

Food cost and obesity: is there an association?

Preço dos alimentos e obesidade: existe uma associação?

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Resumo

Os ambientes obesogénicos, muito difundidos atualmente, são um dos principais fatores determinantes da obesidade, sendo o baixo custo dos alimentos processados um dos principais determinantes de escolhas alimentares nutricionalmente desadequadas. Apesar da reconhecida importância da qualidade dos padrões alimentares adotados como um fator de risco da obesidade e da sua correlação com o preço dos alimentos, os estudos que analisam o papel do custo da alimentação na prevalência da obesidade são ainda insuficientes. Esta revisão pretendeu avaliar a associação entre o custo dos alimentos e a obesidade. A pesquisa bibliográfica foi efetuada nas bases de dados PubMed, ISI Web of Science e Scopus. Foram analisados 19 estudos e explorada a associação das várias dimensões do custo dos alimentos, nomeadamente o aumento dos preços, a taxação, os subsídios, as leis de preços mínimos e promoções alimentares, com a obesidade. Foram encontradas algumas associações significativas entre o custo dos alimentos e a obesidade, tendo sido identificadas disparidades entre sexos e estratos socioeconómicos, sendo as mulheres de baixo estatuto socioeconómico as mais negativamente afetadas pelo preço dos alimentos em relação à obesidade. A literatura existente sobre este tema ainda é escassa, mas as associações significativas encontradas entre o custo dos alimentos e a obesidade realçam a necessidade de estudar este tópico mais amplamente e a importância da sua inclusão na conceção de ações políticas abrangentes e que promovam a redução das desigualdades sociais.

Palavras-chave: preço dos alimentos, aumento de preço, obesidade, desigualdades socioeconómicas

Abstract

Obesogenic environments, which are widespread nowadays, are one of the main obesity drivers, in which the low cost of junk food is one of the principal determinants of unhealthy food choices. Despite the recognized significance of diet quality as a risk factor for obesity and its correlation with food prices, data studying the role of diet cost in obesity prevalence is still insufficient. This review aimed to evaluate the association between food cost and obesity. A literature search was conducted in PubMed, ISI Web of Science and Scopus databases. A total of 19 studies were analysed and the association of the various dimensions of food cost, namely price increases, food taxes, subsidies, minimum price laws and food discounts, with obesity were examined. There were found some significative associations between food cost and obesity, and disparities between sexes and socioeconomic status were noticed, being low socioeconomic females the most negatively affected by food prices, regarding obesity. The existing literature is still scarce on this topic, but the significant associations found between food cost and obesity highlight the need to study this subject more widely and the importance of its inclusion in the design of comprehensive political actions that aim to reduce socioeconomic inequalities.

Keywords: food cost, price increase, obesity, socioeconomic inequalities

List of abbreviations and acronyms

BMI	body mass index
GDP	gross domestic product
HC	high calorie
HI	high-income
HSSs	high sugar snacks
LC	low calorie
LI	low-income
MI	middle-income
MPLs	minimum price laws
SBC	sugar, butter and cheese
SES	socioeconomic status
SSBs	sugar sweetened beverages
UK	United Kingdom
UP	ultra-processed
USA	United States of America

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Introduction

In 2019 more than 160 million people lost years of healthy life due to high body mass index (BMI), the most accurate predictor of obesity, and this number is expected to rise through the next years^(1, 2). This high obesity prevalence is caused by an energy imbalance, as people consume more energy than they expend⁽¹⁾. Obesogenic environments, which are widespread nowadays, are one of the main obesity drivers, in which the low cost of junk food is one of the principal determinants of unhealthy food choices^(1, 3, 4).

By virtue of the industrialization of food systems and employment of efficient marketing strategies, ultra-processed (UP) foods, frequently containing high amounts of sugar and fat, have become more accessible and desired than ever, unfairly competing with healthy and nutritious food, which are more costly^(1, 5-9). This is even more prominent in low socioeconomic individuals, as they face higher rates of food insecurity. This is explained because they are more likely to experience reduced food accessibility, tend to allocate a greater proportion of their income toward purchasing food, as described by Engel curve theory, and present lower educational attainment^(1, 6, 10, 11).

To tackle this issue some strategies have been introduced, such as taxes, minimum price laws and subsidies. Whereby some of these approaches have not been widely studied, being at the early stages of implementation, which justifies the uncertain effects some of them present^(1, 9, 12).

Despite the recognized significance of diet quality as a risk factor for obesity and its correlation with food prices, the association between diet cost and obesity

still needs to be more widely studied⁽¹³⁾. In an attempt to fill this gap this review aimed to evaluate the association between food cost and obesity.

Methods

Literature search strategy

A literature search of the PubMed, ISI Web of Science and Scopus databases was conducted on May and June 2023 using the expression ("food price" OR "diet cost" OR "food cost" OR ((Diet OR food OR nutrition OR eating) AND (affordab* OR cost OR price))) AND (Obesity OR obese OR overweight OR overnutrition) on PubMed and ("food price" OR "food cost" OR ((Diet OR food OR eating) AND (affordab OR price))) AND (Obesity OR overnutrition) on ISI Web of Science and Scopus.

Inclusion and exclusion criteria

After the literature search, the studies identified were checked to exclude duplicates. Then, titles and abstracts were evaluated for eligibility using the predetermined criteria and when the information provided in titles and abstracts was insufficient to decide on inclusion or exclusion, the full-text articles were assessed. The study eligibility criteria were selected by applying the PICOSquestion format. The outcomes analysed included obesity indicators, such as overweight, obesity, weight, body mass index (BMI), % of body fat and/or waist circumference. Only the literature from the last 5 years was included, comprising all types of research articles, and excluding all kinds of reviews. Only articles written in English, Portuguese, or Spanish were included. A total of 5673 studies have been identified in the literature search (294 from PubMed, 664 from ISI Web of Science and 4715 from Scopus). After the duplicates removal and the inclusion and exclusion criteria analysis, 19 studies were included in this review.

Results

Study and sample characteristics

Table 1 provides a summary of the key features of the studies that have been included (Appendix 1). Out of the 19 included studies, four were conducted in the United States of America (USA)⁽¹⁴⁻¹⁷⁾, two studies each were conducted in Canada^(18, 19) and the United Kingdom (UK)^(20, 21), and one study each was conducted in Brazil⁽²²⁾, New Zealand⁽²³⁾, Spain⁽²⁴⁾, Mexico⁽²⁵⁾, China⁽¹³⁾ and Australia⁽²⁶⁾. Five studies gathered information from several countries⁽²⁷⁻³¹⁾.

Regarding the study types analysed, nine were observational studies^(13, 14, 17, 18, 20, 23, 25, 29, 31), nine were classified as theoretical research^(15, 16, 21, 22, 24, 26-28, 30) and one as a cross-sectional study⁽¹⁹⁾. The outcome of most of the studies was obesity^(22, 23, 27, 30, 31) and BMI^(15, 17, 25, 26). Three studies each aim to collect data related to body weight^(18, 28, 29) and both weight and BMI^(16, 20, 21). Two studies assessed obesity and BMI^(23, 24) and one study each intended to evaluate simultaneously waist circumference and % of body fat⁽¹⁹⁾, obesity, overweight and BMI⁽¹⁴⁾ and fat mass index and weight⁽¹³⁾ as outcomes.

Population

The number of participants included in the studies varied, with sample sizes ranging from 381 to 2 916 880 individuals. Most of the included studies involved general adult populations^(15, 16, 18-21, 24, 26, 27, 30, 31). However, five studies^(13, 14, 17, 25, 26) specifically targeted individuals younger than 18, while three other studies^(22, 28, 29) included participants of all ages.

Methods used for data collection

A wide range of instruments and methods was employed in the analysed articles to collect the data and to evaluate the impacts on obesity. Most of the studies used secondary data, namely databases provided by Health Organizations^(17, 25-30) or collected it using questionnaires^(16, 18, 20-24). Other studies obtained the data by simultaneously using questionnaires and secondary data^(19, 31), measuring height and weight⁽¹³⁾, measuring height and weight, and using secondary data⁽¹⁵⁾ and measuring height and weight and applying questionnaires⁽¹⁴⁾.

During the conducted literature review, various food cost dimensions, namely price increases, food taxes, subsidies, minimum price laws and food discounts were found to be associated with obesity. Therefore, each one of these dimensions was explored individually.

Food cost

Of the total 19 included studies, and regarding food cost, two studies suggested a positive association with obesity indicators^(13, 19), towards the cost of an energy-adjusted diet⁽¹³⁾, the regular price of vegetables compared to sugar sweetened beverages (SSBs) and regular food prices in general. The association between the vegetables price compared to SSBs and obesity was more pronounced when people had a higher genetic susceptibility to being obese⁽¹⁹⁾. Three studies found negative associations between food cost and obesity^(15, 22, 23), but one of them only for lower socioeconomic status (SES) women and to a small degree⁽¹⁵⁾. One of those studies suggested that water being cheaper than SSBs was negatively associated with obesity⁽²³⁾. It was also proposed that having food cost as a barrier to healthy eating was positively associated with obesity indicators, regarding older and female children and had no association concerning younger and male children⁽¹⁴⁾.

Price increases

With regard to price increases, two studies established a positive association with obesity^(25, 31). One of them related with SSBs, being this association more prominent when the price change was greater than 10%⁽²⁵⁾. Another study found that association to be more pronounced in high SES women⁽³¹⁾. Two studies stated a negative association between price increase and obesity when doubling the prices of UP foods, when implementing a 1 dollar increase in UP food and beverages⁽¹⁵⁾, and when studying the rising of general food prices due to inflation⁽³¹⁾. Both studies found the differences to be more evident in women and low SES individuals.

Minimum price laws (MPLs)

Regarding establishing a minimum price for some food products, the two studies analysing this topic found an inverse association concerning BMI and obesity^(16, 26). Related to SSBs it was suggested that both 8 and 10 cents/ounce price floors had an impact in BMI and obesity, which was larger in the 10 cents case study. This action had a stronger impact on Black and Hispanic adults than on other race/ethnic groups⁽¹⁶⁾. This law regarding alcohol prices showed a greater impact on body weight in middle aged and older male adults, particularly those aged 65–74 years⁽²⁶⁾.

Taxation

Regarding taxation, two studies found a positive association with BMI, only for rich countries when analysing high calorie (HC) foods⁽²⁸⁾ and for high-income (HI) households classified as obese when analysing the impact of a 20% price increase in high sugar snacks on obesity⁽²¹⁾. Eight studies found a negative association

between taxes and obesity indicators^(16, 17, 21, 25-29). One of them only showed this association in HC food regarding poor countries and more accentuated in richer people⁽²⁸⁾. Another study found a negative association between sugar and confectionery product taxes and obesity, which was greater in lower SES individuals. It was also suggested a negative association with regard to fat and oil taxes and overweight and obesity indicators⁽²⁹⁾. A 20% price increase in high sugar snacks (HSSs) showed an inverse association with obesity markers, especially in middle-income (MI) overweight households, while a combination of HSSs and beverages taxation also presented an inverse association with obesity markers, which was more noticed in low-income (LI) obese households⁽²¹⁾. Another study also found an inverse association regarding soda tax, despite being relatively small⁽²⁵⁾. An alcohol tax was found to be negatively related to obesity⁽²⁶⁾. The differences in taxes applied to UP and processed food showed an inverse association with obesity, especially in upper-middle-income and LI sub-Saharan African countries, mainly in women⁽³⁰⁾. Regarding SSBs, it was also stated an inverse association with obesity, particularly with taxes of 1, 1.58, 2, and 2.60 cents/ounce⁽¹⁶⁾, largely in females, only for the ones at risk of being obese or overweight⁽¹⁷⁾ and after two years of the tax implementation, only for girls⁽²⁵⁾. It was found no association between a 20% price increase in HSSs and obesity, in households that were not overweight nor obese⁽²¹⁾, in low and upper-middle-income countries, HI and lower-middle income non sub-Saharan African countries⁽³⁰⁾ and after only one year of the implementation⁽²⁵⁾.

Subsidies

It was found a positive association between subsidies given to consumers on low calorie (LC) food and obesity^(28, 29), mostly in rich countries⁽²⁸⁾. The association between the simultaneous reduction of sugar, butter and cheese (SBC) subsidies and BMI was found to be positive, mainly in low SES females⁽²⁴⁾. Conversely, the implementation of SBC subsidies and sugar subsidies alone demonstrated an inverse association with obesity, greater in elderly male individuals and low SES females⁽²⁴⁾. Subsidies simultaneously in butter and cheese and only in butter did not show any association with obesity indicators⁽²⁴⁾. A significant association between farm subsidies paid at the expense of consumers and obesity or overweight was also not found⁽²⁷⁾.

Tax-subsidy dynamic

The association between the simultaneous effect of taxes and subsidies and body weight was found to be ambiguous during periods of financial instability, due to the distinct body weight changes outcomes. In the short term after the tax implementation, it is suggested a tendency towards a decrease in body weight, while in periods of economic development subsidies may lead to an increase in body weight⁽²⁸⁾.

Discounts

The association between food discounts and body weight was suggested to be positive^(18, 20), despite being small⁽²⁰⁾ and only significant among obese women⁽¹⁸⁾. Regarding the association of food discounts with BMI, one study found no association⁽²⁰⁾, while another one reported a negative association when the vegetables discount frequency was higher than soft drinks⁽¹⁹⁾. In this study a

negative association between food discounts, waist circumference and % of body fat was also shown, which increased with genetic susceptibility to obesity⁽¹⁹⁾.

Discussion

Food affordability

The affordability of HC and unhealthy food and beverages, justified by the lower cost per kilo-joule⁽¹³⁾, encourages their purchase and consumption⁽³⁾. On the other hand, healthier diets tend to be more costly due to the need to include a broader range of food items in a balanced diet⁽¹³⁾. A recent study found that nutritious food items, like fruits and vegetables, are priced 40% higher than what is considered efficient to ensure that the population is able to comply with the recommended guidelines. Also, the price of healthier foods is projected to cause a 15% decrease in fruit and vegetable consumption, accounting for about one-third of the gap between the actual and the recommended consumption⁽³²⁾.

Minimum price laws (MPLs)

In Scotland, the recent introduction of a floor price of 50 cents of gross domestic product (GDP) in alcoholic beverages was projected to reduce consumption by up to 7% for harmful drinkers, showing the potential benefits of this measure's implementation⁽²⁶⁾. Regarding the magnitude of the rates applied, it is suggested that steeper rates will have a greater impact on reducing obesity⁽¹⁶⁾. It was also proposed that a MPL with a floor of 10 cents/ounce could significantly reduce the discrepancy in SSBs consumption between White and Black adults by 22%, reducing their consumption. MPLs only affect consumers paying less than the price floor before policy implementation and unlike taxes, they increase prices and industry profit without raising revenue for the government and may therefore be less

politically feasible in jurisdictions where public support is tied to these policies' ability to fund programs and services⁽¹⁶⁾.

Taxation

Contrary to the results of the majority of the studies included in this review, it was found that a rise in cake prices was linked to higher consumption of energy among overweight and obese LI households⁽²¹⁾. An increase in the price of SSBs also showed a higher positive association with obesity in females^(17, 25, 31). This was possibly due to a shift towards calorie dense alternatives to cakes, showing the potential negative effect of substitution in response to these measures⁽²¹⁾. Taxing SSBs is identified as one of the most promising policies to address public health issues, namely the obesity epidemic, and they are increasingly being adopted by numerous countries worldwide^(1, 3, 16). A 20% tax on HSSs was suggested to reduce health inequalities derived from diet related disease, given the potential for a greater reduction in sugar consumption in obese and LI households⁽²¹⁾. Regarding the magnitude of the tax, the greater the tax, the more significant the decrease in obesity markers⁽²⁵⁾. Concerning economic impact, taxes raise prices for all consumers in the same proportion⁽¹⁶⁾. A full exemption of the tax or the offer of a tax credit for LI families can help reduce inequalities, whereas the second is less effective, although being less expensive for governments^(33, 34).

Subsidies

Implementing healthy food subsidies to the population, such as fruit and vegetables, is a recommended measure^(1, 32) that positively affects dietary habits across different socioeconomic groups without exacerbating food access

inequalities. If financed by an incremental increase in income tax, theoretically can contribute to achieving efficient relative price levels⁽³²⁾.

Food discounts

Consumers frequently opt for cheaper products or which are on offer⁽⁴⁾ and in England in 2017, around one-third of consumer purchases made for home consumption were categorized as "purchase promotions"⁽³⁵⁾. It was found that up to 83% of purchases made on price promotion are impulse purchases, with only 17% being planned⁽³⁶⁾. Notably, products classified as high in fat, salt, and sugar, such as regular soft drinks, were twice as likely to be purchased on promotion compared to fruits, vegetables, or starchy foods⁽³⁵⁾. Food discounts are often accompanied by strong marketing strategies, which further promote purchase and consumption⁽¹⁹⁾. The UK government has implemented bans on food discounts as one anti-obesity measure. However, there are suggestions to reverse this political action due to concerns about the cost of living and its potential impact on businesses and economic growth^(1, 37, 38). Although the World Health Organization recommends restricting the discounts of unhealthy foods as one of the most promising policies to reduce obesity⁽¹⁾, few of the implemented policies by governments incorporate this focus⁽³⁵⁾.

Measures combination

It also shows to be interesting to combine several approaches as probably MPLs coupled with bans on discounts ensure that retailers cannot undercut taxes with discounts, preventing them from spreading out price increases across many products and resulting in a reduction of their impact on unhealthy food purchases. The best approach must be to include pricing policies as part of a comprehensive

unhealthy food reduction strategy⁽¹⁶⁾. It was suggested that theoretically, it is possible to achieve efficient relative price levels without leaving any consumer worse off, by providing a subsidy on healthy foods and applying a household specific tax on unhealthy foods⁽³²⁾.

Duration

One study found it took two years to identify significant associations between measures implementation and obesity prevalence, and that after one year no significant associations were perceived⁽²⁵⁾. In another study, it was noted an immediate association with the reduction of SSBs consumption, which was even more pronounced after two years of implementation⁽¹⁷⁾. Many of these measures implementations are incremental and so it is complicated to make large-scale changes in a short timeframe, but the results achieved in this review demonstrate their importance as part of obesity management interventions⁽¹⁶⁾.

Sexes

There were some associations that showed to be more prominent in females. Regarding obesity, they were suggested to be more negatively affected by general food prices⁽³¹⁾ and their increases⁽¹⁵⁾, mainly regarding healthier options when compared to less nutritious ones⁽¹⁴⁾. On the other hand, a study showed that increased prices of UP food and beverages were particularly negatively associated with obesity in women^(30, 31). These greater associations may be explained because women are more exposed to the food environment since they are the ones who buy and prepare food in households more frequently^(18, 39). A positive association between food discounts and obesity was found specifically in obese women, which

may be explained because of the greater sensitivity to food cues that women exhibit in the local retail environment⁽¹⁹⁾.

Females are also more vulnerable to food insecurity^(14, 40, 41) and usually driven by a desire to provide higher quality food for their families, may consume less during times of scarcity^(4, 42), a fact that can explain the greater associations found in low SES women, regarding obesity decrease.

The implementation of MPLs for alcohol showed a tendency for a decrease in obesity rates, mainly in male older adults, a fact possibly explained by their greater consumption of alcoholic beverages⁽⁴³⁾.

Socioeconomic status

It was also noted a variability between socioeconomic status. The association between general food costs rise⁽¹⁵⁾, increases in price of UP food and beverages⁽³¹⁾, and obesity, showed a more evident negative association among lower SES individuals. Conversely, a rise in the cost of SSBs produced a negative association with obesity, mainly in high SES women⁽³¹⁾. These effects may be explained because LI individuals consume unhealthy and more processed foods more frequently than high SES individuals^(26, 44, 45) and because they are more likely to have limited budgets, what makes them particularly responsive to price hikes^(3, 17, 46).

The taxation's impact on HC food was only perceived in poor countries and richer people⁽²⁸⁾, among MI people when applied to HSSs, LI people when the joint taxation of HSSs and beverages was studied⁽²¹⁾ and among upper-middle and LI people in sub-Saharan African countries⁽³⁰⁾. Subsidies given to consumers on LC foods were found to have a more pronounced positive association with obesity in

wealthier countries and in the long run⁽²⁸⁾. It may be explained by the higher consumption and attention paid to healthier food in rich countries by HI groups. So, decreasing those foods' price will enlarge the purchasing power of HI groups, increasing even more their consumption and possibly contributing to an obesity increase, derived from overconsumption⁽²⁸⁾.

The higher food prices can lead to a decrease in consumption⁽³⁾, particularly among lower socioeconomic groups who have limited budgets. Healthy food, such as fruit and vegetables, is also perceived as more costly than energy dense food, which can result in a decrease in its consumption by low SES individuals^(4, 42, 47). It has been suggested that LI parents, to compensate for non-food-related activities that contribute to social well-being but are financially unaffordable, tend to purchase unhealthy foods for their families⁽⁴⁸⁾, what may contribute to explaining the higher consumption of more unhealthy food by these groups.

Obesity status

Measures covering the taxation of HSSs, SSBs and the simultaneous implementation of the interventions were also shown to be more effective among people who were already obese or overweight^(17, 21), which may be explained by their greater consumption of these processed products^(49, 50).

A positive association between food discounts and obesity was found specifically in obese women⁽¹⁹⁾, which can be attributed to their greater responsiveness to rewards and stronger motivation to eat when exposed to food cues, with a special preference for HC food options⁽¹⁸⁾. Lowering the vegetables price compared to SSBs was suggested to have a stronger impact on reducing obesity markers in individuals genetically predisposed to obesity. This effect is likely due to the

incentive created by discounted prices for low energy dense foods, motivating individuals to opt for healthier choices and leading to a decrease in obesity markers such as BMI and body fat %⁽¹⁹⁾.

COVID-19 and economic crises

The COVID-19 pandemic led to periods of great food prices instability, increasing food insecurity. Worldwide food prices rose, showing a particularly higher tendency for nutritious food, especially in countries reporting more cases, what threatened nutrition security⁽⁵¹⁻⁵³⁾. These periods are also characterized by an impaired mental health state, which is likely to reduce motivation when it comes to managing obesity, possibly due to biopsychological mechanisms such as using food as a source of comfort⁽³⁷⁾. During crisis times the main determinants of food prices are the imposition of sanctions on food and fertilizers, exporting bans and restrictions. In these periods is also notable supply hoarding, which is mainly associated with large quantities of grains imported and accumulated, contributing to price instability, enhancing food insecurity and potentially obesity⁽¹⁰⁾.

Capitalism

Politics and the way society is organized nowadays have also a great influence on food prices, the way the population consumes and perceives food and ultimately on obesity rates. As a result of the capitalist system we are in, overconsumption, a risk factor for obesity, is legitimised and promoted by the affordability of HC food and increasingly effective marketing strategies, to maintain economic growth. Governments, namely through regulation and strengthening democracy, play a critical role in diminishing these impacts by shifting their focus to protect consumers and promote healthy food environments^(1, 8, 54-56).

Limitations and strengths

It is important to note that many studies in this field consult secondary data as a source of information for analysis. However, this approach has certain drawbacks, specifically concerning the uncertainty regarding the accuracy of the data collection. A part of the analysed articles resorts to simulation models that are frequently simplified, meaning they do not accurately represent the full complexity of real-world data analysis⁽⁵⁷⁾. The disproportionate inclusion of papers focused on taxation compared to other price dimensions may lead to the overrepresentation of this dimension relative to the others. This imbalance is a result of the limited availability of research papers on these specific topics.

To our knowledge, this is the first review that studies the association between food cost, in its various dimensions, and obesity. Additionally, this review includes articles with substantial sample sizes, which ensures more precise mean values.

Conclusion

According to the existing literature, which is still scarce on this topic, the cost of food is significantly associated with obesity and may act as one of its promoting factors. Public policies involving some of the strategies studied in this review, such as taxation and the limitation of discounts on less healthy foods may be effective in reducing obesity. Nevertheless, comprehensive strategies are essential, requiring the combination of various policy measures and the development of actions to promote population education on these issues. A concern of governments in the design of these strategies should be the reduction of inequalities in access to healthy eating and obesity prevalence.

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Appendix 1

Table 1 - General study characteristics of included studies

Title	Author/Year/ Country	Study Design	Population	Method Used to Evaluate Obesity	Outcomes	Main Findings
Monetary diet cost is positively associated with diet quality and obesity: an analysis of school-aged children in Southwest China ⁽¹³⁾	Zhang et al., 2018, China	observational study	individuals younger than 18, n=2.043	fat mass index, weight	measuring height and weight	higher food cost associated with higher rates of obesity
Availability and price of healthier food choices and association with obesity prevalence in New Zealand Māori ⁽²³⁾	Jani et al., 2018, New Zealand	observational study	general adult populations, n=3.817	BMI, obesity	questionnaires	cheaper price of water relatively to sugary drinks, were associated with lower obesity rates
The impact of rising food prices on obesity in women: a longitudinal analysis of 31 low-income and middle-income countries from 2000 to 2014 ⁽³¹⁾	Conklin et al., 2018, several countries	observational study	general adult populations, n=295.984	obesity	questionnaires and secondary data	higher food cost increases were associated with higher rates of obesity; higher rises in general food cost due to inflation were associated with lower rates of obesity
Taxing highly processed foods: What could be the impacts on obesity and underweight in sub-Saharan Africa? ⁽³⁰⁾	Boysen et al., 2019, several countries	theoretical research	general adult populations	obesity	secondary data	differences in taxes applied to UP and processed food were associated with lower rates of obesity, especially in upper-middle-income and low-income sub-Saharan African countries, mainly in women; it was found no association between a price increase in high sugar snacks, in low and upper-middle-income countries, high-income and lower-middle income non sub-Saharan African countries
The Price of Ultra-processed Foods and Beverages and Adult Body	Powell et al., 2019, USA	theoretical research	general adult populations, n=2.602.758	BMI	measuring height and weight and secondary data	doubling the prices of UP foods, implementing a 1 dollar increase in UP food and beverages

Weight: Evidence from U.S. Veterans ⁽¹⁵⁾						were associated with lower rates of obesity
Potential impact on prevalence of obesity in the UK of a 20% price increase in high sugar snacks: modelling study ⁽²¹⁾	Scheelbeek et al., 2019, UK	theoretical research	general adult populations, n=36.324	body weight, BMI	questionnaires	a 20% price increase in sugar snacks was associated with higher rates of obesity in high- income obese households and with lower rates in middle- income overweight households; a combination of high sugar snacks and beverages taxation was associated with lower rates of obesity in low- income obese households; it was found no association between a 20% price increase in high sugar snacks, in households that were not overweight nor obese
We are what we eat: Obesity, income, and social comparisons ⁽²⁸⁾	Mathieu-Bolh et al., 2020, several countries	theoretical research	all ages	body weight	secondary data	taxation of high calorie foods was associated with higher rates of obesity in rich countries and with lower rates in poor countries and more accentuated in richer people; subsidies on lower calorie food were associated with higher rates of obesity mostly in rich countries; simultaneous implementation of a tax and a subsidy showed an ambiguous effect
Diet Quality and Food Prices Modify Associations between Genetic Susceptibility to Obesity and Adiposity Outcomes ⁽¹⁹⁾	Han et al., 2020, Canada	cross- sectional study	general adult populations, n=3.718	waist circumfe rence	questionnaires and secondary data	higher food cost associated with higher rates of obesity; vegetables discount frequency higher than soft drinks was associated with lower obesity rates
Temporal discounting does not influence body mass index ⁽²⁰⁾	Veillard et al., 2020, UK	observational study	general adult populations, n=381	body weight, BMI	questionnaires	food discounts were associated with higher rates of obesity despite the association; no association was found between food discounts and BMI

Association between the price of ultra-processed foods and obesity in Brazil ⁽²²⁾	Passos et al., 2020, Brasil	theoretical research	all ages, n=55.570	obesity, overweight	questionnaires	higher food cost was associated with lower rates of obesity
Increasing the Price of Alcohol as an Obesity Prevention Measure: The Potential Cost-Effectiveness of Introducing a Uniform Volumetric Tax and a Minimum Floor Price on Alcohol in Australia ⁽²⁶⁾	Robinson et al., 2020, Australia	theoretical research	general adult populations, individuals younger than 18	BMI	secondary data	MPL in alcohol was associated with lower rates of obesity; an alcohol tax was associated with lower rates of obesity
Food policies and obesity in low- and middle-income countries ⁽²⁹⁾	Abay et al., 2021, several countries	observational study	all ages, n=600.000	body weight	secondary data	sugar and confectionery product taxes were associated with lower rates of obesity, especially in low SES individuals; fat and oil taxes were associated with lower rates of obesity; subsidies on lower calorie food were associated with higher rates of obesity
Sugar-Sweetened Beverage Pricing Policies: Simulation of Minimum Price Laws and Taxes in New York City ⁽¹⁶⁾	Grummon et al., 2021, USA	theoretical research	general adult populations, n= 64.000	BMI, body weight	questionnaires	establishing 8 and 10 cents/ounce price floors for SSBs was associated with lower rates of obesity; taxes of 1, 1.58, 2, and 2.60 cents/ounce in SSBs were associated with lower rates of obesity
Longitudinal geo-referenced field evidence for the heightened BMI responsiveness of obese women to price discounts on carbonated soft drinks ⁽¹⁸⁾	Wu et al., 2021, Canada	observational study	general adult populations, n=1.622	body weight	questionnaires	food discounts were associated with higher rates of obesity among obese women
When Industrial Policies Conflict With Population Health: Potential Impact of Removing	Mireles et al., 2021, Spain	theoretical research	general adult populations, n=1.747	BMI, obesity	questionnaires	simultaneous reduction of subsidies given to SBC producers was associated with higher rates of obesity, mainly in low SES women;

Food Subsidies on Obesity Rates ⁽²⁴⁾						implementation of SBC subsidies and sugar subsidies alone were associated with lower rates of obesity, greater in elderly male individuals and low SES females; Subsidies simultaneously in butter and cheese and only on butter did not show any association with obesity
Changes in Weight-Related Outcomes Among Adolescents Following Consumer Price Increases of Taxed Sugar-Sweetened Beverages ⁽²⁵⁾	Gračner et al., 2021, Mexico	observational study	individuals younger than 18, n=12.654	BMI	secondary data	higher SSBs cost increases were associated with higher rates of obesity; soda tax was associated with lower rates of obesity; SSBs taxes were associated with lower rates of obesity in girls after 2 years of the implementation; it was found no association between a price increase after 1 year of the implementation
Food policies and obesity in low- and middle-income countries ⁽²⁹⁾	Abay et al., 2021, several countries	observational study	all ages, n=600.000	body weight	secondary data	sugar and confectionery product taxes were associated with lower rates of obesity, especially in low SES individuals; fat and oil taxes were associated with lower rates of obesity; subsidies on lower calorie food were associated with higher rates of obesity
Do sugar-sweetened beverage taxes improve public health for high school aged adolescents? ⁽¹⁷⁾	Flynn, 2022, USA	observational study	individuals younger than 18, n=25.000	BMI	secondary data	SSBs taxes were associated with lower rates of obesity especially in females who were at risk of being overweight or obese
The impact of agricultural subsidies on obesity ⁽²⁷⁾	Wunderlich et al., 2022, several countries	theoretical research	general population	obesity, body weight	secondary data	farm subsidies paid at the expense of consumers were associated with lower rates of obesity

