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The Relationship Between Free Sugar Intake and Long-Term Weight Change in a cohort of Swedish Older Adults

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Dedication

To my Children, Rayna and Zayn. You are my luck charms ya Mamma.

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I would like to acknowledge the efforts of my supervisors; Dr. Mujahed Shraim and Dr. Muhammed Marie. A special thanks to Dr. Mujahed for his immense patience, cooperation and continuous guidance despite physical distance. His work ethics will always be one of the most valued lessons I learned from this experience. My deep appreciation also to Dr. Merie, who stepped up into the occasion and was very supportive during this journey. The deepest appreciation and gratitude goes to Dr. Emily Sonestedet from Lund University who has extremely cooperative and accommodating of new ideas and has been very generous with information and advice. This study would not have come to light if it was not for her great desire to improve the research skills of students from around the world.

Aida I.M. Koni

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

The Relationship Between Free Sugar Intake and Long- Term Weight Change in a Cohort of Swedish Older Adults

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يُقدم لنيل أية درجة أو لقب علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Nam: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

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The Relationship Between Free Sugar Intake and Long- Term Weight Change in a Cohort of Swedish Older Adults

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Abstract

The thesis includes two studies. The first study is a prospective cohort study of the association between free sugars intake and long- term weight change in a cohort of older adults. The data made available to this study from the Malmö Diet and Cancer (MDC) study which was done between 1991-1996 in Sweden. In total 18,133 people were included in the study. The participants were categorized according to their free sugar intake as follows <5%, 5–<7·5%, 7·5–<10%, 10–<15%, 15-<20% and ≥20E%. The results showed that there was no significant association between free sugars intake and annual weight change, relative annual weight change or BMI change. The results also showed that there was no significant risk of becoming overweight among normal weight men and women based on their free sugars intake. Excluding misreporters and diet changers did not change this conclusion. The results suggest that the only mechanism that free sugars could influence a person's weight is by disturbing the energy balance.

The second study utilizes a qualitative approach using semi-structured interviews with heads of nutrition departments at the Palestinian ministries of health and education and the Palestine Standards Institution to

investigate potential challenges facing applying policies to reduce free sugars intake in Palestine. The analysis of the transcribed interviews resulted in three overarching themes, these are Economic Barriers, Health Literacy, Regulations/ Laws.

CHAPTER I
INTRODUCTION

1.1 Background of the study

Overweight and obesity are prevalent worldwide including in Palestine (Ng et al., 2014; Abdeen et al., 2012). To minimize the incidence and prevalence of overweight and obesity and associated mortality and morbidity e.g. diabetes and cardiovascular disease, the WHO calls on countries to reduce total sugar intake among adults and children and recommends that adults and children reduce their daily intake of free sugars to less than 10% of their total energy intake (WHO, 2015). Free sugars are defined as "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates" (FAO/WHO, 1998).

A systematic review commissioned by the WHO showed a modest association between free sugars intake or Sugar Sweetened Beverages, SSB and body weight (Te Morenga et al., 2013). Although, the results of the cohort studies included in the review showed that comparing the highest sugar intake groups with the lowest sugar intake groups were congruent with the WHO recommendations to restrict sugar intake to below 10% of total energy intake, however, the included studies did not show a dose-response relationship. Moreover, the empirical studies included in this review were prone to some methodological limitations. For example, the

methods used to assess sugar intake i.e. diet recall methods used in the trials, or Food Frequency Questionnaires, FFQ used in the cohort studies (Bes-Rastrollo et al., 2010; Halkjaer et al., 2006; Halkjaer et al., 2009; Dhingra et al., 2007; Drapeau et al., 2004) were prone to significant measurement error even when using validated methods. These measurement errors could explain in part the review's inability to find a dose-response relationship between changing the daily sugar intake and the subsequent weight change (Te Morenga et al., 2013). Moreover, the majority of studies mainly focused on SSBs to measure the association between free sugars intake and subsequent weight change, leading to underestimate the association between free sugars intake and subsequent weight change. Furthermore, the duration of the Randomized Control Trials (RCTs) included in the review ranged from ten weeks to eight months making it difficult to properly assess long-term association between free sugars intake and subsequent weight change (Te Morenga et al., 2013). Therefore, intensive and detailed dietary information on total free sugars intake associated with long follow up periods can provide more precise measurement of the potential association between free sugars intake and long-term weight gain, which may provide stronger evidence to support the current knowledge regarding the WHO recommendations on free sugars intake.

Implementing the WHO recommendations on free sugars intake in adults and children is challenging and requires developing country-specific regulations. Challenges facing the adoption and implementation of the

WHO recommendations on free sugars in adults and children are not clear. Identifying such challenges may help the Palestinian policy makers to develop plans to lower the risks of overweight or obesity among Palestinian adults and children.

1.2 Statement of the problem

Overweight and obesity are increasing across the world with the adverse health effects associated with them. To minimize the risk of overweight and obesity, the WHO recommends to reduce free sugars intake among adults and children to less than 10% of their total energy intake (WHO, 2015). The WHO based its recommendation on a systematic review which included evidence from RCTs and cohort studies among children and adults (Te Morenga et al., 2013). However, the studies included in the systematic review did not show a dose-response relationship between daily intake of free sugars or SSB and body weight. Moreover, the empirical studies included in this review had some methodological limitations. Therefore, evidence from other epidemiological studies and among different ethnic groups and age strata is required to examine the true association between free sugars and subsequent weight change.

1.3 Aims and objectives

1.3.1 Main aims

1. To examine the association between free sugars intake expressed as percentage of total energy intake (E%) and long-term weight change in the MDC study.

2. To explore Palestinian policy makers' opinions on perceived challenges with regards to limiting free sugars intake among children and adults in Palestine.

1.3.2 Specific objectives of the quantitative study

1. To examine if there is a significant difference among free sugars intake groups in an older adults' cohort and absolute weight change after nearly 5 years of follow up.

2.To examine if there is a significant difference among free sugars intake groups in an older adults' cohort and relative annual weight change in kg after nearly 5 years of follow up.

3. To examine if there is a significant difference among free sugars intake groups in an older adults' cohort and annual Body Mass Index (BMI) change after nearly 5 years of follow up.

4.To examine the risk of developing overweight/ obesity among normal weight subjects in an older adults' cohort with regards to their free sugars intake after nearly 5 years of follow up.

5. To explore the challenges facing Palestinian decision makers, senior officials with regards to limiting free sugars intake among adults and children in Palestine

1.3.3 Study hypotheses

H1-A: there is a relationship between total free sugar intake as percentage of total energy intake and weight change in kg (absolute and relative) after nearly 5 years of follow up.

H1-B: there is a relationship between total free sugar intake and BMI change after nearly 5 years of follow up.

1.4 Significance of the study

The study provides more precise estimates of the association between daily intake of free sugars and long-term weight change among older adults in the MDC study, which may provide more evidence to support the current knowledge regarding the WHO recommendations on daily free sugars intake. Additionally, this study provides a lens on potential challenges facing the adoption and implementation of the WHO recommendation on limiting free sugars intake among adults and children in Palestine; which can lend a hand to developing plans to overcome these challenges and minimize the risk of overweight and obesity among Palestinians.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of the association between diet and disease including most frequently used methods to collect dietary intakes, methods of measuring overweight and obesity, the prevalence of overweight and obesity worldwide and in Palestine, mortality and morbidity attributed to overweight and obesity and associated factors, strategies to decrease the prevalence and incidence of obesity and current international recommendations on free sugars intake. Finally, the chapter presents an overview of the challenges facing public health initiatives to address the epidemic of overweight and obesity.

2.2 The relationship between diet and disease

Nutritional epidemiology investigates the role of diet in the prevention or causation of illness or the advancement of health (Willett,1998). However, diet is a unique exposure; because multiple factors affect food choices and metabolism including genetics, behavioral traits, Socioeconomic Status (SES), environmental factors and physical activity (Langseth, 1996). Over the past decades, diet has been recognized as an important factor associated with chronic diseases (National Research Council, 1989). However, the study of the association between diet and disease is complicated by the difficulty of measuring human diet, the many nutrients and food components found in food and their biochemical interactions, incomplete

data on the nutrient composition of food and the many other factors alongside diet that influence disease risks including socioeconomic and behavioral as well as the long latency period associated with chronic diseases (Willett, 1998). Due to this complex nature, diet might be very difficult to measure with great precision.

2.3 Measurements of overweight and obesity

The following part addresses the definition of overweight and obesity, prevalence of overweight and obesity, assessment methods of body fatness and morbidity and mortality associated with overweight and obesity.

2.3.1 Definition of overweight and obesity

According to the World Health Organization "overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health" (WHO, 2018). The Centers for Disease Control and Prevention (CDC) defines overweight and obesity among adults as "weight that is higher than what is considered as a healthy weight for a given height" (CDC, 2016a). Among children, the CDC defines overweight as a "BMI ≥85th percentile and <95th percentile for children and teens of the same age and gender while obesity is defined as a BMI ≥95th percentile for children and teens of the same age and gender" (CDC, 2016b).

2.3.2 Prevalence of overweight and obesity

In recent decades, obesity has become a public health problem in low- and middle-income countries (Seidell and Halberstadt, 2015). Molarius and

colleagues (2000) explained that obesity used to have an inverse association with SES mainly among women in high income countries while in low- and middle-income countries, obesity was low and affected only people with relatively high SES (Monteiro et al., 2004). The authors noted that in 2003 obesity has also become a problem of lower socioeconomic groups, particularly women in middle-income countries. In 2012, Dinsa and colleagues found that by 2012, the association between SES and obesity in low-income countries was positive for both men and women, however, in middle-income countries the association was mainly negative in women and was different for men. However, obesity was prevalent mainly among children and adolescents of high SES in low- and middle-income countries. According to the World Health Organization (2006) by 2025 some 2.3 billion adults will be overweight and more than 700 million will be obese around the world. The rising prevalence of overweight and obesity in several countries (Stevens et al., 2012) has been described as a global pandemic (Popkin et al., 2012; Swinburn et al., 2011). In 2010, overweight and obesity were estimated to cause 3.4 million deaths, 4% of years of life lost, and 4% of disability-adjusted life-years (DALYs) worldwide (Lim et al., 2012). Data from studies in the USA suggested that the rise in obesity could lead to future decrease in life expectancy (Olshansky et al., 2005).

In 2014, Ng and colleagues conducted a systematic review of global, regional and national prevalence of overweight and obesity in children and adults during 1980–2013. The authors concluded that the proportion of

adults with BMI ≥25 kg/m2 has increased from 28·8%- 36·9% in men, and from 29·8%- 38·0% in women. According to the authors, by 2013 the prevalence of overweight and obesity has substantially increased among children and adolescents in developed countries where 23·8% of boys and 22·6% of girls were overweight or obese. The prevalence of overweight and obesity in children and adolescents has also increased from 8·1% to 12·9% for boys and from 8·4% - 13·4% for girls in developing countries. The study also found that more than 50% of men in Tango and women in Kuwait, Kiribati, Federated States of Micronesia, Libya, Qatar, Tonga and Samoa were overweight. Moreover, the study also showed that since 2006, in developed countries, adult obesity has slowed down. The study included estimates for 188 countries, 21 regions both developed or developing. The same systematic review also reported age-standardized prevalence of overweight and obesity combined and obesity alone for girls, boys, men, and women in Palestine for the year 2013, which shows that overweight and obesity are prevalent among Palestinians (shown in Table 2.1).

Table 2.1 Age-standardized prevalence of overweight and obesity combined and obesity alone in Palestine in 2013.

	Overweight and obese	**Obese**
Boys <20 years	27.9 (23.8-31.9)	11.9 (9.8-14.3)
Men ≥20 years	70.0 (67.4-72.4)	29.8 (28.0-31.5)
Girls <20 years	30.6 (26.4-35.5)	12.5 (10.1-15.2)
Women ≥20 years	77.0 (74.8-79.2)	42.4 (40.5-44.4)

Source: Ng et al., 2014.

Various systematic reviews have also examined prevalence and trends of overweight and obesity. Finucane and colleagues (2011) used data aggregated from 1980- 2008 from 369 national surveys and 591 subnational surveys to estimate country trends in mean BMI change. De Onis and colleagues (2010) used data aggregated from 1990 to 2008 from 450 national surveys to estimate childhood obesity and overweight trends. The reviews conclude that the prevalence of overweight and obesity has increased over the last few decades (Stamatakis et al., 2010).

2.3.3 Assessment of body fatness

There are several methods to measure body fatness, each with its own strengths and weaknesses. The most commonly used methods are Body Mass Index (BMI), Waist Circumference (WC), Waist/ Hip Ratio, skinfold thickness, Bioelectric impedance Analysis (BIA), dual energy x-ray absorptiometry (DEXA), computerized tomography (CT), and magnetic resonance imaging (MRI) (Chong Hwa, 2016).

2.3.3.1 Body Mass Index (BMI)

The BMI (weight/height2) is a universally accepted assessment technique of overweight due to its availability and cost- effectiveness. The most recent classification of overweight in adults by the WHO (2000) is summarized in Table 2.1.

Table 2.1BMI Classification in adults according to WHO

Classification	BMI Category (kg/m2)	Associated Health Risks
Underweight	<18.5	Low but risk of other clinical problems increased
Normal Weight	18.5- 24.9	Average
Overweight	25.0- 29.9	Increased
Obese Class I	30.0- 34.9	Moderately Increased
Obese Class II	35.0- 39.9	Severely Increased
Obese Class III	≥ 40.0	Very Severely Increased

Adapted from World Health Organization (2000)

However, the BMI does not take into consideration a number of confounders including age, gender, ethnicity, leg length and body shape (Sweeting, 2007). Therefore, there have been calls to redefine the BMI cutoff points to take into account these many variations (Wagner and Heyward, 2000). In 2004, a WHO expert consultation concluded that Asian populations may have different fatness levels and fat distribution compared to Caucasian populations but could be misclassified into the same BMI category. The experts' consultation concluded that Asian populations will have higher risks of developing type 2 diabetes and cardiovascular disease at BMI levels lower than the WHO recommended cut off point for overweight (BMI ≥25) (WHO, 2004).

In 2007, the Asia Pacific Cohort Studies Collaboration proposed that overweight should be classified as a BMI >23 and obesity as a BMI of ≥25

in Asian populations. The Examination Committee of Criteria for Obesity Disease in Japan indicated in 2002 that if the proposed new classifications are applied, the prevalence of obesity (BMI ≥25) in Japan will increase by more than 20% rather than the current 2–3%. Xi and colleagues (2012) analyzed data from the China Health and Nutrition Survey which was conducted between 1993 and 2009 and they defined obesity in China as a BMI >27.5.

2.3.3.2 Waist circumference (WC)

Due to the limitations associated with BMI, abdominal fat distribution or waist circumference is proposed as a more well- suited and simpler estimation of overweight and obesity and associated adverse health effects (Lean et al., 1998). Waist circumference measures the abdomen circumference between the lowest rib above the iliac crest.

2.4 Strategies to decrease prevalence and incidence of obesity

In 2011, Swinburn and colleagues proposed that the rising global incidence of obesity was driven mainly by “changes in the global food supply, which offers more processed, affordable and effectively marketed food than ever before”. The McKinsey Global Institute reported that intervention to stabilize or reverse overweight and obesity should include reducing portion sizes, altering marketing practices and restructuring urban and educational infrastructure to facilitate physical activity (McKinsey Global Institute, 2014). In their report, Dobbs and colleagues (2014) argued that all sectors

in the society including “governments, retailers, consumer-goods companies, restaurants, employers, media organizations, educators, health-care providers, or individuals” should collaborate to address obesity. Seidell and colleagues (2012) also proposed that managing obesity requires an integrated care approach. The integrated health-care standard for obesity in the Netherlands has been described as “an example of a national approach towards the management of obesity” (Seidell and Halberstadt, 2015).

Borys et al., (2012) proposed that an effective approach would combine a top-down corporate and government interventions with bottom-up community-led engagement. A successful example is the Ensemble Prévenons l’Obésité Des Enfants or Together Let’s Prevent Childhood Obesity also known as EPODE. The EPODE initiative is a “large scale, centrally coordinated, capacity-building approach for communities to implement effective and sustainable strategies to prevent childhood obesity”. According to Van Koperen and colleagues (2013) the model includes four critical components namely political commitment, public and private partnerships, social marketing and evaluation.

2.5 Morbidity and mortality associated with overweight and obesity

The increasing incidence of overweight and obesity and their associated diseases have become a major public health problem in many countries (WHO, 2000). The global increase in obesity has a major impact on health

and quality of life. Obesity has contributed to the global incidence of cardiovascular disease, type 2 diabetes mellitus, cancer, osteoarthritis, work disability and sleep apnea (Gilmore, 1999). Obesity affects morbidity more than mortality. In 2001, Visscher and Seidell predicted that disability due to obesity-related cardiovascular diseases will increase particularly in industrialized countries more than in non-industrialized countries; because patients have higher survival chances. Moreover, the authors also predicted that disability due to obesity-related type 2 diabetes will increase, particularly in low- and middle-income countries where insulin supply is usually insufficient. As a result, an increase in disabling nephropathy, arteriosclerosis, neuropathy and retinopathy is expected. The Global Burden of Disease Study and the WHO have recently documented that obesity is indeed a major contributor to ill-health, disability and mortality in many of the world regions (WHO, 2009; Lim et al., 2012).

However, when comparing overall mortality between overweight and normal persons, Lenz and colleagues (2009) concluded that the overall mortality of overweight persons (BMI 25–29.9 kg/m2) was the same for normal weight (BMI 18.5–24.9 kg/m2). The threshold for an increase in mortality risk in the European Prospective Investigation into Cancer (EPIC) study by Lenz and colleagues study was a BMI of 28 kg/m2. McGee et al., (2005) speculated that all- cause mortality has increased by nearly 20% for obese persons. The researchers also concluded that both obesity and overweight were associated with increased disease-specific morbidity for some diseases, but decreased or unchanged for others. According to the

authors, overweight has a lower risk than obesity. Both morbidity and mortality are highly influenced by the person's age, gender, ethnicity and social status. Bender and colleagues (2006) found that in Germany, women or men who are morbidly obese (BMI ≥36 kg/m2) have a 1.3 to 3-fold mortality risk relative to the reference population in North Rhine-Westphalia (Bender et al., 2006).

2.6 Strategies to decrease prevalence and incidence of obesity

Established determinants of weight change include sociodemographic factors including education and employment status, physical activity, alcohol consumption, smoking habits, mental stress, voluntary weight loss or dieting behavior (Kroke et al., 2002). The associations between these factors with diet and weight have recently gained considerable attention in scientific circles (Dragano et al., 2009). Moreover, age remains one of the most vital factors affecting almost everything. The following section provides an overview of these factors and the potential association between them and diet and weight change:

2.6.1 Education: Educational level has been proposed as a modulating factor between SES and obesity (Haukkala and Uutela, 2000). Obesity and certain SES characteristics; like education, occupation and employment seem to have complex, reciprocal relationships (Schwitzer et al., 1998). Educational attainment is often used as an indicator of socioeconomic position (Krieger et al., 1997) because it shapes the likelihood of being employed, the kind of job a person can have and income (Ross and Wu,

1995). Therefore, there is interest in the causal relationship between education and health; because education can be improved through policy channels (Woolf et al., 2007). Lleras-Muney (2005) proposed that education could be associated with health via SES characteristics like income and occupation, available social and psychological resources like sense of control and empowerment and health knowledge and health behavior (Cutler and Lleras-Muney, 2006). In an attempt to disentangle the association between educational attainment and good health, Ross and Wu (1995) proposed that "well- educated people are less likely to be unemployed and more likely to have full time jobs, fulfilling work, high incomes and low economic hardship". Moreover, well-educated people have higher sense of personal control and social support as well as economic resources. Lastly, the well- educated adhere to healthier lifestyles, they are more likely to exercise, drink moderately and less likely to smoke. However, education may also depend on health status. Children with poor health may attain less education which could affect other social determinants of health like income (Schnittker, 2004). These general education and health trends may also apply to obesity. The association between educational attainment and obesity seems to depend on both gender and country with inverse association observed for women in Australia (Cameron et al., 2003) Canada (Kahn and Williamson, 1991) and Finland (Kautiainen et al., 2009) and null association observed in Germany (Jurges et al., 2011) and Venezuela (Boissonnet et al., 2011) and positive association observed in Bahrain (Al-Mahroos and Al-Roomi, 2001) and

India (Shukla et al., 2002). However, the association was more varied for men compared to women even within the same country. A systematic review by Cohen and colleagues (2013) of the association between educational attainment and obesity revealed that the association depends on the economic development of the country for women and men.

2.6.2 Physical activity: The WHO (2017) defines physical activity as "any movement produced by the skeletal muscles of the human body that uses energy. It covers a range of bodily movements and activities of daily life, such as playing, working, walking, household chores and recreational activities". Therefore, physical inactivity can be described as "a state in which bodily movement is minimal and energy expenditure approximates the resting metabolic rate" (IARC, 2002). Physical activity affects total energy expenditure, which is "the sum of the basal metabolic rate, the thermic effect of food and the energy expended in physical activity" (U.K. Department of Health, 1991). Physical activity is a complex, multidimensional behavior which include occupational or household activities, mode of transportation to school or work and leisure-time activities like jogging (Miles, 2007). Exercise is a subcategory of leisure-time physical activity (LTPA) and is defined as "physical activity in which planned, structured and repetitive bodily movements are performed to improve or maintain one or more components of physical fitness" (Hardman and Stensel, 2003). The absolute intensity of an activity is defined as "the rate of energy expenditure associated with that activity; this is usually measured in kcal/kg/min or METs which stands for metabolic

equivalents". One MET is a person's metabolic rate when at rest; this is set as a resting metabolic rate (RMR) of 3.5 ml of oxygen consumed per kilogram of body mass per minute (Westerterp and Plasqui, 2004). MET values are given in multiples of RMR, and are assigned to activities to denote their intensity (Miles, 2007).

A number of methods are available to measure physical activity including direct and indirect calorimetry which monitor an individual's physiological responses to physical and the doubly labelled water technique activity (U.S. Department of Health and Human Services, 1996). In epidemiological studies physical activity can be measured using self-reporting tools like physical activity diaries, logs and surveys (Westerterp and Plasqui, 2004).

Physical activity is well established protective factor from cardiovascular disease, stroke, type II diabetes, colon and breast cancers (WHO, 2017). Rissanen et al., (1991) were the first to examine the prospective association between diet, weight change and physical activity among both men and women. The authors found that both men and women who reported "rarely" engaging in leisure-time physical activity had significantly higher mean weight gain and were more likely to have gained 25 kg.

2.6.3 Alcohol Intake: Alcohol or ethanol provides a caloric value of 7.1 kcal/g placing it right after carbohydrates (4 kcal/g) and right before fat (9 kcal/g) (Addolorato et al., 1997). The consumption of alcoholic beverages in excess of the needed energy requirements contributes to a positive energy balance and in the long-term weight gain and possibly obesity

(Suter, 2005). Moreover, alcohol has a distinct feature by having an absolute priority in metabolism. The body eliminates alcohol as fast as possible to minimize potential toxic effects (Suter et al., 1997). This absolute metabolic priority takes place at the expense of other metabolic pathways, including the suppression of lipid oxidation (Schutz et al., 1989). The non-oxidized fat is preferentially deposited in the abdominal area (Duncan et al., 1995; Sakurai et al., 1997; Gonzalez et al., 2000). A study by Sakurai et al., (1997) found an association between alcohol and Waist/Hip ratio but not with the BMI. Another study by Nooyens et al., (2004) reported that drinking alcoholic beverages and walking were related to change in waist circumference but not body weight. Suter and colleagues (1997) reported that alcohol consumption increased appetite for high fat diet. Fat is the most energy-dense macronutrient providing 38 kJ/g (9kcal/g) while high-fat foods are characterized by enhanced flavor and palatability but less satiating effect per kilojoule than low-fat foods that are rich in protein or complex carbohydrates; thus high- fat diet is more likely to lead to positive energy and subsequent weight gain (Doucet et al., 1998). The association between alcohol and weight also depends on gender. Epidemiological studies showed that women may misreport their alcoholic intake due to sociocultural factors (Klag et al., 1990). Therefore, epidemiological studies that measure diet- disease relationships should take these differences into account during the design stages as well as when interpreting results (Suter et al., 1997).

Moreover, alcohol users show different consumption patterns. Moderate alcohol consumers often add alcohol to their normal diet while heavy users use alcohol as substitute to food which could in part explain the lower body weight observed in heavy alcohol consumers who suffer primary and secondary malnutrition (Williams, 1997). In 1983, Gordon and Kannel reported that men who consumed alcoholic beverages at baseline had a higher body weight than abstainers after 20 years of follow-up. The same association was also observed after the 4, 7 and 12-year follow up. However, the authors reported that women showed the opposite effect. The same study reported that people who stopped drinking in the absence of any disease achieved a mean weight loss of several kilograms. Wannamethee et al., (2004) studied the prospective association between alcohol intake and 8-year weight gain among 49,324 women aged 27 to 44 years old who did not have a history of cardiovascular disease, cancer, or diabetes and were not pregnant during the study period. The authors found a nonlinear relationship between alcohol intake and weight gain in all women. Meanwhile, women who continued to drink heavily and those who became heavy drinkers during the study period had higher odds of weight gain. The increased odds of weight gain associated with heavy drinking (30 g/d) were most marked in the younger women (35 years). The same study showed that women of color had higher risks of developing weight gain when consuming light to moderate (up to 30 g/d) compared to Caucasian women. Lahti-Koski et al., (2002) investigated the associations between body mass index (BMI) and obesity with physical activity, food choices,

alcohol consumption, and smoking history among 24,604 randomly selected 25–64 years old Finnish men and women. The authors found that obesity was associated with alcohol consumption and smoking history. The authors concluded that a physically active lifestyle with abstention from smoking, moderate alcohol consumption and consumption of healthy foods maximizes the chances of having a normal weight.

2.6.4 Smoking: the association between smoking and weight has been extensively studied with the general view that smoking is associated with weight loss while smoking cessation is associated with weight gain. Flegal et al., (1995) estimated the prospective association between smoking cessation and the prevalence of overweight among 5247 adults aged 35 years or older who participated in the third National Health and Nutrition Examination Survey (NHANES). The authors found that smokers who had quit within the study's 10 years period were significantly more likely than participants who had never smoked to become overweight. Chiriboga et al., (2008) studied gender-specific predictors of body weight using cross-sectional and longitudinal analyses among 572 healthy adult volunteers from Central Massachusetts, USA. The authors found that cigarette smoking at baseline predicted lower body weight in both men and women. The same association between smoking and lower body mass index (BMI) compared to nonsmokers was also reported in cross-sectional studies (LaRowe et al., 2009). Lahti-Koski et al., (2002) investigated cross-sectional associations between BMI and obesity with physical activity, food choices, alcohol consumption, and smoking history among 24,604

randomly selected men and women aged 25–64 years old. The authors found that among men and women obesity was associated with smoking history. Another study by Lahmann et al., (2000) examined the association between sociodemographic factors and long-term adult weight gain and current general and central adiposity among 5,464 women aged 45- 73 years old who participated in the Malmö Diet and Cancer study. The authors identified smoking as a significant predictor of past weight gain and current obesity. The inverse association between smoking and weight has prompted many adolescent girls to start smoking (Crisp et al., 1999). Moreover, the fear of weight gain has been cited as the main reason that prevents many smokers mainly women to quit smoking (Pomerleau et al., 2001). A study by Borrelli et al., (2001) found that the weight gain associated with smoking cessation has been a major risk factor of relapse to smoking. Meanwhile, Filozof and colleagues (2004) proposed that the recent increase in overweight and obesity in developed countries could be in part attributed to increased smoking cessation.

Audrain-McGovern and Benowitz (2011) proposed that nicotine acts as an appetite suppressant which could in part explain the lower weight among smokers. Bradley et al., (2010) proposed that smoking affects weight via two pathways. According to the authors, nicotine increases metabolic rate and energy expenditure, therefore when smoking cessation is attempted at, this results in decreasing energy expenditure and subsequent weight gain. In 1986, Hofstetter and colleagues reported that 24-hour energy expenditure increased in smokers by 140-200 kcal/day on a day with

smoking compared to a day without smoking with no corresponding change in mean basal metabolic rate. Walker et al., (1992) found a 6% increase in RMR after 20 minutes of smoking. The second hypothesis by Bradley and colleagues is that smoking induced an anorexic effect and therefore smoking cessation leads to increased weight due to increased intake (Moffatt and Owens, 1991). A study by Jessen et al., (2005) found that nicotine administration was negatively associated with hunger and satiety during a two- hour period. A study by Shawna and colleagues (2014) examined whether smoking was associated with weight related behavior including weight loss. The authors surveyed 300 students at the University of Kansas about smoking, weight loss intention, weight-related attitudes, and eating and exercise behavior. Compared to nonsmokers, current smokers ate more at restaurants serving high calorie foods and ate more frequently in front of the TV. Moreover, obesogenic behavior often manifests itself in a cluster of unhealthy habits including smoking, drinking alcoholic beverages, eating in front of the TV or binge eating and consuming more energy dense foods including free sugar (Mullie et al., 2017).

2.6.5 Age: Age plays a central role in almost every aspect of one's health including physical and mental wellbeing; where nutritional needs, food preferences and appetite change according to people's age (Wardlaw, 2003). The Recommended Dietary Allowance (RDA) refers to the "average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all healthy individuals in a particular life stage and gender group"

(Harper, 1985). Old age is often associated with reduced appetite (Pilgrim et al., 2015). In 1988, Morley and Silver were the first to describe this decline as the "anorexia of ageing". In 2013, Malafarina and colleagues estimated that between 15% and 30% of older people have anorexia of ageing, with higher rates among women, nursing home residents, hospitalized people and advanced age. Several factors play a role in reduced appetite among older adults including changes to the digestive system (Ship et al., 2002), depression (Engel et al., 2011), poor oral health including loss of teeth (Lee et al., 2006) and use of medication (Qato et al., 2008). Reduced appetite can lead to reduced food and nutrient intake (Payette et al., 1995) and increased risk of weight loss and nutritional deficiencies (Wilson et al., 2005). Moreover, a condition known as sarcopenia refers to "an age related, involuntary loss of skeletal muscle mass and strength" (Walston, 2012). Older adults may find it hard to regain lost weight (Roberts et al., 1994). As people age, fat distribution changes often accumulating in the abdominal area (Fielding et al., 2011). The physiological changes associated with age as well as anthropometric age-related changes including loss of height due to vertebral body compression and angulation of the spine (Sorkin et al., 1999) require special attention when applying body weight measurement tools in clinical settings. Body mass index or BMI, the most widely used adiposity measurement tool has been criticized for use in older adults because it does not account for age related changes in adipose tissue specifically the ratio between fat mass and fat free mass (Romero-Corral et al., 2008). Instead, waist circumference

was the best predictor of mobility disability in men and women (Angleman et al., 2006).

2.7 Sugar as an exposure: definition and current recommendations

The expert consultations organized by the World Health Organization and the Food and Agriculture Organization of the United Nations and the WHO scientific updates (FAO/WHO,1998) (WHO, 2003) (Mann, et al., 2002) have developed a comprehensive definition of carbohydrates and the various groups of sugars including the category free sugars to facilitate a more standardized approach to study the potential health effects associated with dietary sugar intake. Table 2.3 illustrates the classifications of dietary carbohydrates including free sugar.

Table 2.3 Classification of dietary carbohydrates

Class*	Subgroup	Principle Component
Sugars (1-2)	Monosaccharides	Glucose, fructose, galactose
	Disaccharides	Sucrose, lactose, maltose, trehalose
	Polyols (sugar alcohols)	Sorbitol, mannitol, lactitol, xylitol, erythritol, isomalt, maltitol
	Free sugars	All monosaccharides and disaccharides added to foods by the manufacturer, cook, or consumer; sugars naturally present in honey, syrups, and fruit juices
Oligosaccharides (3-9)	Malto-oligosaccharides (α glucans)	Maltodextrins

Class*	Subgroup	Principle Component
	Non-αglucan oligosaccharides	Raffinose, stachyose, fructo &Galactos oligosaccharides, polydextrose, inulin
Polysaccharides (≥10)	Starch (α glucans)	Amylose, amylopectin, modified starches
	Non-starch polysaccharides	Cellulose, hemicellulose, pectin, arabinoxylans, β glucan, glucomannans, plant gums and mucilages, hydrocolloids

*Degree of polymerization or number of monomeric (single sugar) units in brackets. Adapted from (Mann et al., 2007) (FAO/WHO, 1998).

2.7.1 Recommendations for free sugar consumption

Recommendations on the maximum free sugars intake differ by regions and institutes (Warfa et al., 2016). The WHO recommends that free sugars intake does not exceed 10% of total energy intake, however the US Institute of Medicine recommends that free sugars intake does not exceed 25% of total energy intake (Nishida et al., 2004). The WHO identifies free sugars as "all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus the sugars that are naturally present in honey, syrups and fruit juices" (FAO/WHO, 1998). The terms free sugar and free sugars are sometimes used interchangeably, however free sugars include sugars and syrups added to foods during processing, food preparation, or at the table but does not include honey, syrups, or fruit juice (Johnson et al., 2009). The WHO recommendations do not include "intrinsic sugars" which are present in whole fruit and vegetables because they are encapsulated by a plant cell wall which takes longer to be digested

and to enter the bloodstream than free sugars (Mann, 2014). The term free sugar is more used in the United States and some other countries. The WHO recommends to use the term free sugars because it is more precise.

2.8 Association between free sugar and weight

Te Morenga, Mallard and Mann (2013) proposed that the only mechanism sugar could cause weight gain is by disturbing the energy equilibrium by increasing caloric intake. According to the authors replacing sugar with other carbohydrates did not cause weight gain. However, DiMeglio and Mattes (2000) argued that sugar in the liquid form could promote excessive weight gain because they are less satiating leading to overconsumption. However, this does not mean that sugars contained in solid foods are less harmful. “Sweet on the tooth” foods usually have a higher concentration of calories per bite; or energy dense, therefore overconsumption of energy dense foods is associated with weight gain. However, Johnson and colleague (2009) proposed that sugar could affect weight through in less direct mechanisms that are independent of energy equilibrium. The authors proposed that sugars particularly table sugar, sucrose, and high fructose corn syrup contribute to fructose intake which in some people increases the levels of uric acid and hyperinsulinemia. Hyperinsulinemia has been identified as a “potentially important and independent predictor of obesity and metabolic syndrome” (Johnson et al., 2007).

Moreover, Silbernagel and colleagues (2011) proposed that sugar in the liquid form and other sources of dietary fructose promote the deposition of

liver, skeletal, and visceral fat and increase serum lipids independently from an effect on body weight.

In 1999, a study by Stene and colleagues used a community based cross sectional survey among 500 Palestinians aged 30- 65 years old found that sweetened tea was often consumed between meals and that sugar was the main contributor of energy accounting for 13- 14 percent to total energy intake. According to the study results, the mean household consumption of sugar was 37.8kg/ consumption unit/ year.

In 2010 a study by the A2Z project included 366 children (3-7 years old) and 435 women (18-50 years). The study used cross- sectional population design following multi- cluster random sampling technique. According to the study results between 43 and 88% of the children and 27 to 79% of the women had a daily sugar and sweet intake. Moreover, sugars and sweets intake formed 8% and 4% of the total energy intake in children and women respectively.

In 2012, a study by al- Zain, found that the whole sample of 150 participants had a daily sugar consumption. The study was carried out in three communities, Beit Hanoun, Jabalia and Beit Lahia.

2.9 Limitations of previous studies used in the WHO systematic review

The WHO based its recommendation on the maximum intake of free sugars on a systematic review of a number of epidemiological studies. However,

the review authors acknowledged that the studies included in the review themselves were prone to measurement errors inherited in epidemiology; which could partially explain why a dose-response relationship between sugar intake levels and weight change could not be identified (Te Morenga et al., 2013). Moreover, according to literature, overweight and obese individuals, women, those dieting or with chronic diseases like heart-disease, dyslipidemia, hypertension or diabetes tend to underreport their total energy intakes and weights (U.S. National Research Council, 1989). Moreover, the studies contained in the Te Morenga, Mallard and Mann, review focused mainly on sugar sweetened beverages to measure the association between sugar intake and weight change, leading to an underestimation of the association between total sugar intake and subsequent weight change. Furthermore, the duration of the randomized control trials ranged from 10 weeks to 8 months making it difficult to properly assess an association.

2.10 Factors associated with Diet and Weight Change

Obesity is a growing public health problem that is associated with chronic diseases as well as premature death from all- cause mortality (Burke, 2006). Over the past few years, the public health sector has gained considerable experience from previous epidemiological problems such as smoking in their attempts to fight future epidemics like obesity (Hurt, 2010). However, while the public health initiatives to address obesity and smoking share many similarities, they are also different since abstention

from food is not possible. The following part addresses some of the most common public health initiatives to address obesity and the challenges associated with each initiative.

The first initiative is labeling nutritional content of food products. Nutrition labelling is defined as “a list of nutrients on a food label accompanied by some form of quantification” with the most commonly used types of labelling list either four (energy, fat, carbohydrate and protein) or eight nutrients (with the addition of saturated fat, sugar, sodium and fiber) (WHO, 2007). It is important to understand the effect of nutrition labelling on consumer choices for policy-making.

An RCT study by Borgmeier and Westenhoefer (2009) compared a variety of food labeling strategies including no labeling, food labels with daily recommended levels for specific nutrients, labels with healthy choice designations, and traffic light labels indicating the level of healthiness. The study results showed no significant differences in consumption habits between the different labeling strategies. Another study by Snelling and colleagues (2007) examined the impact of a “stop light” labeling technique used at 3 high school cafeterias showed that the students continued to purchase higher caloric items despite a red warning and providing them with more healthier options. However, nutrition labelling is far from sufficient to address obesity (Leth et al., 2006).

According to Hurt (2010) the main problem with the labeling strategy is that the nutritional information is very difficult for consumers to

understand. Moreover, consumers are often unaware of the dietary content of restaurant foods. Harnack and colleagues (2008) conducted an RCT study to evaluate whether providing information on the caloric content of foods available affected the types of foods purchased at fast food restaurants. In their study, half of the participants were provided with menus containing calorie information, while the other half were given menus without this information. The study results showed that the number of calories consumed was not statistically different between the two groups. Despite the many challenges with nutrition labelling, this method provides the consumers with the opportunity to make informed decision with regards to purchased food.

Another strategy that has been proposed to tackle the obesity epidemic is full elimination of nutrients deemed harmful. One example is the full elimination of trans fatty acids (TFAs) achieved in New York City and Denmark. In 2003, the US Food and Drug Administration ordered that all packaged goods identify their content of TFA if it exceeded 0.5 g. Later in 2006, the New York City Department of Health and Mental Hygiene proposed to eliminate all artificial TFAs from restaurant food. Meanwhile, in 2003 Denmark was the first country to eliminate TFAs from food products (Leth et al., 2006). Leth and colleagues analyzed the consumption of food potentially high in TFAs before and after this ban and the researchers found that the amount of TFA in the same representative food was reduced from 30 g to less than 1 g.

Another initiative that had been proposed to tackle the epidemic of obesity was to place taxation on high caloric beverages (Roehr, 2009). However, a study by Powell and colleagues (2009) concluded that unless the taxes are significant, they are unlikely to influence consumption or long-term consequences such as weight gain. Brownell and colleagues (2009) proposed that unless the tax adds at least 20% to the beverages original price it would not lead to significant change in purchase decisions. According to the authors; consumers only chose healthier beverages which were at least 20% cheaper than diet sodas.

CHAPTER III
STUDY METHODS

Part I

3.1 Introduction

Chapter III provides detailed description of the study materials and the statistical analyses used to analyze the data. The chapter starts by describing the quantitative part of the study then the qualitative part. The quantitative part includes description of the source population i.e. the Malmö Diet and Cancer (MDC) study, including the study design, the recruitment procedure, the data collection method and the validity and reproducibility of the data collection methods. A description of the current study design including the main exposure and covariates assessment, the classification of the study outcomes and the statistical analyses follow. The second part of Chapter III describes the qualitative part of the study.

3.2 Source Population: The Malmö Diet and Cancer Study

The Malmö Diet and Cancer (MDC) study was jointly planned and initiated by the Faculty of Medicine at Lund University, the Swedish Cancer Society, the Swedish Medical Research Council and the International Agency for Research on Cancer (IARC) (Berglund et al., 1993). In 1993, the MDC became an associated member of the European Prospective Investigation into Cancer (EPIC) organized by IARC, Lyon, France (Riboli and Kaaks, 1997). The study took place in the city of Malmo, Sweden between 1991 and 1996 and included men aged 46 to 73 years old and women aged 45 to 73 years old who lived in Malmö city and had Swedish reading and writing skills (Warfa et al., 2016). The participants were

randomly invited using the Municipal Registry from the total source population of 74,138 people who lived in the city of Malmö (Lahmann et al., 2000). Two methods were used to recruit the study participants. First the research team invited the population to participate by distributing invitation letters in public areas e.g. post offices and through local media. This method is referred to as the passive recruitment method. In the second method; the active recruitment method, the research team sent personal invitations to the population and if the participants did not respond to the first letter or the subsequent two letters; the team made phone calls to them (Manjer et al., 2002).

Of the 74, 138 source population, 1,975 were mentally incapable or did not have enough language skills, while 3,241 people died or left before receiving the invitation letter. As many 17 people could not be identified bringing the study final eligible participants to 68,905 people. Of those, 21,817 people did not respond to the invitation letters and 16,942 people did not want to participate. As many as 28,098 people (17,035 women) completed all the baseline examination. Of the 28,098 participants only 22,367 people participated in the follow up re-examination.

More detailed information regarding the MDC study is available on the Swedish National Data Service (https: // snd. gu. se/ en/ catalogue/ study / ext 0012) and the website of Lund University.

3.3 Ethical approval

The Ethical Committee at Lund University approved the MDC study (LU 51–90). The study participants gave written informed consent during their first visit to the study center. For the ethical approval letter in Swedish and the translated version please refer to Appendices; A and B.

3.4 Dietary assessment

The MDC study used a modified diet history method during the baseline examination which aimed to capture total diet but focused mainly on fiber and fat intake. The method took into consideration the participants age which included middle aged urban men and women with regular eating habits with little fast food intake. The dietary assessment method included three parts; a Seven- day food diary, a 168-item semi- quantitative diet history questionnaire and a 45- 60 min diet history interview. Below is a brief description of each part:

3.4.1 Seven- day food diary

In this method, the participants were asked to record the main cooked meals consumed on a daily basis for seven consecutive days. The diary also included cold beverages like juice, milk, water, soft drinks, and alcoholic beverages as well as medications and dietary/ nutritional supplements.

3.4.2 Food frequency questionnaire

During the baseline examination, the participants also filled an extensive food frequency questionnaire which focused on disease history, lifestyle and socioeconomic status including education and work, cohabitation, LTPA including sleeping habits, smoking, alcohol consumption, health status including reported perceived mental and physical health, recalled past weight, past/ current diseases, dietary change, use of medication and family history of diseases. The questionnaire also included questions regarding the participants psychological well-being (Lahmann et al., 2000). The food diary and the diet history questionnaire were filled out at home.

3.4.3 Diet history interview

The diet history interview took place on the second visit to the research center during the baseline examination. The participants were asked to estimate the usual portion sizes of foods and dishes reported in the food diary using a more detailed and comprehensive book of photographs. The participants were presented with a group of four photos showing different portion sizes. The participants also described in details the food preparation methods including added ingredients and the type of cooking fat. The data collected from the three methods were then entered into the data system using the interactive software KOSTSVAR (AIVO AB). The software guided the interviewer through a system of recipe identifiers which helped identify the preparation methods and ingredients in mixed dishes.

The participants dietary intake collected from all methods was converted into the average daily consumption (gram per day). The participants total

dietary intake was analyzed to get average total energy intake and nutrient intake using an interactive computer software and the Swedish Food Database of the Swedish National Food Administration (Livsmedelsverket, 2015). The database has complete information on free sugars intake including monosaccharides and disaccharides for all individuals (Callmer et al., 1993).

3.5 Representativeness of the MDC study

In order to examine the representativeness of the MDC study, Manjer and colleagues (2001) examined cancer incidence and mortality prior to, during and after the baseline examination among the 28,098 MDC participants versus 40,807 non- participants. The authors also compared the MDC participants health, sociodemographic characteristics and lifestyle with a random sample of participants from a corresponding birth year cohort using a mailed health survey with a higher participation rate of nearly 75%. The results showed that mortality was higher among the non- participants during recruitment and follow up while cancer incidence was lower in non-participants prior to recruitment but higher during the recruitment period. Furthermore, the results showed that despite the low MDC participation rate, the sociodemographic characteristics and the prevalence of smoking and obesity were similar between the MDC participants and the corresponding sample with higher participation rate (Manjer et al., 2001).

3.6 Validity and reproducibility of the dietary assessment method

The relative validity of the MDC dietary assessment method was tested in 1984 and 1985 among 206 Malmo residents (105 women) aged 50- 69 years (Elmstahl et al., 1996). Two methods; an extensive FFQ and a combined food record with a quantitative FFQ were compared with a reference method. The reference method included an 18- day weighed dietary record kept for three consecutive days every two months over one-year period. Both methods yielded high correlation coefficients for most foods and nutrients, however, the combined food record overestimated most food groups (Elmstahl et al., 1996) and most nutrients (Riboli et al., 1997).

The examination of the reproducibility of the MDC methods namely the extensive FFQ and the combined food record with a quantitative FFQ, included 241 participants (115 women) aged 50- 69 years (Elmstahl et al., 1996). The MDC study methods were applied twice with one-year interval and 120 participants used the food record combined with a quantitative FFQ. The energy adjusted Pearson correlation coefficients for the men and women were between 0.5 and 0.9 for most food groups and nutrients (Elmstahl et al., 1996).

3.6.1 Reliability of the MDC questionnaire

In order to assess the reliability of the MDC FFQ, a random sample of the study participants were invited nearly three weeks after the baseline examination to the research center. During the follow up examination, the questionnaire was administered a second time (Manjer et al., 2002). A total of 211 participants or 91% of the participants responded to the questionnaire twice including 209 people who had completed the baseline examinations. Kappa statistics were used to determine the consistency between the baseline and follow up questionnaires. A majority of the variables showed high reproducibility (> 0.75) (Manjer et al., 2002).

3.7 Anthropometric measurements

During the baseline examination, trained nurses performed anthropometric measurements for all the participants. The participants weight (kg) was measured to the nearest 0.1 kg using a calibrated balance- beam scale while wearing light indoor clothing and without shoes. The height (cm) was measured using a wall- mounted stadiometer and waist circumferences (cm) were measured midway between the lowest rib margin and the iliac crest and horizontally at the level of the greatest lateral extension of the hip, respectively (Dias et al., 2016).

3.8 The present study population

The present study population is derived from the MDC study. The original study sample included all participants in the follow up examination (22,367 people). However, of those 336 people were excluded because they did not

have data on their weight either at baseline or at follow up. In total 22,031 people were considered eligible participants. When inspecting the weight change variable two extreme values were detected, one man who had weight change of 105 kg (weight at baseline= 73 kg; weight at follow up= 178 kg) and one woman who had weight change of 98 kg (weight at baseline= 50 kg, weight at follow up= 148 kg) which did not seem biologically plausible. One explanation could be that this was a typo and the weights were more likely 73-78 and 50-48. After consultation with the supervisors, it was decided to remove the two extreme values bringing the participants total number to 22029 people. Of those 3896-people reported to have been diagnosed with a disease that leads to involuntary weight loss including, cardiovascular, diabetes, and cancer and has subsequently been removed in accordance with previous literature which states that involuntary weight loss is frequently reported in elderly patients and usually caused by acute or chronic diseases (Fischer and Johnson, 1990). A majority of the participants (94.9%) had the follow up examination between 4-5 years after their baseline.

The current study sample size is 18133 people.

3.9 Assessment of exposure and covariates

the following section demonstrates how the study main exposure under study i.e. free sugars was calculated as well as other covariates included in the study.

3.9.1 Free sugars intake

The main exposure under study is the percentage of non-alcohol energy (E%) from free sugars intake. In line with the WHO definition, free sugar intake was calculated by subtracting the estimated amounts of monosaccharide and sucrose from vegetables, fruits and juice from the total intake of monosaccharide and sucrose from diet; as follows:

Free Sugar Intake= Total intake of monosaccharides and sucrose from diet minus ((vegetables*0.05) + (carrot juice * 0.05) + (vegetable juice * 0.03) + (non-citrus fruits*0.1) + (citrus fruits * 0.085) + (citrus juice * 0.08) + (non-citrus juice * 0.1)). This is the amount of monosaccharides and sucrose in the specific foods. E.g. 5 g/100 for carrot juice.

The participants were later categorized according to their free sugars intake at baseline into six groups. The WHO recommendation to limit energy from free sugar to less than 10% (WHO, 2015) and the study objectives guided selecting the cutoff points. The study was also interested to examine weight change just below the WHO recommendation (7.5-<10E%) as well as in higher intake groups (15- <20E% and ≥20E%). The free sugars intake was categorized into the following categories: <5%, 5–<7·5%, 7·5–<10%, 10–<15%, 15-<20% and ≥ 20E%.

3.9.2 Age and gender

The participants age was categorized into the following groups: <50, 50- <60, 60- <70 and ≥70. The gender was treated as binary variable (female, male).

3.9.3 Educational level

The participants educational level was organized into five categories; elementary school or less normally up to 8 years, Primary and Secondary normally 9-10 years, Upper secondary, normally 11-12 years, further education without a degree which is at least one year of education after and University degree.

3.9.4 Leisure Time Physical Activity (LTPA)

The participants LTPA was measured from a list of 18 different activities, adapted from Minnesota Leisure Time Physical Activity (Pereira., 1997). The individuals reported the number of minutes they spent on each activity. Later an activity-specific factor was multiplied by the minutes spent on each activity and summed into a score. The LTPA is expressed in number of Metabolic Equivalent hours per week (METh/week) (Dias et al., 2016). The LTPA was divided as follows: <7.5, 7.5- <15, 15- <25, 25- <50, ≥50 METh/week.

3.9.5 Smoking status

The participants smoking status was identified during the baseline examination. For the present study, the participants smoking status was divided into three categories; Smoker including regular and occasional smokers, former smoker, and never smoked.

3.9.6 Alcohol consumption

The last lifestyle variable described is alcohol consumption. Participants who reported no alcohol consumption both in the FFQ and during the seven- day food records were labelled as zero consumers. Alcohol consumption was divided into gender- specific quintiles as follows:

Q1: Women: 0-<0.9/ Men: 0-<3.4g/day

Q2: Women 0.9-<4.3/ Men: 3.41-<9.1g/ day

Q3: Women: 4.3-<8.1/ Men: 9.1-<15.7 g/day

Q4: Women 8.1-<14.0/ Men: 15.5-<25.7 g/day

Q5: Women: ≥14/ Men: ≥25.7

3.10 Outcome assessment

The main outcome variables are body weight and BMI changes at follow up. The body weight change was evaluated as both absolute change (kg per year) and relative change (% kg/year). The annual weight change (kg/ year) was calculated as follows:

Annual Weight Change = (weight at follow up - Weight at baseline)/ follow up time.

The relative weight change was calculated as follows:

Relative Weight Change = (Wt.3/Wt.1) ∗ 100 (where Wt.3 is the absolute Weight change and Wt1. is weight measured at baseline).

The Body Mass Index (BMI) was calculated by dividing the participants weight by their squared height (kg/m^2). The participants BMI was calculated at baseline and at follow up. The annual BMI change is measured as follows:

BMI change= (BMI at follow up - BMI at baseline)/follow up time

Additionally, the BMI at follow up is categorized according to the WHO categories (WHO, 2000) as underweight and normal (BMI <25); overweight (BMI ≥25- <30); obese (BMI ≥30).

3.11 Methodological variables

The study design required further adjustments for the following variables:

3.11.1 Season

The variable season refers to the measurement data during the baseline examination. Season was classified as follows: Spring, Summer, Autumn and Winter.

3.11.2 Diet method

Due to reduced funding, the diet recording routines and not dietary reporting at the baseline examination was altered in September 1994 (Wirfalt et al., 2002). The dietary assessment method used before September, 1994 is identified as old and coded as 1 and the dietary assessment method used after that date is labelled as new and coded as 2.

3.11.3 Diet changers

During the baseline examination, the participants were asked if they "had substantially changed their eating habits because of disease or other reasons" to which the answer was Yes or No. Changing food habits violates the assumption that the reported usual diet is stable over time (Sonestedt et al., 2005). Changing diet is also associated with obesity, lifestyle and socioeconomic variables (Sonestedt et al., 2005). The participants who answered Yes were identified as diet changers and the data was analyzed with and without them in the sensitivity analysis.

3. 11.4 Energy misreporting

Potential energy misreporters were identified by comparing reported energy intake with estimated total energy expenditure calculated from basal metabolic rate (BMR) and self-reported physical activity level. Energy misreporting was defined as the ratio of energy intake (EI) to BMR outside the 95% Confidence Interval (CI) limits of the calculated physical activity

level (Mattisson et al., 2005). The data was analyzed with and without energy misreporters.

3.12 Statistical analyses

The following sections provides an overview of the statistical analyses used in the quantitative part of the thesis:

3.12.1 Baseline characteristics of the study participants

The participants demographic characteristics, anthropometric measurements and lifestyle were summarized using descriptive statistics and presented either as Mean and Standard deviation (SD) for continuous variables or as frequencies (%) for categorical variables. The participants' weight and BMI were summarized as both continuous and categorical variables. Since gender plays a major role in food choices and metabolism (Langseth, 1996) the measurements were stratified by gender.

3.12.2 The participants characteristics across the six groups of free sugar intake

In order to understand how the participants characteristics namely age, total energy intake (MJ/ day), BMI, gender, education, LTPA, alcohol consumption and smoking at baseline behaved across the six categories of free sugar intake; One Way Analysis of Variance (ANOVA) was used when the variables were continuous and crosstabs with chi- square (χ^2) was used with categorical variables.

3.12.3 Weight change across the participants characteristics:

The participants weight change according to their age, gender, total energy intake (MJ/day), smoking, education, LTPA, alcohol consumption and BMI at baseline was tested using ANOVA.

3.12.4 Association between free sugars intake and weight or BMI change

The author used univariate and multiple linear regression to test for the mean difference of continuous variables (i.e. absolute annual weight change, relative annual weight change, BMI change) across the six groups of free sugars intake with several levels of adjustments. This is one approach to identify potential confounders and assess how much they influence the association between our exposure and outcome of interest (Boston School of Public Health, 2013).

In the first model; Model I the author used a minimal adjustment approach which included age and baseline weight as continuous variables and method, season and free sugar as categorical variables. In Model II; the fully adjusted model, the author added smoking, alcohol, physical activity and education as categorical variables to the first model (Model I). Furthermore; to account for possible bias, the author performed sensitivity analysis to the fully adjusted model (Model II) by excluding diet changers and energy misreporters (Model III).

3.12.5 Testing for linear trend in the association between free sugars (E%) and weight change (absolute and relative) and BMI change

The author used linear regression to test for *p* for trend (*p*- trend) by introducing free sugars intake as continuous covariate with the same levels of adjustments in the three models as described earlier.

3.12.6 Association between free sugars intake and risk of developing overweight (among normal weight individuals) at follow up

In order to measure the relative risk (RR) (95% CI) of developing overweight among normal weight persons across the six free sugars intake categories the author used Cox proportional hazards regression with invariant. For all outcome measures, the lowest category was used as the reference category including the indicator variable, free sugars intake. The follow up time was used as the time scale. The author built two models, in the basic model (Model I), the author adjusted for gender, age, method and season. In the fully adjusted model, (Model II), the author added smoking, alcohol, LTPA and education. The author repeated the above analyses excluding energy misreporters and diet changers in the sensitivity analysis (Model III).

The author tested for *p* for trend (*p*- trend) by introducing free sugars intake as continuous variable with the same adjustments into the regression model.

The author used cross tabulation to calculate the number and percentage (N/%) of normal weight individuals at baseline who became overweight at follow up, according to their free sugars intake category.

All statistical analyses were performed using IBM SPSS Statistics (Version 24.0) for Mac and all tests were two sided and significance level was set at $p< 0.05$.

METHODS

Part II

3.1 Introduction

The following part describes the methods for the qualitative part of the study. It includes study design, participants recruitment, ethical considerations, data collection methods, data analysis, validity and reliability of data.

3.2 Study design

The study adopts a qualitative approach in order to allow in- depth, comprehensive exploration of the challenges facing the Palestinian policy makers with regards to limiting sugar intake among children and adults (Diefenbach, 2009). The data was collected using semi-structured interviews and analyzed for themes and patterns (Bryman, 2012).

3.3 Participants recruitment

The study participants were chosen on purpose to answer the study objectives. Purposeful sampling helps to “select information rich cases that best provide insight into the research questions and will convince the audience of the research” (Emmel, 2013 pg. 33). The review of the literature showed that the main stakeholders that work with nutrition policy in Palestine are the Palestinian ministry of health, the United Nations Relief and Work Agency for Palestine Refugees, UNRWA and some Non-governmental organizations (Manenti et al., 2016). Moreover, the

Palestinian ministry of education has its own policy with regards to foods and beverages provided to students in school canteens (Totah S. personal interview, February,7 2018). In order to gain a comprehensive view of the challenges facing the implementation of public health initiatives in Palestine, the student in consultation with the supervisor decided to include the nutrition departments in the Palestinian ministries of education and health, UNRWA and the Palestinian National Institute of Public Health (PNIPH) as a representative of Non- governmental organizations. As explained earlier, the aim was to invite the aforementioned bodies to participate in the study, however during the data collection period, UNRWA was on strike and did not respond to the author's calls. The Palestinian National Institute of Public Health answered the student's initial contact by phone and email but later did not respond. After consultation with the supervisor it was decided to exclude them from the study due to limited time and physical constraints. However, in order to enhance the study results rigor, it was decided to include the Palestine Standards Institution (PSI) which prepares standards for products and services allowed in the Palestinian market instead (PSI, 2018).

3.4 Ethical consideration

The Research Review and Ethics Screening Committee (RRESC) at An-Najah National University approved the study in July, 2017 (Appendix D). Moreover, during the initial contact with the study participants, the author explained to them; the study aims and objectives, the rationale for choosing

them, data collection method which includes a semi- structured interview with emphasis that the interview will be audio- recorded to enhance the study reliability and that they were free to decide on whether or not to take part in the study and there was no pressure in any way to join (Watson II and Clement, 2008). Moreover, the student also explained to the participants that if anyone decided to withdraw from the study before the results were reported; the data would be destroyed and not used at all. In order to protect the participants details, the student only referred to their respective ministries. The audio- recorded interviews were saved in password-protected computers and access to the data was limited to the student and the study supervisor (Farrimond, 2013).

3.5 Interview process

The study used semi-structured interview because it is more flexible and offers the opportunity to gain rich and in-depth answers to the research questions (Bryman, 2012). Semi-structured interviews allow the interviewer to be open and ask questions that may arise during the interview process (Wengraf, 2004). The other interview styles include unstructured and structured interviews. In the unstructured interview, the researcher listens to the interviewee's narrative with no or minimal involvement or direction. Structured interviews are often used in quantitative research studies to answer specific lists of questions (Bryman, 2012). The interviews took place in Ramallah at each of the participants' offices and were recorded on a digital recorder. The interview main

questions were prepared in advance, however as indicated earlier, the semi-structured interview style allowed the student to adopt the questions according to the participants narratives and to improvise new questions when needed. Below are the main questions that guided the interviews:

1. Describe the guidelines regarding consumption of Sugar Sweetened Beverages (SSB)/ sugary foods in Palestine.

2. Describe the plans targeting restriction of free sugars intake for children and adults in Palestine.

3. Describe the perceived challenges to limit consumption of Sugar Sweetened Beverages (SSB)/ sugary foods in Palestine.

3.6 Data analysis process

The content of the audio-recorded interviews was transcribed into word document software. The interview transcripts were then analyzed for codes. “A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data (Saldana, 2012). In the initial coding, In Vivo Coding was used where interesting extracts from the participants own words were highlighted and placed in quotation marks. Later, Descriptive Coding where phrases that summarizes the initial codes where generated to reflect the original codes (Saldana, 2012). The relevant codes were then grouped into categories or sub-themes in order to facilitate comparisons, connections, grouping and analysis later.

The subthemes were then revised and rearranged to produce the final themes. According to Bryman (2012) themes provide basic understanding of the data that can contribute to the findings. The following part describes the data analysis process:

1. The transcribed interviews were read several times and interesting concepts or phrases were highlighted using different colors and initial interpretations are recorded into subthemes
2. The emerging subthemes were then reviewed and compared for similarities, differences or new meanings.
3. The final subthemes were then grouped into final themes. The final themes were then reviewed and compared with the original extracts.

3.7 Validity and reliability in qualitative research

Validity in qualitative research means “appropriateness” of the tools, processes, and data (Leung, 2015). In order to enhance the results validity, more than one coder reviewed the transcribed data and generated the initial subthemes. The student generated the codes and initial subthemes, then another independent co- coder who did not see the generated codes or themes, reviewed the transcribed interviews. The author and the co- coder then compared the generated codes and corresponding subthemes. This step helped minimize any conscious or unconscious background bias (Denzin and Lincoln, 2002). After reviewing the codes and generated subthemes some of the themes were renamed or rearranged to form new subthemes. For example, one theme “industrial opposition” was renamed into “food

industry opposition" placed as subtheme under "economic barriers". The final overarching themes and subthemes were then reviewed by the supervisor.

Reliability in qualitative research refers to the exact replicability of the processes and the results. In other words, it means "consistency" of the produced results (Carcary, 2009). In order to enhance the results reliability both co- coders used the same thematic analysis approach to generate the codes and subthemes (Silverman, 2001). Moreover, two audio recorders were used to record the interview. The transcribed interviews from the first recorder were then compared with the second recorder by the second co-coder.

3.7.1 Translation

As translation could threaten the quality of the generated data and to losing meaning, the student conducted the interviews, transcribed and analyzed them in Arabic language (Van Nes et al., 2010). The author translated the generated codes and subthemes from Arabic to English language. Later an official translator translated the codes and subthemes from English to Arabic. The translated versions were then compared for consistency by the author and the supervisor.

CHAPTER IV

STUDY RESULTS

Part I

4.1 Introduction

Chapter IV presents the results from both the quantitative and the qualitative studies. The chapter is divided into two parts. Part I presents the results from the quantitative part of the study. The Chapter starts by describing the baseline characteristics of the study participants, the participants age and lifestyle characteristics across the six categories of free sugars intake and weight change across the participants characteristics. Then, the results from the association between free sugars intake and weight/ BMI change are presented. Lastly, the chapter presents results from the risk of developing overweight among normal weight persons based on the percent of their free sugars intake from total energy intake.

4.2.1 Baseline characteristics of the study participants

The total number of the study participants is 18133 people. The baseline characteristics of the study participants including gender, age, weight in kilograms, BMI, LTPA, educational level, alcohol intake and percentage of energy from free sugar are summarized in Table 4.1. The analysis was stratified by gender to facilitate interpretation of findings.

The majority of the participants were women (62.3%) with mean age of 56.9 ± 7.8, respectively. The mean age and SD for the men was 58.5 and 6.9. The results showed that men had higher mean body weight compared to women (81.0 ±11.5 and 67.3 ±11.0, respectively). The majority of men (36.5%) and women (38.3%) spent 25- 50 METh/week. The majority of men (43.7%) had elementary school or less education followed by 19.9% of men who completed primary and secondary education. Only 14.1% of men had university education. On the other hand, the majority of women had elementary school or less education followed by primary education (37.5%, 31.0 respectively). The majority of men fell in the third quintile of alcohol intake (20.3%) while only 3.6% were zero consumers. For women, a majority (19.7%) fell in the fourth quintile of alcohol intake while only 6.4% were zero consumers. A majority of men (42.1%) were former smokers while a majority of women (45.7%) had never smoked. The mean percentage of energy obtained from free sugars was almost the same for both men and women (10.2% and 10.0%, respectively). The majority of men and women (34.0% and 33.8%, respectively) obtained 10-<15% of their energy intake from free sugars. This is followed by the second group which obtained 7.5- <10% of their energy from free sugars (26.2% for men and 26.3% for women). Only 8.1% of men and 9.1% of women obtained less than 5% of their energy from free sugars. The smallest percentage of men and women (2.6% and 2.4%, respectively) obtained ≥20% of their energy intake from free sugars.

Table 4.1 Baseline Characteristics of Study Participants

N (%)	**Men**	**Women**
	6837 (37.7%)	11296 (62.3%)
Age (year) mean ± SD	58.5 ± 6.9	56.9 ± 7.8
Weight (kg) mean ± SD at baseline	81.0 ±11.5	67.3 ±11.0
BMI. Mean ± SD	26.0 ±3.3	26.0 ±3.3
Leisure Time Physical Activity METh*/week N (%)		
Below 7.5	618 (9.0%)	919 (8.1%)
7.5- 15	1003 (14.7%)	1643 (14.5%)
15- 25	1522 (22.3%)	2719 (24.1%)
25- 50	2484 (36.5%)	4331 (38.3%)
≥50	1210 (17.7%)	1684 (14.9%)
Education N (%)		
Elementary school or less	2985 (43.7%)	4234 (37.5%)
Primary & Secondary	1362 (19.9%)	3507 (31.0%)
Upper Secondary	865 (12.7%)	801 (7.1%)
Further education without degree	660 (9.7%)	963 (8.5%)
University Degree	965 (14.1%)	1791 (15.9%)
Alcohol intake N (%)		
zero-consumers	244 (3.6%)	722 (6.4%)
Q1**: Women 0-0.9/ Men: 0-3.4g/day	1214 (17.8%)	1984 (17.6%)
Q2: 0.9-4.3/3.4-9.1	1294 (18.9%)	2092 (18.5%)
Q3: 4.3-8.1/9.1-15.7	1389 (20.3%)	2085 (18.5%)
Q4: 8.1-14.0/15.5-25.7	1358 (19.9%)	2220 (19.7%)
Q5: ≥14/≥25.7	1338 (19.6%)	2193 (19.4%)

Smoking N (%)		
Smoker	1869 (27.3%)	2993 (26.5%)
Former	2874 (42.1%)	3143 (27.8%)
Never	2094 (30.6%)	5160 (45.7%)
Free Sugar (E%) Mean ± SD	10.2% ±4.3	10.0% ± 4.2
Free sugar (E%) categorized N (%)		
<5E%	551 (8.1%)	1029 (9.1%)
5-<7.5 E%	1317 (19.3%)	2231 (19.8%)
7.5-<10E%	1790 (26.2%)	2970 (26.3%)
10-<15E%	2326 (34.0%)	3818 (33.8%)
15-<20E%	674 (9.9%)	974 (8.6%)
≥20E%	179 (2.6%)	274 (2.4%)

*METh/ week: Metabolic Equivalent Hours/ week

**Q: Quintile

The participants BMI at baseline and follow up are summarized in Table 4.2. The results show that at baseline, 40.3% of men and 56.2% of women had normal weight, while 49.2% of men and 32.7% of women were overweight. Only 10.5% of men and 11% of women were obese at baseline. At follow up the results showed that 49.0% of men and 55% of women had normal weight, while 49.0% of men and 34.0% of women were overweight and only 10.3% of men and 10.6% of women were obese.

Table 4.2Participants BMI values at baseline and follow up

	Men Baseline	Men Follow up	Women Baseline	Women Follow-up
Normal <25	2756 (40.3%)	2778 (40.6%)	6351 (56.2%)	6247 (55.3%)
Overweight ≥25-<30	3365 (49.2%)	3353 (49.0%)	3697 (32.7%)	3846 (34.0%)
Obese ≥ 30	716 (10.5%)	706 (10.3%)	1248 (11.0%)	1203 (10.6%)

4.2.2 Participants characteristics across the six free sugars groups

The participants age and lifestyle characteristics were investigated across the six categories of free sugars intake using ANOVA. The older the participants the more they consumed free sugar. Moreover, mean energy intake also increased the more energy from free sugars increased. Table 4.3 below summarizes the differences between the participants age, total energy intake (MJ/day) and BMI across the six categories of free sugars intake.

Table 4.3 Participants Characteristics According To Sugar Intake

Mean ±SD	**Free sugar E%**						
	<5E% (n=1580)	5-<7.5E% (n=3548)	7.5-<10E% (n=4760)	10-<15E% (n=6144)	15-<20E% (n=1648)	≥20E% (n=453)	***P***
age (y)	55.7±6.9	56.7±7.3	57.5±7.5	58.1±7.6	58.2±7.6	57.6±7.3	<0.001
E intake (Kcal/**day)**	1926.47 ±590.4	2100.17 ±596.2	2208.02 ±597.8	2285.60 ±619.5	2358.47 ±664.0	2400.45 ±721.5	<0.001
BMI	25.9±4.2	25.7±3.8	25.4±3.6	25.2±3.6	25.0±3.6	25.1±4.2	<0.001

The participants gender, LTPA, smoking status, education and alcohol consumption at baseline across the six groups of free sugar are described in Table 4.4.

The results showed that women tended to consume more free sugars across the six groups of free sugars compared to men (p= 0.017). The results also showed that participants whose diet included more free sugars were more physically active with the exception of the last group; the most active which consumed less free sugars (p<0.001). Former smokers consumed the least of their energy from free sugars; making up a majority of the first two groups of free sugars (<5E% and 5-7.5%) compared to smokers and those who never smoked. The results also showed that those who had never smoked consumed

more free sugars; except the group which consumed ≥20E% from free sugars which included more smokers (p<0.001). The participants with the lowest education that is elementary education or less, were the highest consumers across the six groups of free sugars (p<0.001). The highest alcohol consumers constituted a majority of the lowest two groups of free sugars intake while, the lowest alcohol consumers constituted a majority of the groups with the highest free sugars consumption (p<0.001).

Table 4.4 Participants baseline characteristics across free sugar groups

N (%)	Free sugar E%						
	<5E% (n=1580)	5-<7.5E% (n=3548)	7.5-<10E% (n=4760)	10-<15E% (n=6144)	15-<20E% (n=1648)	≥20E% (n=453)	*P*
Male	551 (34.9)	1317 (37.1)	1790 (37.6)	2326 (37.9)	674 (40.9)	179 (39.5)	0.017
Female	1029 (65.1)	2231 (62.9)	2970 (62.4)	3818 (62.1)	974 (59.1)	274 (60.5)	
LTPA							
<7.5	169 (10.8)	315 (8.9)	351 (7.4)	484 (7.9)	162 (9.9)	56 (12.5)	<0.001
7.5-<15	256 (16.3)	502 (14.2)	666 (14.1)	902 (14.7)	235 (14.3)	85 (19.0)	
15-<25	314 (20.1)	878 24.9%	1136 (24.0)	1447 (23.6)	359 (21.8)	107 (23.9)	
25-<50	569 (36.3)	1345 38.1%	1864 (39.4)	2230 (36.4)	598 (36.4)	121 (27.1)	
≥50	258 (16.5)	489 (13.9)	714 (15.1)	1065 (17.4)	290 (17.6)	78 (17.4)	

Smoking Status							
Smokers	527 (33.4)	949 (26.8)	1179 (24.8)	1550 (25.2)	482 (29.3)	175 (38.6)	<0.001
Former Smoker	550 (34.8)	1318 (37.2)	1534 (32.2)	1971 (32.1)	509 (30.9)	131 (28.9)	
Never Smoker	503 (31.8)	1280 (36.1)	2046 (43.0)	2622 (42.7)	655 (39.8)	147 (32.5)	
Education							
Elemen. School	542 (34.3)	1306 (36.9)	1822 (38.3)	2529 (41.3)	777 (47.2)	208 (46.1)	<0.001
Primary & Second.	365 (23.1)	982 (27.7)	1279 (26.9)	1737 (28.3)	393 (23.9%	113 (25.1)	
Upper Second.	162 (10.3)	306 (8.6)	459 (9.7)	542 (8.8)	161 (9.8)	36 (8.0)	
Further Edu.	159 (10.1)	333 (9.4)	434 (9.1)	527 (8.6)	131 (8.0)	39 (8.6)	

Univ. Degree	350 (22.2)	612 (17.3)	761 (16.0)	794 (13.0)	184 (11.2)	55 (12.2)	
Alcohol Consumption							
Zero Consum.	82 (5.2)	158 (4.5)	228 (4.8)	331 (5.4)	112 (6.8)	55 (12.1)	<0.001
Q1:w:0-<0.9/m:0-<3.4g/day	242 (15.3)	523 (14.7)	716 (15.0)	1187 (19.3)	411 (24.9)	119 (26.3)	
Q2: 0.9-<4.3/3.4-<9.1	227 (14.4)	523 (14.7)	941 (19.8)	1232 (20.1)	372 (22.6)	91 (20.1)	
Q3: 4.3-<8.1/9.1-<15.7	267 (16.9)	713 (20.1)	918 (19.3)	1219 (19.8)	278 (16.9)	79 (17.4)	
Q4: 8.1-<14.0/15.5-<25.7	317 (20.1)	772 (21.8)	1018 (21.4)	1165 (19.0)	257 (15.6)	49 (10.8)	
Q5: ≥14/≥25.7	445 (28.2)	859 (24.2)	939 (19.7)	1010 (16.4)	218 (13.2)	60 (13.2)	

4.2.3 Weight change across the participants characteristics

The participants absolute and relative weight change according to their age, gender, total energy intake (E%), smoking, education, LTPA, alcohol consumption and BMI are summarized in Table 4.5. The analysis is stratified by gender. According to the results, age, total energy intake (E%), BMI, smoking and gender had significant differences with regards to their absolute weight change (p<0.001). The participants weight change did not change significantly based on their education or alcohol consumption. Education (p = 0.128 for men) and (p= 0.378 for women). Alcohol, (p= 0.183, 0.215 for men) and (p= 0.608 for women). There was a statistically significant difference between the men physical activity with regards to their absolute and relative weight change (p= <0.001) while women physical activity did not have statistically significant difference with weight change (p= 0.225).

Over the follow up period men lost on average 0.015 (SD= 1.0) kg per year while women gained on average 0.016 (SD= 1.0) kg per year. Men over the age of 60 years old lost weight while men younger than 60 years old gained weight. The older the men the more weight they lost. Men over the age of 70 years old lost an average 0.40 (SD= 1.1) kg per year while men younger than 50 years old gained an average 0.2 (SD= 1.0) kg per year. The women weight gain has decreased with age. Women older than 60 years old lost weight while younger women gained weight. Women older than 70 years old lost most weight with an average of 0.33 (SD= 1.1) kg per year while

women younger than 50 years old gained an average 0.16 (SD= 1.1) kg per year. Men in the first three quintiles of total energy intake lost weight while men in the last two quintiles gained weight with men in the last quintile gaining a mean of 0.1 (SD= 1.0) kg per year. Women in the first two quintiles lost weight with a mean of 0.06 (1.2), 0.04 (SD=1.1) kg per year respectively while women in the last three quintiles of total energy intake gained weight. Women in the highest three quintiles of total energy intake gained more weight than less groups with a mean of 0.15 (SD=1.0) kg.

Both men and women with highest BMI values at baseline lost more weight. Men and women with BMI ≥30 lost an average of 0.5 (SD= 1.4), 0.4 (SD= 1.6) kg per year respectively. Both former and never smoker men and women lost weight while smokers gained weight. Smoking men and women gained an average of 0.14 (SD= 1.1), 0.15 (SD= 1.2) kg per year respectively. Men with university degree lost an average 0.05 (SD= 1.0) kg per year while women with university education gained an average 0.04 (SD= 1.0) kg per year. Men with primary and secondary education lost more weight compared to the other groups with a mean of 0.06 (SD= 1.0) kg per year while women with elementary education lost more weight with a mean of 0.05 (SD= 1.6) kg per year. Men in the highest groups of physical activity lost weight while men in the lowest three quintiles gained weight. Only women who spent more than 50 hours per week on physical activities lost an average weight of 0.009 (SD= 1.0) kg per year. Both men and women who did not consume alcohol gained an average weight of 0.07

(SD= 1.0), 0.004 (SD= 1.3) kg per year respectively. Men in the first, fourth and fifth quintiles of alcohol consumption lost an average weight of 0.07 (SD= 1.1), 0.001 (SD= 1.0), 0.03 (SD= 1.0) kg per year respectively while only women in the third quintile lost an average weight of 0.02 (SD= 1.0) kg per year. Men lost an average weight of 0.015 (SD= 1.0) kg per year, while women gained an average weight of 0.016 (SD= 1.1) kg per year.

Table 4.5Participants weight change across participants characteristics

	Men (Mean± SD)			Women (Mean± SD)		
	N	Absolute Wt change	P1	N	Absolute Wt change	P1
	6837	−0.02± 1.0	*P1*	11296	+0.02 ±1.0	
Age			0.001			0.001
<50	805	+0.2± 1.0		3025	+0.16± 1.1	
50- <60	3144	+0.07± 1.0		4146	+0.07± 1.0	
60- <70	2359	−0.13± 0.9		3225	−0.10± 1.0	
≥70	529	−0.40± 1.1		900	−0.33± 1.1	

Total E%			0.001			0.001
M:837.4-<2135.6/ W:513.9- <1640.7	1367	−0.08± 1.1		2259	−0.06±1.2	
M:2135.6-<2451.5/ W:1640.7- <1886.4	1368	−0.1± 1.1		2259	−0.04±1.1	
M: 2452.4-<2753.6/ W:1886.4- <2118.7	1367	−0.007± 1.0		2260	+0.01± 1.0	
M:2753.7-<3167.5/ W:2118.7- <2420.9	1368	+0.003± 0.9		2259	+0.02± 1.0	
M:3167.6-≥6585.2/2421.0-≥5467.5ac	1367	+0.10± 1.0		2259	+0.15± 1.0	
BMI			0.001			0.001
≤ 25	2756	+0.25± 0.9		6351	+0.2± 0.9	
25- <30	3365	−0.13± 1.0		3697	−0.13±1.1	
≥ 30	716	−0.5± 1.4		1248	−0.4± 1.6	
Smoking			0.001			0.001
Smoker	1869	0.14± 1.1		2993	+0.15± 1.2	
Former	2870	−0.07± 1.0		3143	−0.03± 1.1	

Never	2094	−0.08± 1.0		5159	−0.03± 1.0	
Education			0.128			0.378
Elementary	2972	+0.01± 1.0		4212	−0.05± 1.1	
Primary& secondary	1362	−0.06± 1.0		3507	+0.01± 1.0	
Upper secondary.	865	+0.01± 1.0		801	+0.06± 1.1	
Further education without	660	−0.04± 1.0		963	+0.03± 1.1	
University degree	965	−0.05± 1.0		1791	+0.04± 1.0	
LTPA			0.001			0.225
<7.5	618	+0.01± 1.2		919	+0.09± 1.3	
7.5-<15	1003	+0.06± 1.1		1643	+0.03± 1.1	
15-<25	1522	+0.03± 1.0		2719	+0.004± 1.0	
25-<50	2453	−0.07± 1.0		4274	+0.01± 1.0	
≥50	1210	−0.04± 1.0		1684	−0.009± 1.0	
Alcohol			0.183			0.608
zero-consumers	244	0.07± 1.0		722	0.004±1.3	

Q1: w:0-<0.9/m:0-<3.4g/day	1214	−0.07± 1.1		1984	0.03± 1.2	
Q2: 0.9-<4.3/3.4-<9.1	1294	0.007±1.1		2092	0.03± 1.1	
Q3: 4.3-<8.1/9.1-<15.7	1389	0.003± 1.0		2085	−0.02±1.0	
Q4: 8.1-<14.0/15.5-<25.7	1358	−0.001±1.0		2220	0.01± 1.0	
Q5: ≥14/≥25.7	1338	−0.03± 1.0		2193	0.03± 1.0	
Male		6837	Absolute wt. change -0.015±1.2		0.05	
Female		11296	Absolute Weight change0.016 ± 1.5			

4.2.4 Association between free sugars intake and weight and BMI change

There was no statistically significant association between the six free sugars intake groups and annual weight change in model I or II. Model III; sensitivity analysis which excluded diet changers and energy misreporters did not change this conclusion. Table 4.6 Summarizes the association between free sugar and annual weight change.

Table 4.6Association between Free Sugars and Annual Weight Change

	Men			**Women**		
free sugar E%	Model I Mean (CI95%)	Model II Mean (CI95%)	Model III Mean (95%CI)	Model I Mean (CI95%)	Model II Mean (CI95%)	Model III Mean (95%CI)
<5E%	0.020 (−0.062- 0.103)	0.032 (−0.054- 0.118)	0.063 (−0.036- 0.162)	0.008 (−0.056- 0.072)	0.023 (−0.044-0.089)	0.086 (0.005- 0.166)
5−<7.5 E%	−0.034 (−0.087- 0.02)	−0.017 (−0.076-0.043)	0.005 (−0.061- 0.071)	−0.026 (−0.069-0.018)	−0.008 (−0.057- 0.041)	0.076 (0.022- 0.131)
7.5−<10E%	−0.031 (−0.077- 0.015)	−0.010 (−0.063- 0.043)	0.002 (−0.055-0.059)	0.007 (−0.030-0.045)	0.026 (−0.018- 0.069)	0.097 (0.050- 0.144)
10−<15E%	−0.006 (−0.047- 0.035)	0.010 (−0.038- 0.058)	0.025 (−0.027- 0.077)	0.053 (0.020- 0.087)	0.064 (0.024- 0.104)	0.111 (0.068- 0.153)
15−<20E%	0.013 (−0.062- 0.087)	0.023 (−0.055-0.101)	0.018 (−0.067- 0.103)	0.025 (−0.040- 0.091)	0.024 (−0.045-0.093)	0.085 (0.012- 0.157)
≥20E%	−0.128 (−0.271- 0.015)	−0.123 (−0.269-0.022)	−0.102 (−0.263- 0.059)	0.107 (−0.016- 0.230)	0.095 (−0.030- 0.220)	0.128 (−0.006-0.262)

P value	0.44	0.47	0.60	0.05	0.15	0.89
P trend	(−)0.21	(−) 0.18	(−)0.15	(+) 0.08	(+)0.29	(+)0.92

The association between free sugars intake and relative annual weight change is presented in Table 4.7. The mean relative annual weight change was not significantly different across the sugar intake groups among men. Among women, the mean relative annual weight change was statistically different in Model I between the 2nd free sugars intake group and the 4th free intake sugars group as well as between the 2nd free sugars intake group and the 6th free sugars group among women. The pairwise comparison showed that the mean difference between the 2nd free intake sugars group (5−<7.5E%) and the 4th free sugars intake group (10−<15E%) was (−0.118) (*p*= 0.003). The mean difference between the 2nd free sugars intake group (5−<7.5E%) and the 6th free sugars intake group (≥20E%) was (−0.219) (*p*= 0.022). Another difference appeared between the 3rd free sugars intake group (7.5− <10E%) and 4th free sugars intake group (10− <15E%). The mean difference was (−0.074) (*p*= 0.043). The significance disappeared in Model II and the sensitivity model (Model III).

Table 4.7 Association between free sugars & relative annual weight change

	Men Mean (95% CI)			**Women Mean (95% CI)**		
Sugar (E%)	Model I	Model II	Model III	Model I	Model II	Model III
<5	0.073 (−0.028- 0.173)	0.087 (−0.018- 0.191)	0.113 (−0.011-0.236)	0.058 (−0.034- 0.150)	0.086 (−0.009- 0.182)	0.170 (0.050-0.289)
5−<7.5	0.002 (−0.063- 0.068)	0.026 (−0.047- 0.099)	0.041 (−0.041-0.123)	0.018 (−0.045-0.08)	0.052 (−0.018- 0.122)	0.163 (0.083- 0.244)
7.5−<10	0.004 (−0.052- 0.061)	0.032 (−0.033- 0.096)	0.040 (−0.031- 0.112)	0.062 (0.008-0.116)	0.096 (0.034- 0.159)	0.187 (0.118-0.256)
10−<15	0.031 (−0.019- 0.081)	0.052 (−0.007- 0.111)	0.062 (0.003- 0.127)	0.136 (0.087- 0.184)	0.158 (0.101- 0.216)	0.212 (0.149- 0.274)
15−<20	0.064 (−0.027- 0.154)	0.076 (−0.020-0.171)	0.062 (−0.044- 0.167)	0.109 (0.015- 0.203)	0.110 (0.011- 0.209)	0.165 (0.058-0.272)
≥20	−0.082 (−0.257- 0.093)	−0.077 (−0.255- 0.101)	−0.096 (−0.296- 0.103)	0.236 (0.060- 0.413)	0.217 (0.038- 0.397)	0.240 (0.042-0.438)

P	0.53	0.61	0.62	0.02	0.11	0.88
P trend	(−) 0.26	(−) 0.21	(−)0.14	(+)0.01	(+)0.11	(+)0.88

The association between free sugars intake and annual BMI change is summarized in Table 4.8. There was no significant difference between the free sugars intake groups and BMI change among men. Among women, the BMI change was significantly different between 2nd and 4th free sugars intake groups where the mean difference is (−0.025) (p= 0.05). There was also significant difference between the 2nd and 6th free sugars intake groups where the mean difference is (−0.047) (p= 0.029). The significance disappeared in the sensitivity model (Model III).

Table 4.8Association between Free Sugars and Annual BMI change

	Men Mean(95%CI)			**Women** Mean(95%CI)		
Free sugar E%	Model I	Model II	Model III	Model I	Model II	Model III
<5E%	0.006 (−0.017- 0.029)	0.010 (−0.014-0.034)	0.019 (−0.009−0.046)	0.004 (−0.016-0.025)	0.008 (−0.013-0.030)	0.030 (0.004-0.057)
5−<7.5 E%	−0.008 (−0.023- 0.007)	−0.003 (−0.019-0.014)	0.002 (−0.017−0.020)	−0.007[a] (−0.021-0.007)	−0.002 (−0.017-0.014)	0.026 (0.008-0.043)
7.5−<10E%	−0.008 (−0.021-0.005)	−0.001 (−0.016-0.013)	0.001 (−0.015−0.17)	0.003 (−0.009-0.015)	0.008 (−0.006-0.022)	0.031 (0.016-0.046)
10−<15E%	−0.001 (−0.012- 0.011)	0.004 (−0.009-0.018)	0.008 (−0.007-0.023)	0.018[+a] (0.007-0.029)	0.021 (0.008−0.034)	0.036 (0.022-0.050)
15−<20E%	0.004 (−0.017- 0.025)	0.007 (−0.014- 0.029)	0.005 (−0.019-0.029)	0.010 (−0.012−0.031)	0.009 (−0.013−0.031)	0.027 (0.004-0.050)
≥20E%	−0.033 (−0.073−0.007)	−0.030 (−0.071-0.010)	−0.026 (−0.071-0.019)	0.040[+a] (−10.232-0.079)	0.035 (−0.005-0.075)	0.044 (0.001-0.087)
P	*0.51*	0.55	0.61	0.05	0.15	0.90
P trend	(−)0.22	(−)0.19	(−)0.16	(+)0.06	(+)0.24	(+)0.96

The general trend was that free sugars intake seemed to have a negative yet not significant association with annual weight change, relative annual weight change and annual BMI change among men. Meanwhile, free sugars intake had a positive yet not significant association with annual weight change, relative annual weight change and annual BMI change among. The results remained the same in the sensitivity analyses (Model III).

4.3.5 Association between free sugars intake and risk of developing overweight among normal weight individuals at follow-up

The association between free sugars intake and the risk of becoming overweight among normal weight men is summarized in Table 4.9. The results showed that there was no statistically significant association between free sugars and the risk of becoming overweight among normal weight men (HR by % free sugar subgroups 1.0, 0.83 (95% CI 0.5- 1.2), 0.87 (95% CI 0.6-0.3), 0.81 (95% CI 0.5-1.2), 0.95 (95% CI 0.6-1.5), 0.70 (95% CI 0.3-1.5), p trend= 0.65. The risk estimates are derived from the multivariable model. The results did not change when energy misreporters and diet changers were removed from the analysis (p trend= 0.9).

Table 4.9 Association between free sugars and risk of becoming overweight among normal weight men

	Male HR 95% CI					
	Model I	**P value**	**Model II**	**P value**	**Model III**	**P value**
<5E% (ref)	1	-	1		1	
5−<7.5 E%	0.81 (0.5-1.2)	0.317	0.83 (0.5- 1.2)	0.386	1.1 (0.7-2.0)	0.623
7.5−<10E%	0.85 (0.5- 1.2)	0.419	0.87 (0.6-1.3)	0.483	1.2 (0.7-2.0)	0.449
10−<15E%	0.82 (0.5- 1.2)	0.307	0.81 (0.5-1.2)	0.298	1.1 (0.6-1.8)	0.772
15−<20E%	0.97 (0.6-1.5)	0.900	0.95 (0.6-1.5)	0.821	1.3 (0.7-2.3)	0.414
≥20E%	0.78 (0.3- 1.5)	0.458	0.70 (0.3-1.5)	0.399	1.0 (0.4-2.4)	0.974
P trend	0.88		0.65		0.90	

The risk of becoming overweight among normal weight women is summarized in Table 4.10. The results showed that there was a statistically significant inverse association between three groups of free sugars (3rd, 4th, 5th) and the risk of becoming overweight among normal weight women (HR by % free sugar subgroups 1.0, 0.80 (95% CI 0.6- 1.05), 0.7 (95% CI 0.5- 0.9), 0.7 (95% CI 0.5-0.9), 0.7 (95% CI 0.4- 0.9), 0.8 (95% CI 0.5-1.4). However, the significance disappeared when misreporters and diet changers were removed from the analysis (p trend= 0.47). The risk estimates are derived from the multivariable model.

Table 4.10 Association between free sugar and risk of becoming overweight among normal weight women

	Female HR 95% CI					
	Model I	**P value**	**Model II**	**P value**	**Model III**	**P value**
<5E% (ref)	1	-	1		1	
5−<7.5 E%	0.81 (0.62-1.0)	0.124	0.80 (0.6- 1.0)	0.116	0.96 (0.6-1.4)	0.826
7.5−<10E%	0.77 (0.6-0.99)	0.046	0.7 (0.5- 0.9)	0.031	1.0 (0.7-1.5)	0.929
10−<15E%	0.75 (0.6-0.97)	0.028	0.7 (0.5-0.9)	0.011	0.9 (0.6-1.2)	0.464
15−<20E%	0.76 (0.5- 1.0)	0.096	0.7 (0.4- 0.9)	0.026	0.8 (0.5- 1.3)	0.433
≥20E%	0.98 (0.6- 1.6)	0.946	0.8 (0.5-1.4)	0.554	1.2 (0.7- 2.3)	0.489
P trend	0.17		(-) 0.03		0.47	

The number of normal weight men who became overweight/ obese at follow up according to their free sugars intake categories is summarized in Table 4.11. The results showed that among men, the lowest intake group of free sugars (<5E%) had the highest percentage of men who became overweight at follow up 17.5% while in the highest intake group (≥20E%), only 12.2% became overweight.

Table 4.11 No. of normal weight men who became overweight/ obese at follow up

Male	Normal Wt. N (%)	Overweight N (%)	Obese N (%)
<5E%	155 (82.4%)	33 (17.6%)	0
5-<7.5E%	396 (83.9%)	76 (16.1%)	0
7.5-<10E%	608 (84.8%)	107 (14.9%)	2 (0.3%)
10-<15E%	871 (86.7%)	133 (13.2%)	1 (0.1%)
15-<20E%	248 (84.9%)	41 (14.0%)	3 (1.0%)
≥20E%	72 (87.8%)	10 (12.2%)	0

The number of normal weight women at baseline who became overweight/ obese according to free sugars intake categories is summarized in Table 4.12. The same observation was also reported among women, where women in the lowest free sugars intake (<5E%) had the highest percentage of women becoming overweight (15.4%) at follow up. In the highest sugar intake group (≥20E%), only 11.9% women became overweight.

Table 4.12Number of normal weight women who became overweight/ obese at follow up.

Female	Normal Wt. N (%)	Overweight N (%)	Obese N (%)
<5E%	435 (84.0%)	80 (15.4%)	3 (0.6%)
5-<7.5E%	1067 (87.8%)	146 (12.0%)	2 (0.2%)
7.5-<10E%	1471 (87.7%)	205 (12.2%)	1 (0.1%)
10-<15E%	1952 (89.1%)	237 (10.8%)	2 (0.1%)
15-<20E%	527 (89.3%)	62 (10.5%)	1 (0.2%)
≥20E%	140 (87.5%)	19 (11.9%)	1 (0.6%)

RESULTS

Part II

4.1 Introduction

The second part of this chapter discusses the results of the qualitative analysis of challenges facing the Palestinian decision makers with regards to reducing free sugar intake in Palestine. The analysis of the transcribed interviews resulted in three overarching themes which reflected the language, concepts and personal experience repeatedly mentioned in the interviews. The three broad emerging themes are Economic Barriers, Health Literacy, Regulations/ Laws. The overarching themes include a number of subthemes. The theme Economic Barriers includes three subthemes; these are; poverty or low Socioeconomic Status, lack of resources and food industry opposition. The theme Health Literacy includes two subthemes these are; lack of public health literacy and lack of expertise. The last theme, Regulations/ Laws includes two subthemes, these are; Internal Regulations/ Laws and Lack of Legal Jurisdiction The following part describes the overarching themes and subthemes.

4.2 Economic barriers

The first overarching theme that describes challenges facing the Palestinian decision makers with regards to restricting unhealthy dietary intakes is economic barriers. The theme economic barriers included concepts which describe challenges pertaining to the Palestinian society as a whole as well as economic constraints on the health organizations. These concepts or

subthemes are poverty or low Socioeconomic Status, lack of resources and food industry opposition. The following section discusses each of these sub- themes in turn.

4.2.1 Poverty/ low Socio-Economic Status

The issue of poverty and low Socioeconomic Status, (SES) was highlighted as a principle challenge that prevents people, especially young children from purchasing more healthy foods or drinks. According to one participant, children mainly in poor areas always choose to buy cheap products mainly fruit drinks which is often energy dense because it is affordable to them; as mentioned in the text below:

> *"For example, we found that all students whenever they buy something, they also buy juice because it is cheap (…) mainly among elementary school students whose their daily allowance does not exceed One Shekel which they use it to buy a snack and juice……We also instruct the [school canteen] contractor to sell products at the market price because we want to be fair to the student" [Education Ministry interviewee]*

As indicated by one of the interviewees, although some healthier food or drink options might be available for purchase, economic barriers mainly poverty can prevent the consumer being an adult or a child from purchasing them.

"For example, some products imported from Saudi Arabia are high in fruit which is better than locally produced products but the price is different [higher]" [Education Ministry interviewee]

According to the interviewee this issue is very important to keep in mind when even attempting to introduce new products or propose amending food/ beverage recipes to the food industry. As indicated by the interviewee while they press the local food industry to improve the quality of the product, it is often challenging because better quality means higher price which many children cannot afford.

"The problem is that whenever you improve the quality of the product, the student cannot buy it. For example, we have juice products which are high in Nectar but they cost 2 shekels and in many areas the student cannot buy it" [Ministry of Education interviewee]

4.2.2 Lack of resources

Another challenge that emerged from the interviews is lack of resources both financial and manpower available to the ministries to implement health initiatives. During the interview with the education ministry, the participant explained that schools do not have special allocations from the government and therefore their budgets are very limited which also limit their ability to make any improvements, as mentioned in the text below:

> *"We rely on the school budget which includes the student tuition fees and the school canteen deposit. As you know the government does not have financial allocations for schools. The ministry provides us with some funding which we use for many things like purchasing equipment for school canteens. We also try if we have external funding projects to renovate the canteens especially in old schools" [Education Ministry interviewee].*

As indicated by the interviewee's own words, public schools in Palestine have limited financial resources which hinders their ability to make improvements as they wish. This lack of resources also extends to manpower who can work on new public health initiatives. In one interview the participant asked if the research study could help provide them with information about the most consumed sugary products which they could use in preparing their studies.

> *"We cannot work on everything at the same time. If your study can tell us what are the most consumed sugary products please let us know" [Health Ministry interviewee].*

According to the participants, the lack of manpower or financial constraints prompted them to make work priorities as they cannot work on many issues at the same time:

"We cannot work on everything at the same time, we need to have priorities so we chose to work with salt intake" [Health Ministry interviewee].

"Every year we have new work priority, so we focus on the consumption of sausages and canned/ processed meat" [Education Ministry interviewee].

The participants also stressed that they need to work on one subject at a time or make work priorities for fear of "war" waged by the food industry as will be highlighted in the following section.

"We have some results regarding sugar but we cannot announce them or we will enter into war with the factories" [Education Ministry interviewee]

During the interview with an interview from the Palestinian Standards Institution, the lack of material and personnel experience was also highlighted as one of the challenges facing the Palestinian health ministry to perform tests on products as mentioned below:

*"Although the Palestinian health ministry central laboratories often have the main equipment, the kits needed to test a product are in many times unavailable; so, they need to order them which takes time" [*Palestinian Standards Institution interviewee*]*.

4.2.3 Food industry opposition

The issue of food industry opposition to any proposed health initiatives was highlighted and stressed on by all participants as a major challenge to health initiatives. The food industry opposition was the most frequently emerging concepts in the interviews which was frequently used with the term "war" to indicate the ferocity of the objection to any new initiatives

> *"We face a lot of difficulties with the Federation of National Industries and factories. They wage a war against us and accuse us of harming national economy……The factories wage a war against us… They threaten us of resorting to courts……. Every time a new minister of education or minister of economy is appointed, they [food industry] file complaints against us" [Education Ministry interviewee]*

> *"We have a problem with the [food/ beverages] industry. Every time we impose new regulations we must talk to the industry. We spoke to them, but they did not implement anything…… Then the importer [food] will file complaints against the Ministry of Health claiming they cannot import due to our instructions" [Health Ministry interviewee]*

The participants agreed that the biggest challenge came from local food industry, however when the question was asked about imported products; one participant believed the challenge is bigger because imported products

are often destined for the entire Arab world and not only for Palestine. According to the participant, even if the Palestinian regulations conform with international health standards, it is difficult to make the same guidelines for imported ones:

> *"We proposed to the sugary beverages companies to adjust the recipe and reduce their content of sugar, but they said no, because this is a prepared recipe to the entire world not only Palestine……. We have bigger challenge with imported products because the importers say the product is produced for the entire Arab region therefore, if we change the recipe, either the change must be for the entire region or open a special production line for Palestine and thus increase the cost. Then the importer will file complaints against the Ministry of Health claiming they cannot import due to our instructions" [Health Ministry interviewee]*

However, another participant saw that imported products are some times better than locally produced ones and meet better health guidelines which creates good opportunity for more healthy snacks and a positive challenge to encourage the local food companies to try and produce similar products.

> *"For example, some products imported from Saudi Arabia are high in fruit which is better than locally produced products but the price is different [higher]" [Education Ministry interviewee].*

The fact that the participants had opposite views with regards to imported products where one participant saw it as a challenge while the other as an opportunity indicate that when evaluating any new public health initiative, it is important to take all these perspectives and feedbacks and to consider their benefits as compared to their negative impact so that the approach is more holistic.

4.3 Health literacy

The second subtheme that emerged from the interviews is Health Literacy. According to the United States Department of Health and Human Services, also known as the Health Department (HHS for short) health literacy is the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions (HHS, 2010). The theme health literacy included two subthemes; these are lack of public health literacy and lack of expertise.

4.3.1 Lack of public health literacy

The issue of knowledge and information regarding healthy lifestyle and diet as a challenge for public health initiatives was not only because of the consumers but also included lack of knowledge regarding intervention mechanisms among decision makers. The participants used different concepts to refer to lack of public health awareness among the general public some were direct like referring to examples of prevalent unhealthy

behavior while others were indirect by emphasizing the importance of raising the public awareness or involving parents of school students in healthy related activities.

> *"One of the programs we work with through the department of health education in the Ministry of Health or us through local media or through the ministry of education is raising awareness about the importance of reducing free sugar in home- made products or sugar added to tea for example…… Unfortunately, we face two problems people do not how to read the nutrition label. I mean even if they read it, they do not know if these levels are harmful or not" [Health Ministry interviewee].*

"We also have a survey to measure student behavior which shows that students do not have proper physical activity and tend to eat unhealthy snacks….We also have curricular and extracurricular activities to change the students' knowledge and behavior and we involve the parents, because it not helpful to provide healthy food for the student but cannot select it" [Education Ministry interviewee]

"Sometimes we have guidelines on the maximum amount of a certain material in a product, however overconsumption due to lack of health awareness leads to negative consequences" [Palestinian Standard Institution interviewee].

4.3.2 Lack of expertise

The second subtheme that was collided under the theme of health literary extended to the ministry's lack of knowledge regarding the best way to intervene and reduce free sugar intake which could be in part attributed to the fact that yet again free sugar is not a working priority for them and which needs further investigation.

> *"We are not sure, what is the minimum level that provides the same palatability and same price but does not affect sales…..We are yet not sure how to intervene. Should we look at artificial sweeteners which give taste but are not absorbed by the body or should we reduce sugar added to by manufacturer" [Health Ministry interviewee]*

The other challenge that could be collided under the subtheme of lack of expertise extends to the lab technicians working in the Palestinian health ministry central public health labs to carry out tests for products.

"The lab technicians need more capacity building and training to perform the tests" [Palestinian Standard Institution interviewee].

4.4 Regulations/ Laws

The last theme that emerged from the interviews is regulations or laws. This theme included two subthemes; the first internal regulations/ laws and the second is lack of legal jurisdiction.

4.4.1 Internal regulations/ Laws

Throughout the interviews, the participants emphasized the importance of having clear, concise and deterrent laws whether regarding the marketing of sugar sweetened beverages or unhealthy snacks to the general public and children in particular or regarding foods available in the market at large.

> *"In Palestine, the market is open….. The law in the country is the thing that controls everything…….All these laws need to be made by decision makers to take action" [Education Ministry interviewee]*

The other concept that could also be part of the regulations or laws is the diversity of bodies that govern schools in Palestine and/ or food services at school canteens which needs harmonization between all these actors to reach common law. In Palestine, the school system is unique in the sense that it is governed by more than one party, these include the ministry of education and UNRWA. Even within the ministry of education, different departments are responsible to follow up with school canteens in public and private schools.

> *"We do not follow up on them [UNRWA schools] meaning I do not visit an UNRWA school to follow up on the foods available in their canteens……..UNRWA schools have different system to run their school canteens. They do not have [outside] contractor, they have self - management meaning the school runs the canteen……..What controls private schools is the price. You will find that the school*

principal allies with the [school canteen] contractor because they share [financial] interest meaning the contractor in private schools pays more [insurance] and they do not have contract like in public schools" [Education Ministry interviewee]

According to one participant, the fact that there are few regulations regarding foods available in the local markets strengthens the food industry argument that these foods are already available in the market so why limit them in schools.

"The national committee for foods which puts the technical guidelines concerning which foods enter the market. Now regarding sugary beverages, it allows them. The limitations are only placed in our public health school canteens…….The factories [food industry]always argue that the foods are allowed in the country [market], so why do you prevent them in schools……..The problem is with the factories which say the product is already available in the market" [Education Ministry interviewee]

4.4.2 Lack of legal jurisdiction

The last subtheme describes the Palestinian Authority's lack of legal jurisdiction over its external or internal borders due to the Palestinian-Israeli political reality. In the interview with the Palestinian Standards Institution, PSI, the participant explained how the Palestinian authority's inability to control material imported for the Palestinian market constitutes

a major challenge to deciding the type of material or products consumed by the Palestinian public as mentioned below:

> *"Another obstacle is lack of control over Palestinian borders. Israel is responsible for the borders. As Palestinians we do not have control over our borders. Israel controls the borders and the material that enters" [*Palestinian Standards Institution interviewee*]*.

According to the participant, this means that although the Palestinian authorities might have guidelines for products that should be consumed by the Palestinian public, Israel could allow material that do not conform with the Palestinian standards for imports to enter the Palestinian market as mentioned below:

> "*Israel has different standards for material that enters the Palestinian markets than those destined for the Israeli market. I mean even if we have guidelines we do not control things that enter*" [Palestinian Standards Institution interviewee]

Moreover, according to the interviewee, dividing the West Bank into three areas, Area A, B and C which have different legal jurisdictions as well as civilian and military control systems and authorities represents a major challenge because importers can smuggle material that does not conform with the Palestinian standards simply because they have businesses in areas that do not fall under the Palestinian legal jurisdiction as indicated below:

*"The West Bank division into Areas A, B and C is a major obstacle to controlling material that enters the Palestinian market whether imported from abroad or even from Israel. For example, merchants in Area C sometimes do not apply for import license from the Palestinian authorities under the pretext that they operate in areas outside their jurisdiction" [*Palestinian Standards Institution interviewee*]*.

According to the interviewee, one way to combat the smuggling of material into the Palestinian territories has been the forming of Public Safety Committees which include representatives from the Palestinian ministries of health and economy as well as customs control and the local governorates because each Palestinian governorate has its own unique situation which depends on its location in Areas A, B or C or its proximity to the Israeli territories.

> "*We have the ...mmmm.. Public Safety Committees which ... mmmm include not only the ministries of health and economy but ... mmm the custom control and the governorate because each Palestinian governorate has its own circumstances which differs from other governorates… So you have to be creative when you try to find a solution*" [Palestinian Standards Institution interviewee]

CHAPTER V
DISCUSSION
Part I

5.1 Introduction

This chapter discusses the main findings from the two studies' results within context of previous literature. As with the rest of the thesis, the chapter is divided into two parts. Part I discusses the main findings from the quantitative study while part II discusses the main findings from the qualitative study. This part, part I starts by attempting to interpret the results from investigating the association between free sugars intake and weight change; including factors that may have affected this association. Then it attempts to interpret the results from examining the risk of becoming overweight among normal weight persons based on their free sugars intake. Each part concludes by presenting the strengths and limitations for both studies as well as recommendations for future studies.

5.2 The association between free sugars intake and weight/ BMI change:

The results showed that there was no statistically significant association between the free sugar intake categories and annual weight change, relative annual weight change and BMI change. Excluding misreporters and diet changers did not change this conclusion.

Our results are in concordance with previous studies. Colditz et al., (1990) studied the association between sucrose intake among 31940 female nurses

in the US and subsequent weight change. The authors found no statistically significant association with weight gain after four years of follow up.

Another study by Halkjaer et al., (2004) included 2275 Danish adults found no relation between sweet foods consumption and waist circumference after six years of follow up. The same results were also observed in a study by Hendriksen et al., (2011) which included 11,111 adults in Holland. The authors found no association between sweets and cakes intake and weight change. The follow up period in the study by Hendriksen and colleagues ranged from 4.9 to nearly 10 years.

Kvaavik, Andersen and Klepp (2004) studied the association between long term intake of Sugar Sweetened Soft Drinks, SSSD and the prevalence of overweight or obesity after 8 years of follow up. The authors found no association between long term consumption of SSSD and overweight or obesity.

Meanwhile, Halkjaer et al., (2006, 2009) studied the association between intake of hams, syrups or SSSD among 20,126 men and 22,570 women in Denmark and change in waist circumference (WC) after 5 years of follow up. The authors observed that the intake of jams, syrups, sugars, or SSSD was not associated with change in WC in women or men. However, energy intake from foods with free sugar at baseline was significantly associated with a 5- year increase in waist circumference in women only. Parker et al., (1997) found no association between intake of sucrose and sweets at baseline and weight change at follow up among 465 adults after four years

of follow up. Moshtaghian et al., (2016) found no significant different BMI change between free sugar categories despite reporting a lower energy intake in the lowest free sugar category. The same results were also observed in South African, British, and Australian studies where there were inconsistencies between trends of BMI and energy intakes across the different free sugar (E%) categories (Gibson, 2001; Cobiac et al., 2003).

There are several explanations for our results, including characteristics pertaining to the MDC cohort age group and other variables that may have affected the association between our main exposure and outcome. The following section attempt to disentangle these associations within the existing literature:

5.2.1 Age:

People over the age of 60 lose weight in the form of muscle mass mainly due to reduced physical activity, which is accompanied by reduced basal energy requirement (Marcell, 2003; Weyer et al., 1999). They also, on average, accumulate more fat mass in the abdominal region (Borkan et al., 1985; Seidell et al., 1988). According to Tang Fui and colleagues (2014) declining testosterone and growth hormone levels in combination with declining rates of lipolysis of visceral fat with aging may play a role in men. Seidell et al., (1990) found that low testosterone levels in men and estrogen levels after menopause in women were associated with increased visceral fat mass. This increase in abdominal fat mass, increases waist circumference without changing body weight (Gallagher et al., 2000).

Further, many older adults experience a decrease in appetite. Between 15% and 30% of older people are estimated to have anorexia of ageing; with higher rates in women, nursing home residents and hospitalized people (Malafarina et al., 2013). Reduced appetite can lead to reduced food and nutrient intake (Payette et al., 1995), increases risk of weight loss and nutritional deficiencies (Wilson et al., 2005). Older adults may find it hard to regain the lost weight (Roberts et al., 1994).

Changes associated with age makes interpreting epidemiological data based on anthropometric measurement to differ across different age strata (Seidell and Visscher, 2000). For instance, a 20 years old man with BMI of 30 kg/m2 has 24.4% body fat, whereas an 80 years old man with the same BMI has 38.8% body fat. Moreover, women have a much larger relative fat mass than men at every age and level of BMI.

According to Seidell and Visscher (2000) the prevalence of obesity is highest among subjects aged 50 – 65 years, then levels off and subsequently declines. The authors propose several explanations for this; including selective survival where obese young and middle-aged persons have prematurely died; old people come from cohorts in which obesity was less common also known as cohort effect; and finally, the fact that people start to lose weight after the age of 60 years. According to the authors all three possibilities are likely to play some role, but their exact quantitative contribution has not been studied systematically yet. Van Leer et al., (1992) and Launer et al., (1994) explained that changes associated with aging such

as a decline in stature even when weight is maintained in all people, would lead to an increase in the prevalence of obesity with aging.

Visser and Harris (2015) concluded that the BMI is not an optimal indicator of body composition in the elderly while Allison et al., (2001) speculated that the U-shaped relation between BMI and mortality resulted from an inverse linear association between lean body mass and mortality and a positive association between body fat mass and mortality; while the BMI does not allow separation of these two phenomena. Seidell and Visscher (2000) recommended that because of the redistribution of body fat with aging, BMI would be a poor indicator of both overall fatness and abdominal fatness while waist/ hip circumference ratio and, more recently, waist circumference alone have been recommended as better indicators of abdominal fatness than BMI.

The age range of the MDC cohort at baseline was 44.5- 73.6 years old for women and 45.4- 73.4 years old for men. As many as 38.7 % of the MDC cohort, (36.5% of women and 42.2% of men) were over the age of 60 years old. Moreover, women gained an average 0.016 kg per year while men lost an average 0.015 kg per year. Therefore, it is possible that the weight change in both men and women is related to advancing age rather than influenced by their diet or sugar intake. This thesis would have benefited from including WC change as predictor of body fatness than the sole reliance on weight/ BMI change.

5.2.2 Social and lifestyle confounder

Body weight changes including overweight and obesity have multifactorial etiology (Kumanyika et al., 2002). Genetic inheritance, multiple environmental factors and several components of lifestyle and sociodemographic variables all might possibly contribute to weight change (Gerace and George, 1996). Body weight change may be separately influenced by demographic, lifestyle and psychosocial factors which could also differ between men and women (Chiriboga et al., 2008). The intensive data collection method used in the MDC study allowed to adjust and asses the association between these factors and our outcome variable including smoking, alcohol intake, education, LTPA and education.

5.2.3. Smoking:

The results showed that both men and women smokers gained weight while former and those who had never smoked lost weight. The results contradict with previous studies which found an inverse association between smoking and body weight (Kvaavik et al., 2004; Chiriboga et al., 2008).

The general consensus is that smoking is associated with weight loss, while smoking cessation is associated with weight gain (Meltzer and Everhart, 1996). The mechanisms are apparently both physiological; where the cigarettes nicotine yield seems to be associated with increased resting energy expenditure (Collins et al., 1996) as well as psycho- behavioral where smoking cessation leads to increased appetite (Miyata et al., 1999).

In the present study, only men and women smokers experienced weight gain while never and former smokers lost weight. Our sample population are mainly elderly, therefore coupled with reduced physical activity due to age or an underlying health complication including chronic obstructive pulmonary disease that the author did not account for have all led to positive energy balance and subsequent weight change. Moreover, it is also common that smoking is associated with a cluster of unhealthy or fattening behavior which often include increased alcohol consumption, eating in front of the TV and opting for unhealthy diet which in our case does not necessarily included free sugars; have all contributed to the weight gain (Linardakis et al., 2013; Shawna et al., 2014).

The results also showed that former smokers have lost weight which also contradicts with the literature. However, a study by Munafo and colleagues (2009) found that cigarette smokers who achieve long-term abstinence may revert to a mean BMI roughly equivalent to that of never-smokers. However, since the author does not have information on the date of smoking cessation, this observation cannot be confirmed. Moreover, the study was conducted only on men, therefore the author cannot generalize its findings to our female sample.

5.2.4. Alcohol consumption:

The results showed that all zero consumers gained weight which is consistent with another prospective study conducted by Wang et al., (2010). Alcohol is identified as a risk factor for obesity by decreasing the

body's capacity to oxidize lipids leading to a positive energy balance (Schutz et al., 1989) and increasing appetite for high fat diet (Suter et al., 1997). The effect of alcohol on body weight depends on several factors including age (Meier and Seitz, 2008) gender, body weight (Gordon and Kannel 1983), food ingested with alcohol, genetic factors (Suter, 2005), physical activity, the drinking pattern i.e. frequency and amount consumed and whether alcohol is taken alone or with food (Suter, 2005).

Suter and colleagues (1997) proposed that unlike other sources of energy, alcohol cannot be stored in the body and appears to have absolute priority in metabolism. Alcohol contributes more easily to weight gain among consumers on high-fat diet than alcohol consumers with a lower dietary fat intake mainly because alcohol suppresses fat oxidation rate which leads to a positive energy balance. The non-oxidized fat is deposited in the abdominal area (Gonzalez et al., 2000). Although the mechanism by which alcohol specifically enhances abdominal fat deposition is not completely understood, it has been proposed that alcohol-induced endocrine changes may be of central importance. A study by Sakurai et al., (1997) found an association between alcohol and Waist/Hip ratio but not with the BMI. Another study by Nooyens et al., (2004) reported that drinking alcoholic beverages and walking were related to change in waist circumference, but not to changes in body weight. However, the effects of alcohol on abdominal obesity depends on several factors including the type of the alcoholic beverage and the food ingested with it. The type of alcohol consumed have different effects on adiposity. Duncan and colleagues

(1995) proposed that beer promotes abdominal fat distribution while wine may even have an inverse effect. Moreover, epidemiological studies suggest that calories from alcohol enhances weight gain in overweight persons, but not in lean subjects (Clevidence et al., 1995). With almost half of the MDC cohort being overweight or obese at baseline, it might be possible that alcohol has contributed to the weight change seen; however, it may not be sufficient to explain the entire weight change observed whether reduced weight among men or gained weight among women, not only due to other factors associated with alcohol itself, but factors associated with weight change which the author did not account for in our analysis like other dietary intakes.

Moreover, gender plays a vital role in alcohol absorption and metabolism (Wardlaw, 2003).

Although this thesis could have benefited from information regarding other dietary factors that could have contributed to the weight change among our study group i.e. fat and protein, or factors associated with alcohol consumption other than quantities, however it was not possible to investigate this for the purpose of this thesis, unfortunately. However, since the main aim of this thesis is to measure if there is an association between free sugars consumption and weight change after nearly 5 years of follow up, rather than predictors of weight change, those factors remain outside the scope of this thesis.

Therefore, it is that in men, caloric intake either from alcohol, sugar or any unaccounted dietary source was not enough to cause positive energy balance or that they were physically active that they burned the excess calories, while in women the caloric intake from sugar or alcohol was high enough that it caused positive energy balance leading to weight gain. Furthermore, similar to free sugar, it is possible that whatever effect alcohol had on body weight our adiposity indices i.e. annual weight change, relative annual weight change and BMI change were incapable to capture it. This thesis would benefit from an analysis of waist circumference change instead of relying only on weight change.

5.2.5. Leisure Time Physical Activity (LTPA):

The results showed that active men lost weight while only most active women lost weight. It is possible that men in the first three quintiles of LTPA have retired from active jobs which led to an increase in their body weight. Nooyens and colleagues (2004) found that after retirement an increase in weight and waist circumference were associated with a decrease in several physical activities, such as household activities, bicycling, walking and doing odd jobs. The weight loss observed among the active men and only most active women may not have been caused by increased activity, per se, since weight loss by itself could also lead to increased activity levels (Williamson, 1996). In other words, it is possible that the participants may have lost weight partly due to their participation in the MDC study which led to increased physical activity (Wickstrom and

Bendix, 2000). The lack of difference between LPTA quintiles with regards to weight change among women could in part be explained by the fact that behavioral changes associated with retirement including physical activity have more effect on fat distribution than they have on total fat storage (Williamson, 1996). This thesis would benefit from including information regarding LTPA change at follow up.

5.2.6. Education:

The results showed that education was not significantly different among men and women with regards to weight change. Although the literature indicates that the variables included in the present study are associated with weight change, they only explained 7% of the variance in the fully adjusted models (r^2= 0.07) suggesting that they had weak to no influence on our outcome of interest. Moreover, a multivariable model which included these variables that were weakly measured could produce attenuated estimates between exposure and outcome, especially using self- reported data. While weight and height were directly measured using standardized procedures in the MDC study, alcohol consumption, smoking, LTPA and education were self- reported and therefore the author cannot rule out possible biases.

5.2.7 Other dietary intakes not accounted for in the study

Weight is multifactorial and is influenced by other dietary intakes like protein, fat or other carbohydrates. Protein provides 4 kcal/ g while fat

provides 9 kcal/g (Wardlaw, 2003). Of the three macronutrients, protein is known to be the most satiating with a higher diet-induced thermogenesis and possibly a greater energy expenditure (Mikkelsen et al., 2000) making it the main macronutrient in diets used for long-term body weight regulation (Paddon-Jones et al., 2008). A study by Due et al., (2004) showed that ad libitum diets (that is, with no strict control of food intake), the high-protein diet group who consumed 25% of energy from protein and 30% of energy from fat had a greater weight loss and abdominal fat loss after 6 months including persistent abdominal fat loss after 12 months compared to the low/medium high-protein diet group consuming 12% of energy from protein and 30% of energy from fat. Another study by Chiriboga and colleagues (2008) revealed that the percentage of calories from protein was associated with weight loss while total caloric intake and percentage of calories from fat were associated with weight gain.

Meanwhile, Lissner, Heitmann and Bengtsson (2000) and Koh-Banerjee et al., (2003) found direct association between fat intake and weight change. Another study by Drapeau et al., (2004) found that the intake of fat and fatty foods was positively associated with waist circumference. Fat contributes to weight gain mainly abdominal obesity if consumed along with alcohol which inhibits fat oxidation (Suter et al., 1997) or if included in diet with food items with high glycemic index like refined grains and potatoes (Brand-Miller et al., 2002; Ludwig, 2000).

Previous studies also revealed that due to their low energy density, high water content and fiber; fruits and vegetables could be related to weight control despite their content of fructose (Rolls et al., 2004). Nooyens et al., (2004) reported that weight gain and increase in waist circumference were associated with a decrease in fruit consumption and fiber density of the diet. A study by Halkjær et al., (2006) found that carbohydrate energy from fruit and vegetables was inversely associated with difference in waist circumference whereas carbohydrate energy from all other food groups was positively associated with subsequent difference in waist circumference. The associations were significantly stronger in women than in the men, but in the same direction. The most commonly used dietary guidelines in the 1990s recommend a diet low in total fat and high in carbohydrates from fruit and vegetables and grain products (Skerrett and Willett, 2010). Yet, Halkjær et al., (2006) suggested that the focus should not necessarily be on the ratio between types of fat and carbohydrate but also on the types of protein.

Other studies have also reported a strong association between total energy intake and weight change indices including BMI change and weight change (Mullie et al., 2017). This association suggests that adiposity is caused mainly by the imbalance between energy intake and expenditure. In this sense, the consumption of free sugar whether in the form of solid foods or drinks contributes to weight gain mainly due to its energy content just like any other food or caloric beverages rather than a specific mechanism.

In conclusion, the effect of a single nutrient might be too small to detect and therefore it might be more beneficial to study diet as a whole rather than single macro/ micronutrients in order not to neglect the possible metabolic interactions between different compounds within a specific food item (Halkjær et al., 2009).

From a public health perspective, it might be more beneficial to identifying food groups or patterns that predict weight changes which in turn could lead to improving the dietary guidelines over those based on nutrients.

5.3 Association between free sugars intake and risk of developing overweight among normal weight individuals at follow up

There was no statistically significant association between the amount of free sugars and the risk of becoming overweight among normal weight men. Among men, the lowest intake group of free sugars (<5E%) had the highest percentage of men becoming overweight at follow up (17.5%) while people in the highest intake group (≥20E%) had the least percentage of men becoming overweight (12.2%). The results did not change when misreporters and diet changers were removed from the analysis. A possible explanation is that people in the lowest free sugars intake groups had higher dietary intakes from more energy dense nutrients i.e. fat or alcohol or were less physically active compared to those with higher free sugars intake groups which may have contributed to the weight gain (Moshtagian et al., 2016). Alcohol intake was significantly higher in low sugar intake

groups in several studies suggesting that these alcoholic beverages may be replacing sugar sweetened beverages (Moshtagian et al., 2016). Our results showed that as many as 52.4% of highest alcohol intake quintiles consumed less than 7.5% of their energy from free sugars. A prospective study by Koh-Banerjee et al., (2003) reported a positive association between decreased consumption of fiber and total physical activity among men aged 40 – 75 years and waist circumference over a 9-year follow-up. The observation that men in the highest sugar intake group had the least percentage of men becoming overweight could be attributed to consuming more protein which promotes satiety and helps maintain weight and/ or increased physical activity, although we could not test for this.

Among women, there was a significant inverse association between the middle categories of sugar consumption (2^{nd}, 3^{rd} and 4^{th}) and the risk of becoming overweight among normal weight women. However, the significance disappeared when energy misreporters and diet changers were removed from the analysis indicating that the results were influenced by this particular group of people. Among women the lowest free sugars intake group (<5E%) had the highest percentage of women becoming overweight (15.4%) while in the highest sugar intake group (≥20E%), only 11.9% women became overweight. It is important to note that previous studies within the MDC study showed that sucrose consumption did not show high reproducibility among this cohort's women (Elmstahl et al., 1996; Riboli et al., 1997). Furthermore, despite the relative validity of the alcohol variable in this cohort, the MDC women have underreported their

mean daily alcohol intake by nearly 60% compared with the reference method raising question of misclassification (Elmstahl et al., 1996).

Studies examining the association between free sugars and weight change have different and conflicting conclusions with some positive (Malik et al., 2006), inverse (Nooyens et al., 2005) or no association (Halkjær et al., 2004). The differences between the studies may be related to differences in the definition of free sugar such as non-milk extrinsic sugar, which include natural sugars in fruit juice in their definitions. The differences in findings between isoenergetic and ad libitum intervention studies indicates that the effect of free sugar in sugar sweetened beverages on weight gain may have resulted from the sugar's energy content and not some physiological effect that would be independent of thermodynamic properties (Buchholz and Schoeller, 2004). Another difference could be the use of different dietary data collection methods like 24-h recalls (Charlton et al., 2005) and weighed food records (Gibson, 1990). The MDC study used two dietary collection methods with the hope that it captures more aspects of diet.

Obesity is multifactorial therefore it is no wonder that the effect of reducing sugar intake on weight change was relatively small (Te Morenga et al., 2013). Moreover, the recommendation to further reduce free sugar intake to less than 5% has received criticism due to the lack of evidence related to beneficial dietary and/or health outcomes (Erickson and Slavin, 2015). Charlton, Kolbe-Alexander and Nel (2005) demonstrated that nutrient intakes are similar between low and intermediate free sugar intake groups

while Gibson (2001) explained that even a moderately high intake of energy from free sugar (8%–15%) did not compromise adequacy of nutrient intakes in older adults. This is particularly true for sugar sweetened beverages, where energy in liquid form could be less satiating than when derived from solid foods, resulting in increased consumption (DiMeglio and Mattes, 2000)

Moreover, many observational studies do not consider changes in food, energy intake and physical activity during the follow up period, assuming that dietary and energy intakes as well as energy expenditures are stable. This thesis would benefit from information on the participants LTPA, alcohol consumption and smoking status at follow up.

Moreover, during the data collection, the MDC participants were asked about the use of sugar, however no specific emphasis was put on the use of sweeteners in cakes, candies and some beverages, or how much sugar there was in jam and desserts. The percentage of free sugar was calculated later which could need validation. To our knowledge a current research is being conducted with the newly created free sugar categories and mortality both within the MDC study and a cohort study in Northern Sweden to examine the reliability of the free sugar intake measurement.

5.4 Study Strengths and Limitations

The analysis of the data has several strengths. First, as a prospective cohort study, the likelihood of reverse causality is minimized because information

on the exposure and risk factors was gathered at baseline before the development of the outcome. Second, the dataset of the MDC study included information on potential confounders like, age, season, diet method, total energy intake, smoking, alcohol intake, LTPA and education which allowed adjustment for them. The data set also included information on diet changers and potential energy misreporters which facilitated the sensitivity analyses. Moreover, the database created for the MDC study was comprehensive, and any missing foods were updated into the database.

There are also certain limitations to the present study. Dietary intake was self-reported; therefore, we cannot rule out measurement errors. There was also a tendency by women and obese individuals to under-report their consumption of free sugars and snacks consumed between meals (Poppitt et al., 1998). However, performing sensitivity analysis with and without such individuals provided an idea about the magnitude and direction of such potential bias. Another limitation is the age group of the study participants which ranged between 44 and 73 years old which limits the generalizability of the results to younger and older populations.

5.5 Conclusion and recommendations for future studies

The study results suggest that free sugars consumption does not contribute to weight change. The findings strongly suggest that sugar acts like any other dietary intake by disturbing the energy balance and influencing body weight. However, due to limitation pertaining to the MDC cohort age group and the study design further analyses are needed to confirm this finding.

We also propose to investigate other dietary components that may have influenced weight change.. We propose to conduct the following future studies:

1. To conduct further analyses within the same cohort while taking into consideration other dietary intakes mainly, protein, fat and carbohydrates that may have contributed to the weight change.
2. To conduct further analyses within the same cohort about other adiposity indices like waist circumference and waist/ hip ratio.
3. To investigate the association between free sugars intake and weight change among other birth- year cohorts to have better evaluation of the association between sugar intake and weight.
4. To investigate the potential biological mechanism by which sugar may influence weight.

DISCUSSION

Part II

5.1 Introduction

The aim of this study was to investigate the challenges facing Palestinian decision makers with regards to restricting unhealthy dietary intakes. As detailed in the previous chapter, the Results Chapter, the interview resulted in three main, overarching themes, these were: economic barriers, health literacy, regulations/ laws. The second part of chapter discussion attempts to interpret the emerging themes in light of existing knowledge. The chapter concludes with the study limitations and strengths as well as recommendations for future studies

5.2 Economic barriers

The results generated from the interviews indicated that economic barriers were one of the main challenges facing the Palestinian decision makers with regards to restricting unhealthy dietary intakes. These barriers included poverty or low SES, lack of resources both financial and manpower on the policy makers side and opposition from the food industry against any new proposals to introduce further restrictions on unhealthy components in their products. In 2017, the Palestinian Central Bureau of Statistics issued a detailed report on poverty profile in the Palestinian territories which concluded that the poverty line and deep poverty line for a reference household of two adults and three children were NIS 2,470 and NIS 1,974 respectively (PCBS, 2017). According to the report; as many as

29.2 percent of Palestinians were living below poverty level; with 53 percent of individuals in Gaza Strip found to be poor compared to 13.9 percent in the West Bank. The report also highlighted that the incidence of deep poverty has increased from nearly 13 percent in 2011 to 16.8 percent in 2017.

Moreover, the report found that poverty increased with household size, living in a refugee camp and when the head of the household had low earning capacity. Easton, Safadi and Hasson (2017) investigated internal and external limitations which affected the formation of anti-poverty programs in Palestine using semi- structured interviews with Palestinian policymakers in the Palestinian Ministry of Social Development (MOSD) and the Ministry of Planning and Administrative Development (MOPAD). In their analysis, the author found four principal categories of limitations; these are funding uncertainties for antipoverty programs, conflict with Israel, national and ministerial limitations, and insufficient information.

According to the study, since the Palestinian National Authority (PNA) relies heavily on external funding, interrupted funding inhibits both planning and implementation of antipoverty programs. Moreover, the ongoing conflict with Israel including political instability, ongoing violence, and basic security concerns constrain antipoverty efforts and increase social problems in the Occupied Palestinian Territories (OPT). The third limitation was internal, where the PNA has focused mainly on gaining international support for the establishment of an independent state

which made it detract from social policy making. At the ministerial level, competition for high-level posts within ministries, lack of staff members and specialists or insufficient resources have all limited the effectiveness of any anti- poverty initiative. The fourth limitation, according to the study was lack of quality and quantity information on poverty in the Palestinian territories.

Prior studies have also highlighted the negative impact of economic barriers and lack of resources as a main challenge facing the fight against obesity. According to the American Psychological Association, Socioeconomic Status (SES) is a "consistent and reliable predictor of a vast array of outcomes across the life span, including physical and psychological health" (American Psychological Association, 2018). Food prices play an important role in food selection (Popkin, 2001). Drewnowski and Darmon (2005) proposed that food prices may explain in part the unhealthy diets consumed by poorer people. In 1992, Basiotis proposed a behavioral model which showed that household members who face economic difficulties choose to consume less expensive foods to maintain energy intakes at a lower cost. According to the model, the association between poverty and obesity is mediated by the low cost of energy-dense foods, which could promote overconsumption and subsequent weight gain. According to the Healthy Eating Index (HEI); a 100-point scale developed by the United States Department of Agriculture, (USDA) to measure the quality of the total diet, income disparities have more pronounced impact on diet quality than on total energy intakes (Bowman, 1998). The strong

association between higher incomes and higher quality diets was also reported in studies in Canada (Kington and Smith, 1997) and the United Kingdom (Papadaki and Scott, 2002).

Meanwhile, limitations in financial and human resources as well as institutional capacities are some of the main challenges that could lead to programs failures (Mohapatra et al., 2016, Frieden, 2014). To address any public health problem like obesity in this case, it is important to measure and analyze the factors that cause it as prelude to solve them (Green and Kreuter, 2000). Our study results revealed that due to financial constraints and lack of resources the schools in Palestine do not receive any financial allocations from the government which hinders any plans to rehabilitate the schools' infrastructure or implement more health-related initiatives for the students and their families. Frieden (2014) proposed that partnership and coalition building can compensate for the lack of human or financial resources and support public health program activities as well as build effective long-term coalitions that extend beyond a specific issue.

Finally, the food and beverages industry has been criticized for being a major culprit in causing health- related problems (Moss, 2013). Many food and beverage companies produce products that contain large amounts of salt, sugar, and fat, which are important contributors to obesity, type 2 diabetes, and other lifestyle diseases (Stuckler and Nestle, 2012). A study by Barquera and colleagues (2013) reviewed the main challenges facing Mexico's fight against obesity. The authors found that lack of

harmonization between the food and beverages industry interest and the campaign's objectives has led to the country's national campaign to fight obesity to fail, because the companies saw the campaign as a threat to their profit. The food industry opposition may be understood in part, since its main goal is to make profit (Tjidde et al., 2017). "Food systems are not driven to deliver optimal human diets but to maximize profits" (Stuckler and Nestle, 2012). Bakan (2012) described a corporation to be "an entity that relentlessly seeks both power and profit without paying heed to the harmful consequences of its behavior". However, this does not have to be the case. The literature suggests that there are several areas where partnering with the food industry could yield mutually beneficial results. These include providing the companies with practical information on how to reformulate their food recipes to be healthier (Kraak and Story, 2015).

5.3 Health literacy

The second overarching theme that emerged from the interviews is health literacy. This theme included two sub- themes; these are lack of public health literacy and lack of expertise. Health literacy refers to the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions (HHS, 2010). Health literacy has functional and complex skills (Wikkeling-Scott and Rikard, 2017). Functional health literacy skills, includes the ability to obtain health information, demonstrate basic reading skills, and understand health information while complex skills refer to the

ability to fully utilize information obtained, and interact with health care providers.

The public's ability to understand health related information including the ability to read and understand nutrition labels or calculate cholesterol levels is very important to promote healthier lifestyle, after all the key to control the epidemic of obesity lies on the individuals who act on health promotion advice and efforts (U.S. Department of Health and Human Services, 2010).

Wikkeling-Scott and Rikard (2017) conducted a systematic review of health literacy and research on nutrition related health outcomes including diabetes, overweight, and obesity in the Middle East. The authors found that in the entire Middle East region, only three studies employed a validated health literacy measure to examine the relationship between health literacy and nutrition-related disease outcomes. Two of the studies were conducted in Iran while the third study was conducted in Saudi Arabia. However, the findings from the three studies cannot be generalized to larger populations because they were very specific in their focus, in that they targeted persons familiar with chronic disease only.

The World Cancer Research Fund (2007) proposes a number of policies to raise the public awareness and knowledge about healthier choices as prelude to changing their behavior to be more health conscious, including information dissemination, teaching healthy food preparation in schools and food-based dietary guidelines. A study by Chan and colleagues (2009) examined clients experience of a community-based lifestyle modification

program in Hong Kong. The results highlighted the importance of providing patient-centered care to achieve lifestyle modification.

In 2009, Sacks and colleagues proposed the Obesity Policy Action (OPA) framework; which is modified from the World Health Organization framework for the implementation of the Global Strategy on Diet, Physical Activity and Health. According to the framework, policies that directly influence behaviors should have a direct effect in the settings where people live including schools, home, workplaces and community. School- based intervention policies which include nutrition education for students as well as parents and physical activity programs have been found to be most effective to control the epidemic of obesity (Foster et al., 2008).

According to the American Heart Association Council schools play key role in promoting healthy dieting and behavior because the children spend long hours in schools where many extracurricular physical activities are incorporated into the educational program (Pate et al., 2006). A study by Golan and Weizman (2001) also identified home or the parents' knowledge and behavior as an important source in causing or preventing overweight and obesity. The authors proposed a framework for the management of childhood obesity that is totally based on the parents rather than on the obese child. The authors proposed a number of strategies that are based on the parents being role models for healthy lifestyle to combat childhood obesity which included restricting television time, choosing healthier meals and increasing physical activities.

The second sub-theme which emerged from the interviews was the ministry's lack of expertise regarding the best way to intervene and reduce free sugar intake which could be attributed to the fact that yet again sugar is not a working priority for them or because they lack financial and manpower to address this issue at the time being. Moreover, the interviews also revealed that the staff working in the Palestinian ministry of health central laboratories also lack some of the expertise to carry out certain tests on products. Previous studies have also identified lack of staff members as well as experts within the Palestinian ministries as one of the main obstacles that affect the ministries work.

A study by Sayigh and Shikaki (1999) found that while some of the Palestinian ministries are overstaffed, others are understaffed, especially those requiring specialized or highly qualified personnel which resulted in suboptimal quality and efficiency of public services and reduced cost-effectiveness. Moreover, a study by Giacaman, Abdul Rahim and Wick (2003) reviewed health sector reform in the Occupied Palestinian Territories (OPT). The authors concluded that the Palestinian government sector with its low pay scale, aggravated by the depreciation of the Israeli currency, has made it difficult to attract the most qualified health providers. The authors called to review the participants selection criteria and the methods used for extensive training courses offered to certain health sectors. Heller and colleagues highlighted that in many low and middle-income countries, there is a huge demand for well-trained health staff, however due to many constraints including financial and physical; it might

be difficult to enroll them in capacity building trainings or further education programs (Heller et al. 2007). To solve this dilemma, the WHO proposed a new educational approach that is based on open access educational resources that is available on the internet.

5.4 Regulations/ Laws

The third overarching theme that emerged from the interviews is Regulations/ Laws. The theme regulations and laws included two sub-themes; the first is internal laws and regulations and the second is the lack of legal jurisdiction. Throughout the interviews, the participants emphasized the importance of having clear, concise and deterrent laws whether regarding the marketing of sugar sweetened beverages or unhealthy snacks to the general public and children in particular or regarding foods available in the Palestinian market at large. Gostin (2000) identified public health law as “the legal duties of states to ensure the necessary conditions for people to be healthy”. Galbraith-Emami and Lobstein (2014) and Persson (2012) argued that public health laws are more effective than self- regulatory models because they could cover all relevant market actors, have more stringent criteria, clear objectives and outcome measures, be binding and less easily to be reversed.

Meanwhile, the WHO identifies marketing as “any commercial communication or message that is designed to, or has the effect of, increasing the recognition, appeal and/or consumption of particular products and services (WHO, 2010). The United States Institute of

Medicine (2006) found strong evidence that advertising had an impact on overall diet for children aged 2–11 years as well as between exposure to television advertising and obesity in children aged 2–11 and in young people aged 12–18. According to the WHO Global Strategy on Diet, Physical Activity and Health “messages that encourage unhealthy dietary practices or physical inactivity should be discouraged, and positive health messages encouraged”. In 2010 the WHO highlighted the strong impact that marketing of unhealthy foods rich in saturated fats, trans-fatty acids, free sugars and salt have on childhood obesity. The expert committee commissioned by the WHO recommended that in view of the strong association between marketing and childhood obesity, to reduce children exposure to marketing of foods high in saturated fats, trans-fatty acids, free sugars, or salt. The committee has also recommended that places where children gather should be free from all forms of marketing of foods rich in saturated fats, trans-fatty acids, free sugars, or salt “including - but not limited to- nurseries, schools, school grounds and pre-school canters, playgrounds, family and child clinics and pediatric services and during any sporting and cultural activities that are held on these premises”.

The last sub-theme that emerged from the interviews is lack of legal jurisdiction over the Palestinian external and internal borders. Under the Oslo accords, the West Bank was divided into areas A, B and C. Area A includes the main Palestinian city (excluding Hebron) is under Palestinian civil and security control. Area B is under Palestinian civil control and joint Israeli and Palestinian security control while Area C makes up 61% of the

West Bank is under Israeli civil and security control (World Bank, 2013). The provision of health care in Palestine is particularly challenging due to the complex political situation where Israel controls not only healthcare budgets but border crossings, building permits and pharmaceutical import/exports (Efrat, 2015). In a paper on the provision of health care in the Palestinian territories, Keelan (2016); highlighted that one of the main constraints to the provision of healthcare in the Palestinian territories is the so- called Separation Wall which affects the lives of nearly 2.9 million people who live in the West Bank and contributes to dividing the area both physically and economically as well as inhibits the freedom of movement.

Khalil and Del Sarto (2015) highlighted that the Palestinians live in a highly fragmented legal space. "The Palestinians are subject to different legal and judicial regimes. The Palestinian Territories are characterized by an extreme disjuncture of jurisdictions, territorially defined entities and categories of people. According to the authors, the existence of various legal borders across the Palestinian Territories and Israel which are not necessarily based on territory or identity has created regimes of inclusion and exclusion which separate the Palestinians from the Israelis and even Palestinians from each other as well as from their lands and sources of income. Adds to this dilemma is the Palestinian Authority limited jurisdiction over a number of territorial areas mainly Palestinian cities. As explained by one of the interviewees these fragmentations and various legal and territorial entities constitute major challenge to the application of

regulations and policies including controlling raw material or products that enter the Palestinian territories or prosecuting those who violate the law.

5.5 Study strengths and limitations

As with all studies, this study has several strengths as well as several limitations. The study is the first to investigate the challenges facing policy makers in Palestine with regards to reducing sugar intake among children and adults. The review of the literature did not result in previous academic studies that investigated the challenges facing the fight of obesity in Palestinian from the perspective of policy makers or senior administrative officials. Moreover, the utilization of semi- structured interviews allowed to free adopt to the interviewee's work area. However, the study is limited in terms of its location and number of participants. Due to political and physical limitations, the interviews were only conducted in West Bank and not Gaza which has a separate governing authority. Moreover, the number of participants is relatively small. The study's original design aimed to include more participants, however at the time of the data collection, two of the participants; namely UNRWA and the Palestinian National Institute of Public Health did not participate. In order to overcome this gap and enhance the results rigor, a final participant; the Palestine Standards Association was included in the study.

5.6 Conclusion and recommendations for future studies

The results of the qualitative analysis of challenges facing the Palestinian decision makers with regards to reducing sugar intake in Palestine resulted in three overarching themes and these are Economic Barriers, Health Literacy, Regulations/ Laws. The overarching themes included a number of subthemes as follows: the theme Economic Barriers included three subthemes; these are; poverty or low Socioeconomic Status, lack of resources and food industry opposition. The theme Health Literary included two subthemes these are; lack of public health literacy and lack of expertise. The last theme, Regulations/ Laws included two subthemes, these are; Internal Regulations/ Laws and Lack of Legal Jurisdiction. However due to the study limitations we propose to conduct the following future studies to better evaluate the challenges facing reducing sugar intake among children and adults in Palestine:

1. To conduct quantitative studies that measures the most consumed sugary products across different age groups.

2. To include more stakeholders including from the West Bank and Gaza Strip in qualitative studies that explore the challenges facing the Palestinian decision makers to design and implement health related initiatives to fight obesity.

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APPENDIX A: MDC Ethical Approval in Swedish

LUNDS UNIVERSITET
MEDICINSKA FAKULTETENS
FORSKNINGSETISKA KOMMITTÉ

Professor Anders Gustafson
Inst för medicin
Lasarettet
221 85 LUND

PROTOKOLLSUTDRAG
Sammanträdesdatum
1990-02-14

Professor Göran Berglund
Med klin
MAS
214 01 MALMÖ

§ LU 51-90

Kost och cancer. En prospektiv studie i Malmö.

Ansökan godkänns under förutsättning att Datainspektionen ger sitt medgivande.
Göran Berglund deltog ej i beslutet.

Vid protokollet

Anders Gustafson
Ordförande

Krister Nilner
Tf sekreterare

Bestyrkes å tjänstens vägnar

Margareta Daler
Adm sekr

Appendix B: MDC study ethical approval- English translation

The Malmö Diet and Cancer Cohort, a prospective study in Malmö is granted ethical approval from Datainspektion Agency.

APPENDIX C: Najah National University Ethical Approval

An-Najah
National University
Faculty of medicine
&Health Sciences
Department of Graduate
Studies

جامعة النجاح
الوطنية
كلية الطب وعلوم الصحة
دائرة الدراسات العليا

IRB Approval Letter

Study Title :

The relationship between total sugar intake and long term weight gain and related challenges in Palestine

Submitted by:

Aida Koni, Mujahed Shraim

Date Reviewed:

17th May 2017

Date Approved:

28th May, 2017

Your Study titled "**"The relationship between total sugar intake and long term weight gain and related challenges in Palestine"** with achieved number 6 May. 2017 was reviewed by An-Najah National University IRB committee and was approved on 28th May..2017.

Hasan Fitian, MD

IRB

IRB Committee Chairman

An-Najah National University

جامعة النجاح الوطنية
كلية الدراسات العليا

العلاقة بين اجمالي استهلاك السكر وتغير الوزن على المدى الطويل في مجموعه من كبار السن

إعداد
عائدة عماد الدين مصطفى كوني

إشراف
د. مجاهد شريم
د. محمد مرعي

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الصحة العامة، بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس- فلسطين.
2018

العلاقة بين اجمالي استهلاك السكر وتغير الوزن على المدى الطويل في مجموعه من كبار السن

إعداد

عائدة عماد الدين مصطفى كوني

إشراف

د. مجاهد شريم

د. محمد مرعي

الملخص

تتضمن الأطروحة دراستين. الدراسة الأولى هي دراسة ترابية للعلاقة بين تناول السكريات الحرة وتغيير الوزن على المدى الطويل في مجموعة من كبار السن. وتحقق الدراسة أيضًا في خطر زيادة الوزن لدى الأفراد ذوي الوزن الطبيعي على المدى الطويل. البيانات المتاحة لهذه الدراسة من دراسة مالمو للغذاء والسرطان(MDC) . بلغ المجموع الكلي للمشاركين في الدراسة 18،133 شخصًا. تم تصنيف المشاركين وفقا لكمية السكر المستهلك على النحو التالي <5٪، 5- <7 · 5٪، 7 · 5- <10٪، 10- <15٪، 15- <20٪ و20٪ .أظهرت النتائج انه لا توجد علاقة بين كمية السكريات الحرة المستهلكة ومعدل التغير السنوي للوزن أو معدل التغير النسبي السنوي للوزن أو تغير مؤشر كتلة الجسم. كما أظهرت النتائج أيضا أنه لا توجد علاقة بين السكريات الحرة وخطر زيادة الوزن بين الرجال والنساء ذو الوزن العادي. تشير النتائج إلى أن الآلية الوحيدة التي يمكن أن تؤثر السكريات الحرة على وزن الشخص هي عن طريق ارباك توازن الطاقة.الجزء الثاني من الأطروحة هو مكمل للدراسة الأولى ويهدف إلى التحقيق في التحديات المحتملة التي تواجه الحد من استهلاك السكر بين البالغين والأطفال في فلسطين. تم اعداد الجزء الثاني من خلال عمل مقابلات_مع رؤساء أقسام التغذية في وزارة الصحة الفلسطينية ووزارة التربية والتعليم الفلسطينية ومؤسسة المواصفات والمقاييس الفلسطينية. تشير نتائج الدراسة إلى ثلاثة تحديات رئيسية تواجه صانعي السياسات الصحية في فلسطين لمكافحة السمنة والحد من تناول السكريات الحرة وهي الحواجز الاقتصادية، انعدام الوعي الصحي والأنظمة / القوانين.