

Economic Policy, Obesity and Health: A Scoping Review

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Contents

1	Abstract	4
2	Executive Summary	5
3	Introduction	8
3.1	Background	8
3.1.1	The economic view of diet and exercise choices	8
3.1.2	Rationale for Economic Intervention	9
3.1.3	Theoretical Considerations of Economic Policy to Address Obesity	11
3.1.4	Learning from Tobacco Control	13
3.2	Existing and Proposed Economic Interventions	14
3.2.1	What Are Economic Interventions?	14
3.2.2	Examples of Existing and Proposed Interventions	14
4	Review of Empirical Evidence	16
4.1	Literature Search: Methods and Results	16
4.2	Expert Consultation: Delphi Survey and Panel Meeting	18
5	Taxes and Subsidy Measures	19
5.1	Nutrition	19
5.2	Physical Activity	21
5.3	Targeted Income Transfer Programs	22
5.4	Agricultural Subsidies	23
6	Policy Considerations and Recommendations for Canada	25
6.1	Reviewing Agricultural Policy and Subsidies	25
6.2	Caloric Sweetened Beverage Tax	26
6.3	Food taxes	28
6.4	Fruit and Vegetable Subsidies	29
6.5	Physical Activity	30
6.6	Income Transfers	30
7	References	32
8	Appendix 1. List of Panel Experts	42
9	Appendix 2. Review Papers	43
10	Appendix 3. List of Reviewed Empirical Studies	47
11	Appendix 4. Review of Empirical Studies in the Nutrition Domain	61
12	Appendix 5. Review of Empirical Studies in the Physical Activity Domain	67
13	Appendix 6. Review of Empirical Studies on Income Transfer Programs	71
14	Appendix 7. Review of Empirical Studies on Agricultural Subsidies	73
15	Appendix 8. Delphi Survey Results	79

1 Abstract

This report presents the findings of a scoping review examining the empirical evidence related to the effectiveness of using economic instruments to address obesity. This review focuses on three bodies of literature: first, taxes on high-energy food and subsidies on healthy foods, physical activity, and public transport; second, agricultural subsidies that determine the relative prices of certain commodities used to produce high energy foods, and; third, targeted income transfer programs that focus on increasing both healthy food consumption and physical activity for low income and disadvantaged groups.

The main findings can be summarized as follows. First, there appears consistent evidence that weight outcomes respond to food and beverage prices. The debate on the use of food taxes and subsidies to address obesity should now shift to how best to address practical issues in designing such policies. Second, very few studies have examined the impact of economic instruments to promote physical activity and clear policy recommendations cannot be made at this time. Third, general food-based transfer programs can improve nutrition and birth weight, but might also encourage excessive caloric consumption. Fourth, there remains some debate as to whether US agricultural commodity subsidies have contributed to rising obesity rates. However, there is evidence that the US agricultural Research and Development subsidies have an unintended consequence of reducing the prices of obesity-linked commodities and that the United States Department of Agriculture (USDA) distribution programs regarding surplus commodities have contributed to childhood obesity in the US.

Based on empirical evidence and expert opinion, we recommend that further consideration be given to the following:

- 1) Create and implement an effective health filter to review new and current agricultural policies to reduce the possibility that such policies have a deleterious impact on population rates of obesity.
- 2) Implement a caloric sweetened beverage tax.
- 3) Further examine how to implement fruit and vegetable subsidies targeted at children and low income households.

2 Executive Summary

The obesity epidemic: The cost of food and physical activity

The causes of overweight and obesity, and the potential solutions to preventing and reducing obesity prevalence are complex. We live in an obesogenic environment that increasingly promotes a high energy intake and sedentary behaviour. No single strategy will solve this health problem. Drawing on a social-ecological framework, it is recognized that physical activity and dietary behaviours are influenced by factors across multiple domains including the individual, social, physical and policy realms. Accordingly, comprehensive, multi-level approaches are required to address obesity and the economic domain is one target for intervention.

Over time, the total (money plus time) price of consuming various food and beverages has declined, and this has at once reduced the price of calories and increased purchasing power. At the same time, higher wage rates and longer hours spent in sedentary employment have made physical activity more expensive. Standard economic theory predicts that these price changes would rationally lead individuals to increase caloric intake and reduce caloric expenditure. Madore (2007) succinctly describes that the increasing prevalence of obesity “has coincided with a decrease in the relative price of consuming a calorie over time and a rise in the opportunity cost of burning a calorie. Thus, economic instruments altering the price of food, and of sport and fitness equipment and activities, could affect food consumption and physical activity” (p. 1). This scoping review focuses on an evaluation of such economic instruments – defined as policies that aim to change individuals’ behaviours and weight outcomes through changing relative prices and through income transfers.

Methodology

Arksey and O’Malley’s (2005) methodological framework for conducting scoping reviews was adopted for this study and consists of two main phases: 1) a structured literature search and review, and 2) consultation with experts in the research field through a Delphi survey and an in-person expert panel meeting. Policy recommendations for further reflection reflect both the empirical evidence and expert panel consensus findings.

Summary of Findings and Policy Recommendations:

A comprehensive combination of educational, regulatory, direct provision, and economic policies will be essential for effectively tackling the public health burden of obesity. Economic interventions by themselves are not the answer but should be one component of such a comprehensive approach. In terms of economic interventions, shifting from empirical evidence to policy recommendation remains challenging. Overall, the evidence is not sufficiently strong to provide clear policy direction. Additionally, the nature of the experiments needed to provide definitive evidence supporting certain policy directions is likely to be complex and potentially unfeasible. However, these are not reasons to take no action. It is likely that policies need to be implemented in the face of an incomplete evidence base – and parallels can be drawn with tobacco control - initial tobacco control interventions were not evidence based but represented sound judgment at the time. On this basis, we recommend the following for further consideration:

Agricultural subsidy: Due to the difficulties in isolating the role of specific agricultural policies on food prices, the issue of whether agricultural subsidies on commodities are responsible for rising obesity rates remains debatable. However, there is empirical evidence that agricultural policies have contributed to childhood obesity indirectly through the US commodity distribution programs (e.g. National School Lunch Program). Also, agricultural R&D subsidies have increased agricultural output and lowered farm commodity prices, and thereby have had an important impact on consumption and obesity. Agricultural subsidy-specific recommendations include:

- a) Create and implement an effective health filter to review new and current agricultural policies to reduce the likelihood that such policies have a deleterious impact on population rates of obesity. Specifically, an agricultural support policy should become secondary to a food and health policy.

To that end, immediate research support is required for two key areas:

1. empirical research on the effect of Canadian agricultural policies on food choices and weight outcomes, and;
 2. research on the spillover effect of cheap foods and commodities from the US on Canadian obesity rates. Such research may point to the need for imposing higher tariffs on cheap food imports.
- b) Restructure R&D subsidies to promote increased development of fruit and vegetable production and distribution. Measures to raise domestic supply of fruit and vegetables can also be complemented by lowering tariffs on imported fruits and vegetables.
 - c) Develop transportation and subsidized revenue insurance policies to assist farmers who grow fruits and vegetables, widely considered a more riskier commodity than other agricultural products. Farmers should be engaged as ‘anti-obesity’ partners.
 - d) Develop measures that promote easy access to fruit and vegetables for Canadian households. For example, both the European Union and the United States have recently implemented policies to actively promote farmers’ markets.

Caloric sweetened beverage tax: There is evidence that adult weight is modestly responsive to soft-drink taxes. A tax on caloric sweetened beverages is justified for a number of reasons. Unlike fast foods, caloric sweetened beverages serve no nutritional value. In addition, empirical evidence shows no indication that such a tax would be regressive and unfairly penalize low income individuals and households. Finally, the successful tax-based tobacco control policies provide a promising case for adopting similar financial instruments to address obesity particularly in the context of imperfect evidence. Specific recommendations include:

- a) Apply the tax on the amount of caloric sweetener in the beverage (e.g., 10 cents per ounce of sweetener);
- b) Rationalize the tax in terms of broader health benefits as opposed to a single focus on obesity. Regardless of an impact on obesity, decreasing sugar consumption has other health benefits;
- c) Combine the implementation of such a tax with targeted unsweetened beverages and/or fruit and vegetable subsidies, or in other obesity prevention interventions, and;
- d) Monitor any unintended consequences of the tax implementation in terms of producers’ formulation responses.

Fruit and vegetables: The empirical evidence clearly demonstrates a link between lower obesity risk and greater fruit and vegetable consumption. In particular, lower prices of fruits and vegetables are associated with lower child weight. Panel members were uniformly in favour of fruit and vegetable subsidies – primarily targeting children and low income households. Specific recommendations for the Canadian context include:

- a) Implement subsidy coverage and ensure that eligible products include both fresh and frozen as well as canned fruit and vegetables. For low-income adults, such subsidies may be delivered through grocery or debit cards. These cards can be connected with the Canada Revenue Agency for monitoring and reimbursement purposes;
- b) Offer children and youth free fruit and vegetables at school;
- c) Dedicate beverage tax revenue to fund fruit and vegetable subsidies, and;
- d) Shift agricultural policy and subsidies to enhance the production and distribution of fruit and vegetables.

Fast foods: Even though there is empirical evidence that low fast food prices may contribute to higher consumption and obesity, panel members did not recommend proposing such taxes at this time. There are a number of difficulties with the design and implementation of food taxes that require further research before specific recommendations can be made. Canadian context recommendations include investigating the research potential of scanner data (records consumer food and beverage spending habits). Such data can be used to examine and estimate the impact of different food taxes on consumer food choices.

Physical activity: It is difficult to draw clear conclusions from existing studies on the effectiveness of economic instruments targeting physical activity. Panel members expressed little confidence that economic instruments, as defined within the scope of the report (tax and/or subsidies), was an effective means to increase population level physical activity. In terms of economic instruments, it was proposed that a more effective move is to target food consumption as opposed to energy expenditure.

In summary, the panel suggested that there is insufficient evidence to clearly recommend specific tax credits or subsidies to promote physical activity. This is not to discount that particular subsidies may play a role. At the least, public funds should be transferred from potentially inefficient economic measures to encourage physical activity (e.g., the Children's Fitness Tax Credit) to economic measures that show more promise (e.g., subsidized participation for targeted populations). The promise of such economic measures should be tested in a matching program of research to determine the actual effects of such measures on increasing physical activity participation and reducing obesity.

Income transfer programs: The existing evidence suggests that unrestricted, non-food transfer programs to pregnant women have a positive effect on improving infant birth weight. In contrast, while food-based transfer programs have the effect of improving nutrition for the poor, they might have an adverse effect of encouraging excessive energy consumption that leads to overweight and obesity for adult women. Given that existing evidence does not clearly support a simple inverse relationship between income and obesity, expert panel members were generally not supportive of income transfer programs as an obesity prevention intervention.

3 Introduction

There has been a general recognition that the fitness of Canadians has declined over time, yet we have never had a clear sense of the magnitude of this decline. Due to cost and time, most population surveys tend to rely on self-report to collect data about health factors such as weight, body mass index and fitness. Such reports tend to provide a less accurate picture of population health. More recently, a comprehensive and objective assessment of Canadian fitness levels has been conducted, the first such study in almost twenty years. The 2007-2009 Canadian Health Measures Survey by Statistics Canada administered over 3000 comprehensive health interviews across Canada in the home, and utilized a mobile examination center to administer body composition measurements and fitness tests.

Comparisons were made with data drawn from the 1981 Canada Fitness Survey (CFS). In terms of body composition, average BMI rose by approximately 2 units for males across all age groups (Shields et al., 2010). The increase was similar for middle-aged females, but younger and older females experienced a larger increase of 3 units. Increases were particularly dramatic for children. The percentage of children classified as overweight or obese rose from 14% to 31% among boys, and from 14% to 25% among girls (Tremblay et al., 2010). Alongside significant temporal declines in strength and flexibility across the lifespan, these findings confirm that Canadian fitness levels have declined over time. Such data indicates a movement towards accelerated noncommunicable disease development. If such declines are not addressed, increased health care costs may result.

The causes of overweight and obesity, and the potential solutions to prevent and reduce obesity prevalence are complex. We live in an obesogenic environment that increasingly promotes a high energy intake and sedentary behaviour (Swinburn et al., 1999). No single strategy will solve this health problem. Drawing on a social-ecological framework, it is recognized that physical activity and dietary behaviours will be influenced by factors across multiple domains including the individual, social, physical and policy spheres. Accordingly, comprehensive, multi-level approaches are required to address obesity and one target for intervention is the economic domain.

The focus of this scoping review is an evaluation of policies that change prices and incomes; we refer to these as “economic” instruments. This report is organized as follows. The next section provides background information and rationale for government intervention. Theoretical models of tax and subsidy impacts as well as transfer programs on food demand and weight outcomes are also presented. Section three lists existing and proposed economic interventions. Section four describes the project search strategy and then reviews available empirical evidence concerning the effect of taxes, subsidies, and transfer programs on weight outcomes. The final section presents policy and research recommendations based on the empirical evidence and expert consultations.

3.1 Background

3.1.1 The economic view of diet and exercise choices

Standard economics posits that individuals typically make decisions to make themselves as well off as possible. In other words, individuals attempt to satisfy objectives subject to constraints. Both objectives and constraints are germane to diet and physical activity choices (Cawley, 2004). On the objectives side, economics emphasizes that human welfare depends on multiple factors, and individuals make trade-offs between them. If health were the only goal, then there likely would be no obesity and individuals would spend all of their time and money on health-enhancing activities. Clearly this is not the case. Obesity, then, could be the result of the trade-off that individuals make between health and other desired goods, such as the consumption of calorie-rich food and beverages, in order to maximize self-perceived welfare. While preferences are certainly relevant, they alone cannot

explain the dramatic growth in obesity prevalence over the last several decades – it seems unlikely that preferences for calorie-rich food or physical activity have changed so suddenly. What *have* changed are time and budget constraints. Changes in diet and activity might then be interpreted as optimizing responses to changes in these constraints. In particular, the total (money plus time) price of consuming various food and beverages has declined and this has at once reduced the price of calories and increased purchasing power. At the same time, higher wage rates and longer hours spent in sedentary employment have made physical activity more expensive. Standard economic theory predicts that these price changes would rationally lead individuals to increase caloric intake and reduce caloric expenditure.

Why has the price of calories declined? The answer: productivity-enhancing technological change. In particular, during the last five decades, from about 1960 to the present, there have been marked increases in the production of corn, soybeans, potatoes, beef, pork, poultry and other agricultural products. Farmers are able to get a lot more output per unit of input. At the same time, there have been tremendous changes in industrial food processing; these changes have led to the creation of calorie-dense, mass-produced foods and beverages with long shelf lives. Cutler and colleagues (2003) cite the example of the potato. Before World War Two, they note, Americans ate large quantities of potatoes, either boiled, mashed or baked. These were typically prepared at home. French fried potatoes were uncommon, in large part because of the manual labour required in their preparation. Since that time, French fry production – peeling, cutting, cooking and freezing – has become almost entirely mechanized. The only remaining step in their preparation is deep-frying or, less commonly, baking for home consumption. These economists note that French fries are now the dominant form of potato consumption and are Americans' favourite vegetable. Innovations in French fry production have essentially reduced the “time price” – the amount of manual labour required in their production. Innovations in potato production have made the principal ingredient into French fries – potatoes – less expensive. The combined effect is to reduce the price of calories to consumers. The widespread adoption of microwave ovens has also made it particularly easy to heat up processed foods.

The decline in the price of calorie dense foods has been accompanied by an increase in the time price of physical activity and meal preparation at home. Women's formal labour force participation rates and hours worked have increased markedly over the last several decades, reducing time available for exercise, the preparation and clean-up of nutritious meals as well as child supervision. Also, for both men and women, higher wage rates increase the opportunity cost of physical activity (in terms of forgone earnings). Taking a long-term perspective, the rising opportunity cost of exercise can be traced back to productivity-enhancing technological change in the agricultural and other sectors.

Technological change, by freeing individuals from subsistence and then agrarian lifestyles, has fundamentally changed the nature of work. Indeed, Philipson (2001) notes “historically, work was strenuous; in effect, individuals got paid to exercise. Now work is more sedentary: individuals have to pay (in terms of foregone earnings and gym memberships) to exercise.”

3.1.2 Rationale for Economic Intervention

Should governments even be in the business of attempting to reduce rates of overweight and obesity? The answer to this question depends on one's perspective. Public health scientists typically favour government intervention because obesity is linked to diabetes, cardiovascular disease and other health problems, and part of the government's responsibility is to protect its citizens. Economists are much more divided on the issue. Most mainstream economists agree that government can potentially improve outcomes in the presence of market imperfections, which include informational deficits, self-control problems and externalities (Cawley, 2004). Each of these is discussed in turn.

Informational deficits. If obese adults understand the health consequences of their diet and exercise choices, then presumably these health risks are an acceptable price for the perceived benefits of excess caloric intake. To the extent that individuals are obese because they do not understand these health risks, then some educational interventions may be warranted. Nutritional labeling may be one solution, but as Cash et al. (2007) note, even if consumers read the contents of the nutrition labels, they might not necessarily be aware of the implications of consuming that item for their health. Some other form of education may thus be required. Of course, many of those with weight control problems understand the consequences of obesity, just as most smokers understand that smoking is harmful (Viscusi, 1990). It is therefore unclear if education alone will effectively combat obesity.

Self-control problems. The size of the North American diet industry indicates that many of those with weight problems have difficulty controlling their food intake or devoting sufficient time to physical activity, despite knowledge of the consequences of excess net caloric intake. Behavioural economists suggest that this self-control problem could be grounds for government intervention. These economists think of individuals as having two ‘selves’: a relatively myopic ‘today’s’ self – which is the one that makes diet and exercise decisions – and a relatively far-sighted ‘future’ self, which lives with the health consequences. There is sometimes a conflict between the two selves: Today’s self may not adequately take into account future self’s welfare and succumb to the temptations of calorie rich foods and sedentary lifestyles. The theory suggests that individuals who recognize this dilemma – ‘sophisticates’ – will use self-commitment devices (e.g., diets, fitness club memberships) to make today’s self account for the consequences of their decisions on their future selves. Excise taxation of unhealthy foods or physical activity subsidies can be thought of as a commitment device to improve the ‘future-selves’ welfare of non-sophisticates (Gruber & Kozegi, 2004; O’Donoghue & Rabin, 2006).

It is important to note that while excise taxation might help some, it would also harm others. Innovations in food production unambiguously benefit those who are able to maintain a healthy weight; these innovations have provided much more choice and increased their purchasing power. For such individuals, excise taxation might lower well-being.

Externalities. Yet another rationale for economic intervention is that obesity results in large health care costs and these costs are borne collectively, so that obesity imposes financial externalities on those who are able to exercise self-control. Simply put, the thin are subsidizing the health care costs of the obese. Similarly, the obese may be less productive than the non-obese and yet receive comparable wages. Excise taxes on unhealthy foods would make obese individuals ‘internalize’ the costs that they impose on others. While this argument has some merit, there are two reasons for pause. First, while the obese likely incur higher health care costs than the non-obese at any given age, they also have shorter lifespans (Lawlor et al., 2006). Hence the obese might have lower total *lifetime* healthcare costs than the non-obese. Second, excise taxes apply to everyone, obese and non-obese alike. It is true that they disproportionately impact the obese, but even individuals with healthy weights enjoy the occasional indulgence. If obesity-related externalities were the only motivation for excise taxes, then such taxes would be warranted only if they reduce lifetime health care costs amongst those who lack self-control by a sufficiently large margin to offset the direct harms that taxes incur to those who exercise self-control.

Equity concerns. The discussion has so far focused on the desirability of tax and subsidy policies to correct various types of market failure. Another rationale for government intervention is to improve the welfare of low income households. Those with limited means often economize by purchasing calorie-dense, processed foods and drinks. The reason is that, although these items are not particularly nutritious, they may provide the most calories per dollar. Transferring income to such households would enable them to purchase more costly nutritious foods. The advantage of income transfers is that they can be targeted at those who are less affluent (most excise taxes and subsidies, on the other hand,

target everyone.) One limitation is that there is no guarantee that less affluent households will use the subsidy to purchase healthy foods. They very well might have different priorities. This limitation can be overcome, however. In particular, food stamp programs, common in the US but not in Canada, have the advantage that they can at once be targeted at less affluent households and could be designed to permit the purchase of nutritious foods only.

3.1.3 Theoretical Considerations of Economic Policy to Address Obesity

People maximize their self-perceived welfare by deciding how much to eat, how much to exercise and how much other goods and services to consume subject to their limited resources in terms of both time and income (Cawley, 2004). Changes in total income, the prices of various foods, and the cost of physical activity will change these constraints and hence will change desired levels of exercise and food consumption. An important implication is that, changing prices of calorie dense, unhealthy foods relative to that of low-energy, healthy foods, or altering the cost of physical activity relative to that of sedentary alternatives may lead to changes in diet and physical activity.

The effect of income changes on obesity is less clear. Suppose that it is the case that individuals ultimately care about their weight (or perhaps their health), and the fat and sugar content of the food they consume. Other things equal, individuals like to be closer to some subjectively determined “ideal” weight, and enjoy consuming fat and sugar enriched (“unhealthy”) food. In short, suppose that individuals derive utility from personal appearance and consuming unhealthy food. Increases in income allow individuals to acquire more of both of these; the net effect of income on weight outcomes hence depends on individual preferences. As Lakdawalla and Philipson (2009) note, the manner in which income is earned is also important. Specifically, income earned by working in a sedentary job is likely to generate a positive relationship between income and weight, while earnings from active work will do the opposite.

Consider what practical questions a government must answer in introducing an economic policy to combat obesity: Which particular goods and services should be taxed? Which ones should be subsidized? How much should these taxes and subsidies be? How much income should be transferred to less affluent households?

The degree to which individuals actually change diet and exercise choices in response to changes in prices and income is an empirical question that is examined later on in this report. Economic theory, however, can provide some guidance for policy making.

The first basic insight from economics is that, in response to price changes, individuals may substitute lower priced goods for higher priced ones. One implication for economic policy is that taxes and subsidies should be broadly applied. To illustrate, suppose that government decides to apply a special tax on cola. Individuals might then substitute root beer or other kinds of sodas for cola. If governments tax all sodas, then individuals might switch to sugar added sports drinks. This suggests that to reduce caloric intake, governments tax all drinks that consumers consider to be substitutes in proportion to their added sugar. A similar principle might guide the taxation of foods with added sugars and fats.

The principle of substitution applies more generally. For example, individuals derive utility from personal appearance and consuming unhealthy food and if government reduces the cost of engaging in physical activity, individuals respond by exercising more and they lose some weight. It is possible that, in response, individuals eat more unhealthy food. Substitution might also take place across time and space. For instance, a mandatory physical education program at school might not affect overall activity levels if students compensate by exercising less away from school. As another example, individuals who eat healthy lunches may feel entitled to eat unhealthy dinners.

Another principle from economics is that price increases reduce the purchasing power of one's income, and reductions in purchasing power can affect diet and exercise choices. For example, if people spend a lot of their budget on unhealthy food and the government imposes an excise tax on these foods, people respond by reducing, but not eliminating, their consumption of these foods. This reduces their purchasing power. In response, individuals reduce their consumption of relatively expensive fruits and vegetables and other healthy foods. Such "income effects" will thus mute the effectiveness of tax policies in controlling weight. The lesson for policy here is that if governments apply excise taxes to discourage the consumption of unhealthy foods or beverages that constitute a considerable share of the household budget, it should also apply subsidies to encourage the consumption of healthy foods and beverages. This way, the subsidies can mitigate the loss in purchasing power created by the taxes and thus mitigate unwanted income effects.

A final economic principle that can guide policy is the notion of cost-effectiveness – adopting policies that yield the largest social benefit per dollar spent on the policy. For example, the government elects to subsidize gym memberships to all adults in an attempt to increase physical fitness. One measure of social benefit of this policy is the number of individuals who become physically active on account of the subsidy. It is possible, however, that most of the benefit accrues to those who were already physically active – individuals who would be active even without the subsidy. For such individuals, the subsidy is a windfall gain. In this case the policy creates largely private benefits.

In summary, economic policies need to take into account:

Substitution. In response to changes in relative prices, individuals might substitute between different types of food and drinks in ways that mute the intended effects of the policy. Similarly, policies that do reduce caloric intake might not reduce weight if individuals adjust their levels of physical activity.

Income effects. Changes in relative prices that materially affect an individual's purchasing power might change consumption of calorie rich foods, or physical activity, in ways that mute the intended effects of the policy.

Substitution and income effects operate in tandem. The change in the price of one commodity can affect not only the amount of that commodity that consumers wish to use but it can also affect the desired amounts of other commodities. Thus the imposition of a tax on soda for example, can affect consumption of sodas, snack foods, fruits and vegetables and other product categories. The presence of substitution and income effects also suggests that when marshalling evidence on the effectiveness of economic policies it is necessary to obtain evidence on how changes in prices and income affect weight outcomes *directly*.

Cost-effectiveness. Policies that reward desired behaviours, such as physical activity, will create windfall gains to those who already engage in the desired behaviour. This may make the policy a costly way to change relatively few individuals' behaviour.

We also note here that there are several other economic factors that affect behavioural responses to changes in prices and incomes. Recent research has highlighted how the salience or visibility of taxes affects behaviour: taxes that are included in the posted price reduce consumption more than taxes that are added at the sales register. Standard economic models would predict the same behavioural response in both scenarios (Chetty, Looney & Kroft, 2009). Tax and subsidy salience are addressed more fully as policy options at the conclusion of this report.

Finally, the term "elasticity" requires further explanation as it is used throughout this report. Economists present estimates of the impact of one variable on another, such as the effect of price on weight outcomes, as "elasticities". The elasticity is defined as the effect of a percentage change in one variable on the percentage change in the other. So, for instance, the elasticity of weight with respect to

price is the percentage change in weight due to a one percent increase in price. The effect of a one percent increase in price of a commodity on the percentage change in the amount of that commodity demanded has a special name; it is called the (own-price) elasticity of demand.

3.1.4 Learning from Tobacco Control

Given uncertainty in the effectiveness of any policy intervention, the successful story of using tobacco taxation to reduce smoking presents a strong case for considering a similar approach in the context of obesity. Tobacco taxation has been recognized internationally as one of the most effective population-based strategies for decreasing smoking prevalence and consumption and the adverse health consequences (WHO, 2008).

Historically, the effectiveness of taxation as a tobacco control measure has been evaluated in the context of price elasticity of demand, the extent to which the consumption of a product (cigarettes) falls or rises after a change in its price. Recent research estimates that, in high income countries, a 10% increase in cigarette prices results in a 3% to 5% decrease in demand for cigarettes per adult (Gallet & List, 2003). While price elasticity estimates are comparable among high income countries (Hopkins et al., 2001), the impact of taxation appears to be greater in low and middle income countries, where smoking rates are generally higher and tobacco control policies weaker (Ross & Chaloupka, 2006). Further, there is growing evidence that youth and young adults are generally more sensitive than adults to price changes in cigarettes (Carpenter & Cook, 2008; Chaloupka & Wechsler, 1997; Ding, 2005; Ross & Chaloupka, 2003). This is especially important, given their vulnerability to aggressive industry marketing and the fact that adolescence is when most smokers initiate smoking (Khuder et al., 1999).

Many studies in different populations at different points in time show a strong inverse relationship between relative price, and both the prevalence of smoking and the per capita consumption of cigarettes (Chaloupka & Warner, 2000; Russell, 1973). Utilizing taxation as an effective population-based strategy is highlighted by the 1994 decision of the Canadian federal government and five provincial governments to reduce cigarette and tobacco taxes by about 50% as a means to curb smuggling. As a result of the cuts, smoking rates among youth and young adults increased significantly (Zhang et al., 2006; Hamilton et al., 1997).

Tobacco use is also socioeconomically stratified, with disadvantaged populations experiencing higher rates of smoking (Jha et al., 2006). Some (including the tobacco industry) have raised the issue of regressivity of taxation, pointing to a potential disproportionate burden on the poor (Giskes et al., 2007; Powell & Chaloupka, 2009). However, the potential progressivity of tobacco taxation has been demonstrated by the greater price sensitivity of deprived smokers and the use of revenues generated by tax increases to support public insurance and other programs targeting deprived populations (Farrelly et al., 2001; Gruber & Zinman, 2004; Ross & Chaloupka, 2000; Siahpush et al., 2009). There is, however, little research evidence on the effectiveness of taxation and price as a tobacco control policy in Aboriginal and other disadvantaged subpopulations.

While the evidence supports the effectiveness of taxation as a means to reduce tobacco consumption and smoking prevalence, other valuable lessons have been learned in relation to this tool. There is strong public support for taxation, especially if revenue is channeled to fund tobacco control programs and expanded health insurance coverage (CDC, 1997; Hamilton et al., 2005; Lum et al., 2009). Further, given its effectiveness, taxation is a relatively underutilized tobacco control tool. While a multitude of factors may explain this, a significant barrier is the tobacco industry, as initiatives to raise tobacco taxes and strengthen tobacco control policies generally elicit strong responses from the

industry and related interest groups. It is likely that the food industry will take similar actions to the tobacco industry in response to the possibility of taxation (see Brownell & Warner, 2009).

3.2 Existing and Proposed Economic Interventions

3.2.1 What Are Economic Interventions?

Governmental interventions can be broadly categorized into four approaches including:

- a) to inform (e.g., provide nutritional content information on food packaging),
- b) to regulate (e.g., zoning bylaws that may affect how new communities are built or banning food advertising targeted at children),
- c) to directly provide goods or services (e.g., finance construction of parks and recreational facilities),
- d) to change prices and income.

Although all these approaches have economic content, the focus of this scoping review is on this last approach (**i.e., policies that aim to change individuals' behaviours and weight outcomes through changing relative prices and through income transfers**). Specifically, there are three types of economic instruments that are the focus of this report¹. The first group involves taxes on high-energy food and subsidies on healthy foods, physical activity, and public transport. The second group relates to agricultural subsidies that determine the relative prices of certain commodities used to produce high energy foods. The third group consists of targeted income transfer programs that focus on increasing healthy food consumption and physical activity for low income and disadvantaged groups.

3.2.2 Examples of Existing and Proposed Interventions

There have been many policy proposals and recommendations, however few of these have been implemented. Existing financial measures in the food domain include food taxes that have been imposed in a number of countries, but mainly for the purpose of raising revenue. Among existing diet-based economic policies, “junk food” taxes are the most common. For example, 47 American states impose fast food restaurant taxes, 33 states have soft drink sales taxes, 29 states have candy taxes, and 14 states tax chips and pretzels. Among these taxes, the highest sales taxes are on fast-food restaurants and soft drinks, with a mean tax rate of 5.6% and 5.2% respectively (Powell & Chriqui, 2010). Other countries, such as Canada and Australia, apply general sales taxes to chips, soda, chocolate and other snack foods but exempt most other grocery items from taxes. European countries impose value-added taxes on foods such as soft drinks, snacks and sweet confectionaries. Healthy food subsidies (e.g., free or subsidized fruit and vegetable programs) have been tested in a number of schools in the US, Canada, Norway, England and Holland. The US in particular has large food subsidy programs such as the national breakfast and school lunch programs. Numerous developed countries provide farm subsidies to those who grow particular commodities; governments also subsidize agricultural research and development.

A number of economic interventions have been proposed to affect food and beverage consumption. Brownell et al. (2009) recommended an excise tax of 1 cent per ounce for beverages that have any added caloric sweetener. They further recommended that the resulting tax revenues fund obesity

¹ Empirical studies were reviewed that evaluated the effects of direct financial incentives on weight outcomes. In essence, this type of intervention also involves using financial instruments to alter the relative costs of making obesity-related choices and affect weight outcomes. However, due to the focus on interventions that can be applied on a broad scale and due to limited space, this section is presented in Appendix 8.

prevention programs and health-related services for obesity. More recently, in 2009 Toronto Public Health advocated for the Ontario government to "Put Food in the Budget" by introducing a \$100 Healthy Food Supplement for all adults on social assistance².

In the physical activity domain a number of financial measures have been adopted in Canada. The federal government approved the Children's Fitness Tax Credit (CFTC)³, beginning January 2006, that enables parents of children under 16 years old to claim a tax credit for up to \$500 spent on eligible fitness expenses for each child. Since July 1, 2006, the Government of Canada introduced a public transit tax credit that includes buses, streetcars, subways, commuter trains and local ferries⁴. Unlike the CFTC program, the primary goal of the public transit pass tax credit is to help cover public transit costs and to reduce traffic congestion and air pollution. However, this program might result in higher energy expenditure in the population because those who use public transit are found to be more physically active (see, for example, Lachapelle & Frank, 2009). In addition, some Canadian provinces also exempt certain goods used in sports or physical activity from sales taxes. Starting December 1, 2007, the Ontario government exempted bicycles, bike helmets and other safety equipment from the provincial sales tax⁵. This program ceases at the end of 2010.

Proposals to directly encourage physical activity include tax credits for gym membership, removal of sales taxes on sport and recreation equipment as well as subsidies on sport and recreation activities. In Canada, there are calls for the Children Fitness Tax Credit to be expanded to include adults (the province of Nova Scotia has already adopted such a measure⁶). The Center for Spatial Economics (Centre for Spatial Economics, 2007) estimates that the adult tax credit would take just three years for healthcare cost savings (resulting from a more active and healthier population) to outweigh the net personal tax losses. Furthermore, projecting over the next 21 years, the federal government would save \$2.5 billion (from cumulated health care savings of \$9.1 billion and cumulated net personal tax losses of \$6.6 billion).

Another policy option is to remove the federal sales tax from wellness programs for adults (International Council on Active Aging, 2007). Some other financial measures have also been proposed to improve the built environment: gasoline taxes, road congestion taxes, property tax exemption for private fitness facilities, income tax credits for certain types of land use development that promote physical activity (IOM, 2005), health impact fees on developments unfriendly to physical activity (Pratt *et al* 2004), allocation of transportation funds to pedestrian, bikers, walk-to-school and transit projects, and investments in parks, etc. The most commonly described interventions are presented in Table 1.

² <http://wx.toronto.ca/inter/it/newsrel.nsf/bydate/7A687D8CB98B49BC85257670005EBD87>

³ <http://www.cra-arc.gc.ca/whatsnw/fitness-eng.html>

⁴ <http://www.transitpass.ca>

⁵ <http://www.rev.gov.on.ca/en/notices/rst/61.html>

⁶ <http://www.gov.ns.ca/hpp/pasr/healthy-living-incentive.asp>

Table 1. Existing and Proposed Economics Interventions

	Existing Interventions	Proposed Interventions
Nutrition	- Small taxes on soft drinks and snacks in some US states	- Fruit and vegetable subsidies - Tax on soft drinks - Tax on fast foods - Healthy Food Supplement
Physical activity	- Children's Fitness Tax Credit - Public Transit Tax Credit - Sporting equipment sales tax exemption - Road congestion tax	- Adult Fitness Tax Credit - Subsidize physical activity programs - Remove adult wellness program federal sales tax

4 Review of Empirical Evidence

Given that the current situation is described as ‘a cacophony of policy in which different analyses and policy solutions have been developed and proffered, each clamouring for support, funding and adoption’ (Lang & Rayner, 2007), there is clearly an urgent need for clear and solid evidence to emerge and be synthesized to guide policy responses. To achieve this, the project adopted Arksey and O’Malley’s (2005) methodological framework for conducting scoping reviews. Scoping reviews are distinct from systematic reviews in that a) they often address broad topics where a variety of study designs and secondary topics may be relevant, b) they are less likely to formally assess the quality of included studies or use study quality criteria to guide the synthesis of data, and c) they are used to identify parameters around a body of literature, and to identify gaps in the existing body of research. This study’s scoping review consisted of two main phases: 1) a structured literature search and review, and 2) consultation with experts in the research field through a Delphi survey and meeting (see Appendix 1 for a list of the experts). Engaging external experts was critical. Given that this is a nascent area of inquiry in Canada, much of the knowledge may not appear in the published or grey literature and engaging additional expertise was deemed necessary.

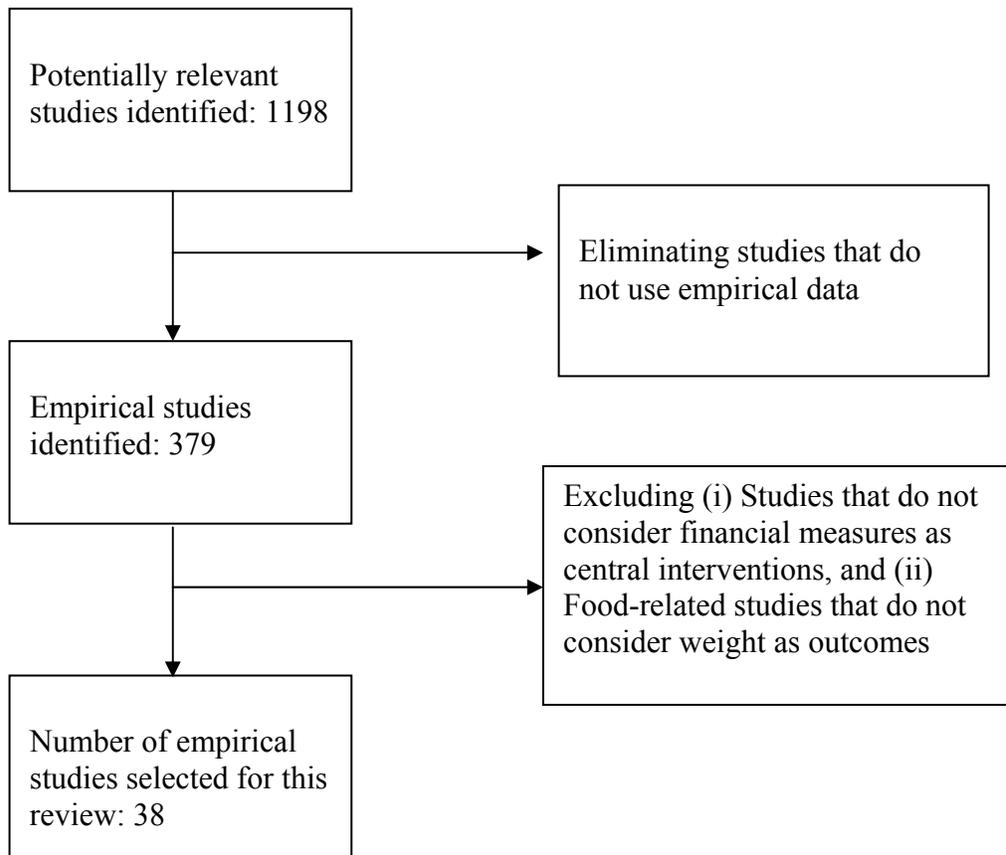
4.1 Literature Search: Methods and Results

The search strategy was designed in consultation with an information coordinator from the Ontario Tobacco Research Unit (OTRU) and expert panel members. Detailed and extensive searches were conducted on Medline, PsycInfo, PubMed, Econlit, Policyfile, Pais International, OVID, Web of Science, Cochrane Reviews and Google Scholar from September to December 2009. Searches were also performed on a range of grey literature sources including NBER, U.S. Department of Agriculture (USDA)’s Economic Research Service, and other governmental agency websites. Search term combinations were used to identify relevant studies in the nutrition domain: ‘overweight, fat, diet, nutrition, caloric, weight, obesity, BMI, consumption, demand, intake’ with ‘taxes, subsidy, intervention, economic policy, transfer program, income support, WIC, food stamp, cash transfer, agriculture subsidies, farm policy’. For physical activity related studies, combined search terms included: ‘tax credit, tax exemption, tax, subsidy, monetary incentive, financial incentives, tax exemption’ with ‘urban design, transportation, built environment, park, recreational activity, walkability, walking, physical fitness, exercise, physical activity, exercise, sports, lifestyle, sport equipment, active living’ with ‘overweight, fat, weight, obesity, BMI’. Reviews were done of retrieved primary and review article reference lists (including those from previously published systematic reviews); hand searches of key physical activity, nutrition and health economics journals (to

December, 2009), and; expert panel members were asked to review the final reference list for completeness. In May 2010, an updated literature search was completed that focused from December 2009 to May 2010. Panel experts were also consulted for any new studies that were recently available. This updated search yielded one recent review and two empirical papers which were incorporated into this project.

Figure 1 summarizes the search results and study selection procedure. This comprehensive search resulted in 1198 potentially relevant studies. The initial screening identified 379 studies that employed empirical analysis. Next, studies were selected that focused on financial measures such as prices, subsidies, taxes or income transfer programs as the central intervention. In addition, due to the commodity substitution concerns discussed earlier, the availability of an existing comprehensive review (Andreyeva, et al., 2010) and limited space, we excluded studies that focused on the effects

Figure 1. Selection of empirical studies



of food prices on food consumption/demand. Instead, studies that explicitly focused on weight outcomes (such as obesity and body mass index), physical activity or caloric intake were assessed. Finally, the review focused solely on observational or RCT studies that estimated behavioral responses and hence, excluded simulation studies. These requirements further reduced the number of studies reviewed to 38. In addition to these empirical studies, we identified 7 relevant reviews. Data from each empirical study was abstracted (e.g., authors, study location, year of publication) including some analytical detail such as design and key findings. Next, the abstracted information was collated and summarized in chart form (see Appendix 2 for reviews and Appendix 3 for empirical studies) and the

identified studies were thematically organized. Overall, this represents the most current and comprehensive review of the existing literature.

4.2 Expert Consultation: Delphi Survey and Panel Meeting

Named after the ancient Greek oracle, the Delphi Technique was developed in the United States (1950-60s) as a means of forecasting future scenarios. It is a mixed-method research approach, designed for exploring the range of opinions, and exploring (or achieving) consensus on a specific topic. The technique is considered particularly useful in areas of limited research or in areas where there is controversy, debate or lack of clarity (Iqbal & Pison-Young, 2008). Expert consultation is an increasingly acceptable source for gathering evidence about a topic particularly when the extant literature is weak (Faulkner et al., 2006). The Delphi has been successfully applied to a range of issues, including views on the most suitable monetary incentives on food to stimulate healthy eating (Waterlander et al., 2009). The approach has a number of key characteristics. First, it uses a group of panelists specifically selected for their topic expertise. Its success is dependant on the extent to which panel members represent expert opinion; expert status therefore needs to be clearly defined. In this case, panel members (see Appendix 1) were identified through an initial literature search for researchers prominent in the field of economics and obesity. Each panel member was also asked to nominate others who should be on the panel. The primary inclusion criteria included publications on economic interventions or consequences of obesity. Second, the Delphi is conducted across a series of two or more 'rounds' using questionnaires. It starts with an initial idea generation stage to identify relevant issues after which a survey instrument is developed and distributed over successive rounds. Third, there is an evaluation phase where panelists review and re-evaluate their original responses against the full panel's responses.

This project applied a four-round conference style format to examine economic instruments for addressing obesity. During round one, telephone calls were conducted with all panel members to identify potential economic instruments and to confirm the project's literature search strategy. Based on these discussions and the reviewed literature, a survey was created that listed the most commonly reported economic instruments. In round two, this survey was sent to all participants with the request to rate each instrument in terms of its potential impact on obesity, consumption or physical activity, its cost-effectiveness, potential for unintended benefits or harm, equitability, and political feasibility. Experts were then asked to return their responses to a nominated facilitator external to the Delphi process. Respondent names were removed, replaced with a number and then forwarded to the first author. During the third round, questionnaires were returned to each individual expert, containing a summary of their score for each item, along with the score for the group as a whole. Panel members were invited to review their individual ratings against these group means, and resubmit their responses with changed or unchanged scores. Final responses were returned to the facilitator and forwarded to the lead expert. Group means were calculated for each item and then ranked according to their score within each of the major type of economic instrument. This ranking represented the group's consensus, and was distributed via email to the expert panel with summary statistics purposely timed to precede an in-person panel meeting held in Toronto. At this meeting, panel member opinions and views on their Delphi rankings and attendant recommended policies were solicited. The final section of this report includes policy recommendations that reflect both the empirical evidence and the expert panel consensus.

5 Taxes and Subsidy Measures

5.1 Nutrition

This study found five existing systematic reviews focused on the effects of food taxes on obesity. Overall, these reviews suggest that food taxes have a limited impact on obesity levels.

Goodman and Anise (2006) provided the first systematic review on the effectiveness of economic instruments to reduce consumption of energy dense unhealthy foods. The authors reviewed two observational studies that used longitudinal survey data and site-specific interventions in 20 randomized controlled trials (RCTs). Their review also considered food prices and food consumption evidence due to insufficient numbers of studies that explicitly considered body weight as the primary outcome.

Goodman and Anise's (2006) review could not establish causal relationships between food prices and weight outcomes. Furthermore they noted that the RCTs had low external validity. Overall the authors highlighted that "available evidence suggests – but does not demonstrate – that introduction of policy-related economic instruments, particularly in the form of taxes and price policies, could reduce food consumption, including of high saturated fat and other energy-dense foods, and increase the purchasing of healthful foods". They conclude: "At present, there appears to be insufficient evidence to support widespread implementation of policy-related economic instruments intended to reduce consumption of foods high in saturated fats for preventing or reducing obesity".

Cash et al. (2007) reviewed twelve articles on the possible effects of fat taxes and thin subsidies. Seven of these articles examined fat taxes and five focused on thin subsidies. Only two studies used population survey data and the others were simulation studies. The authors found that estimates of the population health effects of food price interventions vary widely and sometimes offer conflicting policy responses. Some studies that suggest taxation policy can achieve health benefits often find that modest taxes will produce only modest health benefits. These authors concluded that there is incomplete economic evidence for food price interventions and highlighted the practical challenges in implementing such interventions.

Von Tigerstrom (2009) reviewed evidence on financial instruments on both food intake and physical activity. The author suggests that there is limited evidence on the effectiveness of financial measures used to promote healthy diet and physical activity to reduce overweight and obesity. Powell and Chaloupka's (2009) recent review studied the evidence on food taxes and subsidies to address obesity. Arguing that RCTs are often conducted in controlled environments that have very low external validity their review was restricted to nine studies that only used large-scale observational data. They found limited evidence on the impact of food taxes and subsidies on obesity. Powell and Chaloupka note that "when statistically significant associations were found between food and restaurant prices (taxes) and weight outcomes, the effects were generally small in magnitude, although in some cases they were larger for low-socioeconomic status (SES) populations and for those at risk for overweight or obesity". They concluded that, "the limited existing evidence suggests that small taxes or subsidies are not likely to produce significant changes in BMI or obesity prevalence". However, they suggest that, "nontrivial pricing interventions may have some measurable effects on Americans' weight outcomes, particularly for children and adolescents, low-SES populations, and those most at risk for overweight". They also note that more research is needed to build the evidence base, including studies that control for contextual features to obtain a pure effect of food prices, studies that draw on alternative sources for price data, such as food and beverage taxes, and studies that use longitudinal data.

More recently, Thow et al. (2010) reviewed 24 empirical and simulation studies that estimated the effects of subsidies and taxes on specific food products on consumption, body weight and chronic conditions. Their findings indicate some evidence, albeit of low quality, that taxes and subsidies reduce consumption and improve health outcomes such as body weight and chronic disease risk. Their review recommended that more research be performed in two broad areas: empirical evaluations of existing taxes as well as research into the effectiveness and differential impact of food taxes in developing countries.

Summary of Empirical Research

We reviewed 20 empirical studies of the effect of food and beverage prices on weight outcomes. Of these, 5 focused on soft drink taxes, 4 on fast-food prices, 2 on sugar prices, 1 on fruits and vegetables prices, 2 on general food prices; the 6 remaining studies considered both fast-food prices and fruit and vegetable prices in their analyses. A detailed review of these papers is found in Appendix 6. Below is a summary of the findings.

First, there is evidence that adult weight is modestly responsive to soft-drink taxes. For children and adolescents, soft drink taxes lead to only small weight reductions, but they may induce a healthy substitution from soft drinks to whole milk. Teens at risk of being overweight may also experience weight reduction.

Second, there is consistent evidence that lower prices of fruits and vegetables are associated with lower child weight. For adolescents and adults, the evidence also suggests that weight is sensitive to fruit and vegetable prices. The most price-sensitive populations include lower income and lower educated young adults as well as children with lower educated mothers and middle-income parents.

The existing evidence indicates that fast food prices are negatively correlated with children and adolescents' weight but less so for adults. Further, teens' weight in low- to middle-socioeconomic status families is most sensitive to fast food prices.

Finally, there is evidence of a negative correlation between sugar prices and weight. Taken together, the existing evidence suggests that imposing taxes on high-energy foods such as soft-drinks and fast-food, and providing subsidies on fruit and vegetables may reduce body weight.

Given that the evidence supports an effect of food prices on weight outcome, the key question is the magnitude of this effect. According to studies that were selected and reviewed in this review, price effects are small. However, it might be inaccurate to conclude that prices have small effects on weight outcomes. In fact, the estimated price effects should only be considered as the lower bound of price effect, as there are a number of factors that might cause the effect to be underestimated.

First, the current state-level soda and snack taxes in the US may be too small and lack the variation necessary to help identify meaningful effects on people's weight. To date, none of the implemented food taxes were designed with the primary purpose of addressing obesity. For example, average state taxes imposed on soda and soft drinks are very low, at \$0.0425 on a \$1.00 bottle of soda when sold through grocery stores (Powell *et al.*, 2009). This is in contrast with cigarette excise taxes of as much as \$2.75 on a pack of cigarettes (in New York) and the combined state and federal taxes that more than double the retail price of cigarettes in many states (Orzechowski & Walker, 2008).

Second, prices of fast foods are determined in part by demand conditions, therefore they may not be exogenous. Goldman et al. (2009) point out that if food prices are determined by both supply (i.e. manufacturers) and demand conditions, the effect of prices on weight outcomes will be underestimated in the empirical studies.

Third, measurement errors in weight and price data might bias price effects downward. The information on weight and height used to calculate BMI are mostly self-reported. At the same time, limitations of price data from ACCRA (American Chamber of Commerce Research Association) are well known (Powell & Chaloupka 2009; Sturm & Datar 2005). These price data were collected in larger cities and metropolitan statistical areas and as a result are skewed towards higher income households and will produce considerable measurement error when matched to low-income or rural populations. Further, only a small number of food items are surveyed, so the data are not fully representative across food groups. Also, ACCRA does not always continuously sample the same cities, and hence the data are not fully comparable over time.

Fourth, there is an inherent difficulty in estimating the effect of economic factors on weight outcomes. Because these effects follow a nonlinear accumulation pattern (i.e., as Katan & Ludwig (2010) explain, in response to continuous increases in caloric intake, weight does not increase continuously, but rather can adjust in discrete jumps), one needs to distinguish between short term impacts (which can be modest in magnitude) and long term impacts (which as Goldman et al., (2009) demonstrated, can be substantial).

5.2 Physical Activity

Economic instruments related to nutrition and obesity prevention have been widely studied; however, that is not the case for physical activity. Evidence is far more limited and indirect. Von Tigerstrom (2009) has conducted the only literature review on the use of economic measures to encourage physical activity. The author concluded that very little evidence is available on which to base any conclusions about the likely impact of tax or subsidy measures to increase physical activity. One exception is a recent study (Spence et al. in press) that examines the effect of the Child Fitness Tax Credit (CFTC) program. No other new empirical evidence directly assesses the effectiveness of tax or subsidy interventions in promoting physical activity. Despite available evidence that the CFTC would have no impact on increasing physical activity, it was introduced in Canada (Madore, 2007). A commonly suggested economic instrument to increase physical activity levels in Canada is to subsidize physical activity programs (Madore, 2007; von Tigerstrom, 2009). This current project found no direct empirical evidence that examines interventions subsidizing physical activity programs and their impact on physical activity levels and/or body weight. More recent research does examine the potential impact of transport costs and road congestion taxes on physical activity.

Summary of Empirical Research

This project reviewed four studies: two studies focused on the impacts of subsidized physical activity programs and two studies investigated the effect of gas prices and road usage taxes on physical activity. All of these studies are reviewed more fully in Appendix 5.

From the existing studies, it is difficult to draw clear conclusions on the effectiveness of economic instruments targeting physical activity. Conflicting findings are evident in the two studies that focus on the correlation between gas prices and physical activities; these discrepancies may be largely attributable to differences in how physical activity was measured in each study. There is evidence from one quasi-experimental study that road congestion taxes may increase physical activity.

While there are numerous studies that evaluate various strategies to promote physical activity in various settings such as schools and worksites, it is rare to locate empirical studies that investigate the effectiveness of population-wide financial instruments to promote physical activity. This research gap is likely due to the challenges in evaluating the implementation of such instruments in the form of natural experiments (Ramanathan et al., 2008). Many interventions (such as rebates on sporting goods)

have been implemented with no intention to conduct an effectiveness evaluation (Faulkner et al., 2006).

Physical activity research has a number of unique challenges when compared to empirical research on nutrition. Unlike food prices, aggregate price indices of ‘physical activities’ – arguably an exogenous source that could be used to evaluate the effect of financial measures on physical activity in population-based studies – are difficult to measure and obtain. Without exogenous financial determinants to link with physical activity and weight outcomes, it is difficult to estimate causal effects regarding financial measures on weight outcomes via increases in physical activity. From this perspective, the appearance of studies that employ exogenous sources of price variation, such as gas prices and road congestion taxes or studies that directly evaluate a large-scale fiscal intervention⁷ suggests that future research may provide more definitive evidence.

Existing financial incentives for exercise programs or equipment appear to favour individuals of higher socioeconomic status (Pratt et al., 2004). As Block (2007) points out, such concerns may be particularly salient when considering interventions such as the Children’s Fitness Tax Credit which requires sufficient taxable income in the first place for it to be of any benefit. Such programs will have “no value for parents whose income is not taxable, such as social assistance recipients”. Indeed, Spence et al. (2010) presents evidence that the CFTC program benefits the wealthier families in Canada.

5.3 Targeted Income Transfer Programs

In addition to using taxes and subsidies to alter the relative prices of healthy foods versus unhealthy foods, another potential tool to address obesity is to use income transfer programs. As mentioned earlier, affluence can affect food choices and thus obesity in offsetting ways: those with more income can afford to consume more calories, but may choose not to if they desire higher levels of health. The net effect of income transfer programs on weight outcomes is therefore *a priori* unclear and is thus an empirical question.

This project’s review of empirical research distinguished two groups of transfer programs. The first group generally involves income support whose main goal is to address poverty and is referred to as ‘unrestricted’ income transfers. There are many such programs in the US, including for instance, Temporary Assistance for Needy Families (TANF) for single mothers, Disability Insurance, Supplemental Social Security Income for older adults, and the Aid to Families with Dependent Children (AFDC).

Another group of transfer programs – ‘restricted’ income transfers – can be redeemed for food and beverages only.⁸ One example is the Food Stamp Program (FSP). Participants in the Food Stamp programs are distributed cards (historically, paper denominational stamps or coupons worth \$1, \$5, and \$10) that can be used to purchase any food or food product intended for human consumption, except alcoholic beverages, tobacco, and hot meals and hot food products prepared for immediate consumption (GAO, 2008).

It is necessary to make a distinction between subsidies and transfer programs. In the food context, several foods can be purchased under the transfer program such as the Food Stamp program, while

⁷ Currently, the Heart and Stroke Foundation and CIHR is funding von Tigerstrom and her colleagues to evaluate the use and impacts of the Canadian Childhood Fitness Tax Credit program on child enrollment in sports and other activities as well as on their weight outcomes.

⁸ We did not identify a transfer program that is targeted directly at promoting physical activity.

subsidies are normally tied to specific foods such as fruit and vegetables. Another difference is that transfer programs often involve a payment limit (for example, a \$10 voucher to buy foods) while subsidy programs reduce food prices but impose no limit on the quantity purchased. Thus, subsidies create more potential for resale. Finally, it is important to note that depending on the current consumption level of the products or goods targeted by subsidies, subsidies can become a pure income transfer. For example, a person may currently spend \$25 on fruit and vegetables a month without subsidy and then participate in a recently introduced fruit and vegetable subsidy program. If that person still spends \$25 per month on fruit and vegetables, this suggests that the subsidy has no impact on the person's total fruit and vegetable consumption. The savings from buying cheaper fruit and vegetable are likely to be spent on other goods, making the fruit and vegetable subsidy in essence a pure income transfer. These implications are discussed in the fruit and vegetable subsidy section.

Summary of Empirical Research

This project reviewed eight articles that examined the effect of income transfer programs on adult and child weight outcomes, and two empirical studies that investigated the impact of income directly on weight outcomes (see Appendix 6).

The existing evidence suggests that unrestricted, non-food transfer programs to pregnant women have a positive effect on improving infant birth weight. In contrast, while food-based transfer programs have the effect of improving nutrition for the poor, the empirical evidence suggests that they might have an adverse effect of encouraging excessive energy consumption that leads to overweight and obesity for adult women.

In light of the possible adverse effects of food-based transfer programs on adult weight outcomes, there have been calls for revising the Food Stamp program in the USA so that stamps can be redeemed exclusively for healthy foods. Further, WIC (The Special Supplemental Nutrition Program for Women, Infants and Children) food packages have recently been revised to reduce the amount of saturated fat, cholesterol, and total fat provided in the supplemental food package in order to encourage eating patterns that promote healthy weight (Oliveira & Frazao, 2009). The revised WIC food package also includes new vouchers for buying fruits and vegetables (currently, \$10 monthly for mothers and \$8 monthly for children). Some recently proposed programs follow this direction. For example, Toronto is considering a program called the Healthy Foods Supplement that will provide \$100 per month for people to buy healthy foods only although such foods have not been defined as of yet.

It should be noted that such food-based programs may have unintended consequences. Alston et al. (2009) used a theoretical economic model to predict the effect of the proposed revisions to the Food Stamp program. Their simulation results suggest that while people might consume more healthy foods, the overall effect on weight outcomes is unclear. The reason is that, when demand for healthy foods increases as a result of the revised food stamp program, the prices of healthy foods also increase, and these price increases will harm low income households that do not participate in the program. However, the authors also note that in the longer term, increases in supply of health foods would offset some of the price increases.

5.4 Agricultural Subsidies

Broadly defined, agriculture policies refer to any programs or policies that aim to promote agricultural output, increase farmers' earnings, or reduce earnings uncertainty. The policies that are most often linked to obesity – and the focus of some debate in the US – are public subsidies on agricultural commodities and on agricultural R&D programs. Other policies that could lower food prices paid by consumers or expand food availability include public subsidy of irrigation, loans for farmers, and

transportation programs. Not all policies, however, operate to lower food prices. Import tariffs may increase prices of certain products and discourage consumption.

Summary of Empirical Research

This project reviewed three empirical studies on the role of agricultural subsidies on obesity (see Appendix 7). The issue of whether agricultural subsidies on commodities are responsible for obesity rates is the matter of some debate. This debate is due to the difficulties in isolating the role of specific agricultural policies on food prices. As a result, indirect means of inference have had to be used and such studies often invite controversy. For example, Alston et al (2008) downplay the link between agricultural supports and food prices. This study, however, relied on comparisons of countries that have different levels of agricultural support (such as Japan and US). The challenge is that these countries can differ in many ways besides agricultural support levels.

Although the role of agricultural subsidies in the rise of aggregate obesity has not been solved, it seems likely that agricultural policies have contributed to childhood obesity indirectly, through the US commodity distribution programs (such as National School Lunch Program, the Child and Adult Care Food Program, and the Summer Food Service Program). These programs accept donated commodities from the USDA, many of which are energy-dense, such as cheese, milk, beef, pork, shortening, and oils. As a result, two-thirds of schools in the US serve lunches that exceed USDA guidelines for fat and saturated fat. Cawley and Kirwan (2010) estimated that these USDA commodity distribution programs are responsible for raising the risk of childhood overweight by 0.14 percentage points among children who consume school lunches.

It is also clear from the data that agricultural R&D subsidies have increased agricultural output and lowered farm commodity prices, and thereby have had an important impact on consumption and obesity. This unintended consequence of agricultural R&D on obesity does raise issues about the appropriate measurement of the social payoff to research and the need for rebalancing the public research portfolio to identify what diverse mix of crops and farming methods can best meet public health goals sustainably (Wallinga, 2010).

In Canada, there has been little empirical research on the effect of agricultural policies on food choices and obesity outcomes. It seems plausible, however, that Canadian agricultural support policies have, at best, only a modest effect on obesity. Canada has little influence on prices of obesity-linked commodities such as soybeans and corns (Canada is a large agricultural exporter, but it is a small player in most commodity markets, except for wheat and canola oil). Also, the size of agricultural subsidies in Canada is relatively small compared to those in the United States and the EU.

Despite this lack of research evidence there are still other agricultural policies that are likely to have had an impact on food choices and contributed to rising obesity in Canada. These policies are reviewed and assessed qualitatively by Cash et al. (2006). The authors note that Canada's dairy supply management program has encouraged consumption away from fluid milks and towards dairy products that have higher fat and sugar content. For example, milk processors will pay less for milk used in the manufacture of ice cream than for milk that is processed into fluid milk. Cash et al. (2006) suggest that the grade standard and inspection program that is applied to meat products may have affected rates of overweight and obesity: more marbled beef (i.e. meat with greater fat content) is given a higher quality rating. They note that the only agricultural policy that might have promoted health and reduced obesity in Canada is trade liberalization in fruit and vegetables. This policy has allowed Canadians year-round access, and lowered prices, of many fruit and vegetables.

6 Policy Considerations and Recommendations for Canada

A comprehensive combination of educational, regulatory, direct provision, and economic policies will be essential for effectively tackling the public health burden of obesity. Economic interventions by themselves are not the answer but should be one component of such a comprehensive approach. In terms of economic interventions, shifting from empirical evidence to policy recommendation remains challenging. Overall, the evidence is not sufficiently strong to provide clear policy direction. Additionally, the nature of the experiments needed to provide definitive evidence supporting certain policy directions is likely to be complex and potentially unfeasible. However, these are not reasons to take no action. It is likely that policies need to be implemented in the face of an incomplete evidence base – and parallels can be drawn with tobacco control - initial tobacco control interventions were not evidence based but represented sound judgment at the time (Yach et al., 2005). Where the empirical evidence is still not sufficiently strong, perhaps the most important criteria for considering a policy is the potential for harm such a policy might cause, rather than the extent of its impact on obesity. Additionally, even a good policy intervention involves some trade-offs. That is, a good policy may hurt some population segment, but on the whole may benefit society. The concern about the regressive nature of tax measures (that is, taxes may impose a larger burden on the poor than the rich) normally fails to take into account the potentially large health improvements resulting from imposing these taxes.

The Delphi survey completed before the panel meeting (see Appendix 9) highlighted the relatively modest impact any specific economic instrument might have on obesity. The panel meeting discussions largely were in line with these survey findings. To summarize starting with the highest priority:

- a) Panelists agreed that the most important priority was to modify agricultural support policies and food subsidies so as to both lower the prices, and increase the availability, of fruit and vegetables.
- b) Fruit and vegetable price subsidies should be targeted at children and low income households.
- c) While there is some emerging evidence that taxes on energy dense, nutritionally poor foods can reduce rates of obesity, such taxes were not recommended at this time.
- d) The majority of the panel members recommended the implementation of a tax on caloric sweetened beverages as a strategy that could be implemented now.
- e) While subsidising physical activity opportunities has some appeal, panel members believed there was not enough evidence to recommend any specific economic instrument for promoting physical activity at this time.
- f) The majority of the panel members indicated that unrestricted income transfers would not be a viable strategy for addressing obesity.

6.1 Reviewing Agricultural Policy and Subsidies

Panelists agreed that agricultural support policies were influential in the rise in rates of overweight and obesity. Such policies, which include public subsidies for R&D into increasing yields of soybeans, corn and other farm commodities as well as guaranteed minimum prices paid to farmers who grow such crops, have reduced the prices of these commodities, making them cheap relative to fruits and other vegetables. These subsidized commodities provide an inexpensive source of added sugar and fat, both of which are primary ingredients in processed foods. The lower prices and widespread availability of these processed foods, in turn, have encouraged their consumption, and this has in turn contributed to the increase in obesity. Panelists conceded that there is no strong empirical evidence linking

agricultural support policies to the growth in obesity. Nevertheless, panelists felt strongly that the lack of evidence was a result of the complex causal pathway and considerable time lags between policy changes and resulting changes in population levels of obesity. While panel members felt that modifying agricultural policies would have the biggest impact on reducing obesity, such modification also scored the lowest for feasibility. Limiting or eliminating farm subsidies to commodity farmers is unlikely to rapidly change a complex agricultural system that has evolved over decades.

Agricultural subsidy-specific recommendations for further consideration include:

- a) Create and implement an effective health filter to review new and current agricultural policies to reduce the likelihood that such policies have a deleterious impact on population rates of obesity. Specifically, an agricultural support policy should become secondary to a food and health policy.

To that end, immediate research support is required for two key areas:

1. empirical research on the effect of Canadian agricultural policies on food choices and weight outcomes, and;
 2. research on the spillover effect of cheap foods and commodities from the US on Canadian obesity rates. Such research may point to the need for imposing higher tariffs on cheap food imports.
- b) Restructure R&D subsidies to promote increased development of fruit and vegetable production and distribution. Measures to raise domestic supply of fruit and vegetables can also be complemented by lowering tariffs on imported fruits and vegetables.
 - c) Develop transportation and subsidized revenue insurance policies to assist farmers who grow fruits and vegetables, widely considered a more riskier commodity than other agricultural products. Farmers should be engaged as ‘anti-obesity’ partners.
 - d) Develop measures that promote easy access to fruit and vegetables for Canadian households. For example, both the European Union and the United States have recently implemented policies to actively promote farmers’ markets.

Notably, some broad lessons can be derived from tobacco control highlighting the challenges in changing agricultural practice. For example, as stipulated in the Framework Convention on Tobacco Control (FCTC), the world’s first public health treaty, parties are expected to provide support for economically viable alternative activities to tobacco workers and growers as a measure to reduce the supply of tobacco. There is a paucity of research on the effectiveness of such programs. However, important lessons may be drawn from the Tobacco Transition Program (TTP), a \$301 million Federal initiative to help Canadian tobacco farmers and farming communities transition out of the tobacco industry. It was recently discovered that of the 100 tobacco growers in Ontario who participated in the program in 2009, all managed to exploit a loophole that allowed participants to continue to work indirectly in their industry. Consequently, the same amount of tobacco was produced in 2008 and 2009, even though \$30 to \$60 million was spent to subsidize the industry (Physicians for a Smoke-free Canada, 2010). Further, the Federal Government continues to offer interest free loans to tobacco farmers (http://www.accfarmersfinancial.ca/advance_payments_programs_tobacco.html).

6.2 Caloric Sweetened Beverage Tax

The majority of the panel recommended moving forward with a tax on caloric sweetened beverages (sweetened with sugar, corn syrup, or other caloric sweeteners including energy drinks, sports beverages and many juices and iced teas). Sugar-free diet drinks, diet beverages, sugar free juice, and

flavored milk would be tax exempt. There was consensus that while such a tax may in itself have a modest impact on obesity, it could be quite powerful in its impact over time, and have a synergistic effect with other tax, legislative, and educational initiatives to address obesity – this may be largely in relation to changing norms about dietary consumption.

In some respects, such a recommendation was described as a “leap of faith” given the incomplete evidence base. Nevertheless, most panelists felt that a tax on caloric sweetened beverages is justified, for several reasons. First, it was noted that unlike fast foods, caloric sweetened beverages “served no nutritional value”. Second, there was no indication from the empirical evidence that such a tax would be regressive and unfairly penalize low income individuals and households. Finally, just as the (rather successful) tobacco control policies were introduced with imperfect information concerning their effectiveness, so too, many obesity control policies will need to be introduced in the context of imperfect evidence. The actual impact of public policies will only be clear once they take effect.

The current impact of such taxes is believed to be modest because of the lack of variability in soda tax rates. This situation is mainly due to the fact that current soft drink taxes were designed and implemented without the purpose of addressing obesity. They are too low to generate a meaningful influence on body weight. Even so, there is evidence that low income individuals and children are the most sensitive to changes in prices. Additionally, there is strong empirical evidence that the consumption of soft drinks is responsive to its prices (for every 10 percent rise in prices, consumption declines 8 to 10 percent; see Andreyeva et al., 2010). Therefore, it is reasonable to expect that a sufficiently high tax imposed on soft drinks would be likely to reduce consumption and thus curb obesity. However, experts acknowledged that such data relies on many assumptions that may not hold during implementation. Unknown effects regarding substitution, compensatory behaviour, and producer response all serve to lower confidence in such claims.

In terms of magnitude, small taxes on soft drinks will likely do little to lessen soft drink consumption or prevent childhood obesity. The panel experts noted that the current US tax at 7% did not have the desired effect on weight outcomes. The level of the taxes will depend on where the soft drinks are sold (vending machine, convenience stores, and supermarkets) but experts suggest a minimum tax of around 20% of the price. For example, New York State was considering an 18% tax in 2009. Further, taxes should be calculated and implemented on a unit basis, rather than percent of price to avoid quantity discounts. Panelists also suggested that the taxes be salient. That is, taxes are likely to have larger impacts if they are made visible to consumers (Chetty et al., 2009).

The proposed soft drink tax would also deliver several other benefits. First, the revenue from this tax could be used to fund other obesity-related projects. For example, revenue could be earmarked to introduce a large number of free water fountains at public places. Generated revenue could also be used to fund fruit and vegetable subsidy programmes. Second, a decline in soft drink consumption also has the unintended benefit of decreasing sugar consumption (see, for example, Howard & Wylie-Rosett (2002) for the list of cardiovascular diseases associated with sugar consumption). Third, experts noted that fast-foods and soft drinks are often seen to be consumed together, so they may be complementary goods. Thus, consumption of fast foods might also decrease as a result of higher prices of soft-drinks.

Compared to a tax on energy-dense foods, the soft drink tax was considered more politically feasible. This is because the scope of sweetened beverages is easier to define. Further, beverages normally contain little or no nutrition value which makes justifying the case for a tax more compelling and politically palatable.

Critics of soft drink taxes often argue that soft drink taxes aim to raise revenue for the government's budget deficit, create job losses, and hurt poor people. One way to increase political support for soft drink taxes is to exempt bottled water and low energy drinks from sales taxes, as currently proposed and considered in New York State.⁹ Such a decision will make the proposal revenue neutral. Further, exempting taxes for bottled water and low energy drinks will likely boost demand for these products, making up for the reduced demand and jobs loss resulting from soft drink taxes. Finally, these tax exemptions further alter the relative prices of soft drink versus healthy drinks, providing yet more powerful incentives for people to switch away from soft drinks.

Specific recommendations for further consideration included:

- a) Apply the tax on the amount of caloric sweetener in the beverage (e.g., 10 cents per ounce of sweetener);
- b) Rationalize the tax in terms of broader health benefits as opposed to a single focus on obesity. Regardless of an impact on obesity, decreasing sugar consumption has other health benefits;
- c) Combine the implementation of such a tax with targeted unsweetened beverages and/or fruit and vegetable subsidies, or in other obesity prevention interventions, and;
- d) Monitor any unintended consequences of the tax implementation in terms of producers' formulation responses.

Three panel members were not in favour of such a tax, claiming that consumers would substitute unhealthy foods not subject to the tax if faced with higher prices for caloric sweetened beverages. They favored addressing the root economic forces at play, which they viewed as the agricultural R&D and commodity subsidy policies that have lowered the prices and increased the consumption of energy dense foods.

6.3 Food taxes

The panel recognized the potential in taxing certain food items and products in terms of reducing consumption. In many cases, the evidence was more compelling in comparison to data regarding beverage taxes. However, panel members did not recommend proposing such taxes at this time even though there is empirical evidence that low food prices contribute to higher consumption and obesity. There are a number of difficulties with the design and implementation of food taxes that require further research before specific recommendations can be made.

The major difficulty with food taxes is defining the scope of foods to be taxed that fall under the category of energy dense, unhealthy foods. Including all foods is likely to be unfeasible and will involve large administrative costs which might even exceed the revenue from taxing such foods. A more narrow scope will not achieve the goal because people will be able to substitute from one energy-dense food that is taxed to some other energy dense food that is not taxed. A particular concern with food taxes is the issue of food insecurity. For low income individuals, cheap, high energy foods may be the primary source of energy. Accordingly, these individuals may use a higher share of their income to pay food taxes than their wealthier counterparts. In other words, food taxes are more likely to be regressive.

The third challenge is that some foods have a mixture of good and bad nutrients, such as cereals with added sugar. Taxing these foods might eliminate both good and bad sources of nutrients which in turn might have a deleterious impact on health.

⁹ <http://www.wcax.com/Global/story.asp?S=12516684>

Specific recommendations for the Canadian context included:

- a) Further research is required particularly using scanner data (both home consumption data and away food consumption data) to examine micro level food choices to estimate the impact of different food taxes on behaviour.
- b) While food-based taxes may not be feasible, the potential for implementing place-based food taxes should be examined. For example, several US states have proposed to tax foods purchased at restaurants and food outlets.

6.4 Fruit and Vegetable Subsidies

In contrast to concerns about food taxes, panel members were uniformly in favour of fruit and vegetable subsidies – primarily targeting children and low income households. It was believed that the evidence clearly demonstrated a link between lower obesity risk and greater fruit and vegetable consumption although the mechanisms for this relationship are unclear.

Subsidies can become pure income transfer when people already consume some amount of the goods that are targeted by the subsidy. In such a case, there is a risk that the additional income is used for other goods including energy dense foods which counters the goal of the subsidy. This explains the recommendation proposed here that fruit and vegetable subsidies be targeted at children and low income people only. Low-income people often have low fruit and vegetable consumption (see Blisard et al. 2004). For children, encouraging them to eat fruit and vegetables will likely reduce the childhood obesity problem and may help them to develop a healthy habit of consuming fruit and vegetables in later years.

In terms of the subsidy coverage, both fresh and frozen as well as canned fruit and vegetables should be eligible for subsidy. For low-income adults, one way to deliver these subsidies is through grocery cards or debit cards. These cards can be connected with the Canada Revenue Agency databases for monitoring and reimbursement purposes. For children, free fruit and vegetables should be offered at schools. One example is the School Fruit Scheme implemented in the European Union.¹⁰

It was also noted that the total costs of a diet include both the monetary cost of buying the ingredients and the time cost of preparing the ingredients for consumption. Unlike soft drink or junk foods, fruit and vegetable preparation takes greater time. Consequently, manipulating only the prices of fruit and vegetables may not be enough to generate behaviour changes because the time cost of preparation may still result in people failing to consume them (even if they buy them). Therefore, subsidy measures should be accompanied by measures to promote convenient cooking of these increased fruits and vegetables. In this regard, ready-to-eat fruit and vegetables provided at school meals are more attractive than fruit and vegetable subsidies targeted at low income people.

Finally, fruit and vegetable subsidies will generate higher demand and hence increase prices. Although the higher prices will provide incentives for farmers to produce more fruit and vegetables, the potential shortage of supply and its associated high prices will likely put pressure on the government budget. This issue highlights the need to see the synergistic effects of economic interventions. Fruit and vegetable subsidies may need to be supported by any revenue generated by beverage taxes while agricultural subsidies will need to be shifted to support fruit and vegetable production.

¹⁰ http://ec.europa.eu/agriculture/markets/fruitveg/sfs/index_en.htm

Specific recommendations for further consideration included

- a) Implement subsidy coverage and ensure that eligible products include both fresh and frozen as well as canned fruit and vegetables. For low-income adults, such subsidies may be delivered through grocery or debit cards. These cards can be connected with the Canada Revenue Agency for monitoring and reimbursement purposes;
- b) Offer children and youth free fruit and vegetables at school;
- c) Dedicate beverage tax revenue to fund fruit and vegetable subsidies, and;
- d) Shift agricultural policy and subsidies to enhance the production and distribution of fruit and vegetables.

6.5 Physical Activity

There was less confidence among the panel members that economic instruments as defined within the scope of the report (tax and/or subsidies) was an effective means to increase physical activity at the population level. In terms of economic instruments, it was proposed that such instruments might be more effective targeting consumption as opposed to energy expenditure. Additionally, while panel members recognized the two-sided nature of issues related to physical activity – i.e., economic measures to increase physical activity and economic measures to decrease sedentary behaviour, suggestions for economic measures that penalized inactivity were considered to be unrealistic. However, such broad conclusions need to be considered in the light of very little evidence concerning the impact of economic measures to increase physical activity participation.

Tax credits were seen as ineffective at encouraging physical activity amongst the sedentary; indeed they were viewed to provide windfall gains to those who already participate in physical activity programs and hence were inequitable. Panelists suggested that money would be better spent on subsidizing physical activity programs, particularly those designed for children and low income groups. However, there was a concern that this might be directed at ‘organized sports’ which does not necessarily equate to increased physical activity. In general, there was greater support for examining how subsidies might be targeted at specific populations to increase physical activity participation – e.g., immigrant populations, single mothers, etc. There was some speculation that gas taxes be one means to shift modes of transportation but revenue would need to be directed to developing physical activity facilities.

In summary the panel suggested that there is insufficient evidence to clearly recommend specific tax credits or subsidies to promote physical activity. This is not to discount that subsidies in particular might play a role. At the least, public funds should be transferred from potentially inefficient economic measures to encourage increases in physical activity (e.g., the Children’s Fitness Tax Credit) to economic measures that show more promise (e.g., subsidized participation for targeted populations). The promise of such economic measures should be tested in a matching program of research to determine the actual effects of such measures on increasing physical activity participation and reducing obesity.

6.6 Income Transfers

Income transfer approaches did not receive any support from the panel members in terms of addressing obesity. This was primarily due to the perception that existing evidence did not clearly support a simple inverse relationship between income and obesity. That is, obesity impacted all socioeconomic

strata. The panel felt that there are many good reasons to consider income transfers but obesity prevention was not one of them.

Overall, the panel felt it was a safer course of action to focus on subsidies although it was appreciated that there exists a nuanced distinction between income transfers and subsidies.

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8 Appendix 1. List of Panel Experts

1. Tatiana Andreyeva, Director of Economic Initiatives at the Rudd Center for Food Policy and Obesity, Yale University
2. Chris Auld, Associate Professor, Department of Economics, University of Calgary
3. Sean Cash, Assistant Professor, Department of Consumer Science, University of Wisconsin.
4. John Cawley, Associate Professor, Department of Policy Analysis and Management, Cornell University
5. Adam Drewnowski, Director, Nutritional Sciences Program, University of Washington
6. Laurette Dube, Professor, James McGill Chair of Consumer and Lifestyle Psychology and Marketing, Desautels Faculty of Management, McGill University
7. Ian Janssen, Assistant Professor, Departments of Community Health and Epidemiology and the School of Kinesiology and Health Studies, Queen's University
8. Jeffrey LaFrance, Professor, School of Economic Sciences, Washington State University
9. Darius Lakdawalla, Director of Research at the Bing Center for Health Economics, RAND Corporation
10. Lisa Powell, Research Professor, Department of Economics; Senior Research Scientist, Institute for Health Research and Policy, University of Illinois at Chicago
11. Bruce Traill, Professor of Food Economics/AFIT Director, University of Reading
12. Frank Windmeijer, Professor of Econometrics, Centre for Market and Public Organisation; Centre for Structural Econometrics

9 Appendix 2. Review Papers

Authors	Coverage	Main Findings and Suggestions
1 Goodman and Anise (2006)	Nutrition domains; Included all available empirical studies including RCTs and modeling studies.	<p>Evidence on price elasticity for food is limited</p> <p>Concern that price inelasticity for food might dampen the effects of economic instruments because people might consume no less high energy food at higher prices</p> <p>Suggest that implementation of educational campaign should be considered in conjunction with taxing and subsidizing foods;</p> <p>Implementing programs/interventions at school might be beneficial, because those programs encourage student to eat healthy foods and encourage healthy eating habit at an early age.</p>
2 Cash et al (2007)	Included empirical studies (including RCTS and modeling studies) that look at the effects of fat taxes and thin subsidies.	<p>Conflicting evidence on the health effects of food price interventions.</p> <p>Quite skeptical of effectiveness of food price interventions, citing 4 main problem with fat taxes:</p> <p>(i) Targeting problem, which concern defining which categories of food to tax, for example, some goods are bad for a certain group but are necessary for other groups; (ii) Regressivity of the food taxes; (iii) Substitution issue; (iv) Response from the industries.</p> <p>Noted that food prices are already affected heavily by existing taxes, trade restrictions, transportation policy, energy taxes, food assistance programs, etc.</p>

3 Powell and Chaloupka (2009)	Included 9 studies that employ micro survey data to look at the effect of taxes and prices of food on weight outcomes	<p>There is sparse and limited evidence that weight outcome could be improved by using fiscal policies; It would be easier to tax specific food categories (soft drink, snack, candy, fast foods);</p> <p>Tax will generate substantial revenue.</p> <p>Noted that tax is regressive nature. However, if low income people were more food price elastic, and/or consume proportionately more of taxes goods, then they would derive greater benefits from reductions in consumption.</p> <p>Noted that support for fat or food taxes are low because of opposition from industry and people. However, the tobacco experience countered the same opposition but it still succeeded.</p> <p>Nontrivial taxes might change weight outcomes.</p> <p>Substantial price changes are needed to improve these outcomes significantly.</p> <p>Subsidies on fruit and vegetables were found to improve children and adolescents' weight outcome. Heavier children and children from low SES family are more price elastic. So, subsidies directed toward low SES households not only change their behaviour but also offset equity concerns.</p> <p>Conduct studies that link tax data with individual level data to drive BMI or obesity tax estimates. Youths and young adults are found to consume greatest number of soft drinks.</p> <p>Focus on the young group is beneficial because food patterns are less apt to change as one ages, and obesity are shown to continue into adulthood.</p> <p>Need more research to build evidence base. In particular, studies that use panel data and RCT designs, studies use alternative price data (i.e. tax data), studies that include area level control for confounding contextual influences such as food store and restaurant availability.</p>
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4 Von Tigerstrom (2009)	Both nutrition and physical activity domains; Include all available empirical studies as well as reports, mass media news, etc.	Evidence suggests that nutrient content tax might be more effective, although increase administrative cost and might lead to unintended consequences.
		<p>Suggest that combination of food tax and food subsidies would be more effective;</p> <p>Result of pilot projects in controlled environments might be difficult to generalize;</p> <p>Studies that use Canadian data are needed. For example, Child Fitness Tax Credit and sales tax exemption for bikes programs should be evaluated.</p>
5 Thow et al. (2010)	Reviewed 24 studies including both empirical and modeling studies	<p>Empirical evidence indicates that taxes and subsidies reduce consumption and improve health outcomes such as body weight and chronic disease risk. However, quality of empirical evidence is generally low.</p> <p>Empirical evaluation of existing taxes is a research priority, along with research into the effectiveness and differential impact of food taxes in developing countries.</p>
6 Currie (2003)	Reviewed studies (up to 2002) on effects of foods and nutrition programs in the US including effects of WIC participation on child birth weight	Most studies find positive association between participation in WIC and child birth weight.

7	Zagorsky et al (2009)	Reviewed nine studies (six using longitudinal data) on the effect of the US Food Stamp program on adult weight outcomes.	Eight out of nine studies reported positive association between FSP participation and weight gain of women. Conclude that generally, participation in the US Food Stamp program is associated with a small-to-modest increase in the risk of obesity and elevated BMI among women, but not among men.
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10 Appendix 3. List of Reviewed Empirical Studies

NUTRITION							
	Authors	Outcomes	Price/Tax Measure	Data	Study Population	Research Design	Findings
1	Fletcher, Frisvold & Tefft (2009)	Soft drink consumption and weight	Soft drink taxes, 1988 and 2006	National Health Examination and Nutrition Survey	Children and adolescent	Cross sectional	Soft drink taxation, as currently practiced in the United States, leads to a moderate reduction in soft drink consumption by children and adolescents. However, this reduction in soda consumption is offset by increases in consumption of other high calorie drinks.
2	Fletcher, Frisvold, & Tefft (in press)	BMI	Soft Drink Taxes	Behavioral Risk Factor Surveillance System (BFRSS), 1990-2006	Age 18+	Cross sectional	Soft drink taxes influence BMI, but that the impact is small in magnitude
3	Powell, Chiqui & Chaloupka (2009)	BMI	State-level soda taxes	Monitoring the Future, 1997-2006	Adolescents	Cross sectional	Current state-level tax rates are found to be insignificantly associated with adolescent weight outcomes
4.	Sturm et al. (2010)	Consumption and BMI	State-level soda taxes in 2004	Early Childhood Longitudinal Study, 2004	Fifth-grade children	One-year cross sectional	Current soft drink taxes do not substantially affect overall levels of soda consumption or obesity rates.

							However, at-risk children (i.e. overweight children, from low-income families, or are African American) more sensitive to soft drink taxes, especially when soft drinks are available at school.
5	Kim & Kawachi (2006)	State level obesity prevalence	State level taxes on soft drinks and snacks	BRFSS, 1991-1998	States	Cross sectional	Weak statistical evidence that states that had repealed a soft drink or snack food tax were 13 times more likely to have a high relative increase in obesity prevalence compared with states with taxes. No statistically significant differences in obesity between states with no taxes and those with a tax or with at least a 5% tax.
6	Goldman, Lakdawalla, & Zheng (2009)	BMI	Prices for food and other goods (ACCRA Cost of Living, 1992-2003)	Health and Retirement Study, 1992-2004	Age 50+	Panel data	Very modest short-term effects of price per calorie on body weight, and the magnitudes align with the previous literature. Long-term effect is much bigger, but takes a long time for the effect to reach full scale.

7	Beydoun, Powell, & Wang (2008)	Dietary intake, BMI, and obesity risks	Prices of fruits and vegetables and fast-foods (ACCRA)	US Department of Agriculture's Continuing Survey of Food Intakes by Individuals (CSFII 1994-96)	Aged 20-65	Cross sectional	Fast food price indices were associated with higher fiber intake, lower saturated fat, and better overall diet quality. Fruit and Vegetable Price Indices were positively associated with improved dietary quality as well as in terms of lower cholesterol and sodium intakes and lower BMI.
8	Miljkovic & Nganje; & de Chastenet (2008)	BMI and overweight	Prices of sugar, potatoes, and whole milk (USDA)	BRFSS, 1991, 1997, and 2002	Age 18+	Cross sectional	Higher current price of sugar and whole milk statistically significant associated with lower probability of obesity, and higher prices of potatoes statistically significant associated with higher obesity prevalence
9	Miljkovic & Nganje (2008)	BMI and overweight	Prices of sugar, potatoes, and whole milk (USDA)	BRFSS, 1991, 1997, and 2002	Age 18+	Cross sectional	Lower current and past real prices of sugar contribute significantly to higher values of BMI, and increase the likelihood of becoming obese in the United States.
10	Auld and Powell (2009)	BMI	Price data from ACCRA	Monitoring the Future, 1997-2003, n=73,041	Adolescents	Cross sectional	Price of high density food (fast food meals) is negatively related to body weight; Price of low density food (fruits and vegetables) is positively

							associated; Most of the changes in body weight occur in the top quintile of conditional distribution of BMI, suggesting incentive-based policies such as food taxes or subsidies may be most effective in targeting at-risk adolescents.
11	Sturm and Datar (2005)	BMI	Metropolitan-level data on food prices (ACCRA)	Early Childhood Longitudinal Study	Children through 3rd grade	Panel data	Lower real prices for vegetables and fruits predict a significantly lower gain in BMI between kindergarten and third grade; Half of that effect was found between kindergarten and first grade. Lower meat prices had the opposite effect, of smaller magnitude and insignificant for BMI gain over 3 years; No significant effects for dairy or fast-food prices, nor for outlet density, once controlled for individual characteristics and random intercepts to adjust standard errors for the sampling design.
12	Sturm and Datar (2008)	BMI	Metropolitan-level data on food prices	Early Childhood Longitudinal Study -	Children through 5th grade	Panel data	Confirmed initial evidence for an association between weight gain among elementary school children and relative

			(ACCRA)	Kindergarten Class			food prices in their environment. In particular, lower real prices for fruit and vegetables relative to other goods and services (including other foods, housing) may slow excess weight gain.
13	Chou, Grossman & Saffer (2004)	BMI and obesity	Full service restaurant prices, fast-food restaurant prices, prices of home foods.	BRFSS, 1984-1999	Adults aged 18+	Cross sectional	Statistically significant full service restaurant price elasticity for BMI (-0.021) and obesity (-0.667); statistically significant price of food at home for BMI (-0.039) and obesity (-0.622). Fast food price elasticity for BMI (-0.048) and not statistically significant for obesity (-0.650)
14	Powell (2009)	BMI	Fast-food prices	1997 National Longitudinal Survey of Youth	Youth	Cross sectional and panel data models	Higher fast-food prices are significantly associated with lower BMI Cross-sectional model overestimates the effect of price of fast food on BMI by about 25%.
15	Rashad (2006)	Obesity	Calorie intake, activity level, prices of restaurant meals,	First three waves of NHANES for 1971-1994	Adults	structural model of the determinants of	Caloric intake, activity level, and smoking are important determinants of obesity. Prices of restaurant meal and

			cigarettes			adult obesity	the cigarette tax have significant effects in determining obesity.
16	Powell and Chaloupka (2009)	BMI	Fruit and vegetable price, fast food price (ACCRA)	Child Development Supplement of the Panel Study of Income Dynamics	Children	Panel data	Fruit and vegetable price elasticity for BMI is estimated to be 0.25 for the full sample and 0.60 among low-income children. Fast food prices are statistically significantly related to child weight only in cross-sectional models among low-income children with a price elasticity of -0.77.
17	Powell and Bao (2009)	BMI	Price data from ACCRA	1979 cohort of the National Longitudinal Survey of Youth, 1998, 2000 and 2002 waves	Children	Panel data, longitudinal random effects models	A 10% increase in the price of fruits and vegetables associated with a 0.7% increase in child BMI. Fast food prices not statistically significant in the full sample, but weakly negatively associated with BMI among adolescents. Associations of fruit and vegetable and fast food prices with BMI significantly stronger both economically and statistically among low- versus high-socioeconomic status children. Estimated fruit and vegetable and fast food price elasticities were 0.14 and

							–0.26, respectively, among low-income children and 0.09 and –0.13, respectively, among children with less educated mothers.
18	Gelbach, Klick and Stratman (2009)	BMI	Relative food price	National Health Interview Survey (NHIS) for the period 1982-1996	Adults	Cross sectional	Individual BMI measures, as well as the likelihood of being overweight or obese, exhibit a statistically significant positive correlation with the prices of healthful relative to unhealthful foods
19	Meltzer and Chen (2009)	BMI	Minimum wages	Behavioral Risk Factor Surveillance System from 1984-2006	Adults	Cross sectional	\$1 decrease in the real minimum wage was associated with a 0.06 increase in BMI. This relationship was significant across gender and income groups and largest among the highest percentiles of the BMI distribution. Real minimum wage decreases can explain 10% of the change in BMI since 1970
20	Powell et al (2007)	BMI, overweight	Prices of fruit and vegetables	Monitoring the Future Surveys from 1997-2003	Adolescents	Cross sectional	A 10% increase in the price of a fast food meal leads to a 3.0% increase in the probability of frequent fruit and vegetable consumption, a

0.4% decrease in BMI, and a 5.9% decrease in probability of overweight.

PHYSICAL ACTIVITY

	Authors	Outcomes	Price/Tax Measure	Data	Study Population	Research Design	Findings
21	McInnes and Shinogle (2009)	Physical activities	Economics factors such as state beer and cigarette taxes, local transportation costs, availability of gyms and recreational facilities, county unemployment, crime rates, and prices of related goods	2000-2005 Behavioral Risk Factor Surveillance System (BRFSS)	Adults	Cross sectional	Gas prices negatively and significantly related to exercise, while bus fare positively and significantly related. Income and education has a strong and consistently positive effect on physical activity. Sin taxes have no effect on likelihood of any exercise but generally have negative effects on vigorous exercise or moderate and vigorous exercise. Physical activity more likely when there are more parks per capita in a county
22	Rashad (2009)	Cycling	Gas prices and urban sprawl	1990, 1995, and 2001 waves of Nationwide Personal Transportation	Adults	Cross sectional	Increasing the gasoline price by one dollar increased the probability of cycling by 4.3 to 4.7 percentage points and 2.9 to 3.5 percentage points for men and women.

				Survey, plus BRFSS (1996-2000)			Living in a metropolitan area with a lower degree of urban sprawl increased the probability of cycling in the past month by 3.4 to 4.4 percentage points and 1.6 to 2.1 percentage points from the means for men and women
23	Bergman et al (2010)	Physical activities	Road congestion taxes	Self collected physical activity data, as part of a multinational study, the International Physical Activity Prevalence Study (IPS).	823 individuals from Stockholm, Göteborg and Malmö regions , aged 18-74	Cross sectional	Those exposed to the congestion road tax and with access to motorized vehicles register an increase in moderate physical activity, overall physical activity (p 0.015) and a reduction in time spent sitting.
24	Spence et al. (Forthcoming)	Awareness, Physical activity participation	Child Fitness Tax Credit Program	Sample data from Internet-based survey	1004 parents whose children age 2-18 years	Cross sectional	55% sample aware of the CFTC. 42% claimed CFTC benefits in 2007, and half of them plan to claim CFTC benefits in 2008. Few parents (11%) believed CFTC had increased their child's participation in PA programs

AGRICULTURAL SUBSIDIES

	Authors	Research Questions	Data	Design/Methodology	Results
25	Miller and Coble (2006)	Examined whether farm subsidies make retail food products in the US more affordable	Annual time series data from USDA for 1961 - 2002, at aggregate and food category level	Time series regression	Direct payment impact on food affordability is very small and not statistically significant. In contrast the positive and statistically significant TFP implies that advances in agriculture technology have increased the affordability of foods
26	Alston et al (2008)	Examined the links between farm programs and farm commodity prices in the United States, and the implications of farm policy-induced commodity-price changes for food prices, food consumption, and obesity	US and international data	Examine each component in the causal chain: subsidies>commodity price>high energy food prices > consumption of high energy foods	U.S. farm policies have generally small and mixed effects on farm commodity prices, which in turn have even smaller and still mixed effects on the relative prices of more- and less-fattening foods. Other factors such as agricultural R&D have had much more influence on reducing the farm prices of food commodities and the consumer prices of food.

27	Beghin and Jensen (2008)	Examined whether US farm policies for sweetener crops affected consumption and composition of sweeteners in the US diet.	US historical data on sweetener consumption	Regression analysis	The current link between US sweetener consumption and farm policy is weak. Recent evidence from other high-income countries show little relationship between sweetener consumption and sugar policies.
28	Alston et al (2009)	Modeled state-specific U.S. agricultural productivity for the period 1949-2002 as a function of public agricultural research and extension investments over 1890-2002	US historical data	Regression analysis	U.S. public agricultural R&D, whether undertaken by state or federal government, yielded high returns.

TARGETED INCOME TRANSFER PROGRAMMES

	Authors	Research Questions and Outcomes	Data	Design/Methodology	Results
29	Fernald, Hou & Gertler (2008a)	Health effects of the <i>Oportunidades</i> program, including adult weight and BMI	Mexican data	Cross sectional	Adults in the intervention communities had lower age- and sex-adjusted BMI and were less likely to be obese or overweight than those from control communities

30	Fernald, Hou & Gertler (2008b)	Health effects of cash component of the <i>Oportunidades</i> program, including adult weight and BMI	Mexican data	Field randomization	Doubling of cumulative cash transfers to the household was associated with higher BMI, higher diastolic blood pressure and higher prevalence of overweight and obesity
31	Currie & Cole (1993)	Effect of the Aid to Families with Dependent Children (AFDC) on child birth weight	US data	Cross sectional	Improved birth weight of children born to white women
32	Barber and Gertler (2008)	Effect of the <i>Oportunidades</i> program on child birth weight	Mexican data	Cross sectional	Birth weight of beneficiaries of the program is on average 127.3-grams higher than non-beneficiaries and that the incidence of low birth weight is 44.5 percent lower among beneficiaries, thanks to better quality of prenatal care.
33	Leroy et al (2010)	The effect of the <i>Programa de Apoyo Alimentario</i> program (restricted transfer program) on adult weight outcomes	Mexican data	Cross sectional	Cash transfer and in-kind transfer programs may help increase household fruit, vegetable, and micronutrient consumption but can also lead to excess energy consumption.

34	Bitler and Currie (2005)	WIC and child birth outcomes	US data		WIC participation is associated with improved birth outcomes. Further, the positive impacts of WIC are larger among subsets of even more disadvantaged women
35	Figlio et al (2009)	Effects of prenatal WIC participation on birth outcomes in Florida	Florida data	Cross sectional	WIC participation has no effect on mean birth weight and gestational age, but substantially reduces the likelihood of adverse birth outcomes, e.g., birth weights below 2500 g
36	Hoynes et al (2009)	Effect of WIC on child birth weight	US data	Difference-in-difference	Implementation of WIC leads to an increase in average birth weight and a decrease in the fraction of births that are classified as low birth weight
37	Schmeiser (2009)	Effect of income on women's weight	National Longitudinal Survey of Youth 1979 cohort	Instrumental variables technique	Income significantly raise the BMI and probability of being obese for women with EITC-eligible earnings, but have no appreciable effect for men with EITC-eligible earnings

38	Cawley et al (2009)	Effect of income on obesity of elderly Americans	National Health Interview Survey	Instrumental variables technique	Found no significant effect of income on weight
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11 Appendix 4. Review of Empirical Studies in the Nutrition Domain

Evidence on Soft-drink Taxes

We identified 5 recent empirical studies that evaluated the effect of soda taxes currently adopted in a number of US states on BMI and obesity (Kim & Kawachi, 2006; Fletcher et al., in press; Powell et al., 2009; Fletcher et al., 2009; and Sturm et al., 2010). All of these studies used cross-sectional data. Two studies examined the effect of soda taxes on adult weight. Kim and Kawachi (2006) investigated the effect of these taxes on state-level obesity prevalence, using state-level taxes on soft drinks and snacks and the 1991-1998 cross-sections of data from the Behavioral Risk Factor Surveillance System (BFRSS). They found weak statistical evidence (p -value = 0.09) that states that had repealed a soft-drink or snack-food tax were 13 times more likely than states with a tax to experience a relative increase in obesity prevalence. In addition, states without a soft drink or snack food tax were four times more likely (albeit statistically insignificant p -value=0.25) than states with a tax to exhibit a high relative increase in obesity prevalence.

Fletcher et al. (2010) also used the BFRSS data, but for the period 1990-2006, and focused on the effect of soft drink taxes on individual weight outcomes. Using their preferred model, they found that soft drink taxes influence individuals' BMI but the impact was small in magnitude. The authors also reported that tax effects on weight outcomes were larger among low income groups. This result suggests that such taxes may not be regressive as is commonly assumed.

Powell et al. (2009) examined the effect of soft drink taxes on adolescent weight using 'Monitoring the Future' data for the period 1997-2006. They found no statistically significant relationship between soda taxes and adolescent weight outcomes but did find a weak economic and statistically significant relationship between the vending machine soda tax rate and BMI among teens at risk for overweight.

Fletcher et al. (2009) considered the effect of soda taxes on children and adolescent weight using the National Health and Nutrition Examination Survey (NHANES). In addition to examining weight, they assessed whether higher soda taxes lead to increased consumption of milk and juice. Their econometric framework controls for unobserved state-level characteristics (through the inclusion of state-specific fixed effects) that could be correlated with soft drink taxes (failure to control for unobserved characteristics could lead to misleading estimates). They found that soft drink taxes lead to a modest reduction in soda consumption by children and adolescents, but have no effect on children and adolescents' net weight due to an increase in consumption of whole milk (but not juice or juice-related drinks). They concluded soda taxes, as currently practiced, do not reduce weight in children and adolescents. However, as children and adolescents appear to substitute whole milk for soft drinks in response to soda taxes, there may be unexplored broader health benefits of soda taxes for children and adolescents.

Finally, Sturm et al. (2010) investigated the effect of state sales taxes for soft drinks on children's consumption of soft drinks and weight gain. They used the tax rates that were in effect in January 2004 and matched them to the fifth-grade wave of the Early Childhood Longitudinal Study individual-level data. Their results indicated that existing taxes on soft

drinks do not substantially affect overall levels of soda consumption or obesity rates. However, they found that subgroups of at-risk children (i.e. children who are already overweight, come from low-income families, or are African American) may be more sensitive than others to soft drink taxes, especially when soft drinks are available at schools. They suggested that a larger soft-drink tax is required to generate meaningful changes in consumption and weight outcomes.

Evidence on Fast-food Prices

There are not yet any special taxes imposed on fast-foods. Consequently, almost all empirical studies in this literature focus on the impact of fast-food prices on weight outcomes. We identified 4 studies that used longitudinal data (Sturm & Datar, 2005; Powell & Chaloupka, 2009; Powell & Bao, 2009; Powell, 2009) and 6 studies that employed cross-sectional data (Powell et al., 2007; Auld & Powell, 2009; Chou, Grossman, & Saffer, 2004; Rashad, 2006; Beydoun, Powell & Wang, 2008; Meltzer & Chen, 2009).

There is weak evidence that children's weight responds to fast-food prices. Sturm and Datar (2005) investigated weight gain among children followed from kindergarten through third grade using data from the Early Childhood Longitudinal Study. They found no significant effect for fast-food prices on weight outcomes. Powell and Chaloupka (2009) also examined the relationship between fast-food and child's weight. Their regressions control for contextual factors such as availability of fast food restaurants, full-service restaurants, supermarkets, grocery stores and convenience stores. They used panel data from the Child Development Supplement of the Panel Study of Income Dynamics combined with external food price and outlet density data at the zip code level and estimated both cross sectional models and fixed effect panel data models. They found that fast-food prices are significantly related to child weight among low-income children with price elasticity of -0.77, but only in cross-sectional models.

For older children and adolescents, the findings from both cross sectional and longitudinal studies indicate that fast food prices have an impact on adolescents' weight outcomes. Powell et al. (2007) employed cross sectional data on adolescents in 8th and 10th grade from the Monitoring the Future Surveys from 1997-2003. They combined the data with fast food prices (and fruit and vegetable prices) obtained from ACCRA and fast food and full-service restaurant outlet density measures obtained from Dun & Bradstreet. Their results indicate that fast food prices are an important determinant of adolescents' body weight and eating habits: a 10% increase in the price of a fast-food meal leads to a 0.4% decrease in BMI and a 5.9% decrease in probability of overweight.

In another study, Auld and Powell (2009) used the same data from the Monitoring the Future Survey, 1997–2003 for adolescents in 8th and 10th grade but estimated a quantile regression model that can inform how the effect of prices varies across individuals situated at different points in weight distribution. In addition to a statistically significant association between fast-food prices (-0.03) and BMI, their results indicated larger effects at higher BMI quantiles, e.g., for males and females, the fast-food price elasticities were -0.10 and -0.11, respectively, at the 90th quantile.

Turning next to evidence from longitudinal studies, Powell and Bao (2009) used 3 waves (1998, 2000 and 2002) of the child–mother merged files from the 1979 cohort of the

National Longitudinal Survey of Youth, combined with fruit and vegetable and fast food price and outlet density data on fast-food and full-service restaurants, supermarkets, grocery stores and convenience stores. Estimating a random effect model, they found a weak negative association between fast-food prices with BMI among adolescents: a drop of 0.12% in BMI associated with a 1% increase in price.

Powell (2009) employed four waves of the 1997 National Longitudinal Survey of Youth. She estimated her regressions using both cross sectional and longitudinal data. The cross-sectional results demonstrated that higher fast-food prices are significantly associated with lower BMI although the difference is statistically marginal. A one dollar increase in the price of fast food is estimated to reduce BMI by 0.778 units and the corresponding fast food price elasticity of BMI is estimated to be -0.095 . The longitudinal individual-level fixed effects results confirm cross-sectional findings that the price of fast food, but not the availability of fast food restaurants, has a statistically significant effect on teen BMI with an estimated price elasticity of -0.08 . The results suggest that the cross-sectional model over-estimates the effect of price of fast food on BMI by about 25%. The weight of teens in low- to middle-socioeconomic status families was also found to be most sensitive to fast food prices.

There is also evidence that higher fast food prices reduce adult weight, but this evidence is less compelling than for adolescents. Chou, Grossman, and Saffer (2004) used data from BRFSS for 1984–1999 sampling adults 18 years and older. In their regressions, they distinguished between prices charged in full service and fast-food restaurants, and prices of store bought food; they also controlled for contextual variables. They found statistically significant fast-food price elasticity for BMI (-0.048) but not for obesity (-0.650). They also reported statistically significant full-service restaurant price elasticity for BMI (-0.021) and obesity (-0.667); and price of food at home for BMI (-0.039) and obesity (-0.622).

Rashad (2006) drew from three waves of the NHANES for 1971-1994 to estimate a structural model of the impact of a physical activity adjusted measure of caloric intake, smoking and other determinants of adult obesity. She controlled for the potential endogeneity of caloric intake and smoking using instrumental variables estimation. Instruments consisted of state level average price of a restaurant meal, cigarette tax, average summer and winter temperatures, and the presence of clean indoor air laws. Her findings indicated that the prices of restaurant meals had significant effects on obesity.

Beydoun, Powell, & Wang (2008) employed the 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII) and reported no statistically significant relationship between fast-food prices and obesity prevalence as well as BMI. However, their data sample is relatively small ($n=7331$) compared with Chou, Grossman, and Saffer (2004).

Fast-food prices are determined in part by demand conditions and thus may be endogenous. Studies that fail to account for this endogeneity may yield misleading results. Meltzer and Chen (2009) tackled the problem by exploiting exogenous changes in minimum wage labour (which accounts for about one third of the cost of fast food) across US states to identify the impact of fast-food prices on obesity. Their study employed data from the BRFSS from 1984-2006 to test whether variation in the real minimum wage was associated with changes in BMI. They found that a \$1 decrease in the real minimum wage was

associated with a 0.06 increase in BMI, and this correlation was significant across gender and income groups and largest among the highest percentiles of the BMI distribution. Moreover, their results also indicated that declining (inflation-adjusted) minimum wage rates have contributed to the increasing rate of overweight and obesity in the United States by lowering prices rather than affecting people's income. These findings support the hypothesis that lower prices of fast food lead to a higher rate of obesity.

Evidence on Sugar Prices

There are two studies in this category (Miljkovic & Nganje, 2008; Miljkovic, Nganje & de Chastenet, 2008). Both studies are cross-sectional.

Miljkovic and Nganje (2008) investigated the relationship between sugar prices (and prices of potatoes and whole milk) with obesity and weight outcomes in a myopic model, while Miljkovic, Nganje, and de Chastenet (2008) employed the rational additional model. Both studies used data from BRFSS and county level price data from US National Agricultural Statistics Service. The myopic model that controlled for historical prices, suggested that a one-dollar increase in the current price of sugar would be associated with a 0.20 and 0.33 percentage point reduction in the probability of overweight and obesity, respectively.

The rational model that controlled for both historical and future prices, suggested that the higher current price of sugar and whole milk was significantly associated with lower probability of obesity, and high potato prices were significantly associated with higher obesity prevalence. However, a future increase in the price of sweet foods was not associated with a current reduction in weight. Thus, they concluded that the myopic model was more suited to explaining consumption behaviour for obese individuals who are unlikely to be able to self-control or rationalize their behaviour by predicting changes in future prices and adjusting their consumption habits.

Evidence on Fruit and Vegetable Prices

We did not identify any study evaluating the impact of fruit and vegetable subsidies on reducing overweight and obesity directly. However, there is indirect evidence on the effect of prices of fruits and vegetables on weight outcomes. We identified 4 studies that used longitudinal data (Sturm & Datar, 2005; Sturm & Datar, 2008; Powell & Chaloupka, 2009, Powell & Bao, 2009) and 3 studies that employed cross-sectional data (Powell et al., 2007; Beydoun, Powell & Wang, 2008; Auld & Powell, 2009).

Sturm and Datar (2005) used longitudinal data on children followed from kindergarten through third grade in the Early Childhood Longitudinal Study. They found that changes in the children's weight were positively related to the price of fruits and vegetables but not to changes in meat, dairy, or fast-food prices. Specifically, an increase in the price of fruits and vegetables by one standard deviation raised children's BMI by 0.11 units by third grade (equivalent to a BMI price elasticity of approximately 0.05). Their subpopulation analysis suggest that children living in poverty and those at risk for overweight were roughly 50 and 39 percent, respectively, more price sensitive compared with their non-poor and not-at-risk counterparts.

Sturm and Datar (2008) followed up their 2005 study by expanding the panel data to include the fifth grade students. They found that one standard deviation increase in the price of fruits and vegetables increased children's BMI by 0.09 units by third grade and by

0.18 units by fifth grade. This result confirmed their previous finding that children's BMI responds to changes in fruit and vegetable prices. More importantly, their results suggest a consistent long-term effect of fruit and vegetable prices on children's weight outcomes.

Sturm and Datar (2005, 2008) findings are consistent with findings reported by Powell and Bao (2009). The latter study used panel data from the 1979 cohort of the National Longitudinal Survey of Youth and price data for fruit and vegetable and fast food price from the ACCRA. They found that a 10% increase in the price of fruits and vegetables was associated with a 0.7% increase in child BMI.

Another important piece of evidence concerning the effect of fruit and vegetable prices on child weight is from Powell and Chaloupka (2009). Using panel data from the Child Development Supplement of the Panel Study of Income Dynamics, their fixed effects model showed that higher fruit and vegetable prices are significantly related to a higher BMI percentile ranking among children with greater effects among low-income children: fruit and vegetable price elasticity for BMI is estimated to be 0.25 for the full sample and 0.60 among low-income children.

For adolescents, there is weaker evidence that fruit and vegetable prices have an impact on body weight (Powell et al., 2007). However, a recent study found adolescents' weight to be sensitive to the price of fruits and vegetables (Auld & Powell, 2009). In particular, for both males and females, the effects of the prices of fruits and vegetables (and fast-food meals) at the 90th or 95th quantiles were found to be relatively large, between three to five times greater than across the distribution as a whole. Based on this result, the authors suggest that subsidies for fruits and vegetables would have the greatest effect on reducing the weight of teens most at risk for overweight. Finally, Beydoun, Powell and Wang (2008) report a positive correlation between fruit and vegetable prices and adults' BMI.

Evidence on General Food Prices

We identified one cross-sectional study (Gelbach et al., 2009) and one panel data study (Goldman et al., 2009) examining general food prices and the body weight.

Gelbach et al. (2009) investigated how body weight is affected by the price of healthful foods relative to unhealthy foods. They used individual-level data on obesity and demographics from the National Health Interview Survey (NHIS) for the years 1982–1996 and combined them with regional-level food price data. In their regression they included an index of prices of unhealthy foods (such as bacon, ice cream, and sugar), healthful foods (primarily fruits and vegetables) and all foods. They deflated all these price indices using the Consumer Price Index. They found that increases in a healthy food price index are generally associated with higher BMI as well as higher likelihoods of being overweight or obese. They also found that decreases in unhealthy food price index are generally associated with increases in BMI and overweight incidence, and, to a lesser extent, obesity. Together, their results suggest that a tax on un-healthful foods or a subsidy on healthful foods might decrease body weight.

Goldman et al. (2009) studied the short- and long-term body weight consequences of changing food prices using panel data from the Health and Retirement Study (HRS). Their sample consisted of adults aged 50 and over. Instead of measuring food prices, as is

commonly done in other studies, they used information on food-specific caloric content and prices to calculate the price per calorie of various foods. They also included prices of other commodities in the regressions including cigarettes, gasoline, and non-food goods (excluding cigarettes and gasoline). They found a statistically significant but modest short-term effect of price per calorie on body weight. A 10% reduction in price per calorie increases BMI by approximately 0.22 units within two years. However, the long-term effect is much larger: After 30 years, the price reduction will lead to a BMI increase of 1.5 units.

12 Appendix 5. Review of Empirical Studies in the Physical Activity Domain

Subsidised Physical Activity Programs

Subsidizing physical activity programs are a commonly suggested economic instrument within the Canadian context (Madore, 2007; von Tigerstrom, 2009). We found no empirical evidence examining interventions subsidizing physical activity programs and their impact on physical activity levels and/or body weight.

Exercise referral schemes, popular in the United Kingdom, direct individuals to a service offering an assessment of need, development of a tailored physical activity program, monitoring of progress and a follow-up at an exercise facility such as a leisure centre. Such schemes are commonly subsidized. A recent systematic review (NICE, 2006) identified four RCTs demonstrating that exercise referral schemes can have positive effects on physical activity levels in the short term (6 to 12 weeks), but they are ineffective in increasing activity levels in the longer term (over 12 weeks) or over a very long timeframe (over 1 year). Yancey et al. (2006) conducted an RCT in a commercial gym where the financial incentive intervention involved a free 1-year membership to the study site gym. This was provided to participants in both treatment (education and social support) and control groups comprised of 366 predominantly healthy, obese African American women. They found that the incentive was effective, and produced modest short-term improvements in body composition. However, this study has some limitations including the mismeasurement of physical activity and questions of generalizability of study findings.

Indirect evidence of the positive effects of subsidies on increasing physical activity is available from a number of sources. For example, data are available for participation rates in skating, swimming and other recreational programs during the amalgamation of Toronto in 1998. Municipal Parks and Recreation Departments in Canada stopped organizing youth sport leagues in the mid-1970s, in part as a cost-saving measure. The remaining physical activity programs were increasingly subject to user fees (Slack, 2003), and there is now evidence of a resulting decline in participation. Following the 1998 amalgamation of Toronto into a mega-city, the former City of Toronto, which had no user fees, joined with five other municipalities, that all had different user fees. This was harmonized into a single fee-structure – introducing user fees into the former City of Toronto and reducing user fees in the five suburban municipalities. In the initial harmonization model, fees were introduced for all adult programs, but removed for all children's and seniors' programs. The subsequent assessment of the effects showed a significant increase in the number of participants in the suburban municipalities where fees were reduced (e.g., an increase of 45% in Scarborough), and a significant reduction (33%) in participation in the former City of Toronto where fees were introduced for the first time (Clutterbuck & Howarth, 2002; Slack, 2003). These data suggest that user fees may have strong effects on participation.

Gina Browne and her colleagues at McMaster University carried out an extensive four year study which, in part, provided recreation subsidies and transportation to children in low income, sole support families (Browne, et al., 2000). The study, in the form of a field experiment, involved 765 households that included 1,300 children and youth. In a five group comparison, the study found that “the child care / recreation alone group was associated with the lowest per child annual expenditures for use of health and social services four years after intake (\$908 ± \$2,041) even after including the cost of recreation” (p. vi). The report concluded that:

Age appropriate child care and recreation for children on social assistance results in a 10% greater exit of parents from social assistance in one year, maintains the academic, social and physical competence with baseline behaviour disorder at two and four years, and pays for itself within one year because of reduced use of professional and probationary services and after four years, not only continues to pay for itself but results in one-third the annual per child health and social expenditures when compared to children of parents receiving employment retraining (p. vii).

These results provide no direct evidence of levels of physical activity and obesity reduction, but the inferences that may be made (i.e., recreation participation was sustained while cost subsidies and transportation were provided; the children’s health status improved) indicate that further investigation of subsidies for children from low income families is warranted.

In research with a similar population, Dan Offord, a psychiatrist also at McMaster University, provided a one year programme of non-school skill development (including transportation) involving all children aged 5-15 living in a public housing complex in Ottawa. The apparent effect of recreation participation / skill development on improved school performance and home behaviour was marginal. However, overall levels of skill development and self-esteem were believed to have improved, and there was a clear effect on the reduction of anti-social behaviour. In fact, in terms of cost-effectiveness, the savings resulting from reduced vandalism and reduced police and fire costs were far more than the cost of the programme (e.g., Jones & Offord, 1989; Offord & Jones, 1990; Offord, et al., 1992). Offord’s work on this project led him to start the Christie Lake project for children and youth from low income families in Ottawa. In a later study, Offord, et al (1998) found that, “In the community domains, as would be expected, the presence of good parks, playgrounds and play spaces in the neighbourhood was strongly associated with increased rates of participation in supervised sports, and to a lesser extent, in unsupervised sports and the arts” (Offord et al, 1998). As with Browne, et al., Offord provides indirect evidence that participation increases and is sustained for the period of subsidization, or when quality activity spaces are readily available, but no direct evidence about levels of physical activity and obesity reduction.

Wendy Frisby, at the University of British Columbia, started the WOAW (Women Organizing Activities for Women) project in several BC communities, including Vancouver (Frisby, Crawford, & Dorer, 1997; Frisby & Millar, 2002). The physical activity programmes were provided for low income single mothers and, as a result of advice from the participants, the programmes included child care (without which the

mothers would not have been able to participate). Although the main remaining barrier to participation was transport for those who lived some distance from the activity site, participation was sustained for the period of the subsidy. Again, targeted subsidies to a specific population, when combined with additional funding to overcome other barriers to involvement (e.g., child care, transportation) suggests that this economic instrument is worthy of further exploration with regard to obesity reduction.

Transport

Two cross-sectional studies examined the relationship between individual transportation costs and physical activity (Rashad, 2009; McInnes & Shinogle, 2009).

Rashad (2009) studied the association between gasoline prices, urban sprawl and cycling as a form of physical activity. Using data from the 1990, 1995, and 2001 waves of the Nationwide Personal Transportation Survey pooled with data from the BRFSS 1996-2000, she found that one dollar increases in gasoline prices increased the probability of cycling by 4.3 to 4.7 percentage points for men and 2.9 to 3.5 percentage points for women.

McInnes and Shinogle (2009) examined a range of economic factors associated with physical activity using data from the BRFSS 2000-2005 combined with data on several economic factors including local transportation costs and the availability of gyms and recreational facilities. Gas prices were negatively and significantly related to leisure time exercise. This association did not differ by income. These authors suggest that driving to locations to engage in leisure time exercise may be negatively impacted by increasing gas prices.

While there are a number of studies that document the relationship between public transit and physical activities or obesity (see Edwards, 2008; and Lindström, 2008), very few studies investigate the relationship between public transportation cost and physical activity. However, in their study, McInnes and Shinogle (2009) reported a positive and significant relationship between bus fares and leisure time exercise. One interpretation of their result is that activities available to bus riders are substitutes for leisure time exercise. For example, higher bus fares make playing basketball at a neighborhood park cheaper relative to taking the bus to see a movie. This may be indirect, albeit weak, evidence for providing tax credits for purchases of passes or electronic payment cards for public transit in Canada¹¹.

Using a quasi-experimental design, a recent study examined the effects of congestion road taxes on physical activity. Bergman et al. (2010) used the congestion road tax that was enforced on roads in and out of Stockholm for a trial period in 2006 to study this question. With baseline data during October–November 2003 and then follow-up data in May 2006, they compared changes in physical activity in the Stockholm area with changes in the Göteborg and Malmö regions where there were no such congestion road taxes. Small effects were found. Those exposed to the congestion road tax and with access to motorized vehicles had an increase in moderate physical activity and overall physical activity, and a reduction in time spent sitting while there were no such differences for those not exposed. They concluded that policy changes such as a congestion road tax might promote modest increases in physical activity levels in individuals with motorized vehicles by changing mode of transport from a passive to a more active mode.

¹¹ www.transitpass.ca

Tax Credits

Recently, Spence et al (2010) provided the first empirical evidence regarding the effectiveness of the CFTC program. They used data from an Internet-based survey to study level of awareness of the program, the participation rate and parents' beliefs about the program's effectiveness in promoting physical activity. From a sample of 1,004 parents whose children age 2 - 18 years, they found that 55% were aware of the CFTC. Further, 42% of a group of 546 Canadian parents with children in organized physical activity claimed the CFTC benefits in 2007, and half of them reported that they plan to claim the CFTC in 2008. Few parents (11%) believed the CFTC had increased their child's participation in PA programs. Finally, their results show that the tax credit appears to benefit the wealthiest families in Canada.

Apart from the limitations pointed out in the study (not covering disability information that determines the program eligibility for children up to 18 years old; possible biases with self-reported answers, especially with income), the fact that the paper relies on data from an Internet based survey casts doubt on the representativeness of its results. Internet based surveys often suffer from low response rate (only 40% in this study). Further, the paper's study sample includes only those respondents who have had Internet access and self-selected to respond to the offer of monetary prizes to participate in the survey. Smith (2001) showed that even an Internet survey based on probability samples and general populations still produced a notable number of systematic differences in the results compared with those from non-Internet surveys.

13 Appendix 6. Review of Empirical Studies on Income Transfer Programs

Evidence on targeted income programs

Several studies have investigated the effect of income transfers, both unrestricted and restricted, on adult weight outcomes. Fernald et al. (2008a) studied the effects of participation in Mexico's Oportunidades program (an unrestricted transfer) on health outcomes of adults aged 30-65 years. In their analysis, the intervention group of low-income (below the 20th percentile nationally) adults received cash transfers contingent on positive changes in health behaviour such as regular health checkups for 3.5 to 5.0 years. This group was compared with a newly recruited control group of adults who had not yet begun receiving benefits. The authors found that adults in the intervention communities had lower age- and sex-adjusted BMI and were less likely to be obese or overweight than those from control communities. However, this study has two limitations. First, the control group should be formed at the same time as the treatment group rather than at the end of study period. Second, it is not possible to tell whether these effects are associated with the cash transfer component or the health check requirement component of the program.

In a later study that employed a randomized design, Fernald and colleagues (2008b) evaluated the effect of the cash component of the Oportunidades program. They found that a doubling of cumulative cash transfers to the household was associated with higher BMI, higher diastolic blood pressure and higher prevalence of overweight and obesity, while controlling for a wide range of covariates, including household composition at baseline.

Regarding child birth weight, a number of studies reported that the unrestricted transfer programs have a positive impact. For example, Currie & Cole (1993) demonstrated that participation in the Aid to Families with Dependent Children (AFDC) in the US yields a positive effect of participation in AFDC on the birth weights of children born to white women from the poverty sample. Gertler (2006) reports that Progresa children's weight for height (a measure of short-term health) significantly improved. Barber and Gertler (2008) found that the birth weight of beneficiaries of the Oportunidades program is on average 127.3-grams higher than non-beneficiaries and that the incidence of low birth weight is 44.5 percent lower among beneficiaries, due to better quality of prenatal care.

Zagorsky et al. (2009) reviewed the evidence on the effect of the US Food Stamp program (a restricted transfer) on adult weight outcomes. They examined nine studies including six using longitudinal data. The effect of FSP participation differs by gender. For men, none of these studies report any effect of FSP participation on obesity and weight outcomes. In contrast, almost all studies (except Kaushal, 2007) reported positive associations between FSP participation and weight gain of women. The review concludes that generally, FSP participation is associated with a small-to-modest increase in the risk of obesity and elevated BMI among women, but not among men.

Much of the research on the WIC's impact on the health of participants has focused on its effect on child obesity and infant health outcomes, measured using infant birth weight. Regarding child obesity, Ver Ploeg et al. (2007, 2009) analyzed data covering almost 20 years and found no association between WIC participation and children's BMI or the probability of being overweight. Currie (2003) reviewed the literature (up to 2002) on

foods and nutrition programs in the US and reported that most studies reported a positive association between WIC participation and birth weight.

A number of studies on WIC and child birth weight have been completed since the Currie (2003) review. Bitler and Currie (2005) demonstrated that WIC participation is associated with improved birth outcomes. Further, the positive impacts of WIC are larger among subsets of even more disadvantaged women, such as those who received public assistance last year, single high school dropouts, and teen mothers. Figlio et al. (2009) studied the effects of prenatal receipt of nutritional and educational services provided by the WIC on birth outcomes. They found that WIC participation has no effect on mean birth weight and gestational age, but substantially reduces the likelihood of adverse birth outcomes, e.g. birth weights below 2500 g. More recently, Hoynes et al. (2009) found that the implementation of WIC leads to an increase in average birth weight and a decrease in the fraction of births that are classified as low birth weight.

In the context of developing countries, Leroy et al (2010) studied the effect of the Programa de Apoyo Alimentario program on adult weight outcomes. The authors compared three groups: groups of individuals receiving food baskets, and those receiving cash (about \$14 a month) and a control group that received nothing. They found that (i) increases in micronutrients were generally greater in households receiving food baskets than in those receiving cash; and (ii) receiving either food baskets or cash increased energy consumption, including energy from fruits and vegetables, cereals and legumes, and animal food. Thus, cash transfer and in-kind transfer programs may help increase household fruit, vegetable, and micronutrient consumption but can also lead to excess energy consumption.

Finally, a strand of literature investigates the effect of general income on obesity and weight outcomes directly. Cawley et al. (2009) estimated the effects of income on obesity of elderly Americans. They exploited a natural experiment that led otherwise identical retirees to receive significantly different Social Security payments based on their year of birth. Using instrumental variable techniques and data from the National Health Interview Surveys, they found no significant effect of income on weight. Meanwhile, Schmeiser (2009) found evidence on the effect of income on women's weight. She used data from the National Longitudinal Survey of Youth 1979 cohort and exploited exogenous variation in family income caused by the rules of state and federal Earned Income Tax Credit (EITC) program benefits. Income is found to significantly raise the BMI and probability of being obese for women with EITC-eligible earnings, and have no appreciable effect for men with EITC-eligible earnings. Her findings imply that the increase in real family income from 1990 to 2002 explains between 10 and 21% of the increase in sample women's BMI and between 23 and 29% of their increased obesity prevalence.

14 Appendix 7. Review of Empirical Studies on Agricultural Subsidies

Several authors and commentators (e.g., Tillotson, 2003; Schoonover & Muller, 2006; Grunwald, 2007; Pollan, 2003, 2007) have used the strong correlation between increased farm subsidies and rise in obesity rates in the US since 1970s as evidence that farm subsidies have led to an increase in obesity. Their argument runs as follows. These policies have changed the prices of soybeans, corn and other farm commodities, making them cheap relative to fruits and other vegetables. These inexpensive commodities provide a cheap source of added sugar and fat, both of which are primary ingredients in processed foods. The lower prices of these processed foods in turn have contributed to their over-consumption, which has contributed to the increase in obesity.

A number of empirical studies have challenged the claim that farm subsidies have increased rates of obesity. Miller and Coble (2006) investigated whether farm subsidies make retail food products in the US more affordable using annual time series data from Economic Research Service of USDA for the period 1961-2002. The affordability of food, their outcome variable, is captured by the proportion of disposable income spent on food while farm subsidies are measured by direct payments to farmers. In addition to farm-to-retail spread and consumer income, their model also includes agriculture's total factor productivity (TFP) to shed light on the effect of changes in technology on food affordability. They estimated this regression in aggregate data as well as across 6 specific food groups. The results indicated that direct payment impact on food affordability was not statistically significant. In contrast, the positive and statistically significant TFP implies that advances in agriculture technology have increased the affordability of foods. Furthermore, these results are consistent across food groups. These findings provide empirical evidence that the cheap food prices are mainly caused by increases in agricultural efficiency over the last several decades rather than by farm subsidies.

Beghin and Jensen (2008) used historical data to examine whether US farm policies for sweetener crops have affected the consumption and composition of sweeteners in the US diet. The data showed that commodity programs have raised the price of sugar and decreased the price of corn. At the same time, agricultural R&D expenditure lowered the cost of corn more than that of sugar. Thus high fructose corn syrup became an inexpensive substitute for sugar in food and beverages. However, they emphasize that the effect of policy on ingredient prices has become less important over time, with today's farm value share in sweetened food being below 5%. They also noted that increased consumption of sweetened foods and beverages are observed in other countries which have different or no commodity programs.

Alston et al. (2008) examined US and international data to shed light on the impact of farm subsidies on commodity prices and of commodity prices on food retail prices. They found that farm subsidies have had very modest (and mixed) effects on the total availability and prices of farm commodities that are the most important ingredients in more-fattening foods. Second, such small commodity price impacts would imply very small effects on costs of food at retail, which, even if fully passed on to consumers, would mean very small changes in prices faced by consumers.

Alston et al. (2009) provided evidence that agricultural R&D subsidies contribute to high productivity and thus reduce the prices of commodities. They studied the contributions of US public agricultural research and extension investments over 1890-2002 to state-specific agricultural productivity for the period 1949-2002. They found that both state and federal agricultural R&D investment yielded high returns. Specifically, a one dollar increment in investments in agricultural research and extension by 48 U.S. states generated own-state benefits of between \$2 and \$58 and averaged \$21 across the states. They suggested that the returns would be even higher if taking into account the spill-over effects across the states (between \$10 and \$70 per research dollar across the states, with an average of \$32).

Appendix 8. Review of Empirical Studies on Direct Financial Incentives

Personal financial incentives involve offering individuals immediate rewards of some kind such as direct cash payments, vouchers, prizes and other rewards to change their behaviour. They have been used to encourage healthy behaviour and discourage unhealthy behaviour in a number of contexts such as tobacco, food, and alcohol, use of illegal drugs. Recently, personal financial incentives have been increasingly proposed as a promising financial intervention to address obesity (Le Grand & Srivastava 2009, Promberger & Marteau 2009). Financial incentives have been suggested as part of the libertarian paternalism approach. That is, while maintaining people's freedom to choose (libertarian), financial incentives offer an incentive to encourage behaviors that make the actors better off, as defined by the actors themselves (paternalistic).

A number of studies have reviewed the effectiveness of financial incentives to alter behaviors and outcomes in several contexts. Kane et al. (2004) reviewed 42 studies of the effect of economic incentives on preventive behaviors such as immunization, smoking cessation, and exercise. They find that the economic incentives were effective at changing behaviour in 73% of studies. Lussier et al. (2006) conducted a meta-analysis of studies in substance abuse treatment and found strong evidence that financial incentives raise compliance (drug abstinence) by 30% in the short term. Cahill and Perera (2008) reviewed 17 trials using financial rewards to motivate smokers to quit. They found that none of the trials showed higher quit rates at six months when incentives were used. Meanwhile, Volpp et al. (2009), the largest trial to date that uses the highest monetary incentives (\$750), reported highly significant and positive effects on quitting smoking 9-15 months after enrolment in the incentive programs. Overall, a recent Cochrane review of healthcare financing interventions to increase the use of tobacco dependence treatment (i.e., group therapy, nicotine replacement therapy) found that the provision of full financial benefits to smokers increased quit attempts, successful quits and the use of drug treatment (Reda et al., 2009).

Weight outcomes

Finkelstein et al. (2007) estimated the impact of different levels of financial incentives that are tied directly to weight loss among overweight and obese employees during a 3- and 6-month period. Their sample included more than 200 participants recruited from among employees at one university and three community colleges. During the first three months, participants were randomly assigned to receive either no money, \$7 per percentage point of weight lost or \$14 per percentage point of weight lost. At three months, they found that weight loss responded to financial incentives with the largest financial incentive producing the largest weight loss. In particular, participants in the \$14 group were five and a half times more likely than those in the no-incentive group to lose 5 percent of their body weight. However, between baseline and 6 months, there was no statistical difference in terms of average weight loss and the likelihood of achieving a 5% weight loss across treatment groups.

Recently, Paul-Ebhohimhen and Avenell (2008) reported a systematic review of RCTs in obesity treatments that involved the use of financial incentives as rewards. They restricted their review to studies with adults (age 18 years or older), with body mass index of at least 28, and an assessment follow-up of at least one year. Results from their meta-analysis of

nine studies showed no significant effect financial incentives on weight loss or maintenance at 12 months and 18 months. Further, they noted some limitations in study design including the possibility of biased sample of participants and small sample sizes.

Volpp et al. (2008) attempted to determine whether common decision errors identified in behavioral economics such as prospect theory, loss aversion, and regret could be used to design an effective weight loss intervention. They randomized 57 healthy participants into 3 groups: control group, deposit contract group (to examine the regret error) and a lottery prize group (to examine the present bias). They found that the incentive groups lost significantly more weight than the control group at 16 weeks. Specifically, compared with the control group, the lottery group lost a mean of 13.1 lb, and the deposit contract group lost a mean of 14.0 lb.

Cawley and Price (2009) analyzed nonrandomized data on 2,407 employees in 17 worksites who participated in a year-long worksite health promotion program that offered financial rewards for weight loss. Financial rewards differed by employer. Treatment groups received steady quarterly rewards for weight loss, or bonds that could be redeemed at the end of the year, if they had achieved a certain amount of weight loss. Control participants received no financial reward at all. They found that the financial rewards were associated with modest changes in weight. After one year, those in the modified incentives group lose 1.9 pounds more than those in the control group, while the weight loss of those in the standard incentives group was not statistically distinguishable from that of the control group. They also reported that the attrition rate was very high.

The main limitations of their study are the possibility of selection by employers in terms of incentive schedule, and a relatively small control group (129 out of a total sample of 2,407). They suggested that their findings regarding attrition and weight loss indicate that the experience of pilot programs that use small samples may be overoptimistic about what can be achieved on a larger scale. They concluded that their study did not support the finding that financial incentives for weight loss were any more successful than traditional medical methods.

Diet

In the context of obesity treatment, Wall et al. (2006) reviewed RCTs evaluating the effectiveness of monetary incentives in modifying dietary behaviour. Their review of four RCTs demonstrated a positive effect of monetary incentives on food purchases, food consumption, or weight loss. However, they noted that these trials had some methodological limitations including small sample sizes and short durations. In addition, no studies to date have assessed effects stratified by socioeconomic or ethnic group. They concluded that monetary incentives are a promising strategy to modify dietary behaviour, but more research is required.

Physical activity

We identified 4 randomized controlled trials (RCTs) evaluating the effectiveness of using personal direct financial incentives to target physical activity directly. Yancey et al. (2006) conducted an RCT in a commercial gym. The financial incentive involved a free 1-year membership to the study site gym and was provided to participants in both treatment and control groups consisting of 366 predominantly healthy, obese African American women.

They found that the incentive produced modest short-term improvements in body composition. They also noted that longer-term fitness enhancement remains uncertain. However, this study has some limitations including the errors with physical activity measurement used in the study and the difficulty to generalize to wider settings because of its focus on African American women.

Brown et al. (2007) estimated the elasticity of supply of physical activity in response to financial incentives. They implemented a 4-week revealed preference randomized controlled experiment with incentives and pedometers among 52 individuals recruited from a local convenience sample, and conducted a stated preferences survey of 1,019 sedentary U.S. adults. They found that the treatment group in the revealed preferences sample responded strongly to modest financial incentives. They suggested that financial incentives may be a viable policy tool to promote physical activity.

Finkelstein et al. (2008) conducted a 4-week randomized controlled study using pedometers. Their sample consisted of 51 adults aged 50+. Individuals were randomized into one of two groups. The control group received a fixed payment of \$75; the intervention group received a fixed payment of \$50 plus up to \$25 more per week depending on the number of weekly aerobic minutes achieved, defined as 10+ minutes of continuous walking or jogging. They found that the control group logged 2.3 h per week, on average. The intervention group logged 4.1 h per week and received an additional weekly payment of \$17.50, on average. They suggested that modest financial incentives tied to aerobic minutes are an effective, and potentially cost-effective, approach for increasing physical activity among sedentary older adults.

Charness and Gneezy (2009) conducted two field randomized experiments reported in one paper to evaluate whether financial incentives can increase gym visits. The financial incentives involved paying university students to attend the university's gym. In the first RCT, they compared the behaviour of three groups: one group was paid \$25 to attend the gym once a week, another group was first paid the same \$25 to attend the gym once a week and then was paid an additional \$100 to attend the gym eight more times in the following four weeks. The third group was the control group. All three groups were given a handout explaining the benefits of physical activity. They found post-intervention attendance was more than twice as high for the high-incentive group as for the no-incentive group. Furthermore, this difference did not decline at all during the time following payment, suggesting that the effects may have some degree of persistence.

In their second experiment, people were paid \$75 for attending the first meeting and providing biometric data. They were also invited to come back twice more and were promised \$50 for each meeting. The authors randomly divided the participants into three groups. The first group is the control group. Participants in the second group were required to attend the gym once during the one-month intervention period while third group was required to attend the gym eight times during the intervention period. They found a significant and persistent increase in attendance rates for people in the third group. They also found improvements on health indicators such as weight, waist size, and pulse rate, suggesting the intervention led to a net increase in total physical activity rather than to a substitution away from non-incentivized ones.

Discussion of Empirical Evidence on Direct Financial Incentives

Relatively small, short-term experimental manipulations appear promising in increasing physical activity and altering dietary behaviour. However, these studies have a number of methodological limitations including non-random sample of participants, small sample sizes, short follow-up duration, as well as the lack of information on effect by different demographic groups. More importantly, their effectiveness over the medium and long term is not certain. There is no compelling evidence that direct financial incentives assist greater weight loss than control conditions.

We note that there are a number of aspects of direct financial incentives that would likely complicate its large-scale application. First, financial incentives can be considered as a bribe (or being perceived as a bribe). From a self-determination perspective, this is likely to harm intrinsic motivation and lead to reverting back to earlier behaviour when the financial incentive is removed (Deci & Ryan, 2000). Further, Le Grand and Srivastava (2009) suggest that it is extremely difficult to monitor the behaviour of participants when applied at a population level. There is also the problem of moral hazard. People might be actively encouraged to initiate the unhealthy behaviour in anticipation that they will get some kind of reward when they give up or reduce the behaviour concerned. Monitoring or checking this kind of reaction might also be challenging. Furthermore, large-scale application of direct financial incentives might face attrition. Studying a larger sample, Cawley and Price (2009) found a much higher attrition rate (up to 76.4% after one year) than virtually all previous studies.

15 Appendix 8. Delphi Survey Results

Intervention	Impact on consumption			Impact on physical activity			Impact on obesity			Cost effective		
	Mean	sd	IQR	Mean	sd	IQR	Mean	sd	IQR	Mean	sd	IQR
Softdrink tax	2.87	0.52	0				2.07	0.46	0	2.87	0.83	0.5
Food tax	2.73	0.80	1				2.20	0.56	0.5	2.80	0.94	0.5
Fruit & Veg subsidies	2.87	0.52	0				2.13	0.52	0	2.33	0.62	1
Child fitness tax credit				2.33	0.49	1	2.13	0.64	0.5	2.13	0.64	0.5
Adult fitness tax credit				2.27	0.59	1	1.80	0.41	0	2.00	0.53	0
Public transit tax credit				2.13	0.64	0	2.00	0.65	0	2.20	0.68	0
Sporting equipment tax credit				1.93	0.46	0	1.67	0.62	1	1.73	0.70	1
Subsidised PA programs				2.47	0.52	1	2.00	0.00	0	2.13	0.35	0
Road congestion tax				2.07	0.46	0	1.67	0.49	1	2.47	0.83	1
Income transfer unrestricted	2.00	0.93	1.5	1.67	0.62	1	1.87	0.92	1	1.80	0.86	1.5
Income transfer healthy food	2.87	0.83	0.5				2.07	0.59	0	2.60	0.74	1
Income transfer PA				2.27	0.59	1	1.87	0.52	0	1.93	0.59	0
Agricultural subsidies	2.40	0.74	1				2.27	0.70	0.5	2.87	0.83	0.5
Agricultural R&D rebalance	2.40	0.74	1				2.20	0.56	0.5	2.47	0.64	1

Notes: Not at all/None = 1; Low = 2; Moderate = 3; High/A Lot = 4.

IQD = Inter Quartile Deviation; indicates the distance between the 25th and the 75th percentiles. A smaller IQD represents greater consensus.

Intervention	Unintended benefit			Unintended harm			Equitable			Politically feasible		
	Mean	sd	IQR	Mean	sd	IQR	Mean	sd	IQR	Mean	sd	IQR
Softdrink tax	2.47	0.74	1	2.40	0.51	1	2.27	0.80	1	2.47	0.74	1
Food tax	2.40	0.74	1	2.80	0.68	1	1.87	0.52	0	2.07	0.46	0
Fruit & Veg subsidies	2.87	0.35	0	2.07	0.80	1.5	2.53	0.64	1	2.47	0.74	1
Child fitness tax credit	2.80	0.56	0.5	2.00	0.53	0	2.07	0.88	1	3.20	0.68	1
Adult fitness tax credit	2.47	0.64	1	2.00	0.53	0	2.00	0.85	0.5	2.87	0.83	0.5
Public transit tax credit	3.13	0.64	0.5	1.87	0.64	0.5	2.73	0.80	1	3.20	0.68	1
Sporting equipment tax credit	2.33	0.62	0.5	1.93	0.59	0	2.07	0.80	0	2.60	0.83	1
Subsidised PA programs	2.60	0.51	1	2.07	0.46	0	2.33	0.72	0	2.47	0.74	1
Road congestion tax	3.40	0.63	1	1.93	0.46	0	2.40	0.83	1	2.27	0.80	1
Income transfer unrestricted	2.93	0.70	0.5	2.67	0.90	1	2.00	0.93	1.5	2.47	0.64	1
Income transfer healthy food	2.80	0.56	0.5	2.27	0.70	0.5	2.40	0.83	1	2.80	0.56	0.5
Income transfer PA	2.53	0.52	1	2.00	0.38	0	2.33	0.90	1	2.20	0.68	1
Agricultural subsidies	2.93	0.80	1.5	2.60	0.83	1	2.13	0.74	1	1.73	0.59	1
Agricultural R&D rebalance	2.93	0.70	0.5	2.33	0.72	1	2.87	0.64	0.5	2.67	0.72	1