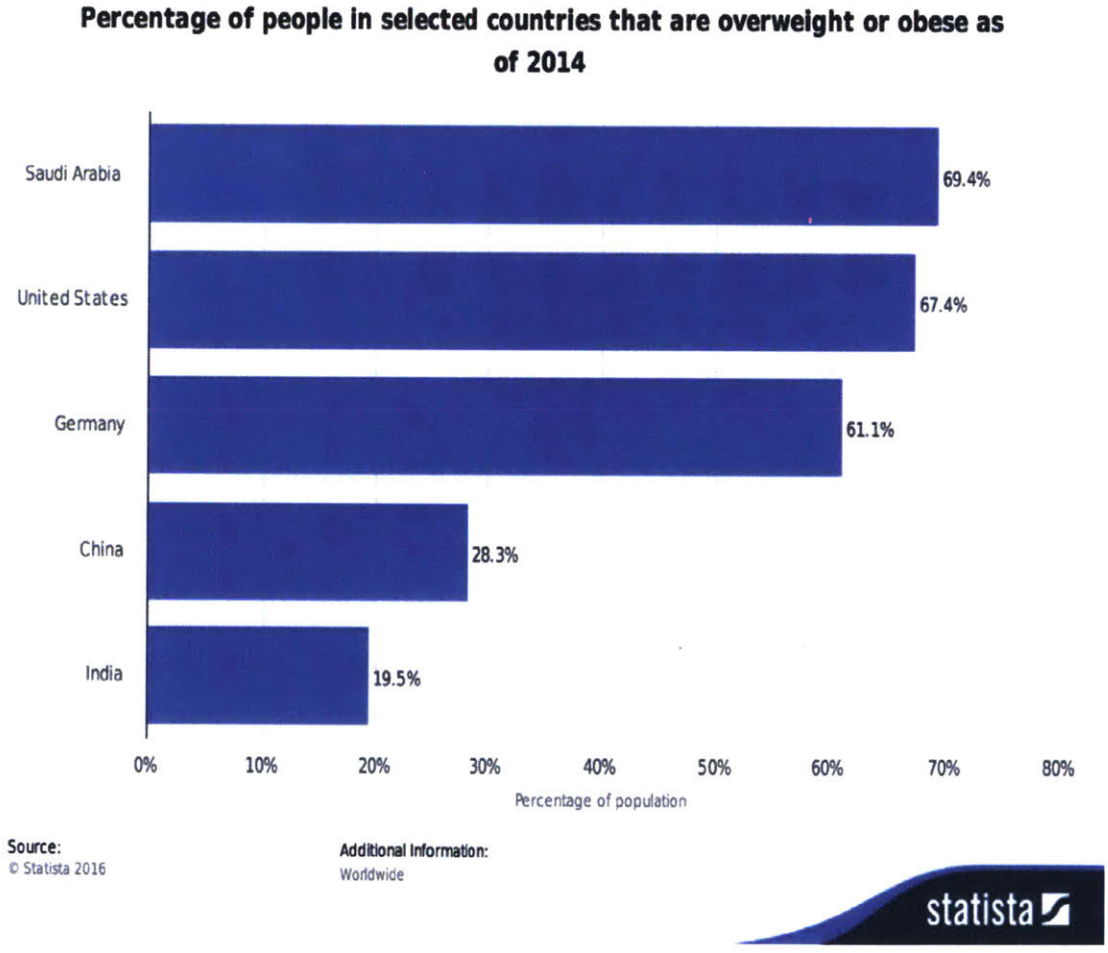


Figure 1 Percentage of people in selected countries that are overweight or obese as of 2014 Adapted form (Time, n.d.)

There was a significant challenge in obtaining meaningful up to date statistics unique to Saudi Arabia with regards to the topic of obesity. This challenge apparently has been previously documented in a study that was previously published (M Alqarni, 2016), (Memish et al., 2014). Similar to other countries of the world, Saudi Arabia was not immune to the epidemic of overweight and obesity.

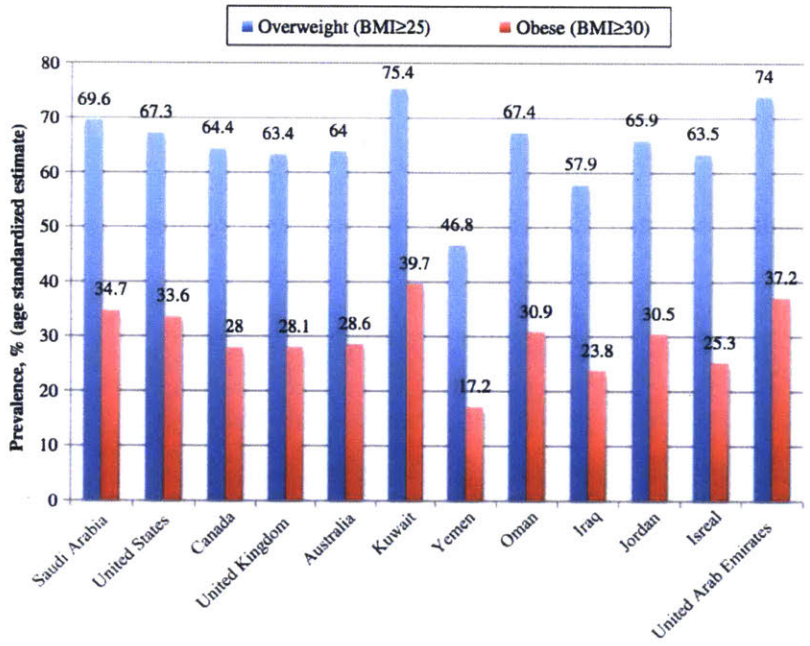


Figure 16 ***Comparison of the prevalence of overweight and obesity, age 18+ (age-standardized estimate), 2014, for both sexes in Saudi Arabia and other countries.***

By referring to Figure 16, we can clearly see that both overweight and obesity are significant issues in Saudi Arabia as well as other Gulf region areas. They appear to mirror the prevalence of countries such as the United States and the United Kingdom.

By reviewing data from the World Health Organization, the prevalence of obesity for women 18 years of age and older, in 2014 was 40.7% compared to 22.2% back in 1975. Obesity in men of 18 years and older in 2014 was documented at 28%

compared to 6.8% back in 1975. This data confirms our concern with regarding the rampant rise in prevalence of obesity in Saudi Arabia. (World Health Organization, n.d.)

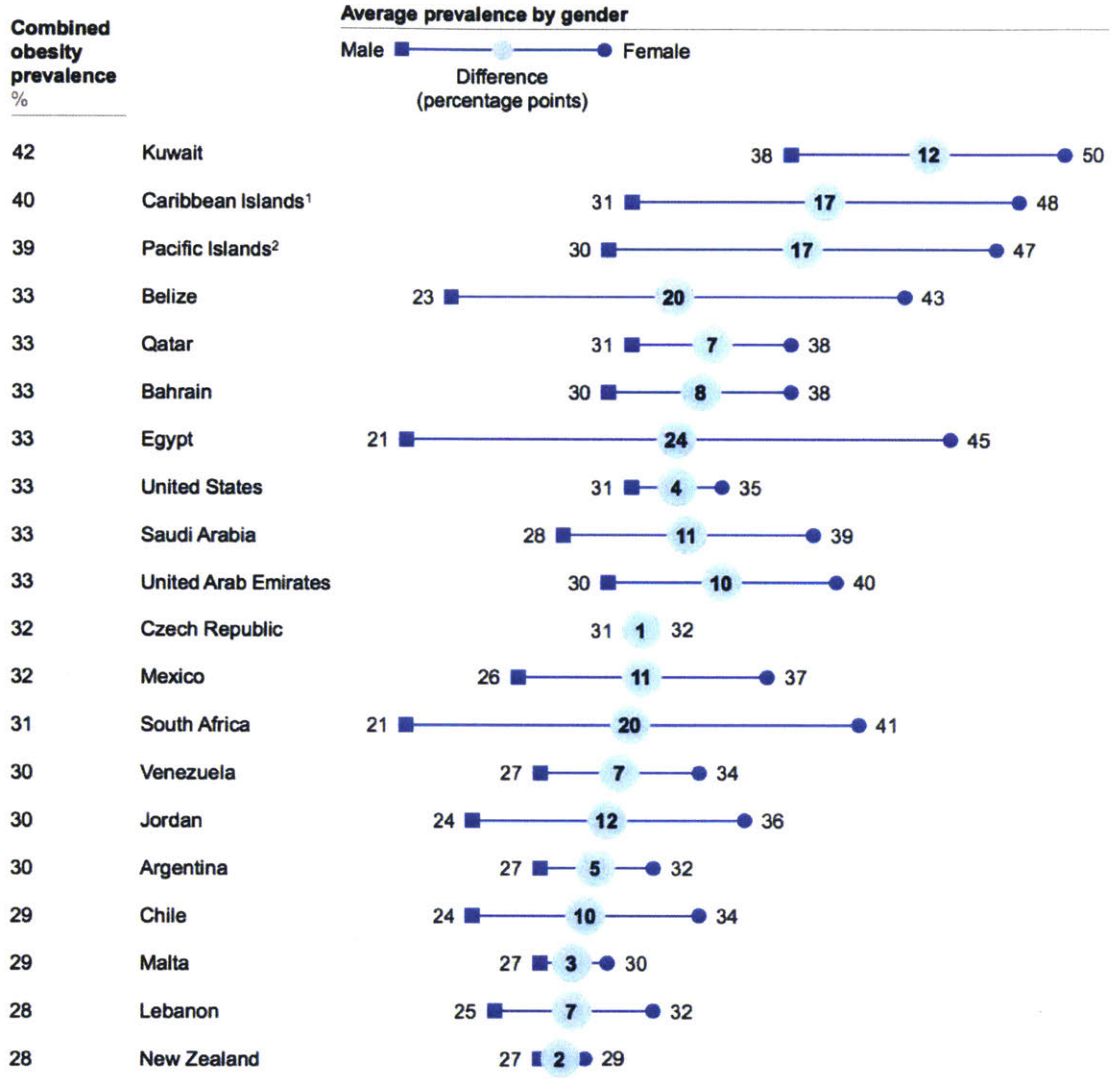
Also, by reviewing data from the World Health Organization, the prevalence of overweight in males 18 years of age and older in Saudi Arabia back in 1975 was 34.9 percent compared to 65.5 percent in 2014. Also, women 18 years of age and older had an overweight prevalence of 49.1 percent in 1975 compared to 70.8 percent in 2014. (World Health Organization, n.d.)

The expected prevalence of obesity in Saudi women in the year 2022 is approximately 77.6 percent compared to Saudi men where it is projected to be at 41.4 percent (M Alqarni, 2016). Both obesity and overweight in Saudi Arabia are more prevalent in the female population when compared to the Saudi males. This is consistent with Figure 17 showing that the prevalence of obesity is consistently higher in women than in men.

The prevalence of obesity is consistently higher in women than in men—with a gap of up to 24 percentage points

Male and female obesity prevalence for top 20 countries with highest prevalence, 2008

% of population



1 Comprising Bahamas, Barbados, Netherlands Antilles, Puerto Rico, and Saint Kitts and Nevis.
2 Comprising Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Marshall Islands, Nauru, Palau, Samoa, Solomon Islands, and Tonga.

SOURCE: OECD statistics; McKinsey Global Institute analysis

*Figure 17 Demonstrating that the prevalence of obesity is consistently higher in women than in men. Adapted from (*Overcoming obesity: An initial economic analysis*, 2014)*

When comparing the prevalence of obesity in the Kingdom of Saudi Arabia back in 1975 to the projected prevalence in 2022, we note that the prevalence is almost tenfold.

It has been documented that the prevalence of obesity amongst adolescents in the Kingdom of Saudi Arabia increased significantly between 1988 to 2005 (M Alqarni, 2016).

We believe that the evidence we have presented thus far in this chapter clearly demonstrates the sizable and rapidly progressive issues of both overweight and obesity in both males and females of Saudi Arabia.

This highlights the potential size of this preventable and reversible problem. We also would like to emphasize at this point the urgent need to address these issues both from a top-down manner (governmental policies and programs) and a bottom-up manner (individuals and groups) in a cost-effective way to curb the advancement of overweight and obesity. The next chapter will discuss the economic burden of obesity.

Economic Burden of Obesity in Saudi Arabia & Sample Other Countries

The global economic impact of obesity is roughly $2.0 trillion, or 2.8 percent of global GDP (*Overcoming obesity: An initial economic analysis*, 2014). We estimate that the economic burden of obesity on the Kingdom of Saudi Arabia is significant but unfortunately could not find the supporting evidence for such estimated costs.

Obesity increased the risk of a range of chronic diseases in the United States of America and is believed to have contributed between $147 billion to $210 billion dollars in preventable healthcare spending. (Christopher et al., 2016).

Obesity is associated with a myriad of chronic Non-Communicable Disease (NCD) diminishing the health of the individual and adding a significant burden on healthcare expenditure and productivity of the workforce. It is, therefore, a significant contributor to the vicious economic cycle caused by Non-Communicable Disease. This vicious cycle is demonstrated in Figure 16.

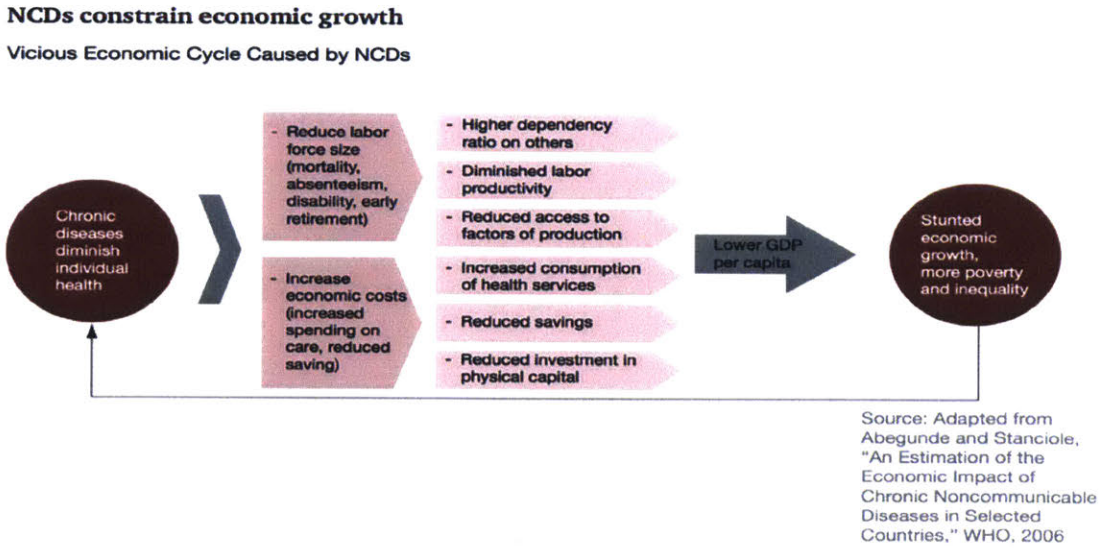


Figure 18 Value Economic Cycle Caused by Non Communicable Disease Adapted from (Abegunde & Stanciole, 2006)

According to a study "A gradient exists between increasing BMI and direct healthcare costs and indirect costs due to reduced productivity and early premature mortality" (Ricci et al., 2005). Also, yearly drug costs were significantly higher in obese compared with normal-weight people "use and cost of medications are markedly increased in obese vs. reference populations. Surgical obesity treatment lowers diabetes mellitus and cardiovascular disease medication costs but increases other medication costs, resulting in similar total costs for surgically and conventionally treated obese individuals for 6 years" (Narbro et al., 2002).

The Need for a Systematic Innovative Approach to Addressing Obesity

It was extremely promising to have come across an article dated Nov 2016 found on the Ministry of Health's website reflecting that the Kingdom of Saudi Arabia was pursuing accurate data collection through a unique and broad survey across all regions of the Kingdom. This survey, "Aims at providing reliable and accurate data on the population health condition, with a view to surveying the Kingdom's health indicators facing the community, as well as identifying the health problems and developing appropriate solutions for them. The Ministry also aims at ensuring the provision of highly reliable information on the Kingdom's health situation, to be internationally comparable, and developing a database and directories to assess the performance of the health system and its ability to achieve the goals, let alone providing decision makers with necessary information to develop and guide policies, strategies and programs when necessary."("Ministry News - MOH to Conduct the Largest Healthcare Survey for 250,000 People," n.d.-a) The article continues to read "in an endeavor to detect diabetes, blood pressure, and fats level. The survey will include the measurements of weight and height for a sample of 25,000 people from family members; to determine Body Mass Index (BMI) for detecting obesity and weight gain. It also includes assessing the health system's

ability to respond to the aspirations and needs of the population and identifying the extent of health services and programs coverage for inhabitants, in addition to the health expenditure at the household level, in line with Saudi Arabia's vision 2030". ("Ministry News - MOH to Conduct the Largest Healthcare Survey for 250,000 People," n.d.-a)

There is clearly need to intervene and tackle obesity in The Kingdom of Saudi Arabia, as is the need that has been recognized by the rest of the world who suffer from the same ailment of obesity. Obesity prevalence is usually trailed by Diabetes, both of which are significant risk factors for cardiovascular disease including heart disease and strokes in addition to cancer and several other health ailments as we have mentioned previously.

The solution is not simple since the problem is not a simple problem. The common error that has been repeated over history in tackling complex problems is trying to use over simplistic solutions (Christensen et al., 2009). Complex problems need to be changed into simple problems and only then can simple solutions be used to address the now simple problems (Christensen et al., 2009). A systematic approach in which innovation concepts are utilized is key to dealing with complex challenges. As an example, from the McKinsey Global Institute analysis, multiple potential intervention groups had been identified. Please refer to Figure 19.

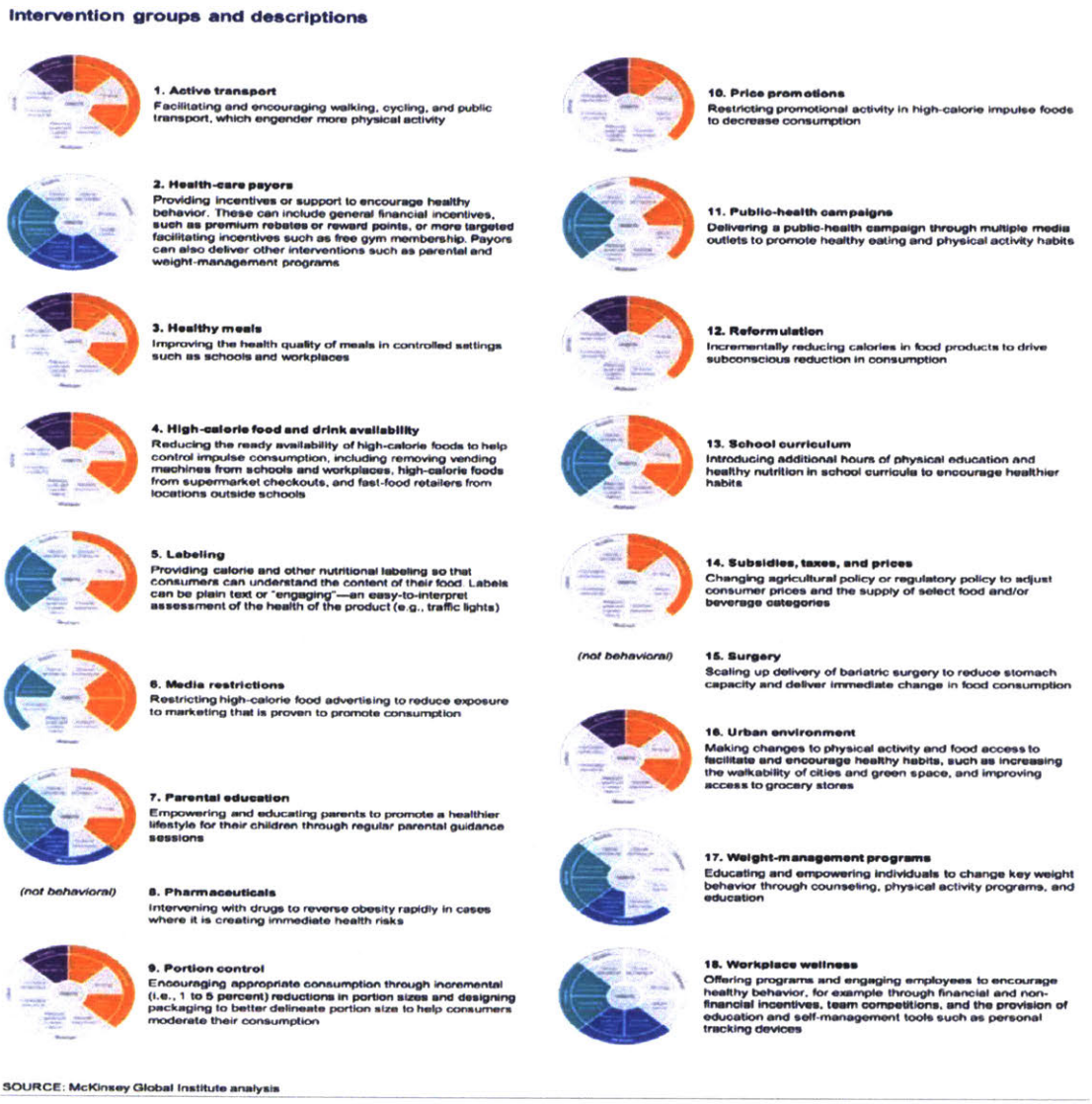


Figure 19 adapted from (Overcoming obesity: An initial economic analysis, 2014)

The majority of these intervention groups addresses some of the proximate causes of obesity but don't seem to address the ultimate cause of obesity as will be explained later according to the "Hormonal Theory of Obesity." This does not mean that they should not be considered, but it does mean that we should look into them more carefully and potentially do a cost analysis to determine if they are cost saving or cost-effective vs. not.

Now that we have defined the problem of overweight and obesity, we will attempt to touch on two theories. The "Caloric Imbalance Theory" discussed in Chapter 5 and the "Hormonal Theory of Obesity" discussed later in chapter 7.

Chapter 5 Caloric Imbalance Theory

Intro

One of the most common theories of obesity is the "Caloric Imbalance Theory," this just implies that obesity or weight gain is simply a result of calories in being more than calories out. This is a drastic oversimplification of the understanding of obesity. It does not take into account the complexity of the metabolic pathways and the different hormonal responses to different food.

"Current Solution to Obesity generally follows the principle of "Eat less, Move More!" – This is not completely true. It may actually be false." (Fung, 2016)

We will actually use the material presented in the book "The Obesity Code" by Dr. Jason Fung (Fung, 2016) as we believe that it best highlights important concepts in a very understandable manner. Full credit is given to Dr. Jason Fung for the material dispersed within this paper and in particular for chapter 5, 6 and 7.

False Assumptions of Caloric Imbalance Theory

There are five false assumptions mentioned and explained in The Obesity Code: Unlocking the Secrets of Weight Loss regarding the caloric imbalance theory of obesity. This chapter is heavily inspired and based on the work of Jason Fung MD.

According to Dr. Jason Fung, the first false assumption is that there is no interdependence between calories in and calories out. *"Calories In and Calories Out are independent of each other"* (Fung, 2016).

In fact, it appears that there is a close relationship between caloric intake and expenditure. The expenditure of calories is reduced as a response to the reduction of calories in. the body reduces metabolism as a response to reduction of calories in

both portion-control and caloric reduction strategies mainly result in an increase in hunger and fatigue. The Women's Health Initiative Dietary Modification Trial published in 2006 by the National Institutes of Health was a randomized controlled trial that recruited almost 50,000 post-menopausal women (Howard et al., 2006). "The results of this trial demonstrated that initially the "Eat Less, Move More" group did well, averaging more than 4 pounds (1.8 kilograms) of weight loss over the first year. By the second year, the weight started to be regained, and by the end of the study, there was no significant difference between the two groups" (Fung, 2016).

The second false assumption he highlights related to the understanding of basic metabolic rate. The assumption is: *"Basal metabolic rate is stable."* (Fung, 2016)

It is important to note that Total Energy Expenditure = Basal Metabolic Rate + Thermogenic effect of food + Non-exercise activity thermogenesis + Excess post-exercise oxygen consumption + Exercise. This just demonstrates that total energy expenditure is much more complicated than the general population believes (Fung, 2016).

"The Basal Metabolic Rate (BMR) is influenced by multiple factors. These factors include genetics, body weight, and height. The BMR increases with increased muscle mass and drops with increased age. The BMR is also affected by overfeeding or underfeeding in addition to body temperature and environmental temperature and organ function" (Fung, 2016).

The third false assumption is concerned with our control over the calories consumed: *"We exert conscious control over Calories In"* (Fung, 2016)

Dr. Fung refutes this assumption by the following, "Hormones drive the decision to eat or not to eat. *Obesity results in reduced metabolism and increased hunger rather than being caused by both"* (Fung, 2016).

The fourth false assumption relates to the regulation of fat stores in the human body: *"Fat stores are essentially unregulated."*(Fung, 2016)

This has been addressed by the fact that, "new hormonal pathways involved in the regulation of fat growth are being discovered. The best-known hormone that regulates fat growth is Leptin. However, adiponectin, hormone-sensitive lipase, lipoprotein lipase and adipose triglyceride lipase may all play important roles. This supports that obesity is not just about the calories and that hormones play a significant role in obesity "(Fung, 2016)

The final false assumption tackled by Dr. Fung was: *"A calorie is a calorie"* (Fung, 2016)

He clarified that "When we assume that all calories are alike, this falsely implies that the only important variable in weight gain is the total caloric intake. Thus, all types of food can be reduced to their caloric energy. As an example when comparing a calorie of olive oil and a calorie of sugar, we find that there is a significant difference. Sugar will elevate the blood glucose level and stimulate an insulin response from the pancreas. Olive oil will not. Different foods evoke vastly different metabolic and hormonal responses" (Fung, 2016).

These five assumptions, which are the fundamental assumptions in the caloric reduction theory of weight loss, have all been proven false. It is, therefore, safe to say that the "Caloric Imbalance Theory" does not do a good job of explaining obesity or weight gain. It is an oversimplification of a complex problem. Although this is the case, many diet recommendations and media messages still communicate a focus on the number of calories in vs. the number of calories out. The wrong message is being sent. (Fung, 2016)

This indicates that our understanding of obesity has been incomplete and incorrect. We underestimated the complexity of obesity, and therefore our solution has been over simplistic and hence did not work. The failure of the approach of "Eat less, Move More" can be seen when we look back at the prevalence and progression of obesity.

Chapter 6 The Role of Exercise & "Body Set Weight" concept

Exercise: The Evidence

Exercise is great for overall health; it is useful but not the key to weight loss

"Diet does 95 percent of the work and deserves all the attention; so, logically, it would be sensible to focus on diet. Exercise is still healthy and important—just not equally important". (Fung, 2016)

"In the United Kingdom from 1997 to 2008, regular exercise increased from 32 percent to 39 percent in men and 21 percent to 29 percent in women. All this activity had no effect on obesity at all. Obesity increased relentlessly. (Fung, 2016)

It was interesting to come across the knowledge of a hunter-gatherer society in Tanzania known as the Hadza in the work of Dr. Jason Fung. It appears that the people of this society travel 15 to 20 miles per day to gather food. A higher energy expenditure could have been made based on this lifestyle, however, Pontzer discusses the surprising results in a New York Times article: "We found that despite all this physical activity, the number of calories that the Hadza burned per day was indistinguishable from that of typical adults in Europe and the United States."(Pontzer, 2012). More evidence comes from the Women's Health Study. "Approximately 39,876 women were divided into three groups representing high, medium and low levels of weekly exercise. The "high exercise" group did not demonstrate significant weight loss and no change in body composition were observed."(Lee, Djoussé, Sesso, Wang, & Buring, 2010).

Understanding "Body Set Weight"

There appears to be a "set point" for body weight, as first proposed in 1984 by Keesey and Corbett (Keesey & Corbett, 1984).

"If weight drops below body set weight, compensatory mechanisms activate to raise it. If weight goes above body set weight, compensatory mechanisms activate to lower it. The problem in obesity is that the set point is too high" (Fung, 2016).This will be discussed further in the chapter regarding the "Hormonal Theory of Obesity" and is key to our understanding of overweight and obesity development and potential solutions.

The body set weight is a crucial concept to understand; as "the body will do it's best to maintain the weight, it is set for" (Fung, 2016).

"Obesity is a result of the body set weight being too high" (Fung, 2016).

If the current body weight, is below that of the body set weight, this will lead to the body trying to gain weight to reach the body set weight by stimulating hunger and/or decreasing metabolism (Fung, 2016).

"This brings us to conclude that excessive eating and a reduced metabolic rate are the results of obesity rather than the cause" (Fung, 2016). This is a paradigm shift in the understanding of obesity.

To further explain this concept we will utilize the example mentioned in *The Obesity Code: Unlocking the Secrets of Weight Loss.*

"Suppose our body set weight is 200 pounds (approximately 90 kilograms). By restricting calories, we will briefly lose weight—say down to 180 pounds (approximately 81 kilograms). If the body set weight stays at 200 pounds, the body

will try to regain the lost weight by stimulating appetite. Ghrelin is increased, and the satiety hormones (amylin, peptide YY and cholecystokinin) are suppressed. At the same time, the body will decrease its total energy expenditure. Metabolism begins shutting down. Body temperature drops, heart rate drops, blood pressure drops and heart volume decreases, all in a desperate effort to conserve energy. We feel hungry, cold and tired."(Fung, 2016)

"The body set weight also works in the reverse. If we overeat, we will briefly gain weight—say to 220 pounds (approximately 100 kilograms). If the body set weight stays at 200 pounds, then the body activates mechanisms to lose weight. Appetite decreases. Metabolism increases, trying to burn off the excess calories. The result is weight loss. Since obesity results from a high body set weight, the treatment for obesity is to lower it." (Fung, 2016)

This concept of "Body Set Weight" is very important to facilitate our understanding of why our body behaves the way it does. Circumstances that influence the body set point are key to our understanding of the problem and potentially one of many solutions. Also, this concept of "Body Set Weight" helps us highlight the importance of intermittent fasting as part of the solution to the obesity problem and the potential utility as a preventative measure.

Chapter 7 A New Theory to Assist in Understanding Obesity

The Hormonal Theory of Obesity

Now, we move on to describing the "Hormonal Obesity Theory "as an alternative to the "Caloric Imbalance Theory." We acknowledge and understand that with further research and advancement in knowledge, we might learn that this theory is not complete. However, we believe that it better explains overweight and obesity when compared to the "Caloric Imbalance Theory."

"A "Body Set Weight" which is set too high is the cause of obesity. However, this high setting is caused by a hormonal imbalance." (Fung, 2016)

"The hormone that regulates hunger known as Ghrelin and hormones that regulate satiety such as peptide YY and cholecystokinin all have a role in initiating eating and halting it (Fung, 2016). These hormones do not seem to influence the body set weight. When we inject the hormones mentioned above into humans, they do not cause weight gain. "These hormones do not pass the causality test." However, there are two hormones that do: insulin and cortisol." (Fung, 2016)

The hormonal theory of obesity addresses the previously made assumptions of the caloric imbalance theory as follows:

"Assumption 1: Calories In and Calories Out are independent of each other. The Hormonal Theory explains why Calories In and Calories Out are tightly synchronized with each other. (Fung, 2016)

Assumption 2: Basal metabolic rate is stable. The Hormonal Theory explains how hormonal signals adjust basal metabolic rate to either gain or lose weight (Fung, 2016)

Assumption 3: We exert conscious control over Calories In. The Hormonal Theory explains that hunger and satiety hormones play a key role in determining whether we eat (Fung, 2016)

Assumption 4: Fat stores are essentially unregulated. The Hormonal Theory explains that fat stores, like all body systems, are tightly regulated and respond to changes in food intake and activity levels. (Fung, 2016)

Assumption 5: A calorie is a calorie. The Hormonal Theory explains why different calories cause different metabolic responses." (Fung, 2016)

In diabetes mellitus type 1, Insulin is not produced due to the destruction of the insulin-producing cells in the pancreas through an autoimmune process resulting in Insulin deficiency. In diabetes mellitus type 2, cells are resistant to insulin and insulin levels are elevated. In the landmark 1993 Diabetes Control and Complications Trial, researchers compared a standard dose of insulin to a high dose designed to tightly control blood sugars in type 1 diabetic patients. ("Influence of intensive diabetes treatment on body weight and composition of adults with type 1 diabetes in the Diabetes Control and Complications Trial." 2001) Participants in the high-dose group gained, on average, approximately 4.5 kilograms compared to participants in the standard group.

Obese individuals tend to have a higher fasting insulin level, as well as an exaggerated insulin response to food. High insulin secretion has long been associated with obesity. (Polonsky, Given, & Van Cauter, 1988)

In the San Antonio Heart Study, high fasting insulin was tightly correlated to weight gain over eight years of follow-up (Han et al., 2002).

Consumption of refined carbohydrates and certain types of food will result in a rise in blood sugar levels leading to an elevation of insulin. It is important to know that protein raises insulin levels as well, but its effect on blood sugars is minimal. Finally, dietary fats tend to increase both blood sugars and insulin levels minimally. (Fung, 2016).

We can clearly see from the evidence presented thus far that there is a relationship between Insulin and weight. The higher the insulin levels are and the longer these high levels are present, the more likely it is for the body set weight to be re-set to a higher weight ultimately resulting in weight gain and obesity.

The International Study of Macronutrients and Blood Pressure (INTERMAP) compared the diets of the U.S., U.K., China and Japan in detail. The study found that although people in China and Japan had elevated intakes of carbohydrates, sugar intake was lower in these countries than in the U.S. and U.K. and thus it appears that sugar seemed to be contributing much more to obesity than other refined carbohydrates. (Zhou et al., 2003). Please refer to figure 20.

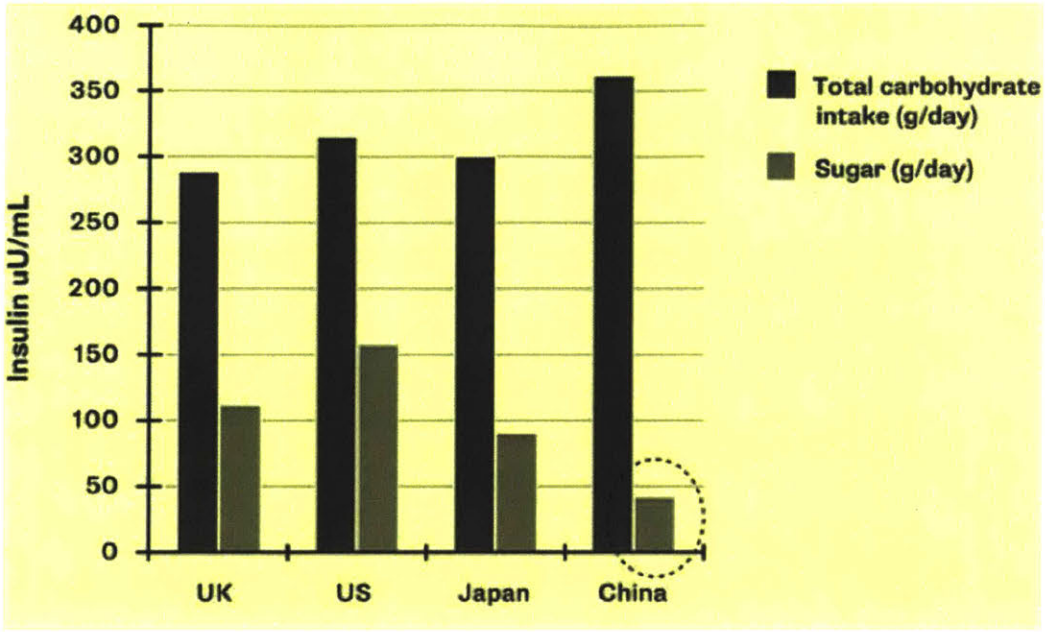


Figure 20 Insulin levels in relation to total carbohydrate intake and sugar intake in United Kingdom, United States, Japan and China. Adapted from (Fung, 2016)

"Insulin resistance is the hidden force behind obesity and diabetes and fatty liver amongst other medical conditions." (Fung, 2016)

To better understand what insulin resistance is, we need to consider the key and lock model. "If we consider that insulin is the key and that it needs to fit into the lock, which is the cell receptor, then when the key (Insulin) does not fit into the lock (Insulin receptor) then the cell becomes insulin resistant. Due to the ill-fitting key and lock, the door does not open fully. As a result, glucose entry is hindered, and less can enter the cell. Glucose piles up outside the cells that are demanding more. To compensate for the low entry of glucose, the body produces extra insulin (keys). The fit of the key to the lock is still poor. However, more doors are opened, allowing a normal amount of glucose to enter." (Fung, 2016)

The initiator of this cycle is the high insulin level. "High levels alone do not lead to resistance. There are two requirements for resistance—high hormonal levels and

constant stimulus." Insulin resistance depends on two critical components, what the meal is and when it is consumed. (Fung, 2016)

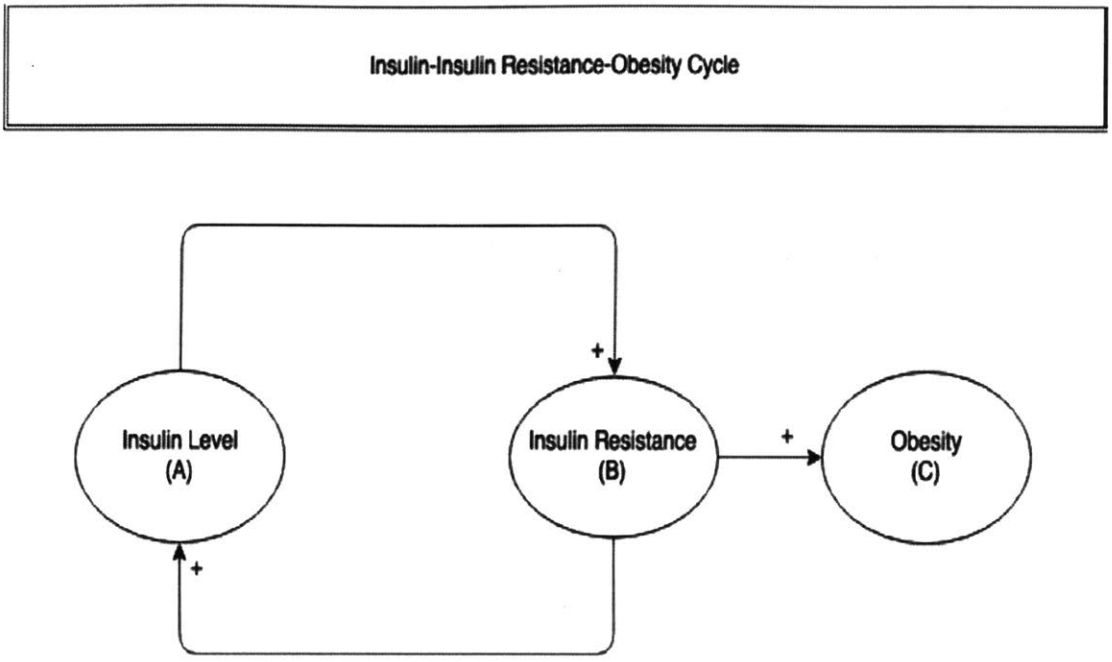


Figure 21 Insulin-Insulin Resistance Obesity Cycle *Source: inspired by* (Fung, 2016)*, created by Ahmed Al Tayyar, MD., 2017.*

As we can see from Figure 21, persistently elevated insulin levels (A) results over time in the development of insulin resistance (B), This insulin resistance (B) in turn will further aggravate an elevation in insulin levels. The persistently high insulin levels work at resetting the set body weight to a higher set point ultimately driving the body to gain weight to reach the new elevated set body weight. This will eventually lead to weight gain and the development of obesity. The higher the insulin levels, the more insulin resistance develops and the greater the insulin resistance is, the higher the insulin levels become. Insulin resistance becomes a larger part of the problem over time and eventually might become the primary driver of high insulin levels. The longer this cycle continues, the worse it becomes. "A diet high in foods that provoke an insulin response may initiate obesity, but over time, insulin resistance becomes a larger and larger part of the problem and can

become, in fact, a major driver of high insulin levels. Obesity drives itself." Simple dietary changes are unlikely to suffice at that point of time. (Fung, 2016)

"The brain, liver, and muscle are the main compartments when looking at Insulin resistance. The resistance of each of these compartments is individualized and if the resistance changes in one compartment it does not necessarily alter the resistance to insulin in the other compartments. Excess carbohydrates ingestion leads to the development of hepatic insulin resistance. Hepatic insulin resistance can be reversed by significant dietary intervention; however, the dietary intervention will have no effect on the insulin resistance in the brain or at the muscles. Insulin resistance at the muscles may be a result of lack of exercise hence; insulin sensitivity at the muscles will increase with exercise. Exercise has minimal effect on insulin resistance in the liver or brain. "In response to hepatic or muscle insulin resistance, overall insulin levels increase. However, at the appetite centers in the hypothalamus, insulin's effect is unchanged. The brain is not resistant to insulin. When high insulin levels reach the brain, the insulin retains its full effect to raise body set weight." (Fung, 2016)

Finally, figure 22 shows "The Hormonal Obesity Theory" as per the work of Dr. Jason Fung. Based on this theory, we have a new understanding of overweight and obesity. We can see how obesity can be driven by hormones rather than the narrow scope of calories. However, remember that theories are imperfect and this theory is not immune from imperfections although we believe it addresses a significant contributor to overweight and obesity. We also believe that inflammation might be implicated and related to the development of obesity. Keeping in mind the basis of genetic and environmental factors.

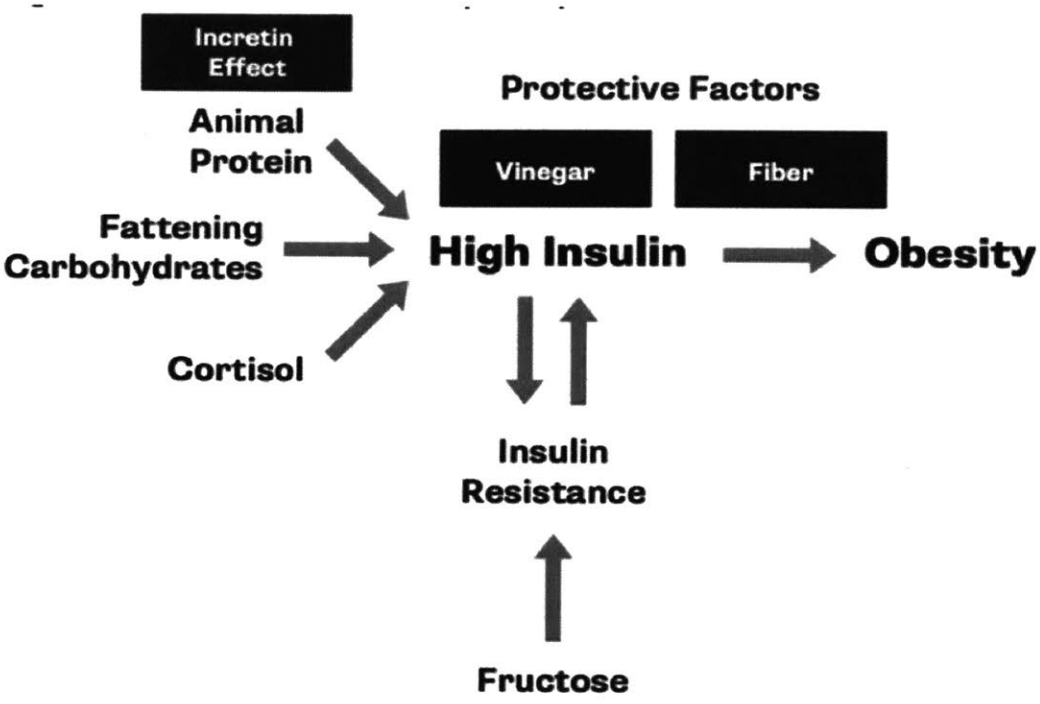


Figure 22 "The Hormonal Theory of Obesity" adapted from (Fung, 2016)

Diabesity

At this point of the paper, we would like to introduce the term "Diabesity" which is a term coined by Dr. Francine Kaufman and is derived from Diabetes + Obesity (Chriss Kresser, n.d.).

Type 2 Diabetes is a disease typically characterized by insulin resistance and hyperglycemia (high glucose), but it also has a relative impairment in the secretion of insulin. There is a significant clinical correlation with obesity. (Weiss et al., 2005), (Elder et al., 2015).

No single theory can thus far explain Diabesity; however, there appears to be some evidence to support the "Hormonal Theory of Obesity" and "The Autoimmune-Inflammatory Model." We must keep in mind that all models are imperfect. However, some are useful. As we make progress in our understanding of the

pathophysiology of disease over time, we are more likely to employee more appropriate solutions to solve the problems we face. We believe that diabesity is a very complex disease. It may likely be a basket of conditions that will be further subdivided and characterized, as we understand the mechanisms behind the development of each potential subcategory. When we consider both diabetes and obesity, we observe, "The common root cause of both diseases is high, persistent insulin levels. Both are diseases of hyperinsulinemia (high insulin levels). Because they are so similar, both diseases are beginning to be observed as a syndrome, aptly termed diabesity. The treatment for both is to lower insulin levels, yet current treatments focus on increasing insulin levels, which is exactly wrong." These insights from Dr. Jason Fung's work are most valuable to assist in reaching a better understanding of the problem. (Fung, 2016)

A Sweeter Understanding of Sugar & Artificial Sweeteners

To gain an even deeper understanding, we will compare Glucose to Fructose and then briefly describe Sucrose, and touch on artificial sweeteners Refer to table 1.

Glucose	Fructose
-Six-sided ring	-Five-sided ring
-Every cell in the body can utilize it	-Metabolized only in the liver
-The main sugar found in the blood & circulates throughout the body	-Does not circulate in the blood
-The Preferred energy source in brain. -Muscle cells can utilize it directly. -Certain cells can only use glucose for energy.	-Brain, Muscles & most other tissues **cannot** use fructose directly for energy
-Can be stored -Can be made de novo	-Can only be metabolized by Liver -
-Changes blood glucose levels	-Eating fructose **does not** appreciably modify the blood glucose level
-Single Sugar (Monosaccharaides)	-Single Sugar (Monosaccharaides)
- Produces a rise in Insulin Levels	-Produces only a mild increase in insulin levels
-Requires insulin for maximal absorption	-Does not require Insulin for maximal absorption
Excess glucose consumption is handled through several distinct metabolic pathways, such as glycogen storage and de novo lipogenesis	-At the liver, fructose is rapidly metabolized into glucose, lactose, and glycogen. -Excess fructose is converted into fat in the liver. -High levels of fructose will cause fatty liver.

Table 1 Key differences between glucose and fructose adapted from (Fung, 2016)

What we know as table sugar is Sucrose. It is made of one molecule of glucose and one molecule of fructose. The high-fructose corn syrup, which was developed in the 1960's as a liquid equivalent to sucrose, is composed of 55 percent fructose and 45 percent glucose. Carbohydrates consist of sugars. Both glucose and fructose form

sucrose when they are together in a fifty-fifty mix. Sucrose thus plays a double role in obesity. (Fung, 2016)

The increase in obesity closely mirrored the rise in the use of high-fructose corn syrup as shown by Dr. George Bray from the Pennington Biomedical Research Center of Louisiana State University. (Fung, 2016)

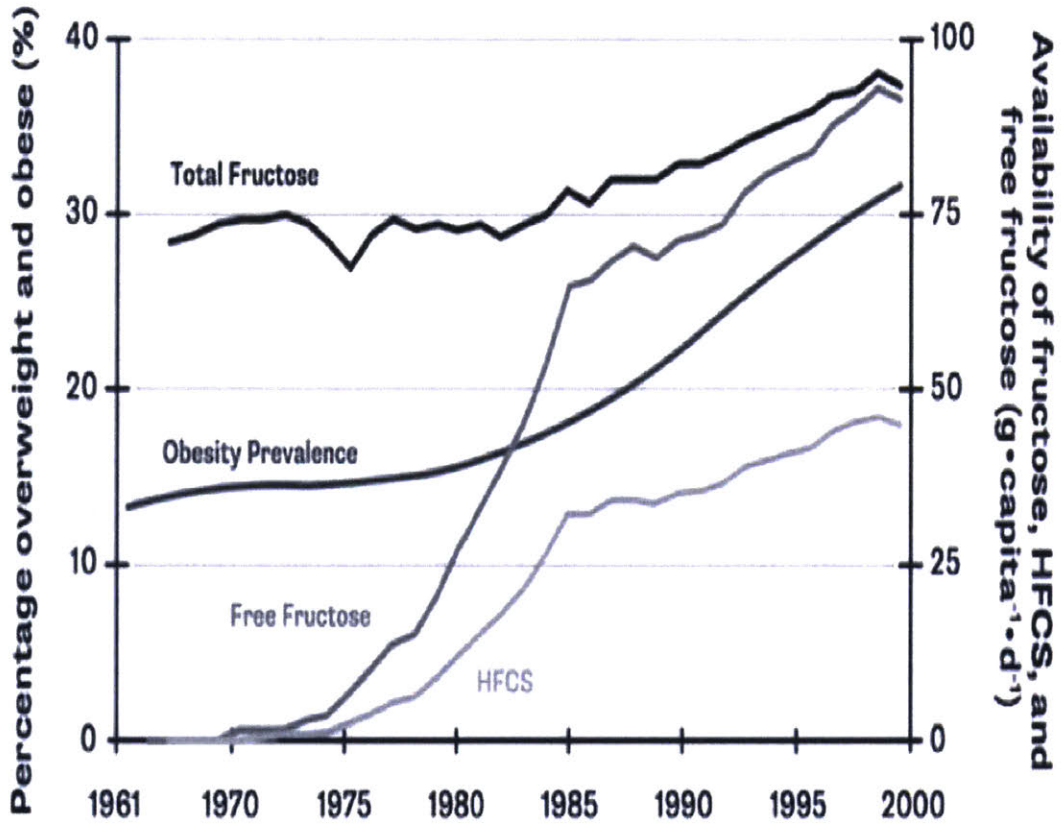


Figure 23 Rising obesity rates with relation to availability of fructose, High Fructose Corn Syrup and free fructose Adapted from (Fung, 2016)

"As far back as 1980, experiments proved that fructose (but not glucose) caused the development of insulin resistance in humans. (Beck-Nielsen, Pedersen, & Lindskov, 1980) "Healthy subjects were given an extra 1000 calories per day of either glucose or fructose. The glucose group showed no change in insulin sensitivity. The fructose

group, however, showed a 25 percent worsening of their insulin sensitivity— after just seven days." (Fung, 2016)

"The liver acts like a balloon. As energy comes in, it fills up. As energy is needed, it deflates. In the short term, glucose is stored as glycogen in the liver, but the liver's storage space for glycogen is limited. Once it's full, excess glucose is stored as fat: that is, the liver begins manufacturing fat from glucose through de novo lipogenesis. It takes higher and higher levels of insulin to move the same amount of food energy into a fatty liver. The body is now resistant to the efforts of insulin, since normal levels will not be enough to push sugar into the liver. Voilà—insulin resistance in the liver. The liver, like an overinflated balloon, will try to expel the sugar back into circulation, so continuously high insulin levels are also required to keep it bottled up in the liver. If insulin levels start to drop, the stored fat and sugar comes whooshing out. To compensate, the body keeps raising its insulin levels. Thus, insulin resistance leads to higher insulin levels. High insulin levels encourage more storage of sugar and fat in the liver, which causes even more over-cramming of fat in the already fatty liver, causing more insulin resistance—a classic vicious cycle."(Fung, 2016)

Dr. Sharon Fowler, from the University of Texas Health Sciences Center at San Antonio, in the 2008 San Antonio Heart Study (Fowler et al., 2008). Prospectively studied 5158 adults over eight years. She found that instead of reducing the obesity, diet beverages substantially increased the risk of it by a mind-bending 47 percent. She writes, "These findings raise the question whether [artificial sweetener] use might be fueling—rather than fighting—our escalating obesity epidemic."

Artificial sweeteners may seem to decrease sugar and calories, but they do not decrease insulin. They cause harm not only by increasing insulin levels but also, they might result in harm by increasing cravings. (Fung, 2016)

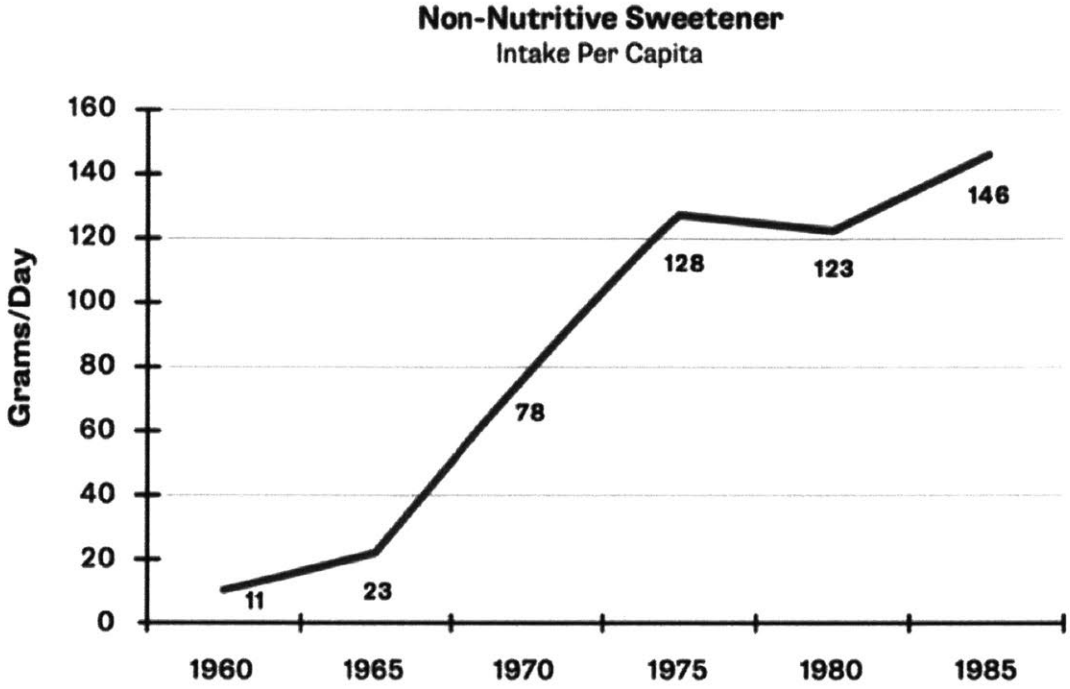


Figure 24 ***Per capita consumption of artificial sweeteners increased more than 12 fold between 1965 and 2004 adapted from*** (Fung, 2016)

Artificial Sweetener	Comment
Cyclamate	Removed due to bladder cancer concerns
Aspartame	Cancer causing potential in animals/Raised insulin level more than table sugar
Acesulfame potassium	
Sucralose	Raises insulin by 20 percent, despite the fact that it contains no calories and no sugar.
Stevia	Raised insulin level more than table sugar
*Agave nectar	Mainly fructose

Table 2 ***Inspired by information adapted from (Fung, 2016)***

Researchers looked at seventeen different reviews of sugar-sweetened drinks and weight gain. (Popkin, Bray, & Hu, 2015). "A full 83.3 percent of studies sponsored by food companies did not show a relationship between sugar-sweetened drinks and weight gain. But independently funded studies showed the exact opposite— 83.3

percent showed a strong relationship between sugar-sweetened drinks and weight gain." (Fung, 2016)

A Sample of Protective Factors

The good news is that there seem to be some protective factors that contribute to reducing the negative effects of poor dietary choices. These factors include fiber and vinegar, and most importantly vegetables and fruits. In addition to the role of exercise which we have described earlier in Chapter 6.

The initial and simplest step in addressing global obesity would be limiting or ideally eliminating intake of sugar-sweetened beverages or added sugar in food. Also, minimize or eliminate fruit juice. Some countries have already undertaken such an initiative. Other countries have banned sugar-sweetened beverages in schools, and a smaller number have banned fruit juice. The banning of promotion of sugar-sweetened beverages has already been demonstrated in a few countries, particularly on TV. Another example of mitigation of obesity is the prohibition of Importation of sugar-sweetened beverages in selected countries. (T. Gill, 2014)

Food portion sizes are another issue that we will briefly address. Research demonstrated an increase in food portion sizes. This is supported by studies conducted in several countries such as USA, UK, Denmark and the Netherlands (Benton, 2015). The identified trends reveal three main issues:

First, "original sizes of products have enlarged, with the smaller original size being no longer available on the market" (T. Gill, 2014).

Second, "larger sizes have been added to the portion size portfolio" (T. Gill, 2014).

Third, "multi-packages have been introduced, with an increased number of sub-items within a multi-package since their introduction. (T. Gill, 2014)

This increase in food portion size and consumption can be attributed mainly to the "value for money principle" and "portion distortion phenomenon" (T. Gill, 2014)

Therefore, portion control although might not be an ideal solution, it is still worth pursuing. The lack of addressing portion size will only add to the existing problem of obesity (T. Gill, 2014).

"Soluble fiber reduces carbohydrate absorption, which in turn reduces blood glucose and insulin levels. If fiber can protect against elevated insulin, then it should protect against type 2 diabetes and that is precisely what is supported by studies." (Liese et al., 2005), (Fung, 2016)

Vinegar is also a protective factor. "Two teaspoons of vinegar taken with a high-carbohydrate meal assists in lowering blood sugar and insulin by as much as 34 percent and taking it just before the meal was more effective than taking it five hours before meals (Fung, 2016).

A high fiber diet is protective. It can assist in combating obesity and has been linked to a reduction in risk of coronary heart disease, stroke, hypertension diabetes and obesity. (T. Gill, 2014)

Fat was historically framed as the culprit in obesity. However, this has been proven untrue by studies and time, "Eating fat does not make us fat, but may protect us against it." The consumption of fat with other foods tends to decrease glucose and insulin spikes. (Collier & O'Dea, 1983). "A comprehensive review of all the studies of high-fat dairy finds no association with obesity with whole milk, sour cream and cheese offering greater benefits than low-fat dairy." (Fung, 2016) This is further supported by considering the Women's Health Initiative Dietary Modification Trial in which, "nearly 50,000 women were randomly assigned to low-fat or regular diets. Over seven years, the low-fat, calorie-restricted diet produced no benefits in weight loss. Nor were there heart-protection benefit either. The incidence of cancer, heart disease or stroke was not reduced. There were no cardiovascular benefits. There were no weight benefits. The low-fat diet was a complete failure." (Fung, 2016)

In addition, extra virgin olive oil and avocado and whole grains, vegetables and fruits are healthy choices that need to be incorporated in a person diet. Increasing the consumption of fruits and vegetables can help reduce the risk of chronic diseases, hypertension, coronary heart disease, and strokes. These may protect against obesity (Boeing et al., 2012).

Adequate intake of water is another key factor for weight maintenance and weight loss. Weight is one factor to consider, but the general health of the individual is important and is influenced by weight.

Finally, numerous studies have shown that the "Mediterranean Diet" is a healthy diet. It combines good taste and quality food with positive health benefits. It has a large potential for long-term sustainability. "This diet is characterized by the abundance of vegetarian foods, fresh and minimally processed food, in addition to fresh fruit as the daily dessert. " (T. Gill, 2014)

Myths & Truths

Myth	Truth
Eating frequently will increase your metabolic rate.	Eating more frequent meals does not aid in weight loss. (Cameron, Cyr, & Doucet, 2009)
Eating frequently controls hunger	Evidence is difficult to find ("Influence of intensive diabetes treatment on body weight and composition of adults with type 1 diabetes in the Diabetes Control and Complications Trial.," 2001)
Eating frequently keeps blood glucose from becoming too low.	Unless you have diabetes, your blood sugars are stable whether you eat six times a day or six times a month. People have fasted for prolonged periods without low blood sugar, the world record being 382 days. (Stewart & Fleming, 1973)
Breakfast is most important meal of the day.	The Bath Breakfast Project, a randomized controlled trial, found that "contrary to popular belief, there was no metabolic adaptation to breakfast." Total energy expenditure was the same whether one ate breakfast or not. Breakfast eaters' averaged 539 extra calories per day compared to those that skipped breakfast—a finding consistent with other trials. (Betts et al., 2014)

Table 3 Adapted from information obtained from (Fung, 2016)

Chapter 8 Applying Innovation Concepts to Tackle Obesity in Saudi Arabia

Intro

We have hopefully explained, "What is overweight and obesity?" and "How big of a problem both overweight, and obesity are for the world?" Also, we highlighted that Saudi Arabia was not immune to this global issue. We then updated our understanding of obesity through shifting our mindset from the "Caloric Imbalance Theory" to "The Hormonal Theory of Obesity" mainly crediting the work of Dr. Fung, titled "The Obesity Code: Unlocking the Secrets of Weight Loss."

We can clearly see from the information presented in the earlier chapters that overweight and obesity are global issues that have not spared the Kingdom of Saudi Arabia of their adverse effects. The need to address obesity has been documented in the scientific literature. "There is a dire need to raise the issue at the national level, and design efforts and strategies to combat obesity in the country" (M Alqarni, 2016). Genetic and environmental factors both contribute to the risk of developing obesity and diabetes.

As we have seen, obesity is not the cause but rather a symptom of the disease. Obesity and diabetes are not simple, but rather, complex. We are starting to have a better understanding of obesity and diabetes. We believe that with more research the current Type 2 Diabetics will probably be further sub-classified to a different disease that will require different tailored approaches as opposed to what is currently being practiced. This deeper understanding will likely result in a more tailored approach and better outcomes. The solution will not likely be a single medication or procedure but rather a tailored approach with emphasis on addressing the core contributing factors within our current control.

"The determinants of obesity are complex and varied and it is important to recognize that no single intervention is likely to prevent obesity in the population. Actions to prevent obesity need to be taken in multiple settings and incorporate a variety of approaches and involve a wide range of stakeholders. This requires intervention at all levels of society, from communities through to governments, private organizations and nongovernmental organizations. It is generally accepted that comprehensive and coordinated interventions which support and facilitate physical activity and healthy diets in the context of a social-determinants-of-health approach represent the best way forward for obesity prevention." (Al-Shehri et al., 2014)

Definition of Innovation

Innovation, as defined by Merriam-Webster's dictionary ("Innovation | Definition of Innovation by Merriam-Webster," n.d.), is defined as:

1. the introduction of something new
2. a new idea, method, or device

It is beyond the scope of this thesis to discuss innovation in great depth. However, we will touch on what we believe to be valuable concepts relevant to tackling obesity via innovation as applied within the context of the Kingdom of Saudi Arabia. In particular, we touch on some of the ideas and work of Prof. Clayton Christensen. We will focus on applying a selection of these general concepts in our quest to tackle obesity in the Kingdom of Saudi Arabia.

Although there are many different suggested types of innovation and although innovation can be categorized in several different ways, we have elected to pursue the categorization that divides innovation into "Incremental Innovation" and "Disruptive Innovation." We believe that both these types are necessary, but our

focus will be more on the disruptive arm of innovation in the healthcare and national system context of Saudi Arabia.

Disruptive Innovation "Explains the process by which complicated, expensive products and services are transformed into simple, affordable ones." The aim is usually to make services or products cheaper, faster and better. (Christensen et al., 2009)

"Jobs to be done" Theory

The theory, of jobs to be done, which, "focuses on deeply understanding your customers' struggle for progress and then creating the right solution and attendant set of experiences to ensure you solve your customers' job well, every time." (Christensen, Hall, Dillon, & Duncan, n.d.-a)

Prof. Clayton Christensen describes three types of medicine in his book "The Innovator's Prescription" these are Intuitive Medicine, Empirical Medicine and Precision Medicine. We found this to be particularly useful abstract view on dividing the practice of medicine to understand better where obesity as a healthcare issue would best be served.

According to Prof. Clayton Christensen, each of the types is described as follows:

- Intuitive Medicine: "where expensive and highly trained professionals solve medical problems through intuitive experimentation and pattern recognition." (Christensen et al., 2009)
- Empirical Medicine: "Where data are reviewed to show that certain ways of treating patients are, on average, better than others."(Christensen et al., 2009)
- Precision Medicine: "the precise diagnosis."(Christensen et al., 2009)

Intuitive Vs. Rule Based Chronic Disease

Chronic diseases can be divided into, intuitive chronic diseases and rules based diseases.

"The intuitive chronic diseases are those that lack clarity of diagnosis and treatment requires a multi-disciplinary, solution shop such as what we term today as a hospital"(Christensen et al., 2009).

The rules based chronic diseases are those where "a single practitioner can diagnose, and prescribe evidence or rule based therapy" (Christensen et al., 2009).

Obesity is currently, perceived to be in the intuitive chronic diseases list, and while diabetes mellitus type 2 is currently categorized into the rule-based chronic disease basket (Christensen et al., 2009).

It is worth noting that a significant portion of the cost of chronic care is wasted because the prescribed therapy solves the wrong problem for the wrong patient.

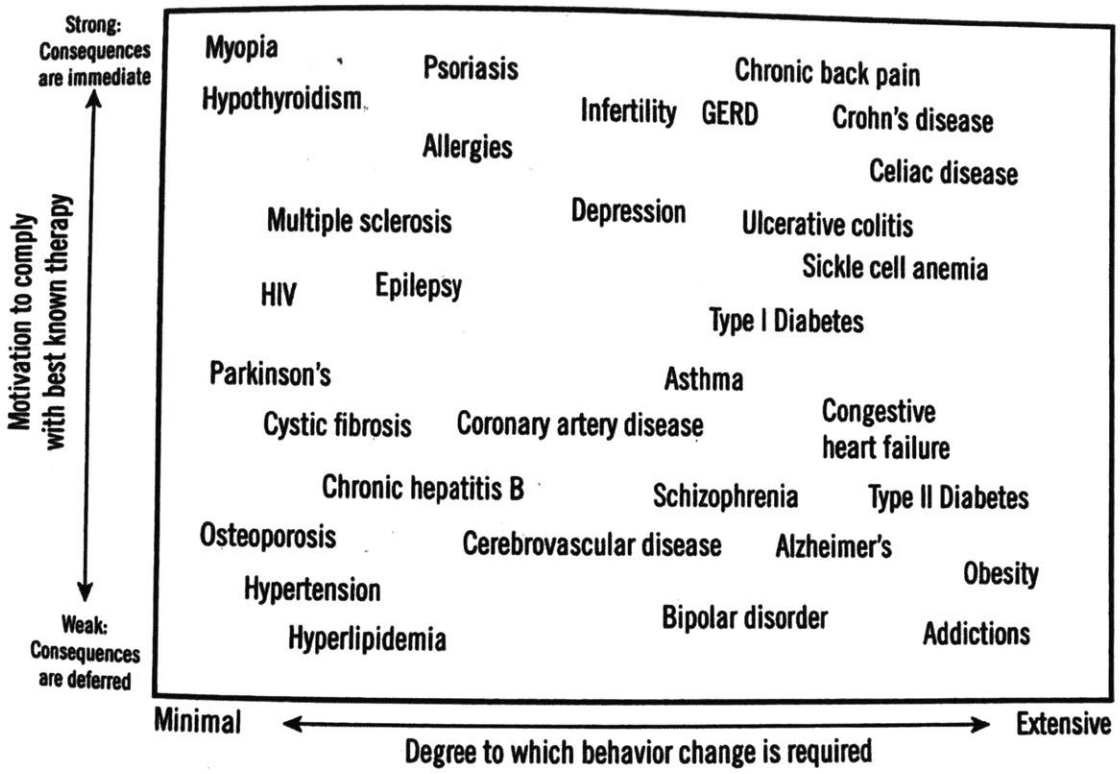


Figure 25 ***Compliance motivations vs. Degree of behavior change required. Source: (Christensen et al., 2009)***

"The vertical access measures the intrinsic motivation of patients to avoid the complications or symptoms of the disease by adhering to the prescribed therapy. What largely drives this motivation is the intensity and immediacy with which patients feel the complications." (Christensen et al., 2009)

As we can see from Figure 20, both, Type 2 diabetes and obesity are on our bottom right-hand corner. This indicates that both these conditions require an extensive degree of behavior change however the motivation to comply with the best-known therapy is very weak since the consequences of non-compliance are deferred. People tend to worry more about the immediate rather than delayed consequences of poor compliance. This highlights the importance of a behavioral change support component to any endeavor in addressing these issues. It is worth noting that

behavior and hormones are interlinked. When there are hormonal changes, behaviors can be affected by these changes.

FIGURE 5.3 Chronic quadrangle: behavior-intensive diseases with deferred consequences

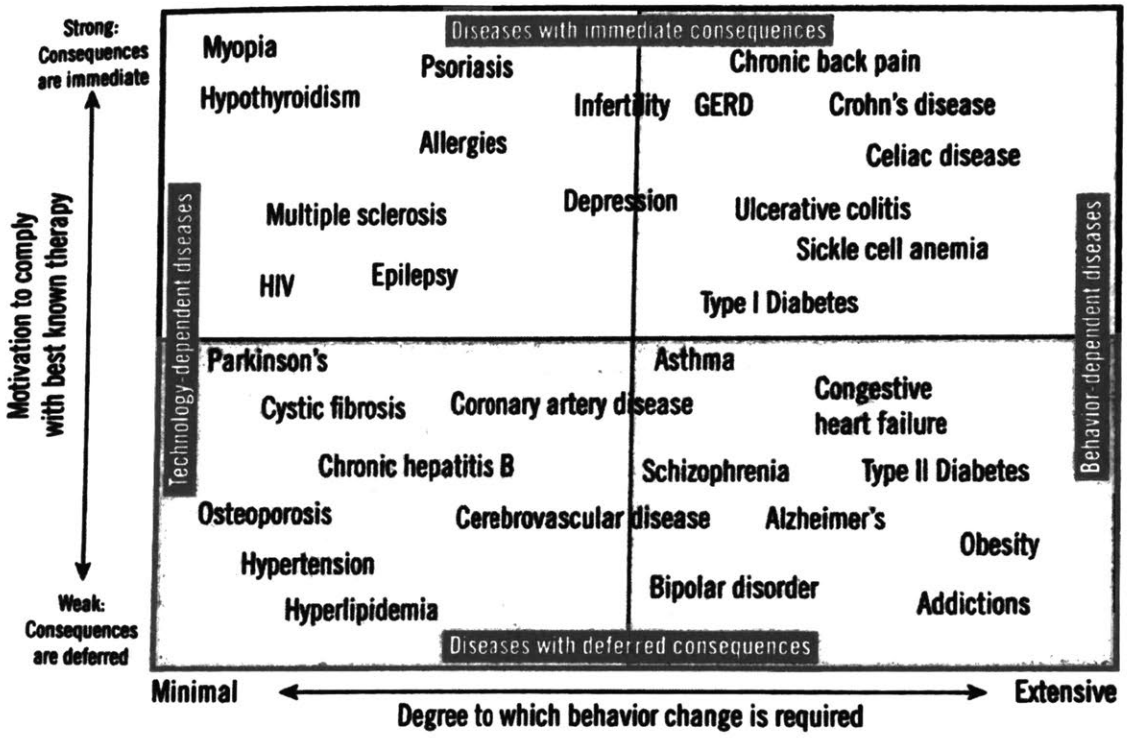


Figure 26 Chronic quadrangle: behavior-intensive diseases with deferred consequences Adapted from (Christensen et al., 2009)

To explain Figure 26 "by drawing a vertical line dividing the X- axis into two halves we can group the diseases on our right-hand side into "behavior-dependent" conditions and the ones on our left-hand side can be considered as "technology-dependent diseases." We can further divide the graphic by drawing a horizontal line at the midpoint of the Y-axis. This line will separate the groups of disease into immediate outcome disease vs. deferred outcome diseases. According to Prof. Clayton Christensen, the majority of the healthcare costs are spent in caring for the lower right-hand corner quadrant that encompasses disease such as obesity and

diabetes mellitus type 2 and other diseases as can be seen in the above figure. This lower right-hand corner can thus be appropriately termed "Chronic Quadrangle." (Christensen et al., 2009)

Through describing the hormonal theory of obesity earlier, we believe it better helps us understand the underlying pathophysiology of development of obesity. Although there will likely be changes in the future to our understanding of obesity as further research and a deeper understanding of the science develops, we believe that the hormonal obesity theory better explains the increasing prevalence of obesity as opposed to the caloric imbalance theory. We acknowledge that there are many other theories that exist that attempt to better our understanding of obesity, but we believe that the hormonal theory does a pretty good job of enabling a deeper understanding of the development of weight gain and obesity. To add to this understanding and apply an innovation concept to tackling obesity we need to consider the functional dimension and the emotional dimension in addition to the social dimension of certain choices a person makes that might contribute to the development of obesity. (Christensen et al., 2009) Our focus on obesity should be related not only to the dietary choices we make but at what points of time do we choose to consume food and drinks, in addition to the nature of what we consume whether it maybe organic or processed. In addition, consideration to the portion and frequency of food consumption should be taken into consideration.

As an example, "When a smoker takes a cigarette break, on one level he/she are simply seeking the nicotine his/her body craves, that is the functional dimension, but that is not all that is going on, cigarettes are hired for the emotional benefit of calming down and relaxing. Going to smoking area and meeting with fellow smokers is a social dimension to the choice made." (Christensen, Hall, Dillon, & Duncan, n.d.-b)

Similarly, when we consider choices made by the individual regarding "what they eat?" and "when they eat?" and "why they eat?" a similar approach can be applied to understanding the different functional, emotional and social dimensions that are in play at any given moment of time. For example, when a person wants to grab lunch at noon time, on one level he/she might be simply seeking to satisfy hunger, that's the functional dimension, but that is not all that is going on, the food items he/she choose to hire to satisfy his/her hunger could be for the emotional benefit of calming down or relaxing or to deal with boredom, etc. Going to a food court if he/she is in a mall and meeting with fellow workers on a meal break is a social dimension to the choice made. (Christensen et al., 2009)

One of the most important steps in our opinion to address the problem, which is in this case obesity, we must clearly define the problem and focus on investigating and understanding the actual cause as opposed to just the symptoms. As documented by Prof. Clayton Christensen, "Precise definition of the problem is essential to the development of a predictably effective solution."(Christensen et al., 2009) We also refer to the work of Dr. Jason Fung in his book The Obesity Code: Unlocking The Secrets of Weight loss in which he highlights the concept of "proximate" vs. "ultimate" cause as applied to our topic of obesity as we explained earlier in this document. Thus, it is key to understand the problem to find an appropriate solution or group of solutions. We do not believe in a root cause as most if not all problems are multifactorial and it would be shortsighted of us to fool ourselves into thinking that a single cause explains the entirety of complex issues. To further elaborate on this, as an example, let us consider the previous notion that obesity was a result of an imbalance between energy intake and expenditure as a theory we clearly established why this argument falls short of helping us understand how obesity develops based on the five false assumptions mentioned earlier. In contrast, we see how Dr. Jason Fung's hormonal obesity theory much better explains how obesity develops and how it is intimately tied to the hormonal balance that is influenced by multiple factors such as what we eat and when we eat and the way the food we

consume is processed. Although we agree with Dr.Fung, we do not believe that the hormonal theory of obesity thoroughly explains obesity but rather is a significant step in the right direction of understanding the complexity of obesity. We might discover in the future that what we currently consider the ultimate cause of obesity is a proximate cause. This would be the result of further research and new developments that will enable us to understand these complex medical states. The better understanding of obesity as a problem will likely, lead to the development of better options for more efficient solutions. Either an incremental or disruptive solution will occur based on our enhanced understanding of the problem. The same applies to diabetes. (Christensen et al., 2009)

Based on "The Innovator's prescription", if the job that we intend to do on a personal level is to reduce our weight, then we should choose what does this job best and delivers the best outcomes faster, cheaper and better, repeatedly with the most sustained results. (Christensen et al., 2009) To explain this further, based on our current knowledge, if we apply the theory of jobs to be done to "weight loss" on an individual level then we get the following structure:

Job to be done: Sustained long-term weight loss

What we hire to do the job: Exercise

However, as we have seen from the research previously alluded to in the paper, exercise does not perform well for the job we hired it to do which is long-term sustained weight loss. 95 percent of weight loss is diet based, and 5 percent is exercise. (Fung, 2016) Keep in mind that obesity has both environmental and genetic potential contributing factors, but the genetic predisposition possibly will require environmental triggers for the expression of what was triggered at the genetic level. Based on this knowledge and the better understanding of obesity through the hormonal theory of obesity we can re-apply the theory of jobs to be done, and the result would be as follows:

Job to be done: Sustained long-term weight loss

What we hire to do the job: Appropriate dietary choices (what we eat, when we eat and how much is consumed in addition to how the food we eat is processed vs. organic etc.) (Christensen et al., 2009)

"It is like preparing for an exam in which we know that 95% of our result will depend on diet and 5% will depend on exercise"(Christensen et al., 2009) Having this knowledge will help us better direct our efforts towards what is likely to give a higher return on our investment (Christensen et al., 2009). This, however, does not negate the importance or the role that exercise has for weight loss or general health. Exercise is paramount for multiple general health issues, just not as important for weight loss as is our dietary choices.

Another concept that we would like to highlight is that we must observe what people "actually do" rather than focus on "what they say they would do." We note that "what people do" is a much better indicator of what happens when compared to "what they say they would do."(Christensen, 1997)

To illustrate this point with a simple example, people might say they will make healthy food selection choices when they go to the food market, but when they are observed, we might note that they make unhealthy selections. We need to understand better why they make the choices they make when they make them. The context of choice made is just as important as the choice that is made to understand better the dynamics that lead to an inevitable choice and ultimately an outcome.

The financial health of a person might take precedent over their physical health when they make choices. Behavioral economics might be part of the solution. In particular, cases of chronic disease such as obesity or diabetes, the complications might seem remote or not immediate while the financial implications of making healthy choices are more immediate and hence a deterrent from making the better choice on an individual level. This can also be extrapolated to a population level and

potentially a national level. What we ultimately choose to hire depends on the job we are considering at a specific place and specific point of time. (This thought process has been inspired by the work of Prof. Clayton Christensen).

Disruptive Business Model Approach to Tackling Obesity

Intro

This chapter has been mainly inspired by the work of Prof. Clayton Christensen.
Let us begin with a brief overview of what is meant by "business model." As explained in "The innovator's Prescription" A business model is "an interdependent system composed of four components." (Christensen et al., 2009)

The first of these elements is a value proposition which is defined in the innovators prescription as "a product or service that can help targeted customers do more effectively, conveniently, and affordably a job that they have been trying to do." (Christensen et al., 2009) If we consider the service that we hope to propose for reducing the prevalence of overweight and obesity in Saudi Arabia, through measures to help prevent the non-overweight from becoming overweight and the overweight from becoming obese and the obese from becoming severely obese, in a more efficient and convenient and affordable way than methods in current existence. That would be our value proposition. (Christensen et al., 2009)

The second component to consider is resources. That includes "intellectual property, supplies, people and equipment, facilities, cash etc. required to deliver the value proposition to the targeted customers."(Christensen et al., 2009) In our case, the customers would be the population of Saudi Arabia who are at risk and the community already considered to be overweight or obese and severely obese.

The third component is processes, which "define how the resources are combined to deliver the value proposition." (Christensen et al., 2009)

Finally, the fourth component is the profit formula, which "defines the required price, markups, gross and net profit margins asset turns and volumes necessary to cover profitably the costs of the resources and processes that are required to deliver the value proposition." (Christensen et al., 2009) Of course, for the purpose of this paper, we are only touching on the high-level concept without delving into the details since the details will be dictated by the model that might ultimately get adopted.

We believe that the business models described by Prof. Clayton Christensen are an excellent way to look at what business model(s) should be considered for the problem of obesity. The business model categories to describe are the following:

1. Solution shops (Christensen et al., 2009)
2. Value-adding process businesses (VAP)(Christensen et al., 2009)
3. Facilitated networks (Christensen et al., 2009)

We would like to highlight that that the general hospital and physician clinics initially emerged as solution shops, however, value-adding process businesses and facilitated networks were later mixed in over time and resulted in intertwined business models that do not truly deliver the value they are intended to (Christensen et al., 2009). "This ultimately resulted in confused and complex institutions in which a good portion of expenditure is directed towards overhead activities rather than direct patient care." (Christensen et al., 2009) Such is the case when we try to tackle obesity without appropriate compartmentalization and integration. We will attempt to elaborate further on each of the models and highlight how each may be tailored to help address obesity and overweight in Saudi Arabia and potentially globally in the following sections.

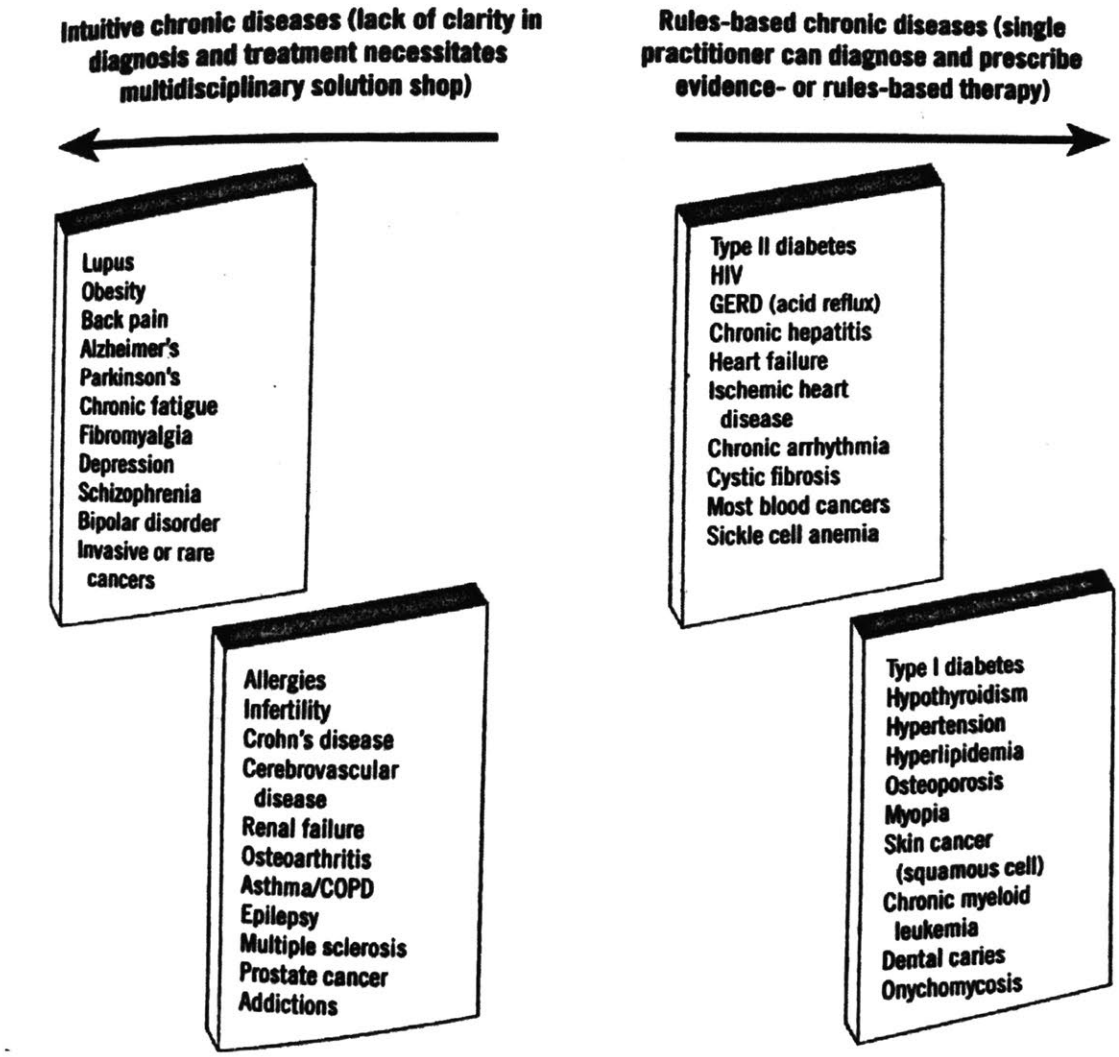


Figure 27 Type of medical practice required to diagnose and devise therapy for a range of chronic diseases. Adapted from (Christensen et al., 2009)

Application of Business Models to Our Problem

Obesity is complex. However, the solutions suggested tackling obesity are often over-simplistic and often take into account only one factor at a time. They often assume that each factor considered is mutually exclusive when in all likelihood they are not (Fung, 2016) is. We have to remember that obesity is also a time-dependent disease i.e. it takes the time to develop and will likely time to treat. The longer obesity is present, the more difficult it becomes to address. (Fung, 2016)

Solution Shops

"Solution shops are structured to diagnose and solve unstructured problems" (Christensen et al., 2009). "Value is mainly provided through the people employed who in the majority of cases are experts that depend on a combination of problem-solving and analytical skills in addition to intuition to diagnose the cause of a problem when the diagnosis is only an uncertain hypothesis"(Christensen et al., 2009). They usually attempt to reach a diagnosis by using the most appropriate, available intervention to test the hypothesis. "The intervention can be one of many available or the single available remedy for what is being tackled. Whether the intervention is direct or indirect and whether it is medical or surgical, temporary or permanent, individualized or population-based approach. Physical or behavioral in nature." (Christensen et al., 2009)

Applying this to the problem of diabesity (obesity and diabetes), we can see that the diagnosis of both these conditions are relatively straightforward since the definitions are clear. In the case of obesity, by referring to Merriam-Webster dictionary, we find that obesity is defined as "a condition characterized by the excessive accumulation and storage of fat in the body."("Innovation | Definition of Innovation by Merriam-Webster," n.d.) However, the methods used to measure body fat directly are not readily available on a day-to-day basis for the majority of the population. For this reason, it has been universally acceptable to use the Body Mass Index (BMI) as a standard measure of obesity and overweight as mentioned earlier. There are also cut off values for lab results to help establish the diagnosis of diabetes in the context of a supporting history and physical examination and more specific confirmatory testing. Therefore, for both obesity and diabetes, diagnosis is not the primary challenge but rather understanding the ultimate cause as opposed to the proximate cause of the disease. That is the biggest problem.

In more than one way, this mirrors the concept of identifying the problem and having a deeper understanding of it to work on finding the solution(s) if we adopt a solution neutral approach. This means we should have an open mind to a multitude

of potential solutions to a given problem. Finding a cause is rare, as many of chronic diseases including obesity and diabetes are usually multifactorial and hence the need for a tailored approach to address the complex issue. Solving a complex problem with a simple solution should be avoided as this is usually destined to fail. We should, however, aim to transform a complex issue to a simple problem(s) and only then, apply an appropriate simple solution to address the now simple problem. (Christensen et al., 2009)

Value Added Process

"These organizations take in incomplete or broken things and then transform them into more complete outputs of higher value"(Christensen et al., 2009)

A definitive diagnosis needs to be made first in a solution shop and only then are VAP useful. It is noted "when VAP procedures are separated from solution shops organizationally the overhead costs drop dramatically"(Christensen et al., 2009) Also, "comparable care at ½ the cost can be provided in focused VAP clinics in comparison to hospitals and physician clinics in which VAP and solution shops are intertwined" (Christensen et al., 2009). Some examples of a VAP model are focused centers for eye surgery and specialized orthopedic and heart hospitals, Shouldice hospital (where they perform hernia repairs) and minute clinics (Christensen et al., 2009). "VAP typically charge for output while Solution Shops usually charge for inputs" (Christensen et al., 2009). We believe that this model has significant value for solutions tackling obesity or diabetes. A center that is specialized in catering for prevention and treatment of overweight, obesity, and diabetes mellitus type 2 would add value and have better outcomes in comparison to currently existing models for managing these conditions, which seems to be muddied with an ineffective and inefficient methodology. The key is not just the designation of these as specialized centers but rather designing them from all aspects to be value adding process businesses.

Facilitated Networks

According to Prof. Clayton Christensen, these are "enterprises in which people exchange things with one another" (Christensen et al., 2009).

This model might be considered as an efficient business model for the care of many chronic diseases that are highly dependent on modifications in patient behavior for successful treatment such as obesity and diabetes amongst other diseases. However, we feel that at present, the region is not ready for implementation of such a model. It will require an educational, cultural and social shift in addition to supporting infrastructure and an enabling system to optimize chances for success.

Although at the moment there is not much readiness to adapt a facilitated networks model, this does not negate the fact that the willingness for such a model might be soon and we would recommend preparing for such a model.

It is worth noting "facilitated network business models in healthcare can be structured to make money by keeping people well; whereas solution shop and VAP business models make money when people are sick" (Christensen et al., 2009).

Therefore, choosing the right business model for the selected task or situation is key, and this perfectly ties into "jobs to be done" theory in which we hire the business model that performs the job it is hired to do best, repeatedly and dependably.

"Solution shops need to become focused so they can deliver and price the services of intuitive medicine accurately. Focused VAP hospitals need to absorb those procedures that general hospitals have historically performed after definitive diagnosis. Facilitated networks need to be cultivated to manage the care of many behavior-dependent chronic diseases. Solution shops and VAP hospitals can be created as hospitals within hospitals." (Christensen et al., 2009).

Conclusion

To conclude, whatever business model is chosen needs to be monitored and assessed for level of success. Metrics for success need to be defined. Outcomes of intervention need to be followed. Approaches need to be re-evaluated based on gained knowledge and experience. The review of such solutions should be structured to enable adequate updates and assessments, keeping in perspective the constraints of time, budget, and people.

We should always remember that "every process is perfectly designed to deliver the result it gets" for which W. Edwards Deming was credited with this observation. Whatever the solution(s) pursued or tested may be, we should be ready to change our selection if it proves ineffective. Such is the example of hiring exercise for weight loss as the example we previously gave based on the "Jobs to be Done Theory". While exercise is imperative for general health and has many benefits, significant weight loss is not one of these advantages. "It is important to focus on understanding the underlying job, not falling in love with your solution to it." (Christensen et al., n.d.a)

Although exercise might not be great for weight loss, it is still very beneficial for health and therefore should be encouraged and advocated. We should however clearly highlight what exercise does well? Moreover, it does not do well? This is mainly to avoid the frustration that commonly is associated with failing to achieve a goal as a result of hiring the wrong for the required task or job.

Key Concept: Outcomes should be as important if not more important than just focusing on process. To illustrate this idea, "a study found that the accreditation of hospitals by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), an industry dominated group, had scant correlation with mortality rates." (Harvard Business School. n.d.)

Chapter 9 Summary & Recommendations

Obesity is complex. However, the solutions suggested tackling obesity are often over-simplistic and often take into account only one factor at a time. They often assume that each factor considered is mutually exclusive when is all likelihood they are not. (Fung, 2016) We have to remember that obesity is also a time-dependent disease i.e. it takes a time to develop and will likely require time to treat (Fung, 2016).

Obesity is a complex, multifaceted problem. The "Caloric Imbalance Theory" does not do as well a job as the "Hormonal Theory of Obesity" in addressing our understanding of obesity. Since obesity is a complex problem, it warrants involved thinking and re-framing. Tackling obesity is a necessity and not simply a luxury.

In the United States of America, obesity increased the risk of a range of chronic diseases and is believed to contribute between $147 billion to $210 billion dollars in preventable health care spending (Christopher et al., 2016) We believe the economic burden of obesity and associated conditions, including both direct and indirect costs, is significant in Saudi Arabia as well. Capturing the economic burden of obesity on Saudi Arabia should be a part of any suggested solution since good data to help evaluate this is currently lacking.

We predict that leveraging technology and innovation in tackling health related challenges would be one of the key factors to enable success in the near future.

An inter-professional system approach road map has been previously suggested for the prevention and control of obesity/overweight, as evident in a review article published in the Saudi Journal of Obesity. (Al-Shehri et al., 2014)

As we can see from Figure 28, the road map and components includes a call for a national forum (expert panel committee), strategic planning, guidelines, and policies. Also assigning and coordinating working teams, ensuring effective implementation, opportunities and challenges, assessment and monitoring, and international networking with the dissemination of successful experience and research in the area of obesity. However, it is missing a critical component; metrics.

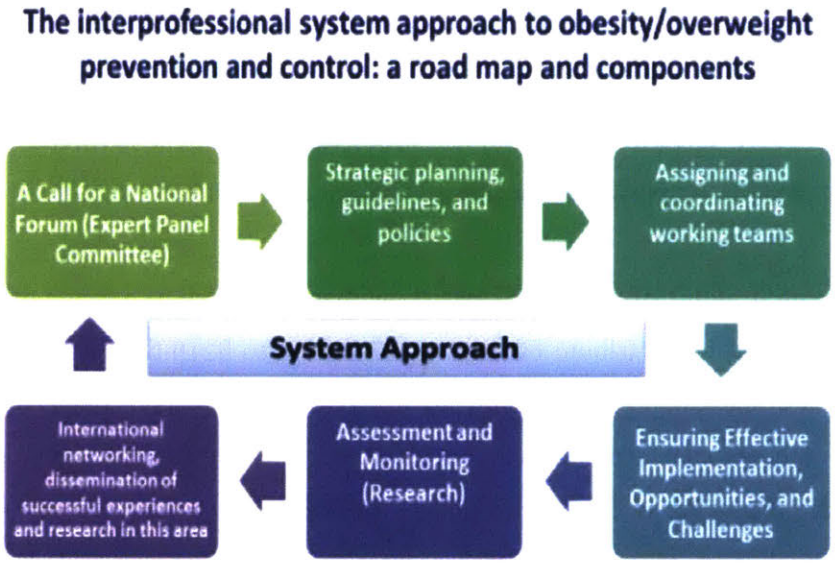


Figure 28 The inter-professional system approach to obesity/overweight prevention and control: a road map and components. Adapted from the Saudi Journal of Obesity, July-December 2016, Volume 4, Issue 2 (Al-Shehri et al., 2014)

Recommendations

Our recommendations are at concept level that will need to be further studied if the implementation is to be considered in Saudi Arabia. We believe that our suggested

recommendations and approach will complement existing efforts to prevent and control obesity and associated diseases.

We have demonstrated the benefit of adopting some high-level innovation concepts into tackling a health issue as exemplified by obesity. We have also highlighted the importance of research and development in addressing challenges and the advantage of having the cross-pollination of thoughts and expertise in dealing with issues by using business and engineering principle and applying key concepts in the healthcare setting.

An integrative, innovative systems approach should be pursued. However, this approach should take into consideration Regina E. Herzlinger's "Six Forces That can Drive Innovation-or Kill It"(Harvard Business School., n.d.). We should aim to optimize the forces to enable driving innovation rather than killing it (Harvard Business School., n.d.).The forces to be considered are the following (Harvard Business School., n.d.):

1. Players
2. Funding
3. Policy
4. Technology
5. Customers
6. Accountability

Finally, to tackle diabesity (obesity + diabetes), we should consider the system at different levels of intervention. These levels are as follows:

a) **Individual level**
b) **Institute level**
c) **National (policy maker) levels**

Our recommendations are based on the following

We have already introduced the definition of overweight and obesity. We explained how people could be categorized according to BMI. We then demonstrated that obesity is a global issue. Highlighted the fact that Saudi Arabia suffers from increasing prevalence of obesity similar to other developed/developing countries seemingly paralleling the trends in the United States. Next, we highlighted some of the causes of obesity, yet we focused on the diet as the main suspect in driving the increasing prevalence of overweight and obesity. We deepened our understanding of how diet influences the currently hypothesized keys to obesity based on the "Hormonal Theory of Obesity." We realized that insulin, cortisol and insulin resistance play a major role in re-setting the body set weight and by that influence body weight. We have hopefully succeeded in re-framing our understanding of obesity and can address overweight and obesity in an innovative manner.

Our recommendations thus include the following

We recommend obtaining buy-in and support from the highest level of authority in the Kingdom of Saudi Arabia i.e. the King of Saudi Arabia or whom he appoints to oversee such endeavor. This will help in addressing any political or policy setting obstacles and will facilitate funding support for nationwide initiatives. Also, this would highlight the pressing need and the urgency of which this problem must be tackled.

Identify and engage all key stakeholders in relation to obesity & overweight & diabetes. Aim to analyze the relationship between them and find innovative ways to align them with two overall goals; preventing and combating obesity. Make the key stakeholders' part of the solution or suggested solutions. Therefore, by identifying and addressing the key stakeholders, we increase the chances of buy-in and can hold them accountable for set goals of preventing and combating obesity and overweight. Please refer to *Figure 28* for sample-identified Key stakeholders. This figure highlights a perspective on identified stakeholders. We have actively decided not to draw out the connections between them to encourage thought about innovative connections and relations for consideration by the reader.

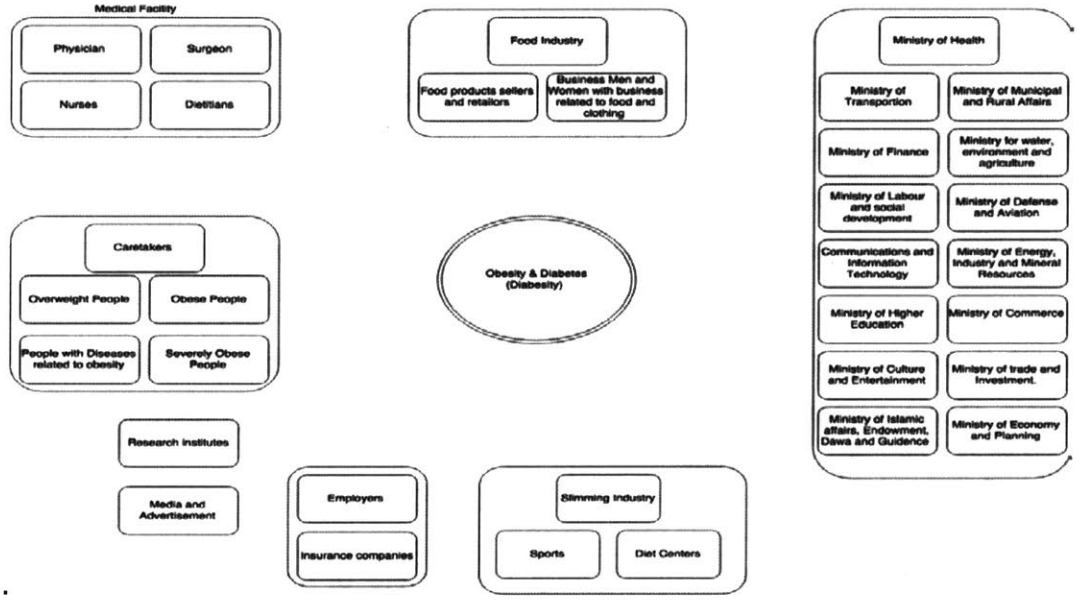


Figure 29 Created by Ahmed Al Tayyar, MD. And represents possible stakeholders' specific to the Kingdom of Saudi Arabia. No arrows or connections were incorporated intentionally, in order to stimulate innovative connections and relations for consideration by the readers. Consider looking at different perspectives of each identified stakeholder and group into factions, keeping in mind the "hidden" faction.

Next, we note that people possibly had misguided actions when it came to tackling obesity or overweight at the individual level. The poor dietary choices and investing in exercise as the major and sometimes sole tool for weight loss could be attributed

at a high level of abstraction to incorrect mental models. This has resulted in repeated frustration and discouragement because they are likely using the wrong tool or hiring the wrong 'employee' at which time the 'employee' was exercise or reduced caloric intake diet as an example.

If we fall back on the "Jobs to be Done Theory."(Christensen et al., 2009) Since the job to be done is weight loss, what had been hired to 'do this job' has thus far proven to be unsuccessful for the past 40 years.

Therefore, a vast majority of the people's mental models operated on the predominant "Caloric Imbalance Theory." This "Caloric Imbalance Theory" has significant flaws as we have demonstrated earlier in this work. We asked ourselves, "Why do people have this incorrect mental model?" The answer in our opinion, is most likely multifactorial, however, we believe that a significant contributing factor to the wrong mental model is related to the incomplete recommendations that only address a small portion of the overall issue rather than having a definite non-bundled recommendation for focus on a diet for the purpose of weight loss.

We must, therefore, correct the mental model to correct the actions. This applies at all levels of the system including the National (policy makers), Institutes and community and finally individuals.

People have been receiving predominantly incomplete or inaccurate politically motivated and occasionally financially driven messages from media and professional bodies that generate recommendations. The recommendations made, although correct can be ambiguous or at times misleading. This results in confusion at the level of the individual with regards to dietary choices. We must keep in mind that choices made depend on multiple factors, however a commonly overlooked factor is the financial health as opposed to the physical health (Christensen et al., 2009).

The confusion might be happening inadvertently since most recommendations include 'healthy diet' and 'exercise' without having a clear message about what is healthy eating nor do they stress that a good portion of weight loss is attributed to diet as opposed to exercising for the purpose of weight loss.

Exercise is important for general health and has many benefits, but it is not the cornerstone of weight loss. It is important and should be encouraged for general health purpose and to support weight loss and weight maintenance.

We noted that the dietary recommendations for Saudi Arabia were heavily influenced or adapted from scientific bodies of other countries. These recommendations could be from the United States or United Kingdom or perhaps New Zealand or Australia, etc.

Although the recommendations are well intended, sometimes it appears that the recommendations are influenced not only by science but rather some political constraints or influences in the countries they originate from. This highlights the need for a local, well-informed, decision-making panel of experts that is comfortable with both the science and politics of issuing recommendations. This emphasizes the need for a cross-professional team including a broad spectrum of experts.

Our recommendation with regards to the above-identified issue is for Saudi Arabia to develop a local Knowledge Institute. This Institute could be the proposed Advanced Management Institute of Diabetes and Obesity and Metabolic Diseases (AMIDOMD). This could be either a private sector and/or a governmental entity that is tasked with tackling obesity, diabetes type 2 and metabolic disease. The focus would be on fronts:

1. **Prevention**
2. **Active Management**

This AMIDOMD knowledge institute would need to collaborate with the international research community and encourage the development of local capable expertise. It would be tasked to transfer knowledge and help guide policymakers and the general public to navigate cutting edge scientific knowledge and leverage technology. This newly formed entity would be enabled to customize an approach to tackling obesity in Saudi Arabia based on the unique policy-making and policy-implementing environment. Please refer to Figure 30.

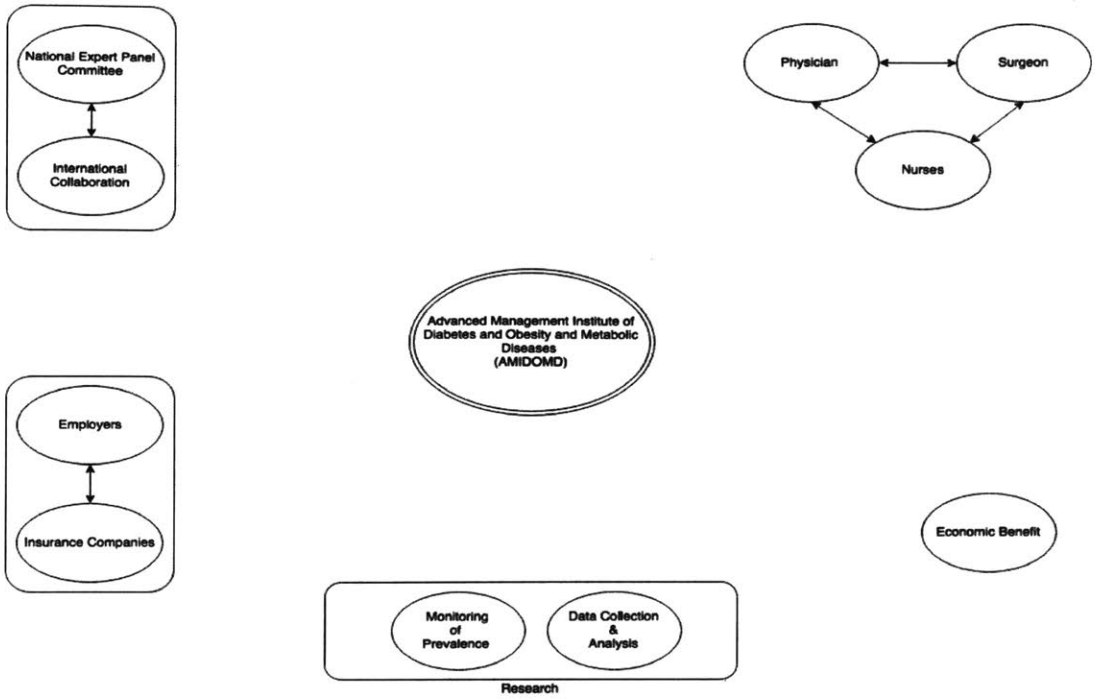


Figure 30 The Advanced Management Institute of Diabetes and Obesity and Metabolic Diseases (AMIDOMD) created by Ahmed Al Tayyar, MD. Please note that white space is intentional to stimulate different considerations for Institute components and relations.

It is both easier and more efficient to prevent unhealthy weight gain than it is to reverse it once it is established and present for a prolonged duration. Prevention should, therefore, be a priority, especially among pregnant women and young children. It is also essential to enable and encourage people to make healthy choices. Of essence is recognizing that there is an element of personal responsibility that needs to be taken into consideration when the aim is to prevent or manage obesity.

The choices made by people are influenced by many different factors, some of which are external to the person such as availability of healthy choices and affordability, and convenience of such options and others internal to the individual based on hormonal imbalances generally influenced by 'what we choose to eat?' and 'when we decide to eat?' and the frequency of food intake in addition to the nature of food intake (processed versus natural unprocessed). That entity would also stress the importance of fasting and adequate sleep.

The impact of where people live, learn, work and play should not be overlooked. Healthy food choices are scarce and usually more expensive, while cheap processed food is widely available and heavily marketed. Access to healthy and safe, easily accessible food and beverage choices can be challenging in particular given the cultural and environmental challenges in Saudi Arabia. However, although the problems are present, they are not impossible to overcome.

Another recommendation would be to pursue a Value Added Process business model that serves to tackle obesity in The Kingdom of Saudi Arabia.

a) Incorporates high-level representatives from each of the identified stakeholders to facilitate translating recommendations into executable action plans and minimizing any duplicated or uncoordinated efforts.
b) Action-plan execution teams empowered to optimize for excellence in performance.
c) Generating reports regarding the state of obesity in The Kingdom of Saudi Arabia annually.
d) Scientific taskforce.

This entails having a focused entity on tackling obesity from all aspects under one roof and breaking the silos.

Policy recommendations at the **national level** (some of these could already exist)

a) A policy requiring targeted, measured physical activity & healthy nutritional options at various institutes.
b) A Policy on easy access drinking water availability in educational establishments and work environments.
c) A policy to encourage natural, unprocessed food (Farm to Plate).
d) A policy to Tax sugar and sugar-sweetened beverages (minimum of 10%-15%).
e) A policy determining "Fast Food Free Zones."
f) A policy requiring quarterly BMI measurements by educational institutes and the workplace.

g) A policy to review food and beverage labeling.
h) A policy for targeted public health education.

Recommendations at the **public institutes and communities level** (Educational facilities, workplace, restaurants, food & beverage markets, farms, transportation and entertainment, shopping mall food courts, healthy food support groups, etc.)

a) Active participation and accountability in facilitating data collection.
b) Formation of partnerships amongst each other and with the governmental bodies to promote best practice and be guided by research.
c) Incorporate specialized team within each entity to coordinate efforts within each sector and facilitate cross-sector collaboration with aims to adopt best practice.
d) Prevention and wellness programs with measured metrics and benchmarking.
e) Indirect taxation on sales of unhealthy options.
f) Re-design and market the healthy food palm given our new understanding of obesity.
g) Collaborate with research institutes (both local and international)

Finally, recommendations at the **individual level** should include targeted monitoring & intervention for the entire scope of the existing population including newborns, children, adolescents, adults and elderly.

a. Can be addressed through a specialized Institute such as the proposed model of Advanced Management Institute for Diabetes and Obesity and Metabolic Diseases
b. Reduce consumption of added sugar (not to exceed 4 to 6 grams per day).
c. Educate on how to read the labels on food and beverages properly.
d. Eliminate desserts and if necessary replace with fresh seasonal fruits (a person can occasionally celebrate just not frequently or daily).
e. No snacking other than on fruits and vegetables.
f. No canned or processed food (avoid as much as practically possible).
g. No candy, but 70% dark chocolate is occasionally allowed.
h. Avoid sugared cereals.

i. No sugar-sweetened beverages (soda pop, fruit juice, vitamin water, smoothies, shakes, flavored milk energy drinks and iced coffee drinks. Hot chocolate, and fancy coffee/ tea drinks)
j. Encourage non-sugared tea and coffee
k. Encourage adequate daily water intake (on average 2 liters per day)
l. Reduce refined grains consumption and promote whole grains
m. Avoid processed bakery food.
n. Encourage eggplants, kale, spinach, carrots, broccoli, peas, Brussels sprouts, tomatoes, asparagus, bell peppers, zucchini, cauliflower, avocados, lettuce, beets, cucumbers, watercress, cabbage, quinoa, chia seeds, beans.
o. Moderate protein consumption.
p. No added salt.
q. Increase consumption of natural fats (unsaturated).
r. Increase use of protective factors (fiber and vinegar, olive oil, super foods).
s. Meal timing (last meal should be at early evening rather than late night) and balanced fasting (fast 2 -3 days per week) – teach proper fasting (pre and post fast feeding behavior modification), breakfast is not the most important meal of the day, and we do not have to eat if we do not feel like eating. Balance the fed state to the fasting state time. Avoid increasing frequency or portions of meals.

General health and fitness surpass the goal of weight. However, excess weight is associated with financial and health burden on several levels including individual, community and national levels.

Ultimately, we aim for balance, since extremes tend to fail more often.

We recognize that further research into the topic of obesity and diabetes is required. As we gain more knowledge, our approach will need to be re-visited and modified.

We would like to stress the need for systems thinking approach, recognizing that although individual components of the system can be optimized, if these elements are not integrated well, the outcomes are not likely to be as favorable as they could be.

We hope that we shed some light on the topic of overweight and obesity.
We recognize that much more work and research are required to overcome our current and future challenges.

Finally, we credit the work of Dr. Jason Fung and Prof. Clayton Christensen for which a significant portion of this paper was inspired by and based on.

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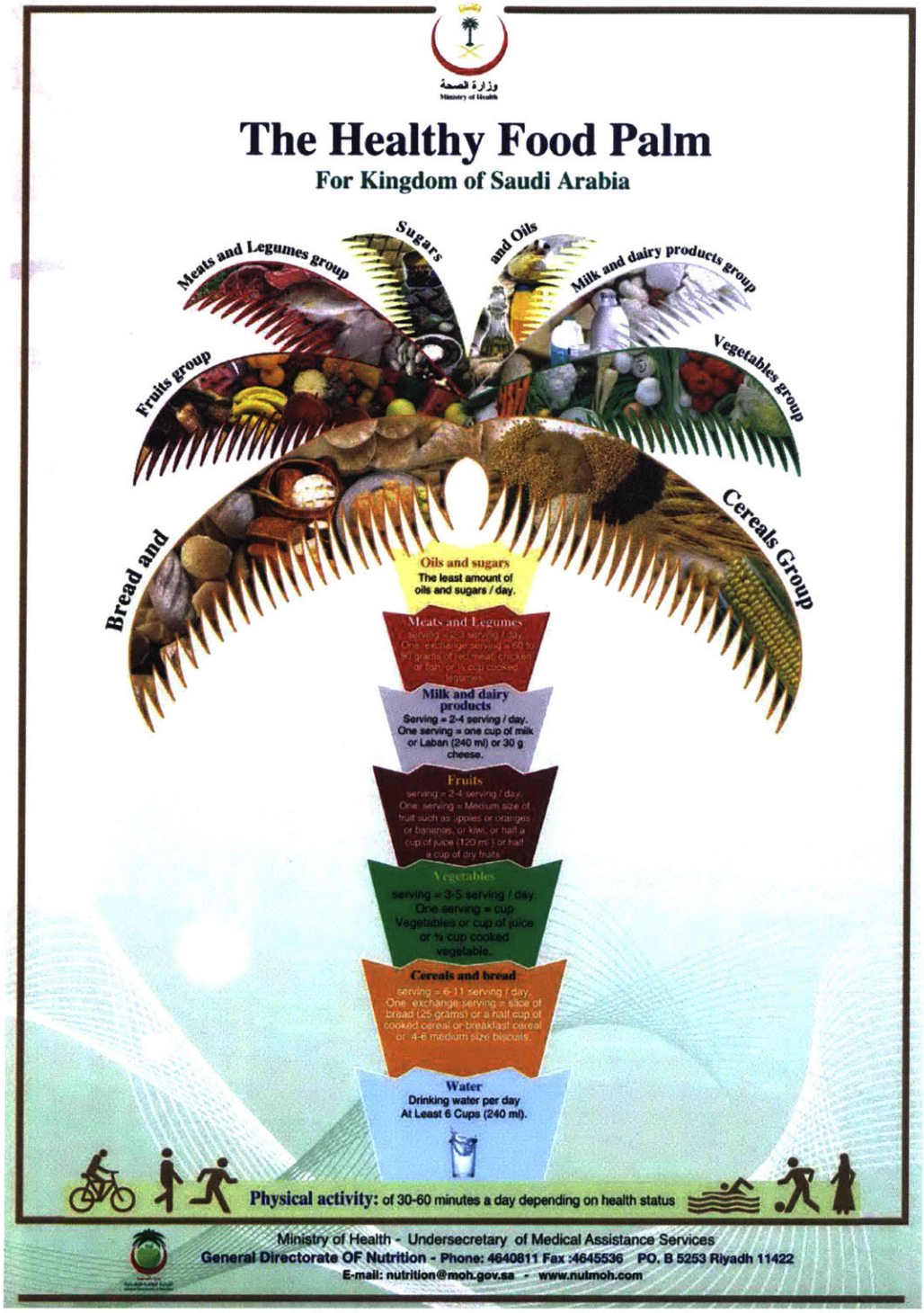
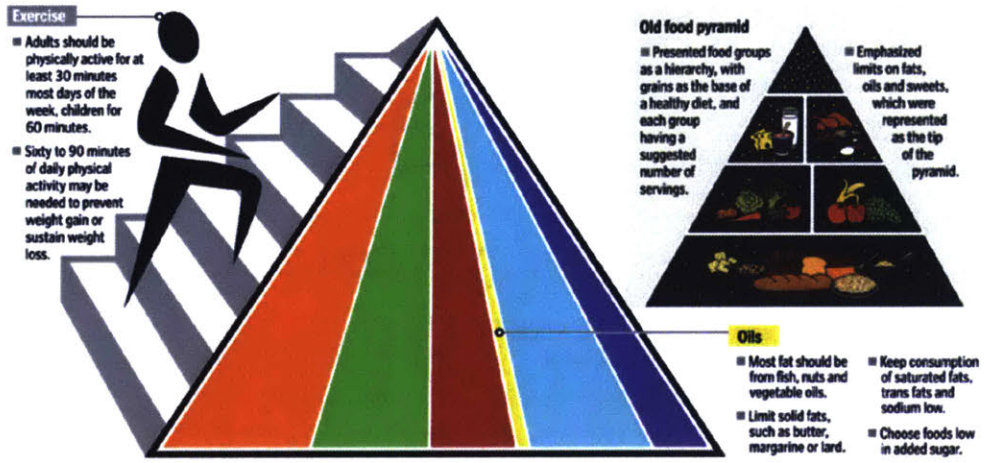
Appendix


وزارة الصحة
Ministry of Health
The Healthy Food Palm
For Kingdom of Saudi Arabia
Meats and Legumes group
Sugars
and Oils
Milk and dairy products group
Fruits group
Vegetables group
Bread and
Cereals Group
Oils and sugars
The least amount of oils and sugars / day.
Meats and Legumes
2 serving = 2-3 serving / day.
One 'exchange serving' = 60 to 90 grams of red meat, chicken or fish or ½ cup cooked legumes.
Milk and dairy products
Serving = 2-4 serving / day.
One serving = one cup of milk or Laban (240 ml) or 30 g cheese.
Fruits
serving = 2-4 serving / day.
One serving = Medium size of fruit such as apples or oranges or bananas, or kiwi, or half a cup of juice (120 ml) or half a cup of dry fruits.
Vegetables
serving = 3-5 serving / day.
One serving = cup Vegetables or cup of juice or ½ cup cooked vegetable.
Cereals and bread
serving = 6-11 serving / day.
One 'exchange serving = slice of bread (25 grams) or a half cup of cooked cereal or breakfast cereal or 4-6 medium size biscuits.
Water
Drinking water per day
At Least 6 Cups (240 ml).
Physical activity: of 30-60 minutes a day depending on health status
Ministry of Health - Undersecretary of Medical Assistance Services
General Directorate OF Nutrition - Phone: 4640811 Fax :4645536 PO. B 5253 Riyadh 11422
E-mail: nutrition@moh.gov.sa - www.nutmoh.com

washingtonpost.com > Nation

The New Food Pyramid

The U.S. Department of Agriculture released a new food pyramid, which breaks food categories into a spectrum to emphasize variety. Exercise was introduced as a component of the food pyramid, and 12 individualized intake profiles were added.



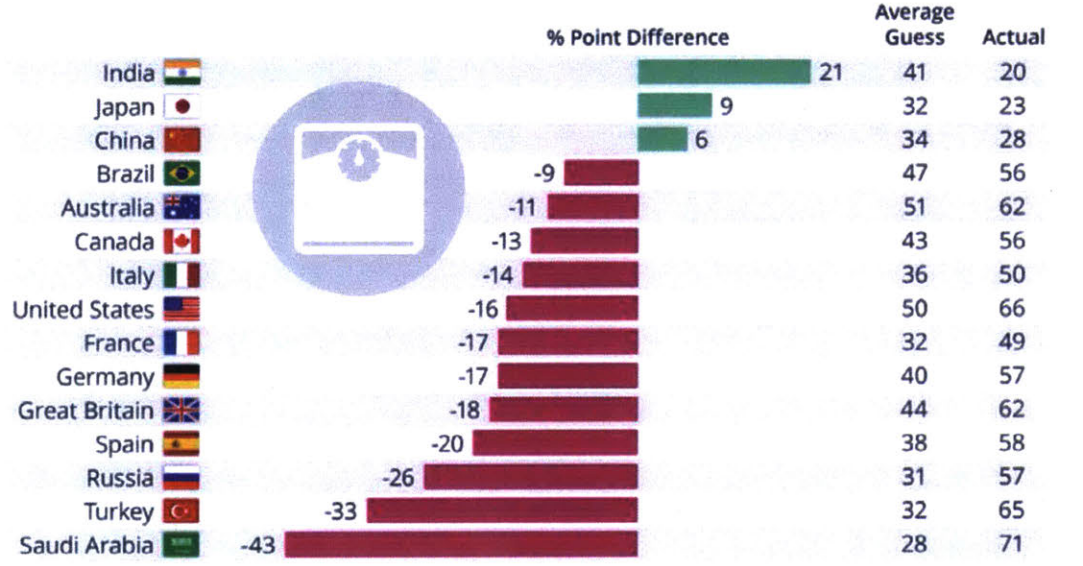
CATEGORY	Grains	Vegetables	Fruits	Milk	Meat and beans
RECOMMENDATION	Half of all grains consumed should be whole grains.	Vary the types of vegetables you eat.	Eat a variety of fruits. Go easy on juices.	Eat low-fat or fat-free dairy products.	Eat lean cuts, seafood and beans. Avoid frying.
DAILY AMOUNT *Based on a 2,000 calorie diet.*	6 oz.	2.5 cups	2 cups	3 cups	5.5 oz.

Recommended nutrient intakes at 12 calorie levels can be found on *mypyramid.gov*.

SOURCE: U.S. Department of Agriculture | The Washington Post

The Public Underestimates The Extent Of Obesity

"Out of every 100 people, how many do you think are overweight/obese?"*



* Selected countries, people aged 20 years or over

Source: Ipsos MORI n=1,000+

Table 4: Settings with corresponding best-evidence interventions, policies, and programs

Setting	Intervention/policies/programs (Best-evidence examples)	Stakeholders*
Leading/legal authority	- A national summit on legal preparedness for obesity prevention and control[13]	MOH, MOL, MOAg, MOE, MOY, MOCo, MOP, MOW, MOSa, MOCu, MOF, MOInf, MOT, MOInd, FDA
	- Committee on National Health Policy[21]	
	- National Expert Panel[18]	
	System approach[15]	
	Policy approaches[17]	
	Evidence-based interventions[16]	
Health professions		
Primary care centers	- Fruit and vegetable trial[19]	Doctors, nurses, healthy volunteers
	- Green prescription program[20]	
Nutrition and physical activity centers	- Five rations of fruits and vegetables[22,23]	Nutritionists, volunteered adults
	- Diet and physical activity modification programme[25]	
Behavior/psychology	- Decrease dietary energy intake, increasing physical activity, and decreasing sedentary behaviors[24]	Psychologists, behavioral therapists, patients
Pharmacotherapy	- Orlistat[26]	Physicians and patients
Bariatric surgery	- Gastric banding[31]	Bariatric surgeons, patients with severe obesity with or without major comorbidities
	Sleeve gastrectomy[32]	
	Gastric bypass[33]	
	Biliopancreatic diversion[35]	
	Sleeve gastrectomy with bilio-pancreatic duodenal switch	
Education		
Schools	- Know your body (adapted) School Health Promotion Programme[37]	Students, teachers, parents
	- Schools-based physical fitness[38]	
Community		
Workplaces	- CHIP (Coronary Health Improvement Project)[40]	Health professionals, employees, and community members
	- Move and improve program[41]	
Households	- Parental role in preventing childhood obesity[42]	Parents, children, health professions
	- Active for Life Program[43]	Elderly households
Community settings	- Dietary, exercise, and behavioral services program[44]	Community clients, nutrition, physical trainer, and behaviorist
	- MEND 7–13 child weight management program[45]	Students, health professionals
Religious activities	- Project Joy[46]	Priests, worshipers, health and other professionals
	- Body and soul intervention[47]	
Mass media	- Fighting fat, fighting fits campaign[48]	Media, public
	- "VERB™"campaign[49]	Media, children
Environment		
Farms and animals	- Increase subsidies and provide places for selling healthy foods[17,21] (e.g., fruits and vegetables Bazaars)	Farmers and government officials
Food industry	- Implement policies and legislations to decrease production and selling of unhealthy foods, sweetened drinks, and sugars[13,15,16,24]	Food and sweetened drinks producers and supermarkets
	- Increase taxations on unhealthy food, sweetened drinks, and sugary products[14,16,17]	Government officials and FDA
Restaurants	- Labeling of calories content of food portions and drinks[13,17,18]	MOL, MOCo, restaurants, supermarkets
Exercise areas	- Increase walking and cycling areas[18]	MOY, MOT, MOSa, public
	- Increase number of community centers[18,21,24]	
Public transportation	- Increase public transportation facilities[13,18,24]	MOT, public
Insurance companies	- Include obesity as a chronic disease worth medical insurance coverage, and bariatric surgery with criteria[51,52]	MOL, MOSa, MOH, private hospitals

*Stakeholders: MOH = Ministry of Health, MOL = Ministry of Law, MOAg = Ministry of Agriculture, MOE = Ministry of Education, MOY = Ministry of Youth, MOCo = Ministry of Commerce, MOP = Ministry of Planning, MOW = Ministry of Work, MOSa = Ministry of Social Affairs, MOCu = Ministry of Culture, MOF = Ministry of Finance, MOInf = Ministry of Information, MOT = Ministry of Transportation, MOInd = Ministry of Industry, FDA = Food and Drug Authority, SCHS = Saudi Commission for Health Specialties.

Source: Adapted from Saudi Journal of Obesity, July-December 2016, volume 4 , issue2

Table 3: Strategic details of the first initiative: establish an expert panel representing all concerned sectors and stakeholders to lead and administer the project system

Goal 1: To establish a national interprofessional expert panel
Strategic initiative (objective): establish an expert panel representing all concerned sectors and stakeholders to lead and administer the project system
Strategic actions:
• Call for a national forum (3-days conference)
• Present and discuss best-evidence practices and research relevant to each profession
• Nominate and elect the lead agency, expert panel members, terms and conditions, and bylaws
• Set the governance structure
• Develop system components and resources
Responsible: Ministry of Health
Accountable: The expert panel committee
Partners: All sectors representing the expert panel committee
Stakeholders: Policy makers, health professions, educationists, engineers, environmental experts, social workers, students, companies, and relevant community members
Time line: January 2017 to March 2017
Expected budget: 5,000,000 SR
Quality indicators:
• More than 75% representation of relevant stakeholders
• Establishment of the expert panel committee
• Establishment of terms, conditions, and bylaws
• Establishment of the governance structure of the project
• Establishment of the system components and resources

Source: Adapted from Saudi Journal of Obesity, July-December 2016, volume 4 , issue2

Table 1: The overall strategic plan of the interprofessional system approach to prevent and control obesity in Saudi Arabia

Vision: Towards a community free of obesity
Mission:
• To involve concerned health care and non-health professions, policy makers, and other stakeholders to work together under one umbrella
• To apply the interprofessional system approach towards vision achievement
• To set standards, guidelines, policies, and best-practices/interventions/programs readily applicable to current settings
• To provide education and training for implementation working teams and relevant stakeholders
• To properly implement standards, guidelines, policies, and best practices/interventions in this field
• To monitor and evaluate the system as a whole (research)
• To disseminate research and successful experiences to public, academia, and government sectors to further support and participate in the system
• To cooperate and coordinate with local and international organizations and societies through continuous networking towards vision achievement
Values:
• Teamwork and commitment
• Social responsibility and accountability
• Societal partnership and consciousness
• Support and reward
• Quality and equality for all
Goals:
Goal 1: To establish a national interprofessional expert panel
Goal 2: To promote and support the interprofessional system components and resources
Goal 3: To develop appropriate standards, policies, guidelines, best practices/interventions, and programs, readily applicable to available settings
Goal 4: To develop and conduct programs for continuous education and training for relevant professions and stakeholders
Goal 5: To build healthy environment and implement collaborative interprofessional anti-obesity programs
Goal 6: To develop assessment methods and tools, establish adequate measurements criteria, and make use of assessment and monitoring results for further improvement
Goal 7: To use media, schools and universities, primary health care and community centers as conduits for dissemination of research and successful results in this field
Goal 8: To increase availability of healthy food and pure water, and decrease consumption of sugars and saturated fat in the community throughout life
Goal 9: To promote physical activity throughout life
Goal 10: To provide health care for all needy patients
Goal 11: To participate in national and international campaigns and programs

Source: Adapted from Saudi Journal of Obesity, July-December 2016, volume 4 , issue2

Table 4: Settings with corresponding best-evidence interventions, policies, and programs

Setting	Intervention/policies/programs (Best-evidence examples)	Stakeholders*
Leading/legal authority	- A national summit on legal preparedness for obesity prevention and control[13]	MOH, MOL, MOAg, MOE, MOY, MOCo, MOP, MOW, MOSa, MOCu, MOF, MOInf, MOT, MOInd, FDA
	- Committee on National Health Policy[21]	
	- National Expert Panel[18]	
	System approach[15]	
	Policy approaches[17]	
	Evidence-based interventions[16]	
Health professions		
Primary care centers	- Fruit and vegetable trial[19]	Doctors, nurses, healthy volunteers
	- Green prescription program[20]	
Nutrition and physical activity centers	- Five rations of fruits and vegetables[22,23]	Nutritionists, volunteered adults
	- Diet and physical activity modification programme[25]	
Behavior/psychology	- Decrease dietary energy intake, Increasing physical activity, and decreasing sedentary behaviors[24]	Psychologists, behavioral therapists, patients
Pharmacotherapy	- Orlistat[26]	Physicians and patients
Bariatric surgery	- Gastric banding[31]	Bariatric surgeons, patients with severe obesity with or without major comorbidities
	Sleeve gastrectomy[32]	
	Gastric bypass[33]	
	Biliopancreatic diversion[35]	
	Sleeve gastrectomy with bilio-pancreatic duodenal switch	
Education		
Schools	- Know your body (adapted) School Health Promotion Programme[37]	Students, teachers, parents
	- Schools-based physical fitness[38]	
Community		
Workplaces	- CHIP (Coronary Health Improvement Project)[40]	Health professionals, employees, and community members
	- Move and improve program[41]	
Households	- Parental role in preventing childhood obesity[42]	Parents, children, health professions
	- Active for Life Program[43]	Elderly households
Community settings	- Dietary, exercise, and behavioral services program[44]	Community clients, nutrition, physical trainer, and behaviorist
	- MEND 7–13 child weight management program[45]	Students, health professionals
Religious activities	- Project Joy[46]	Priests, worshipers, health and other professionals
	- Body and soul intervention[47]	
Mass media	- Fighting fat, fighting fits campaign[48]	Media, public
	- "VERB™"campaign[49]	Media, children
Environment		
Farms and animals	- Increase subsidies and provide places for selling healthy foods[17,21] (e.g., fruits and vegetables Bazaars)	Farmers and government officials
Food industry	- Implement policies and legislations to decrease production and selling of unhealthy foods, sweetened drinks, and sugars[13,15,16,24]	Food and sweetened drinks producers and supermarkets
	- Increase taxations on unhealthy food, sweetened drinks, and sugary products[14,16,17]	Government officials and FDA
Restaurants	- Labeling of calories content of food portions and drinks[13,17,18]	MOL, MOCo, restaurants, supermarkets
Exercise areas	- Increase walking and cycling areas[18]	MOY, MOT, MOSa, public
	- Increase number of community centers[18,21,24]	
Public transportation	- Increase public transportation facilities[13,18,24]	MOT, public
Insurance companies	- Include obesity as a chronic disease worth medical insurance coverage, and bariatric surgery with criteria[51,52]	MOL, MOSa, MOH, private hospitals

*Stakeholders: MOH = Ministry of Health, MOL = Ministry of Law, MOAg = Ministry of Agriculture, MOE = Ministry of Education, MOY = Ministry of Youth, MOCo = Ministry of Commerce, MOP = Ministry of Planning, MOW = Ministry of Work, MOSa = Ministry of Social Affairs, MOCu = Ministry of Culture, MOF = Ministry of Finance, MOInf = Ministry of Information, MOT = Ministry of Transportation, MOInd = Ministry of Industry, FDA = Food and Drug Authority, SCHS = Saudi Commission for Health Specialties.