"Role of food labels in enhancing food security and addressing obesity. Case of Chile"

Polikarpova, Ekaterina

ABSTRACT

This paper investigates the role of front-of-package nutrition labels in improving food security and combating obesity in Chile, focusing on the impact of the comprehensive food labels introduced by Law 20.606. The objective of the study is to assess whether these regulations contribute to increased consumer awareness, healthier food choices, and improved population health. By employing a mixed-method approach that includes a literature review, econometric modelling, consumer surveys, difference-in-differences strategy, and cluster analysis techniques, the research obtains significant results. Although nutrition labels are intended to provide transparent information about product contents, the findings indicate that Chilean consumers do not always pay attention to them. The analysis reveals an increase in expenditures across many product categories, with the exception of soft drinks, suggesting insufficient effectiveness of the labelling system. Further analysis using cluster methods demonstrates that consumption habits among social groups remain unchanged before and after labels introduction, and access to a variety of nutritious foods is still limited in certain clusters. OECD statistics confirm unhealthy food consumption by high obesity rates in Chile, emphasising the need for a more comprehensive approach that considers not only food labels but also environmental, educational, and socio-economic factors. Policy recommendations include banning unhealthy food advertising on public transport, introducing free drinking water sources, and developing mobile food markets in ...

CITE THIS VERSION

UCLouvain

UNIVERSITÀ CATTOLICA del Sacro Cuore

AFEPA agricultural, food and environmental policy analysis

AGRO LOUVAIN

Faculté des bioingénieurs

Role of food labels in enhancing food security and addressing obesity

Case of Chile

Auteur : Ekaterina Polikarpova
Promoteur : Frédéric Gaspart
Lecteur : Paolo Sckokai
Année académique 2023-2024
Mémoire de fin d'études présenté en vue de l'obtention du diplôme de Bioingénieur

Abstract

This paper investigates the role of front-of-package nutrition labels in improving food security and combating obesity in Chile, focusing on the impact of the comprehensive food labels introduced by *Law 20.606*. The objective of the study is to assess whether these regulations contribute to increased consumer awareness, healthier food choices, and improved population health. By employing a mixed-method approach that includes a literature review, econometric modelling, consumer surveys, difference-in-differences strategy, and cluster analysis techniques, the research obtains significant results. Although nutrition labels are intended to provide transparent information about product contents, the findings indicate that Chilean consumers do not always pay attention to them. The analysis reveals an increase in expenditures across many product categories, with the exception of soft drinks, suggesting insufficient effectiveness of the labelling system. Further analysis using cluster methods demonstrates that consumption habits among social groups remain unchanged before and after labels introduction, and access to a variety of nutritious foods is still limited in certain clusters. OECD statistics confirm unhealthy food consumption by high obesity rates in Chile, emphasising the need for a more comprehensive approach that considers not only food labels but also environmental, educational, and socio-economic factors. Policy recommendations include banning unhealthy food advertising on public transport, introducing free drinking water sources, and developing mobile food markets in remote areas, all of which require collaboration between government agencies and local communities.

Keywords: food security, food environment, food labels, obesity, Chile, Law 20.606, econometric modelling, cluster analysis, socio-economic factors, unhealthy food advertising, consumers behaviour.

Table of Contents

List of Abbreviations

ANOVA : Analysis of Variance

BMI : Body Mass Index

CPI : Consumer Price Index

CLP / CL$: Chilean Pesos

CI : Confidence Interval

EPF : [Encuesta de Presupuestos Familiares] Family Budget Survey

FOPL : Front-of-Package Labels

INE : National Institute of Statistics

GDP : Gross Domestic Product

n.e.c. : not elsewhere classified

SDG : Sustainable Development Goals

WHO : World Health Organization

Introduction

In the face of escalating rates of obesity and related health concerns, understanding the dynamics of dietary habits and consumption patterns has become imperative (Ameye et Swinnen, 2019). One avenue of exploration lies in the examination of food labelling's role in shaping consumer behavior and addressing obesity risk (Aggarwal et al., 2014). Against this backdrop, this thesis delves into an in-depth analysis of consumption trends over two distinct periods, accompanied by a comprehensive cluster analysis aimed at uncovering nuanced patterns in consumption behavior. Focusing on the case of Chile, this study seeks to illuminate the interplay between food labeling, dietary preferences, and obesity prevalence, since escalation of obesity rates globally underscores the urgency of exploring interventions to promote healthier dietary habits (Anastasiou et al., 2019). Within this context, food labeling has emerged as a potential mechanism for empowering consumers with essential information regarding the nutritional content and health implications of food products (Perumal et al., 2022). However, empirical evidence on the effectiveness of food labeling initiatives, particularly in the context of combating obesity, remains inconclusive.

In this research we link obesity to labelling by the following causal chain: 1. *labelling -> 2. quality of food -> 3. quality of the whole diet -> 4. obesity*. Let us delve into each step of this chain and the intermediary concepts involved. *(1)* Food labels provide consumers with information about the nutritional content of food products. This includes details such as calorie count, fat content, sugar content, and other nutrient values by claims mentioned on the food product (e.g. “low-fat”, “high in fiber”, etc.) (Martini & Menozzi, 2021). *(2)* The information provided on labels influences consumers' perceptions of the quality of food products. Labels indicating healthier options may lead consumers to perceive these products as better choices for their diet. Misleading or unclear labeling can lead to misconceptions about the healthiness of certain foods (Grunert, 2005). *(3)* The cumulative effect of individual food choices, influenced by labeling, determines the overall quality of a person's diet (Gao et al., 2013). If individuals consistently choose products based on healthier labels, their diet as a whole may improve in terms of nutritional content. *(4)* Over time, the quality of the diet impacts health outcomes, including the risk of obesity (Storcksdieck Genannt Bonsmann & Wills, 2012). Diets high in calories, saturated fats, and sugars, which may be chosen due to misleading or inadequate food labeling, can contribute to weight gain and obesity (Ochulor et al., 2022).

Our research on the effectiveness of food labelling laws in Chile is highly relevant due to several pressing socio-economic issues. Time-poverty, where individuals lack the time to make informed and healthy food choices, particularly affects low-income groups (Gough et al., 2019).

Effective labelling can help mitigate this by providing quick and accessible nutritional information (Kalenkoski & Hamrick, 2012). Additionally, gender disparities in domestic responsibilities, with women often shouldering the burden of meal planning and preparation, influence the practical impact of food labelling (Alotaibi et al., 2023). Addressing these disparities ensures that labelling policies benefit all consumers equally. With increasing number of various diseases, rising obesity rates, shortening life span and persistent food insecurity, understanding how food labelling can serve as a public health intervention is critical for developing better policy-making and public health strategies (Storcksdieck Genannt Bonsmann & Wills, 2012).

However, the research also navigates several contradictions that complicate the effectiveness of food labelling. While some studies suggest significant improvements in consumer choices and health outcomes due to food labelling (Shangguan et al., 2019; Zafar et al., 2022; Perumal et al., 2022), others report minimal or no impact (Sobaih et al., 2022; Swetha, 2018). This research aims to clarify these conflicting findings within the Chilean context. Additionally, increased consumer awareness does not always translate into healthier eating habits, especially among low-income groups facing economic constraints (FAO, 2011; Gough et al., 2019). Furthermore, resistance from the food industry to stringent labelling regulations can undermine their effectiveness (Ministerio de Salud de Chile, 2017; Kanter et al., 2017; Reyes et al., 2017). This paper examines consumer perception, nutritional content, health policy, and industry practices. All together they form contradictions and intermediary which allow to provide a nuanced understanding necessary for crafting comprehensive and effective public health policies.

To study everything described above a mixed-methods approach was employed, incorporating both qualitative and quantitative data. It consists of a comprehensive review of existing literature on food labelling, consumer behavior, obesity, and food security helped establish a theoretical framework and identify key variables for analysis. Then, econometric modelling with "Difference-in-Differences Strategy" method to determine correlations and causations between labelling regulations and health outcomes via comparing changes in consumer behavior and health outcomes before and after the implementation of the regulations, between food groups exposed to the policy and those that were not (Bablani et al., 2020). Additionally, we employed cluster analysis with ANOVA means check to provide insights into the differential impacts of food labelling laws across various segments of the population (low- and high-income families), their dietary composition (MacKinnon & Webb, 2020). All that research became possible due to National Institute of Statistics data with Family Budget Survey surveys conducted before and after the implementation of Law 20.606 (Instituto Nacional de Estadísticas, 2024). Originally presented in Spanish the data was translated into English, as well as part of the literature studies for this research (Ministerio de Salud, 2012; Diadio oficial de la Republica de Chile, 2015; Junta Nacional

de Auxilio Escolar y Becas, 2016; Departamento de Nutrición y Alimentos, 2016; Ministerio de Salud, 2016). This translation retains the cultural and contextual specificity essential for understanding the Chilean food environment and its regulatory framework, ensuring that the insights are relevant and applicable to similar contexts worldwide. While the findings are expected to provide valuable insights into consumption trends and patterns, certain limitations, such as data interpretation and the issue of generalization, may impact the robustness of the analysis (Abadie et Cattaneo, 2018; Singh et Xie, 2010). Nevertheless, this research holds significant implications for public health policy, food industry stakeholders, and consumers alike. It equips researcher and readers with Chilean food environment insights and contains policy recommendations for the studied field. These findings are expected to inform evidence-based interventions aimed at promoting healthier dietary choices and combating obesity prevalence in Chile and beyond.

The paper is structured as follows: Chapter 1 provides a comprehensive review of the literature on food labeling, obesity, and consumption behavior. Chapter 2 gives description of the data utilized for the research. Chapter 3 outlines the methodology employed in conducting comparative analyses and cluster analysis. Chapters 4 presents the empirical findings followed by a discussion of the results and their implications as well as policy recommendations. Chapter 5 offers conclusions and avenues for future research.

Research objective, research question and hypotheses

The *objective of this research* is to evaluate the effectiveness of Chile's food labelling laws, particularly Law 20.606, in increasing consumer awareness, influencing food consumption patterns, and reducing obesity rates, thereby improving food security. The study aims to assess whether these regulations lead to more informed food choices and healthier eating habits, and to develop policy recommendations that integrate food labelling with broader public health strategies to address obesity and food security challenges in Chile.

Research question of this study is “What is the role of labeling in addressing obesity?”. To answer this question, we conduct a comparative analysis of consumption patterns over two distinct periods (2016-2017 and 2021-2022) within Chile. These two periods are chosen because June 27th, 2016, Chile's implemented a comprehensive food labelling “Law 20.606”, aimed at curbing the rising rates of obesity and diet-related diseases, serves as a focal point for this study. The law mandates front-of-package warning labels, marketing restrictions, and school-based nutritional standards, with the objective of providing clear, accessible information about the nutritional content of food products (Scarpelli et al., 2020). These measures applied to empower consumers to make informed food choices that align with health recommendations.

This research is guided by the following *hypotheses*:

1) Improved food labelling practices contribute to increased consumer awareness of nutritional content, leading to decrease in the consumption of high-calorie, low-nutrient foods.
2) Via more informed food choice and healthier food consumption, there is a reduction in obesity prevalence in Chile.

Literature Review

1. Food security in Latin America

To begin this discussion, food security needs explanation. World Food Summit (1996) defined food security as follows: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. It could be summarised in four key dimensions: “availability, access, utilization, and stability” (Matthew, 2017). The first one refers to the physical presence of food within a given region or country. It considers factors such as agricultural productivity, food production, distribution networks, and trade. Availability encompasses the guarantee of a consistent and dependable food supply to fulfil the dietary requirements of the population (Giskes et al., 2007). Access to food includes two explanations. Firstly, economic access, which pertains to individuals' capacity to purchase food. This individuals’ ability is influenced by factors such as income, employment prospects, food costs, and access to financial means (Bouis et al., 2011). Secondly, physical access which is an ability to physically reach food sources, such as grocery stores, markets, or agricultural areas. It includes factors such as proximity to food retailers, transportation options, and the availability of safe and convenient pathways to access food. Barriers to access can include transportation limitations, geographic isolation, and inadequate infrastructure (Winkler et al., 2006). Utilization pertains to how effectively individuals and households can make use of the food they have access to in order to meet their nutritional requirements. This includes aspects like varying their diet, cooking and preparing food properly, ensuring food safety, and maintaining sanitation practices. Promoting proper food utilization requires education and awareness about nutrition, cooking skills, hygiene practices, and the importance of balanced diets (Brazil Ministry of Health, 2014). Stability refers to the ability of food systems to withstand and recover from shocks or stressors without compromising food availability, access, or utilization. These shocks can include natural disasters, economic crises, conflicts, and climate change-related events (Timmer, 2010).

In this research we would like to go deeper in food security issue in Latin American countries. Rooted in poverty, food insecurity reflects the inability of individuals or households to consistently meet their dietary needs and maintain a healthy lifestyle. This relationship is underscored by the works of scholars like Drèze and Sen, who argue that poverty and food insecurity are intricately linked phenomena (Drèze & Sen, 1991). In this context, measuring food insecurity goes beyond assessing income levels; it encompasses factors such as access to markets, availability of nutritious food, and socio-economic disparities. While poverty acts as a

foundational driver, food insecurity manifests in diverse ways across Latin America due to varying levels of inequality, political stability, and agricultural productivity (Drèze & Sen, 1991). Countries with high inequality often experience higher rates of food insecurity, exacerbated by limited access to resources and opportunities among marginalized communities. We will provide more detailed description of the Latin American countries in more details in next paragraph. To make our argument about food insecurity stronger, we also mention sustainable development goals (SDG), which emphasize the interconnectedness of poverty alleviation, food insecurity, and environmental sustainability, highlighting the need for integrated solutions that address root causes while building resilience against future shocks (World Food Programme, 2024). Especially SDG 2 "Zero Hunger" which aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture by 2030 (United Nations, 2024).

Figure 1 examines prevalence of moderate or severe food insecurity in Argentina, Brazil, Chile, Ecuador, Paraguay, Suriname, and Uruguay by three-year averages, while making it possible to analyse the evolution of this indicator over time by comparing the prevalence in different countries in the most recent triennium of the analysis (2020–2022) against a previous triennium (2014–2016). It is clearly seen that approximately one third of the population in South American countries such as Argentina, Brazil, Ecuador, and Suriname experience moderate or severe food insecurity. Paraguay and Argentina exhibited the most significant increases, with the prevalence rising by over 17 percentage points in each nation. Conversely, Uruguay and Chile have the lowest prevalence, with 15.2 and 18.1 percent, respectively.

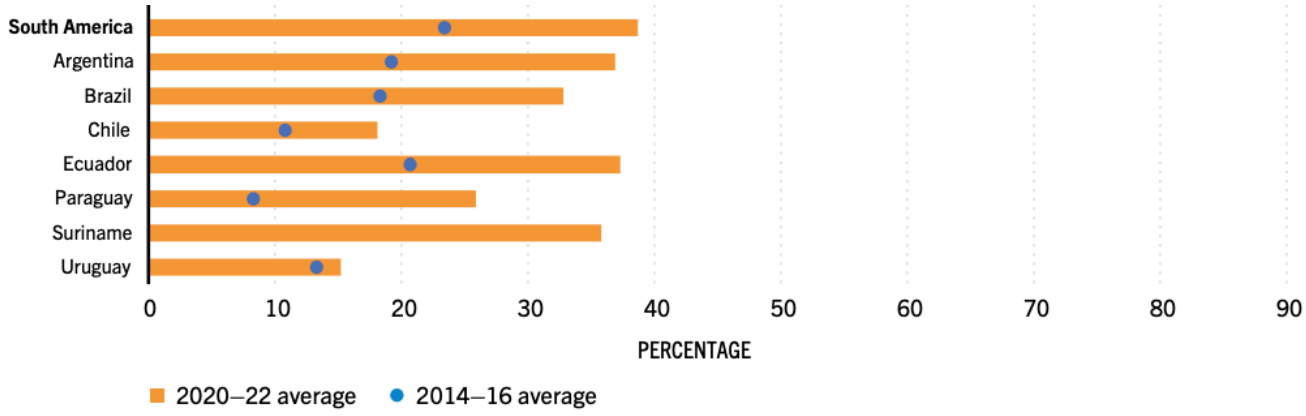
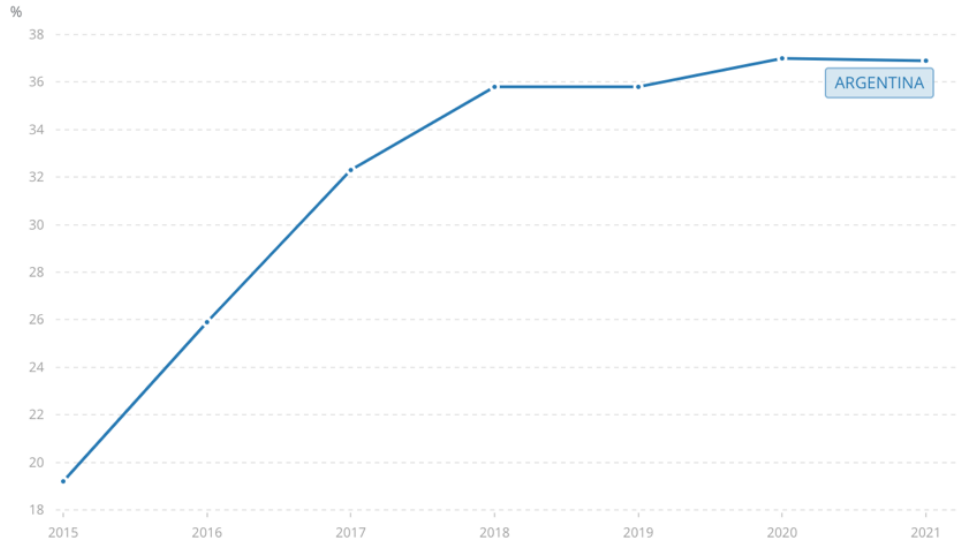


Figure 1. Prevalence of moderate or severe food insecurity in Latin America by country (FAOSTAT, 2023)

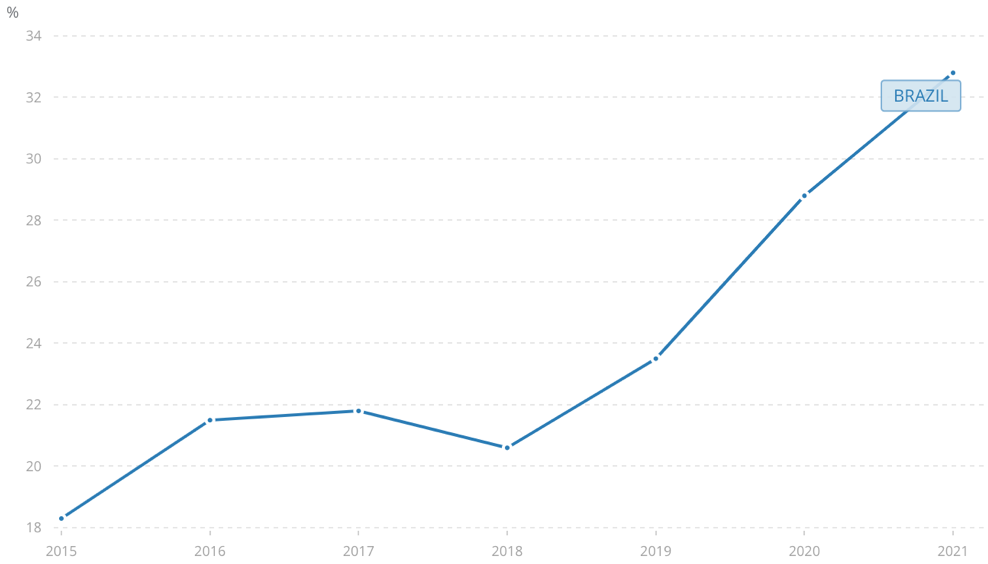
General trend of increasing moderate or severe food insecurity from 2014 to 2022 in South America is attributed to various factors such as economic instability, social inequality, environmental challenges, and political instability (Sousa et al., 2019; Hernández-Vásquez et al., 2022). Economic downturns, currency devaluation, and inflation have contributed to reduced purchasing power and increased food prices for many households, making it difficult to afford an adequate and nutritious diet. Social inequality, including unequal access to education, healthcare, and employment opportunities, has exacerbated disparities in food access and nutrition outcomes. Environmental challenges such as deforestation, soil degradation, and climate change have also impacted agricultural productivity and food systems resilience, particularly in rural areas (FAO, IFAD, PAHO, UNICEF & WFP, 2023). Going deeply in economic, social, environmental, etc. reasons mentioned before Latino American countries have their own trends, which are described below with graphics demonstrating these tendencies.

Argentina (graph 1) has experienced a significant increase in food insecurity from 2015 to 2021, driven by economic crises, high inflation rates, and currency devaluation. These factors have contributed to widespread poverty and food insecurity, particularly among vulnerable populations (Le Coq et al., 2022). In 2015, approximately 20% of the population faced moderate or severe food insecurity. This percentage increased sharply, reaching around 30% by 2017, indicating a rapid deterioration in food security over a short period. After 2017, the prevalence of food insecurity stabilized but remained high, peaking slightly above 35%. This sustained high level of food insecurity underscores ongoing challenges in ensuring adequate food access for the Argentine population.



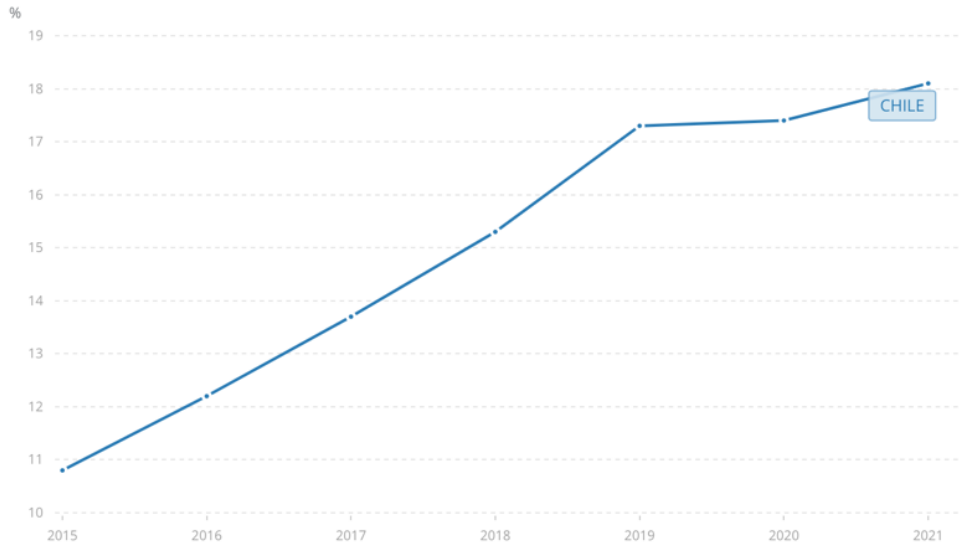
Graph 1. Prevalence of moderate or severe food insecurity in Argentina, between 2015 and 2021 (FAO, World Bank Group, 2024)

Brazil (graph 2) has experienced a troubling increase in food insecurity from 2015 to 2021, driven by economic challenges, social inequality, and environmental degradation. The economic recession, rising unemployment, and income inequality have severely affected access to food, particularly in urban areas. Additionally, deforestation in the Amazon rainforest and land degradation have impacted agricultural production, further exacerbating food security issues in certain regions (Palmeira et al., 2020). In 2015, the prevalence of moderate or severe food insecurity in Brazil was around 18%. This figure rose to about 22% in 2016, followed by a period of slight decrease and stabilization. However, starting in 2019, Brazil witnessed a significant surge in food insecurity, reaching approximately 34% by 2021. This sharp increase in the latter years highlights a growing crisis in food security, necessitating urgent attention and intervention to reverse the trend.



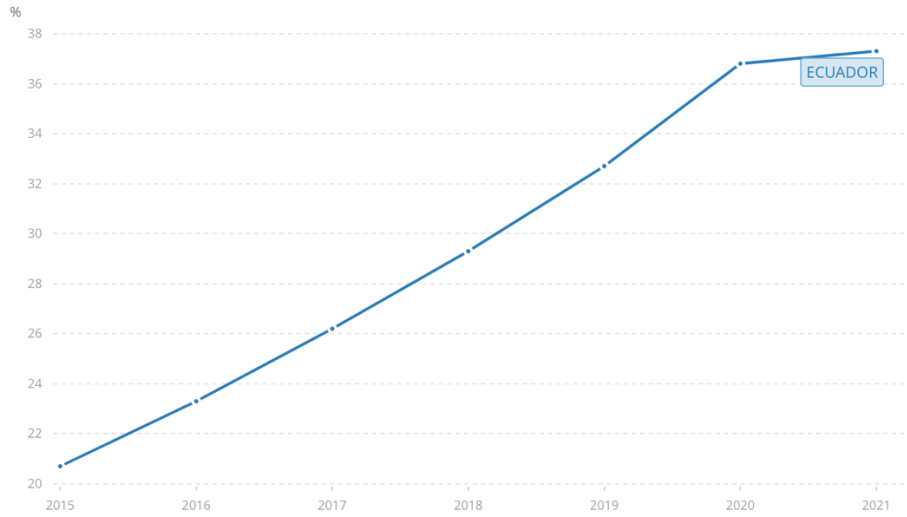
Graph 2. Prevalence of moderate or severe food insecurity in Brazil between 2015 and 2021 (FAO, World Bank Group, 2024)

Chile (graph 3) has maintained relatively low levels of food insecurity compared to other South American countries, yet it has experienced a steady and continuous increase in food insecurity from 2015 to 2021. Strong economic growth, social policies targeting poverty reduction, and investments in education and healthcare have significantly improved food access and nutrition outcomes for many Chileans (Pinhiero et al., 2022). In 2015, around 11% of the population experienced moderate or severe food insecurity. This prevalence increased steadily over the years, reaching about 13% in 2016 and approximately 16% by 2018. The upward trend persisted, and by 2021, the prevalence had slightly surpassed 18%. Unlike other countries in the region, Chile's rise in food insecurity has been constant and almost without fluctuations.



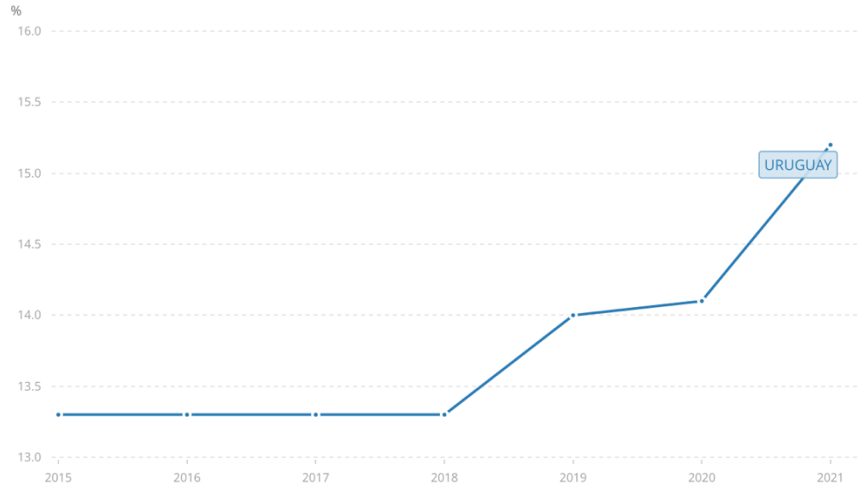
Graph 3. Prevalence of moderate or severe food insecurity in Chile, between 2015 and 2021 (FAO, World Bank Group, 2024)

Economic instability, social inequality, political unrest, environmental degradation, and dependence on oil exports have contributed to poverty and food insecurity in certain regions of Ecuador (graph 4). The prevalence of moderate or severe food insecurity in Ecuador from 2015 to 2021 can be noticed, showing a clear and steady upward trend. In 2015, the prevalence was approximately 20%, and each subsequent year shows an increase, culminating in a prevalence of about 37% in 2021. This significant rise indicates that food insecurity has become an increasingly severe issue in Ecuador over these seven years (Paraje, 2016; ECLAC, 2022).



Graph 4. Prevalence of moderate or severe food insecurity in Ecuador, between 2015 and 2021 (FAO, World Bank Group, 2024)

Uruguay has maintained relatively low levels of food insecurity compared to other South American countries, with around 15.3% moderate or severe food insecurity noted by the end of 2021 (graph 5). Strong social welfare programs, investments in education and healthcare, and a diversified economy have helped mitigate poverty and improve food access and nutrition outcomes for many Uruguayans (Le Coq et al., 2022). In more details, tt can be noticed that unlike Ecuador, Uruguay experienced a relatively stable level of food insecurity from 2015 to 2018, maintaining around 13%. However, starting in 2018, there is a noticeable upward trend, with a sharp increase beginning around 2019. By 2021, the prevalence of food insecurity had risen to approximately 15.5%. This pattern indicates that while food insecurity in Uruguay remained stable initially, it has significantly worsened in the latter part of the observed period.



Graph 5. Prevalence of moderate or severe food insecurity in Uruguay, between 2015 and 2021 (FAO, World Bank Group, 2024)

To conclude, among Latin American countries, Chile is an ideal focus for studying obesity and the impact of food labelling due to several compelling reasons. Firstly, as it could be seen from the graphs, Chile has experienced a significant rise in food insecurity, increasing from approximately 11% in 2015 to over 18% in 2021. What is more important this increase is consistent, what indicates shifts in dietary patterns and food accessibility, closely linked to obesity, making Chile a unique case to explore these dynamics (Pinheiro et al., 2022). Secondly, Chile has implemented some of the world's most stringent food labelling laws, including front-of-package warnings on foods high in sugar, sodium, saturated fats, and calories (Néron & Mateluna, 2022). We will talk about it in more details later. These pioneering measures provide an excellent opportunity to study their effectiveness in influencing consumer behaviour and reducing obesity rates. Lastly, Chile's diverse socio-economic landscape allows for a comprehensive examination of how labelling impacts different population segments (Miquel, 2021). We will check it with

clusters analysis. The country's robust data collection and transparency in public health information further enhance the depth of research.

2. Food environment and its impact on consumers behaviour in Chile

The food environment encompasses various factors that influence food and beverage choices, as well as nutritional status. These include food composition, labelling, promotion, pricing, provision in schools and other institutions, and trade policies. It is characterized by collective physical, economic, political, and sociocultural factors, opportunities, and conditions (Swinburn et al., 2014). Herforth and Ahmed, 2015 characterizes food environment as affordability, availability, desirability, and convenience of various food products. In this paper we focus on the food environment in markets.

In markets where there is a variety of food products, both fresh and processed, people are more inclined to choose healthy options like fruits, vegetables, whole grains, and lean proteins if they are easily accessible and affordable (Thompson et al., 2023). On the other hand, in settings where unhealthy food choices are prevalent and healthy alternatives are scarce or costly, people are more likely to depend on processed and less nutritious foods. This reliance can lead to an unbalanced diet and a higher likelihood of developing diet-related illnesses such as obesity, diabetes, and heart disease (Herforth & Ahmed, 2014).

Let us shed the light on prices for dining out experiences in Chile. Meal at inexpensive restaurant would cost around 8,000.00 CL$ (approximately 8€). This represents an affordable dining option, likely offering simple, locally inspired dishes at a budget-friendly price point, catering to individuals seeking economical meals without compromising quality (Global Data Report, 2023). The problem is that at the same time McMeal at McDonald's (or equivalent combo meal) costs around 7,250.00 CL$ (approximately 7,2€). The price of a McDonald's combo meal is relatively competitive compared to dining at an inexpensive restaurant, making it an attractive option for those seeking convenience and familiar fast-food fare at an affordable price (Mcdonald's Menu, 2024).

Characteristic of the Chilean food environment is not limited to the cheapness and availability of ready-made junk food in fast food restaurants. Processed and packaged foods can be easily and in large quantities found in various types of stores across Chile, including supermarkets, convenience stores, specialty food shops, and even some traditional markets. Large chain supermarkets like Jumbo, Lider, and Tottus offer extensive selections of processed and packaged foods (Herrera, 2023).

Taking about healthy food, the problem is not lack of it in shops. For example, food shops, such as gourmet markets or health food stores (La Reina Gourmet Market, Boulevard Lavaud, Verde y Natural, Terra Mater), offer a selection of premium and niche packaged foods catering to specific dietary preferences or gourmet tastes. The problem with healthy food is its expensiveness. For instance, artisanal chocolates or imported organic snacks may have price tags ranging from 3,000 (~3€) to 5,000 CLP (~5€) per item. As of 2024, Chile's GDP is approximately 333.76 billion U.S. dollars (Statista, 2024). The minimum living wage in Chile during the same period is around 521 U.S. dollars per month (Statista, 2024). Considering these numbers, the prices of premium healthy products in specialty stores may exceed what many consumers can afford within their daily budgets. This could pose a barrier to accessing such products for the most vulnerable segments of the population, given their limited incomes relative to the cost of living.

Moreover, there are products is markets which reflect traditional diet in Chile (Gormaz et al., 2022). It includes a variety of staple foods, among them are grains, legumes, indigenous foods. Grains have wide selection such as arroz [rice] and quinoa. Rice is commonly available and is often used as a side dish or as an ingredient in various traditional recipes like arroz con apio [rice with potato]. Quinoa, known for its nutritional value, is also readily available and can be found in both traditional and organic sections of the market. Chilean markets also offer a diverse range of legumes, including porotos [beans] and lentejas [lentils]. These legumes are commonly sold in dried or canned forms and are popular ingredients for making hearty soups, stews, and salads. Papa [potatoes] and choclo [corn], as indigenous foods, are staples in Chilean markets, reflecting their importance in traditional Chilean cuisine. Potatoes are available in various varieties and sizes, from standard white potatoes to native purple potatoes. Corn, often sold fresh or frozen, is used in dishes like pastel de choclo [corn pie] or as a side dish (Kanter et al., 2019). You can find these indigenous foods in the produce section of the market. The problem is the time needed to cook healthy dishes from these products. As practice shows families do not have time to do. People are “time-poor”. We will talk in more details about this notion in “Obesity in Chile” part of this paper.

3. Law 20.606 in Chile

Law objectives

As part of Chile's comprehensive approach to combating obesity and overweight issues in the country, the food labelling system was introduced under the landmark legislation known as Chile's food labelling and advertising law, formally titled “Ley 20.606, sobre la composición de los alimentos y su publicidad” [Law 20.606, on the nutritional composition of foods and their advertising] (Ministerio de Salud, 2016). It a part of Chile’s multipronged obesity prevention

program, which includes front-of-package warning labels with nutrient profiling model (we will talk about it in more details in the next section), marketing restrictions, school-based restrictions, and future taxation. The law came into effect on June 6, 2012, and its regulations were fully implemented on June 27, 2016 (Ministerio de Salud, 2012). This law had two primary objectives: to inform consumers about critical levels of certain nutrients in foods and beverages and to restrict minors' contact with labelled products at school and in advertising and marketing. A third goal is to promote industry reformulation and the development of healthier products (Ramírez et al., 2016). Changing relative prices of labelled foods and beverages was not a direct target and would have involved taxing labelled products and/or subsidizing healthier ones. All in all, it is a comprehensive approach aimed at addressing the rising rates of obesity and diet-related diseases within the country.

Decree 13-15

Here we will focus more on Decree 13-15 of this law. Decree 13 aims to provide consumers with information to promote informed food purchasing decisions, encouraging the selection of healthier food options (Ministerio de Salud, 2015). This information is designed to equip consumers with enhanced tools for better family meal planning and the care of children. Simultaneously, it seeks to create a safe and healthy school environment by prohibiting the sale of "High in" foods within educational establishments (preschool, primary, and secondary). The law encompasses the following measures:

1. Imposing limits on calories, saturated fats, sugars, and sodium in foods;
2. Prohibiting advertising targeted at children under 14 years old;
3. Banning the sale of foods in schools;
4. Implementing front-of-package warning labeling on foods;
5. Protecting children (Ministerio de Salud, 2015).

School measures

Important area of this law is to create a healthier environment for students and reducing their exposure to potentially unhealthy food options (Junta Nacional de Auxilio Escolar y Becas, 2016). Schools are prohibited from selling or offering for sale foods that do not meet certain nutritional standards. These standards typically restrict the availability of foods that are high in calories, saturated fats, sugars, and sodium, as well as foods that lack essential nutrients. By implementing these restrictions, the law aims to create a healthier environment within schools. By reducing the availability of foods that are considered unhealthy or nutritionally poor, students are

less likely to be exposed to these options during school hours. Instead, schools are encouraged to provide healthier alternatives, such as fruits, vegetables, whole grains, and lean proteins (Junta Nacional de Auxilio Escolar y Becas, 2016). This initiative not only promotes better nutrition among students but also helps to instill healthy eating habits from a young age. Moreover, by limiting access to unhealthy food options within the school environment, students are more likely to make healthier choices both at school and outside of school hours.

Advertisement

Particular attention is paid to advertising. According to Law 20.606 rules, advertisements for foods which composition is over the allowed limit (in calories, saturated fats, sugars, and sodium), are restricted on television and in cinemas. Specifically, these ads are only permitted to audience between 22:00 and 06:00, with the condition that they are not directed at children under 14 years old (Ministerio de Salud, 2015). Exceptions to these restrictions are granted for certain events, including sports, cultural, artistic, or charitable gatherings. However, strict criteria must be met to qualify for exemption (Ministerio de Salud, 2017). Firstly, the event must not be solely organized or funded by the company advertising the product or its affiliates. Additionally, the advertisement cannot target minors nor depict or encourage the consumption of the product. Instead, it is limited to displaying the brand or name of the product (Corvalán et al., 2018). These regulations aim to strike a balance between commercial interests and public health concerns, ensuring that consumers, particularly vulnerable groups like children, are not unduly influenced by advertising for foods that may contribute to poor dietary habits and related health issues (Buijzen et al., 2008). By imposing restrictions on the timing and content of advertisements, the law seeks to promote healthier dietary choices and protect the well-being of the population.

Packaging

Another advertisement area touched packages, specifically removal of imagery featuring cartoon characters and animals (Stoltze et al., 2018). These included iconic figures from animated television shows, movies, and popular culture, as well as recognizable animal illustrations that were frequently used to market products to younger audiences. Packaging for snacks, candies, breakfast cereals, and other processed foods often features figures such as superheroes, princesses, animated animals, and other imaginative beings. These products tend to be rich in calories, sugars, and unhealthy fats (Stoltze et al., 2018). The judgment encompassed brand mascots like Tony the Tiger or Ronald McDonald, as they could be utilized as marketing tactics directed at kids. Additionally, food products subject to regulations are not allowed to use alternative methods

targeting children, such as offering free gifts or toys or encouraging them to participate in contests (Bollard et al., 2016). This particularly affected children's fast-food items like Happy Meals, which often include free gifts or toys, as well as regulated food items that are themselves presented as gifts, such as Kinder Surprise eggs (Corvalán et al., 2018). Figure 2 presents Tony the Tiger cereal package before and after law introduction. Both cereal boxes use bright and appealing colors to attract children's attention and make the product more visually appealing. However, the absence of the tiger on the second box could emphasize a more moderate and tranquil character of the product, without the emphasis on strength and energy. This measure was implemented to disrupt the powerful influence of marketing on children's food preferences and consumption habits, with intention to mitigate the appeal of unhealthy food products that were often associated with these characters and images. By eliminating friendly, cheerful, kind and sometimes well-known, the goal was to reduce children's overall consumption of foods that contribute to obesity and other diet-related health issues (Arrúa et al., 2017).

Figure 2. Cereal package before and after law 20.606 introduction (Aguilar et al., 2016)

Law implementation

The implementation of the law and measures described above involves two main components: Oversight and Surveillance, and Promotion and Participation. Measures of the former mentioned include various strategies such as Directrices V y F, integrated workshops, coordination with SEREMIs (Regional Ministerial Secretariats), distribution of oversight and surveillance kits, establishment of agreements, intersectoral meetings, and engagement with the food industry (Ministerio de Salud de Chile, 2017). The latter mentioned, promotion and participation initiatives

encompass a range of activities aimed at engaging the community and promoting healthier lifestyles. These include citizen dialogues, health forums, training sessions for managers, educational materials, national and local campaigns, guidelines for school canteens, intersectoral collaboration, and capacity-building efforts (Ministerio de Salud de Chile, 2017). By combining oversight and surveillance measures with promotion and participation initiatives, the implementation of the law aims to ensure compliance with regulations while actively involving stakeholders in efforts to promote healthier food environments and behaviors. This comprehensive approach seeks to address the complex challenges associated with improving public health and nutrition.

All these regulations and measures within Law 20.606 allowed Chile to lead the way as a global pioneer with its new regulations, positioning itself at the forefront of efforts to improve public health through nutrition (Kanter et al., 2017). These regulations are grounded in scientific evidence and recommendations from relevant international bodies, such as the World Health Organization. By implementing measures such as prominent warning labels on the front of food packages to offer transparent information to consumers and enacting regulations to protect children and adolescents from targeted advertising and the sale of unhealthy food in educational settings, Chile showcases its dedication to encouraging healthier eating habits and shielding at-risk groups. Through these forward-thinking policies, Chile establishes a model for other nations to address the increasing issues of obesity and inadequate nutrition on a worldwide level (Reyes et al., 2017).

4. Understanding food labelling

General description of front-of-package labelling

This study takes internationally accepted definition of a food label, which is “any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to, a container of food or food product” (FAO, 2024). Labels serve as a means of communication between food producers and consumers, helping individuals make informed decisions about their food choices. The guidelines of the Codex Alimentarius recommend the following varieties of nutrition labelling: Nutrient Declaration, Nutrient Reference Values, Quantitative declaration on ingredients (QUID), Nutrition Claims and Health Claims (Codex Alimentarius, 2024).

Since that study is about labels in Chile, we will work with front-of-package labelling (FOPL), which is used for products there. FOPL is related to both "Nutrition Claims" and "Nutrient Declaration" as it provides summarized information about the nutritional content of the food product directly on the front of the packaging (Food Standards Agency, 2020). This practice

simplifies complex nutritional data into easily understandable visual cues or symbols, facilitating quick interpretation by consumers. Customers are presented with essential data at a glance, empowering them to make informed choices aligned with their dietary preferences and health goals (Oswald et al., 2022).

FOPL systems often employ various visual elements, including color-coded schemes and symbols or icons highlighting specific features such as "low-fat," "high-fiber," or "heart-healthy," to convey nutritional attributes effectively (Lupton et al., 2010). Examples of FOPL systems, such as the traffic light system, health star rating, and nutri-score, showcase the diverse approaches employed worldwide. The traffic light system is widely used in the United Kingdom and some European countries (Statutory Instruments, 2014; Kelly et Jewell, 2019). It utilizes color-coded labels and reminds a traffic light. Colors — green, orange to red — indicate the levels of key nutrients (such as fat, saturated fat, sugar, and salt) present in a food product. Green indicates low levels (same with green light at the rode, it is safe to consume product), orange signifies moderate levels (possible to eat, but not desired), and red signifies high levels (better not to consume large amounts of the product) (Song et al., 2021). The health star rating system is primarily used in Australia and New Zealand. It assigns a star rating to packaged food products, ranging from 0.5 stars to 5 stars, based on their overall nutritional profile. Healthier products receive more stars, while less healthy options receive fewer stars. The system takes into account positive nutrients (such as fiber, protein, carbohydrates, vitamins, minerals, etc.) and negative nutrients (such as saturated fat, added sugar, sodium, refined carbohydrates, artificial additives, etc.) to calculate the star rating (Bablani et al., 2020; Signal et al., 2012). French origine, there is also nutri-score system, which is used in several other European countries, including Belgium, Germany, Luxembourg, the Netherlands, and Spain as well. It assigns a letter grade (ranging from A to E) and a corresponding color (from dark green to dark orange) to food products based on their overall nutritional quality. Healthier products receive higher letter grades and lighter colors, while less healthy options receive lower grades and darker colors (Julia et al., 2018). Each system is tailored to the needs and preferences of its respective region, reflecting a global commitment to empowering consumers and promoting healthier lifestyles.

FOPL in Latin America

FOPL is also gaining popularity in Latin America. It has been implemented to combat rising obesity rates and promote healthier eating habits by providing consumers with clear information about the nutritional content of food products. Different countries have adopted various FOPL systems, often including warning labels for high levels of sugar, fat, sodium, and calories. Let us

illuminate the landscape of FOPL practices in select Latin American nations, with the exception of Chile, as we intend to delve deeper into the specifics of the Chilean case subsequently.

In 2021, Argentina implemented the Law on Front-of-Package Labeling (Law 27.642), which mandates the use of black octagonal warning labels to indicate high levels of sugars, total fat, saturated fat, calories, and sodium. These labels are based on the Pan American Health Organization (PAHO) Nutrient Profile Model. The purpose of this regulation is to provide consumers with clear and concise information about the nutritional content of food products, encouraging healthier dietary choices. In addition to labeling requirements, the law restricts marketing to children and regulates the sale of unhealthy foods in schools to foster a healthier environment for young people (Castronuovo et al., 2022).

Brazil adopted new front-of-pack labeling regulations in October 2020, approved by the Brazilian Health Regulatory Agency (ANVISA). The labeling system uses a simplified black magnifying glass symbol to indicate high levels of added sugar, saturated fat, and sodium. These thresholds are based on daily recommended values, aiming to help consumers quickly identify products with high levels of unhealthy nutrients. The regulations also include restrictions on advertising to children and require modifications to the nutritional facts panel, further supporting consumers in making healthier choices (Mais et al., 2022).

Uruguay was one of the early adopters of front-of-pack labeling, implementing its regulations in 2018 through Decree 272/018. The system uses black octagonal warning labels to signal excessive amounts of sugar, total fat, saturated fat, and sodium, based on the PAHO Nutrient Profile Model. This initiative is designed to discourage the consumption of foods high in unhealthy nutrients and to promote better dietary habits. Additionally, Uruguay's regulations include specific rules about marketing these products to children and their availability in schools, aiming to protect young consumers from unhealthy dietary influences (Ares et al., 2021).

Ecuador introduced front-of-pack labeling in 2014 via Ministerial Agreement 4522. The country employs a traffic light system that uses red, yellow, and green colors to indicate high, medium, and low levels of sugar, fat, and salt. The criteria for these labels are based on the nutrient content per 100 grams or 100 milliliters of the product. This labeling system is intended to help consumers easily identify and compare the nutritional quality of food products at a glance, promoting healthier food choices across the population (Sarasty et al., 2023).

In 2020, following Official Mexican Standard NOM-05, Mexico adopted new front-of-pack labeling regulations. They are black octagonal warning labels for excessive calories, sugars, saturated fat, trans fat, and sodium. The goal of these labels is to provide clear warnings about unhealthy food components, thereby reducing the prevalence of diet-related diseases. The regulations also impose restrictions on marketing to children and limit the placement of these

products in schools, supporting a healthier environment for young consumers (Contreras-Manzano et al., 2022). This Mexican system created by government alignes with national public health strategies and follows recommendations from PAHO.

Peru enacted front-of-pack labeling regulations in 2018 through Law No. 30021 and Supreme Decree No. 012-2018-SA. The labeling system uses black octagonal warning labels to indicate high levels of sugar, saturated fat, and sodium, based on PAHO Nutrient Profile Model thresholds. These labels are intended to inform consumers about unhealthy food components, encouraging healthier eating patterns. Peru's regulations also include restrictions on advertising these products to children and their availability in schools, aiming to foster a healthier environment and better dietary practices among young people (Saavedra-Garcia et al., 2022).

Figure 3 serves as a comprehensive overview of various FOPL systems implemented across the globe, facilitating enhanced comprehension, comparison, and identification of both distinctions and commonalities, allowing to evaluate food labelling around the globe.

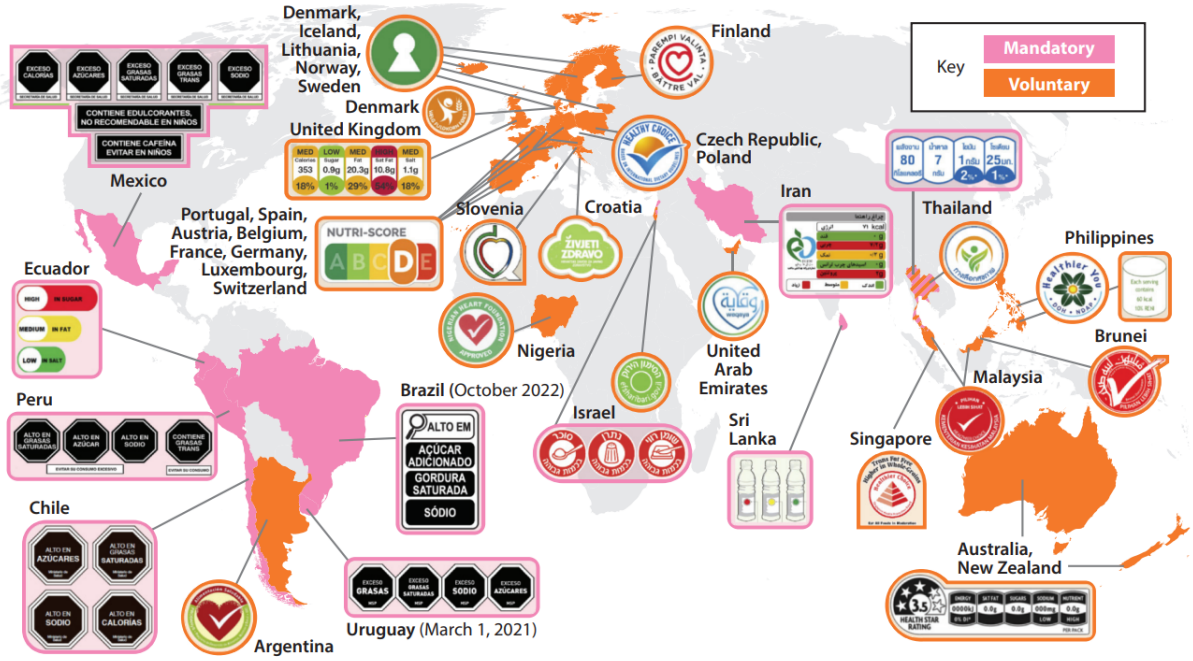


Figure 3. FOPL around the world (Shah, 2023)

Octagonal labels system in Chile

Chile is one of the pioneers in the field of FOPL in Latin America. This system was implemented as part of Chile's Law of Food Labelling and Advertising or Law 20.606, which came into effect June on 27th, 2016, and is known as the "warning labels" or "octagon labels" system. They are required to be prominently featured on the front packaging of the product. Labels features

a distinctive octagonal shape with bold black text on a white background, resembling a black stop sign. The label prominently displays a warning message in Spanish starting with “Alto en…” [High in…], followed by the name of the nutrient surpassing the limit. Four existing labels are, "Alto en calorías" [High in calories], "Alto en Azúcares” [High in sugar], "Alto en sodio" [High in sodium] or "Alto grasas saturadas" [High in saturated fat] (Taillie et al., 2020). Figure 4 demonstrates these labels.

Figure 4. Octagonal labels in Chile (Taillie et al., 2020)

The regulation also specifies the size and placement of the warning labels to ensure visibility to the public, with variations in size depending on the level of the exceeded nutrient. For example, as outlined by the law, a product with a front package exceeding 300 square centimeters and surpassing a critical nutrient limit must incorporate a warning label measuring 3.5 by 3.5 centimeters (Araya et al., 2021). Thus, the sizes of the warning labels can vary from a few centimetres to several dozen, depending on legal requirements and packaging/product characteristics. The main objective of this system and the range of sizes is to offer unmistakable and direct alerts to consumers regarding the existence of specific nutrients surpassing recommended levels (Reyes et al., 2019).

At the time of the system's introduction, limits for energy, sodium, total sugar, and saturated fat content in solid and liquid food products were established. In 2016, the thresholds were set at the following levels. Restrictions for solid food included no more than 350 kcal per 100 grams of product for calorie content, 800 mg per 100 grams for sodium, 22.5 grams per 100 grams for sugar, and 6 grams per 100 grams for saturated fats. Restrictions for liquid food were 100 kcal per 100 milliliters for calorie content, 100 mg per 100 milliliters for sodium, 6 grams per 100 milliliters for sugar, and 3 grams per 100 milliliters for saturated fats. All products exceeding these limits became subject to labeling requirements. These values gradually increased over three periods from the program's inception. Quantities by years (from 2016 to 2019) are presented in Figures 5 and 6.

Nutriente o Energía	Fecha de entrada en vigencia	24 meses después de entrada en vigencia	36 meses después de entrada en vigencia
Energía kcal/100 g	350	300	275
Sodio mg/100 g	800	500	400
Azúcares totales g/100 g	22,5	15	10
Grasas saturadas g/ 100 g	6	5	4

Figure 5. Limits on energy, sodium, total sugars, and saturated fat content in solid foods (Diadio oficial de la Republica de Chile, 2015)

Nutriente o Energía	Fecha de entrada en vigencia	24 meses después de entrada en vigencia	36 meses después de entrada en vigencia
Energía kcal/100 ml	100	80	70
Sodio mg/100 ml	100	100	100
Azúcares totales g/100 ml	6	5	5
Grasas saturadas g/ 100 ml	3	3	3

Figure 6. Limits on energy, sodium, total sugars, and saturated fat content in liquid foods (Diadio oficial de la Republica de Chile, 2015)

These regulations apply to a wide range of pre-packaged food products. For example, bread and cereals include items such as white and whole grain bread, rolls, breakfast cereals, crackers, and pasta. Meat products cover processed and packaged options like sausages, bacon, ham, and deli meats. In the category of fish and seafood, items such as canned tuna and salmon, as well as packaged frozen seafood, are included. Milk, cheese, and eggs encompass flavored milk, processed cheese, yogurt, and packaged egg dishes. Oils and fats consist of margarine, butter, lard, and various cooking oils (Campbell, 2022). Additionally, sugar, jam, honey, chocolate, and confectionery cover packaged sweets, chocolates, jams, honey, syrups, and candy. Food products not elsewhere classified (n.e.c.) involve snacks like chips, instant noodles, and ready-to-eat

meals. Coffee, tea, and cocoa include sweetened and flavored coffee drinks, instant tea mixes, and hot chocolate mixes. Lastly, mineral waters, soft drinks, and fruit and vegetable juices cover sodas, flavored mineral waters, bottled fruit juices, and vegetable juice blends (Rebolledo et al., 2023). To sum up, the products requiring labels include a variety of food categories such as bread and cereals, meat, fish and seafood, milk, cheese and eggs, oils and fats, sugar, jam, honey, chocolate and confectionery, other miscellaneous food products, coffee, tea and cocoa, and mineral waters, soft drinks, and processed, with sugar added fruit and vegetable juices. Later we will use these food items as *treatment group* for our research. However, certain fresh produce categories, such as fruit and vegetables, are not required to display these warning labels. This includes fresh fruits like apples, bananas, oranges, and berries, as well as fresh vegetables like spinach, carrots, broccoli, and tomatoes (Campbell, 2022). They all will be *control group* in our investigation.

To conclude, FOPL serves an educational purpose, enhancing consumer awareness about nutrition and encouraging healthier eating habits. By offering comparative information and promoting understanding of nutritional values, FOPL contributes to public health initiatives aimed at reducing diet-related diseases and fostering overall well-being. Thus, FOPL plays a pivotal role in guiding consumers towards healthier food choices. Its cohesive presentation of nutritional information facilitates informed decision-making, contributing to improved dietary habits and overall public health outcomes.

5. Obesity

Obesity and BMI worldwide

Obesity has become a global epidemic, affecting individuals of all ages, genders, and socioeconomic backgrounds. The prevalence of obesity has been steadily increasing worldwide over the past few decades, with nearly every country experiencing rising rates. Since 1990, global rates of obesity in adults have more than doubled, while rates in adolescents have quadrupled. By 2022, approximately 1 in 8 people worldwide were living with obesity. Among adults aged 18 and over, 16% were classified as living with obesity. Additionally, in 2022, 160 million children and adolescents aged 5–19 years were living with obesity (WHO, 2024).

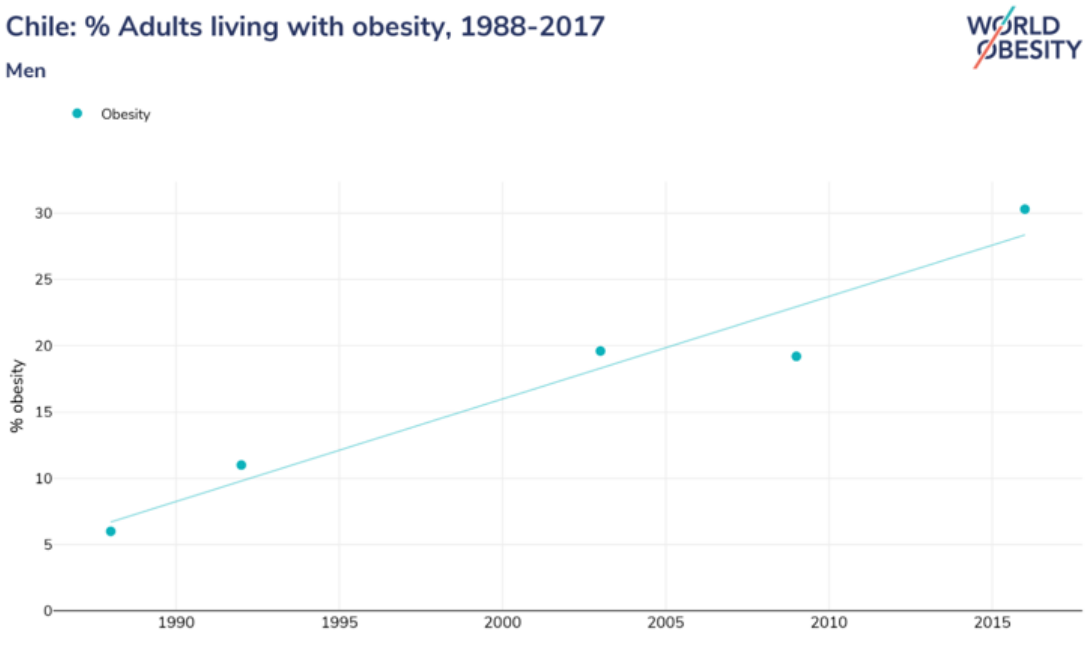
In this research we define obesity as a complex medical condition characterized by the excessive accumulation of body fat, to the extent that it may have a negative impact on health. It is typically measured using the body mass index (BMI), which is calculated by dividing a person's weight in kilograms by the square of their height in meters (kg/m^2) (Khanna et al., 2022).

Alongside with obesity there is a problem of overweight. They both refer to having excess body weight but differ in severity. Overweight generally means having a higher body weight than

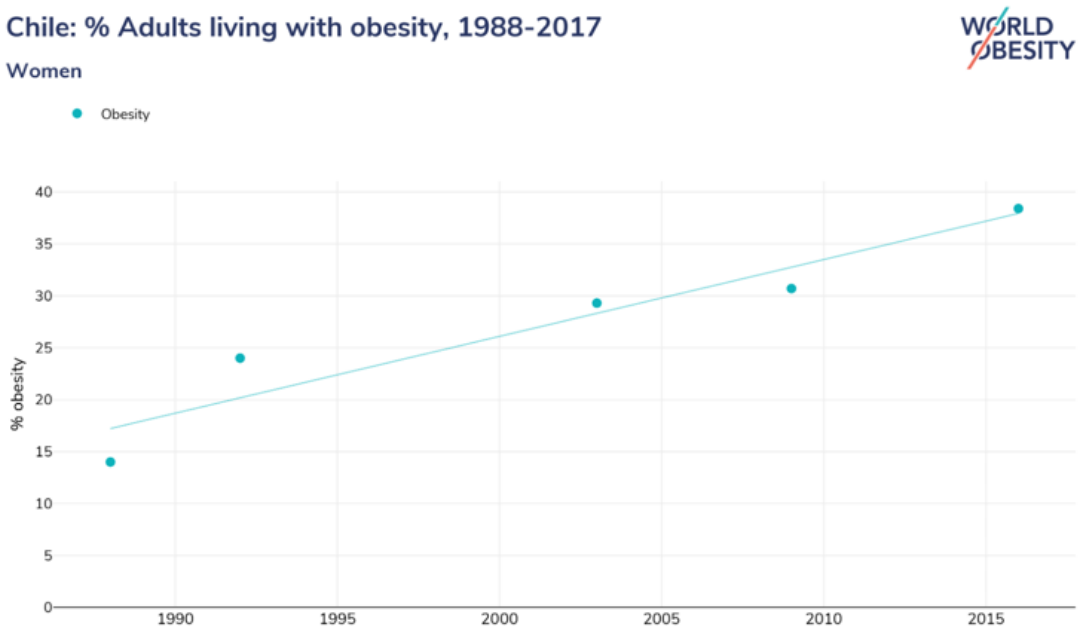
what is considered healthy for a given height, while obesity is a more serious condition characterized by excessive accumulation of body fat. Overweight is typically defined with a BMI between 25kg and 29.9kg/m², while obesity is classified as a BMI greater than 30kg/m² (WHO, 2024). Both conditions can increase the risk of various health problems, but obesity poses a higher risk compared to overweight, thus, in this research we focus on obesity rather than on overweight.

Obesity trend among adults in Chile

In 2023, Chile faced a concerning obesity prevalence rate of 26.4%, which surpassed the OECD average of 18.4% (OECD, 2023). This elevated rate suggests that a significant portion of the Chilean population is grappling with obesity-related health risks. What's particularly worrisome is the trend indicating a steady increase in obesity prevalence over the past years. The Global Obesity Observatory reported a sustained and steady increase in obesity among the Chilean population. Graph 6 demonstrates percentage of adult men living with obesity in 1988-2017 period. Graph 7 provides information about adult women with the same problem in the same time period.



*Graph 6. Percentage of adult **men** living with obesity, 1988-2017, Chile (World Obesity, 2024)*

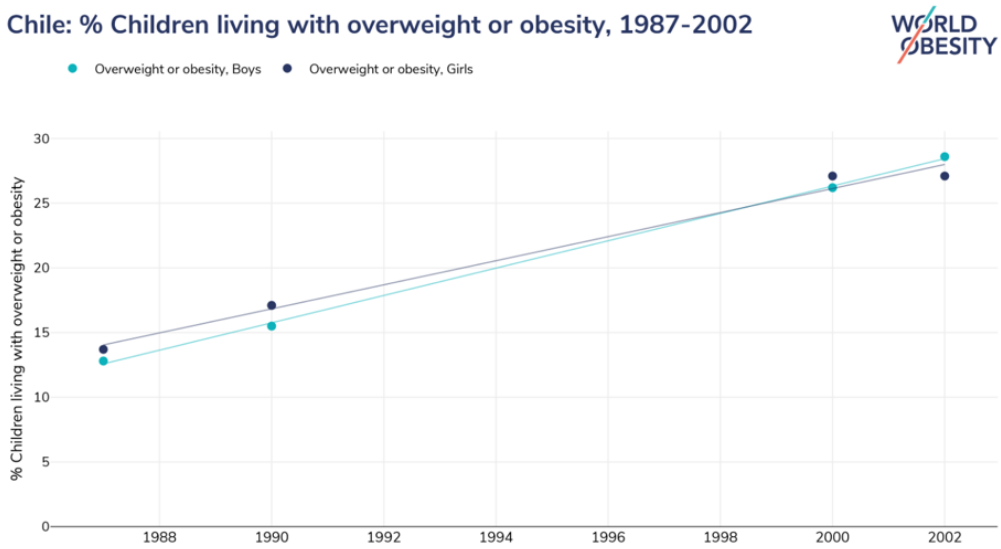


*Graph 7. Percentage of adult **women** living with obesity, 1988-2017, Chile (World Obesity, 2024)*

What is interesting, the higher prevalence of obesity among women is clearly seen comparing the graphs. This phenomenon stems from a combination of biological, sociocultural, and environmental factors and recognized not only in Chile but worldwide (Kain et al., 2014; Ball and Crawford, 2005; Monteiro et al., 2004; McLaren, 2007; Dinsa et al., 2012). This phenomenon stems from a combination of biological, sociocultural, and environmental factors. Biologically, women tend to have higher percentages of body fat than men due to hormonal fluctuations, especially during puberty, pregnancy, and menopause (Garawi et al., 2014). Reproductive factors, such as pregnancy-related weight gain and challenges in postpartum weight loss, further contribute to long-term weight retention in women. Social norms and cultural expectations significantly influence women's health, as they may experience increased pressure to conform to ideals of thinness, resulting in unhealthy dieting practices, limited access to healthy food options and potential weight gain (Jang et al., 2021). The majority of the women from low-income families do not have time (FAO, 2011). This phenomenon of being "time-poor" among women is significant, as it limits their ability to prioritize healthy eating and exercise. They do not have opportunity to improve nutrition, because cooking healthy meals at home takes more time than buying junk or processed food from supermarkets. Reducing women's time burdens has been recognized as a crucial principle for improving nutrition through agriculture and promoting healthier lifestyles (FAO, 2013; Herforth and Harris, 2014). By addressing gender disparities in domestic responsibilities and promoting equitable distribution of household tasks, it becomes possible to create more opportunities for women to engage in healthy behaviours, ultimately contributing to the prevention of obesity.

Obesity trend among children in Chile

Among children, for both boys and girls, also a steadily increasing obesity trend is noticed. Graph 8 demonstrates percentage of children living with overweight or obesity in 1987-2002. It starts with around 14% in 1987 and comes to almost 30% of obese Chilean teenagers in 2002. This situation is attributed to various interconnected factors. Firstly, there have been significant dietary changes, with increased consumption of processed foods high in sugar, fat, and salt. These foods are readily available, affordable, and heavily marketed, especially targeting children (Popkin, 2006). Secondly, modern sedentary lifestyles, characterized by increased screen time and reduced physical activity, contribute to the problem. Lack of outdoor play opportunities and structured physical activity further exacerbate this issue (Drewnowski & Popkin, 1997). Additionally, socioeconomic disparities limit access to healthy food options and opportunities for physical activity, particularly affecting children from lower-income backgrounds (Kanter & Caballero, 2012). Moreover, aggressive marketing tactics by food and beverage companies target children with advertisements for unhealthy products, influencing their food preferences (Kimenju et al., 2015). Lastly, parental behaviours and attitudes towards food and physical activity also play a significant role in shaping children's habits. Busy lifestyles, lack of nutritional knowledge, and reliance on convenience foods contribute to unhealthy eating patterns within families (Mulder et al., 2009).



Graph 8. Percentage of children living with overweight or obesity, 1987-2002, Chile (World Obesity, 2024)

The rising prevalence of childhood obesity in Chile is extremely concerning. Primarily, it has serious health implications, as it is associated with a range of chronic ailments like type 2 diabetes, high blood pressure, and heart disease, all of which can have enduring effects on health and overall wellness (Logue et al., 2011). Additionally, obesity can lead to psychosocial challenges, including stigmatization and low self-esteem, impacting children's social and emotional development (Jaison et al., 2024). Moreover, childhood obesity perpetuates inter-generational transmission, as obese children are more likely to become obese adults, contributing to ongoing public health challenges and economic burdens (Jura et al., 2016). Furthermore, obesity-related health problems can result in increased absenteeism from school, reduced academic performance, and decreased productivity in adulthood, placing strains on educational systems and economies (Goettler et al., 2017).

Data

Data source

For our research, we utilized the results of the Family Budget Survey (EPF). EPF, a socio-economic study conducted among households, primarily aims to delineate the structure and characteristics of spending on final consumption and the overall disposable income of urban households in regional capitals and their agglomerations over a span of one year. (Instituto Nacional de Estadísticas, 2024) This survey is conducted every five years in the Chilean presidential republic. The EPF, developed and executed by the National Institute of Statistics (INE), serves as the official statistical body of the country. We have been granted access to this dataset through the Pontificia Universidad Católica de Chile, Faculty of Agronomy and Forest Engineering.

Sampling strategy

The selection of this data is driven by its ability to provide insights into household spending behaviors, the allocation of funds across various product categories, and the complementary nature of different products within the food basket. Given our research objective to explore the influence of food labeling on consumer demand, we have chosen to analyze two datasets: VIII EPF and IX EPF. The first dataset encompasses household surveys conducted from July 1, 2016, to June 30, 2017, coinciding with the introduction of food labeling and advertising laws. At this stage, food products were not yet labeled, thus having no impact on consumer choices. It encompasses 15,239

surveyed households. The second dataset spans from October 1, 2021, to September 30, 2022, marking five years since the implementation of food nutritional labeling laws. It includes 15,134 households across Chile, encompassing the capitals of each of the country's sixteen regions and their agglomerations. Therefore, our aim is to analyze shifts in consumer demand for various food products over the five-year period, pre- and post-introduction of food labels.

Methodological approach

According to the national statistical system (SEN), a household is defined as "one or more persons, whether related or not, who live in the same dwelling or its part and benefit from the same budget, mainly for food". Participants in both study years were aged 15 and above and belonged to the selected households. To participate, informants had to be 18 years or older and capable of answering for themselves and other household members when they could not. The survey employed three measurement tools: a digital questionnaire administered on a mobile data collection device (DMC) for the majority of the survey, a self-completed paper questionnaire by household members for daily expenses (DG), and a paper questionnaire administered by an interviewer for memory expenses (GR).

Variables included in the study

Our study incorporates the following variables:

- *FOLIO*: This socio-demographic variable serves as a unique identifier for households, facilitating the linkage between the people database and the expenditure database. Utilizing this identifier, we identified identical families participating in both VIII and IX surveys, enabling us to measure differences in expenditures across various product groups.
- *D, G, C*: These variables represent different levels of product classification corresponding to division (D), group (G), and class (C). Initially, both periods' databases included 12 divisions, 59 groups, and 126 classes. Given our research focus on food expenditures from 12 divisions, we retained only Division 1, which pertains exclusively to food expenses. Consequently, this led to subsequent reduction into two groups (1 Food, 2 Non-alcoholic beverages) and 11 classes (1 “Bread and cereals”, 2 “Meat”, 3 “Fish and seafood”, 4 “Milk, cheese and eggs”, 5 “Oils and fats”, 6 “Fruit”, 7 “Vegetables”, 8 “Sugar, jam, honey, chocolate and confectionery”, 9 “Food products n.e.c. (not elsewhere classified)”, 10 “Coffee, tea and cocoa”, 11 “Mineral waters, soft drinks, fruit and vegetable juices”).

- *GASTO*: This variable represents total household expenditures on the product under consideration. It provides insights into the financial allocation towards specific product categories, allowing for a comprehensive analysis of spending patterns.
- *GLOSA*: This variable denotes the theoretical interpretation or name of the product. It offers descriptive information about the product being analyzed, aiding in the interpretation of expenditure patterns and facilitating comparisons across different product categories.

Originally presented in Spanish, the data was translated and utilized exclusively for this research, ensuring complete confidentiality.

Methods

Method 1. Difference-in-differences strategy

For the statistical part of this research, we decided to implement difference-in-differences (diff-in-diff) strategy, which is a statistical technique used to estimate causal relationships. It is a before-after approach exploiting the label implementation in a specific time or territory (Araya et al., 2021). In our research we focus on time, since the data which we are working with includes two databases of the same location and products but in different years, July 1, 2016 - June 30, 2017, and October 1, 2021 - September 30, 2022. Apart from the changes between the years we also paid attention to changes in outcomes over time between a treatment group (which is affected by a specific intervention, in our case label implementation to food class) and a control group (food classes which were not affected by the intervention). Treatment group is:

a. 1 Bread and cereals,
b. 2 Meat,
c. 3 Fish and seafood,
d. 4 Milk, cheese and eggs,
e. 5 Oils and fats,
f. 8 Sugar, jam, honey, chocolate and confectionery,
g. 9 Food products n.e.c.,
h. 10 Coffee, tea and cocoa,
i. 11 Mineral waters, soft drinks, fruit and vegetable juices.

Control group includes:

a. 6 Fruit,
b. 7 Vegetables.

This method was chosen because, firstly, it allows to control for time trends. It accounts for time-varying factors that affect both the treatment and control groups equally, thereby isolating the effect of the intervention. Secondly, by comparing changes over time between groups, it controls for unobserved confounding factors that are constant over time, it mitigates bias. Thirdly, the method is straightforward to implement and provides clear results. It was chosen due to its high interpretability and applicability with two-year data.

What we have done is directly compared the changes in outcomes from one year to the next within each group. Our estimation included 4 steps. Firstly, we worked with pre-Intervention period (July 1, 2016 - June 30, 2017), measuring the average sales for both groups before the label implementation. Secondly, we switched to post-intervention period (October 1, 2021 - September 30, 2022), measure the average sales for both groups after the label implementation. Thirdly, we calculate changes, determining how sales changed for both groups over the two years. Fourthly, we estimated the effect, label's impact on sales, using the difference-in-differences formula.

Formula:

$$\textit{Diff-in-Diff Estimate} = (Y_{T,\,post} - Y_{T,\,pre}) - (Y_{C,\,post} - Y_{C,\,pre})$$

Where:

- $Y_{T,\,post}$ is average outcome for the treatment group after the intervention.
- $Y_{T,\,pre}$ is average outcome for the treatment group before the intervention.
- $Y_{C,\,post}$ is average outcome for the control group after the intervention.
- $Y_{C,\,pre}$ is average outcome for the control group before the intervention.

We also adjusted our data to inflation rate. Since there is six years difference between the compared years (from 2017 to 2022), our data was adjusted to 6 coefficients:

- Coefficient 2017 = 1.022
- Coefficient 2018 = 1.0257
- Coefficient 2019 = 1.03
- Coefficient 2020 = 1.03
- Coefficient 2021 = 1.072
- Coefficient 2022 = 1.128 (inflation.eu, 2024)

Findings of diff-in-diff strategy

Firstly, we have found spendings for each food product for 2017 and 2022. We did it by summing up all the families spendings for each product among 11 categories. In table 1 it is first column for 2017 and second column for 2022. Secondly, we found a difference in spendings between these two years period, adjusting to inflation rates. Third column in the table (dif).

	costs_to_2022		dif
Period	2017	2022	
class_new			
1.0	9726.887130	11344.499578	0.166303
2.0	12723.051058	14840.615355	0.166435
3.0	11009.963645	13826.795626	0.255844
4.0	8627.403279	9824.836543	0.138794
5.0	6574.262050	9365.001940	0.424495
6.0	5221.355562	6489.932573	0.242959
7.0	4860.623368	5074.095451	0.043919
8.0	6626.628071	7821.639161	0.180335
9.0	4461.781787	7090.245866	0.589106
10.0	7839.193966	11630.255540	0.483603
11.0	11082.736890	9286.826662	-0.162046

Table 1. Households spendings on food before and after FOPL-law introduction

Here we can notice that growth in consumption presents in a majority of categories (from 1 to 10), and only in one food category (11) it has decreased. But it is not the idea of diff-in-diff strategy. In order to understand if policy implementation (labels introduction) has influence on consumption we need to apply formula described above. Since we have already calculated changes for all food categories, both treatment and control groups (last column in our table), we have to find Diff-in-Diff Estimate itself.

To do it we summed up all the changes in treatment group (highlighted in orange in Table 2) and got 2,242869. We also summed up all the changes in control group (highlighted in green in Table 2) and got 0,286878. Then we subtracted the change in the control group from the change in the treatment group to isolate the effect of the intervention (2,242869 - 0,286878), and we received **1,955991**. This is our diff-in-diff estimate which represents the effect of the intervention,

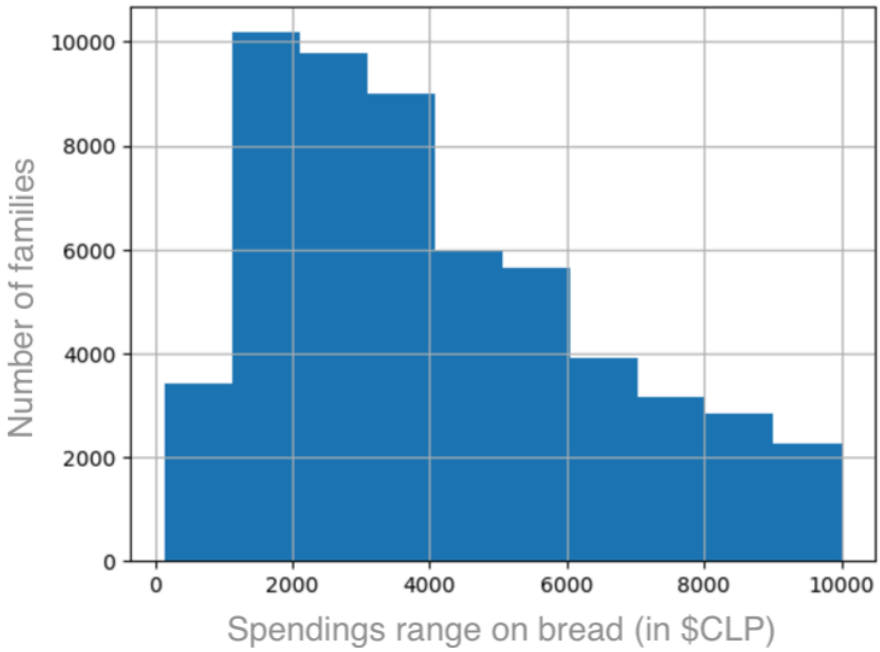
adjusted for time trends and other confounding factors that affect both groups similarly. A positive estimate suggests that the intervention had a positive effect on the outcome. In our case it signifies that label policy increased consumption rates by **1,955991 percentage points** more in the treatment group (where labels were introduced) that in the control group (foods without labels). Thus, we can assume that FOPL system in Chile does not work properly.

	costs_to_2022		dif
Period	2017	2022	
class_new			
1.0	9726.887130	11344.499578	0.166303
2.0	12723.051058	14840.615355	0.166435
3.0	11009.963645	13826.795626	0.255844
4.0	8627.403279	9824.836543	0.138794
5.0	6574.262050	9365.001940	0.424495
6.0	5221.355562	6489.932573	0.242959
7.0	4860.623368	5074.095451	0.043919
8.0	6626.628071	7821.639161	0.180335
9.0	4461.781787	7090.245866	0.589106
10.0	7839.193966	11630.255540	0.483603
11.0	11082.736890	9286.826662	-0.162046

Table 2. Households spendings on food before and after FOPL-law introduction with the division for treatment and control group

Results' significance check

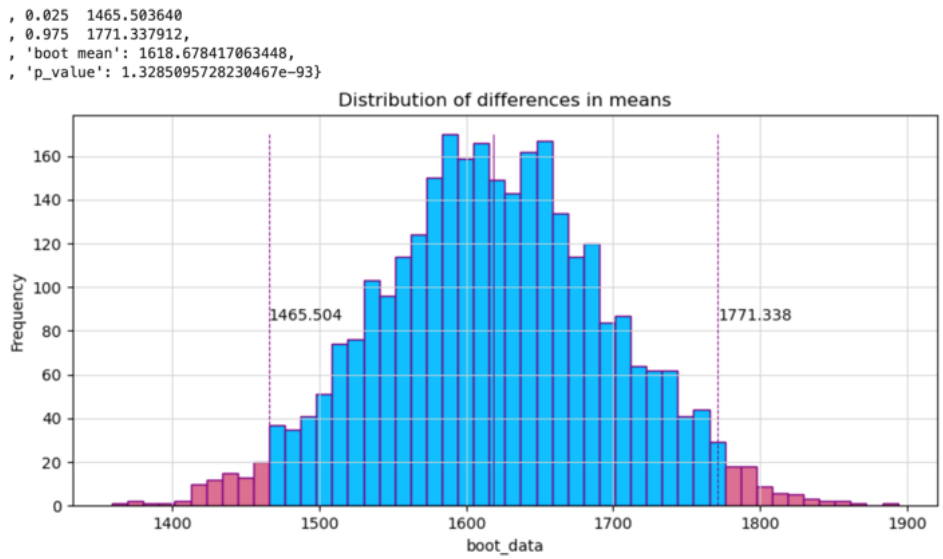
To check our assumption, it is important to understand the significance of the change in our findings. To select a method to check we need to see how our data is distributed. Using the example of the first category (Bread and cereals), we see that our data is not normally distributed (Graph 9). For example, 10,000 families spend from 200 to 1,700 CL$ on bread; 4,000 families spend from 4,000 to 7,000 CL$ on bread and etc.



Graph 9. Histogram of households' expenditure on bread

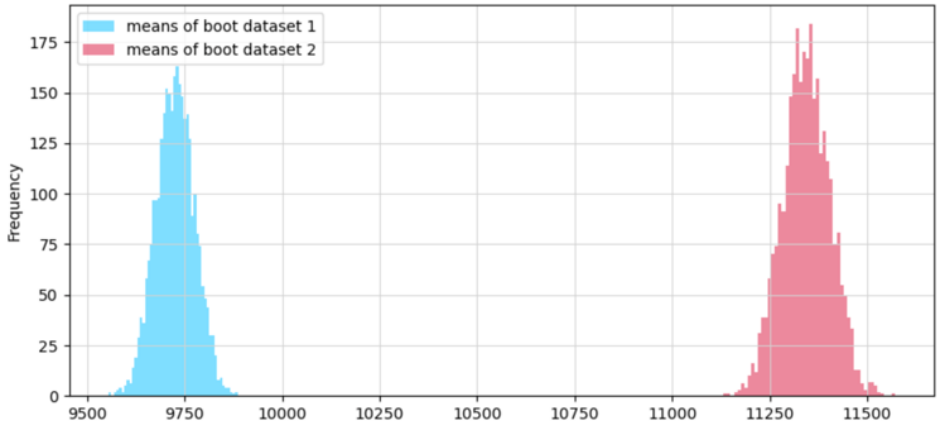
To address this issue, we employ the bootstrap method, a powerful statistical technique that resamples the original data with replacement to create numerous simulated samples. The bootstrap method stands out as an appropriate solution because it does not rely on the assumption of normality. Instead, it directly works with the empirical distribution of the data, making it flexible and robust for various types of data distributions (Singh et Xie, 2010). By resampling with replacement from our original dataset, the bootstrap method generates numerous bootstrap samples, each mirroring the size of the original dataset. Since we need to compare the significance of changes in outcomes before and after the implementation of new labels on food products, we estimate confidence intervals and p-values for the observed changes. Unlike traditional methods that might misrepresent the significance due to incorrect distributional assumptions, the bootstrap provides empirical estimates based on the actual distribution of my data.

We apply bootstrap method for all 11 food categories which we have. Since the results for them all are almost the same, we are interpreting the first food category "Bread and cereal" at length (graphs 10 and 11), notifying that the rest food categories possess approximately similar characteristics with slight numbers' distinction only.



Graph 10. Distribution of differences in means for "Bread and cereal" food category

On graph 10 the X-axis (boot_data) represents the differences in means obtained from the bootstrap samples. The values on this axis reflect how much the means of the two datasets differ in each bootstrap iteration. The Y-axis shows the frequency of these differences. The distribution appears to be approximately normal, centered around the mean difference of 1618.678. Vertical dashed lines mark the 2.5th and 97.5th percentiles of the bootstrap distribution, indicating a 95% confidence interval (CI) for the difference in means, with values of 1465.504 and 1771.338, respectively. We understand that the values 1465.504 and 1771.338 represent the 2.5th and 97.5th percentiles based on standard statistical practice for constructing a 95% CI, because hen constructing a 95% confidence interval, the 2.5th and 97.5th percentiles are typically used because they exclude the lower 2.5% and the upper 2.5% of the distribution, leaving 95% in the middle. On the graph, vertical dashed lines mark the values that correspond to the interval boundaries. The numbers 1465.504 and 1771.338 represent the boundaries of the 95% confidence interval for the distribution of differences in means obtained from the bootstrap samples. 1465.504 (2.5th percentile) value indicates that 2.5% of the bootstrap sample differences are less than this value. It is the lower bound of the 95% confidence interval. 1771.338 (97.5th percentile) value indicates that 97.5% of the bootstrap sample differences are less than this value. It is the upper bound of the 95% confidence interval. Together, these values define the range within which the true difference in means between the two datasets is likely to fall 95% of the time. This interval provides a measure of the uncertainty around the estimated difference in means. The p-value of 0.0 suggests that there is evidence to reject the null hypothesis at the 0.05 significance level. It means that now changes in '*Bread and cereal'* category are statistically significant.



Graph 11. Distribution of means for two bootstrapped datasets for "Bread and cereal" food category in 2017 (blue) and 2022 (red)

On graph 11 the X-axis represents the mean values of the bootstrap samples, and the Y-axis shows the frequency. The blue histogram represents the means of bootstrap dataset 1 (households food expenses in 2017), while the red histogram represents the means of bootstrap dataset 2 (household food expenses in 2022). The blue distribution is centered around mean values approximately in the 9500-10250 range, and the red distribution is centered around mean values approximately in the 11000-11500 range. The fact that the blue and red distributions are centered around different ranges indicates that the means of the two datasets are significantly different. The minimal overlap between the two distributions suggests that the observed difference in means is unlikely to be due to random chance. This strengthens the statistical significance of the difference between the two original datasets.

To sum up, the bootstrap analysis reveals a significant difference between the two datasets related to "Bread and cereal". The bootstrapped distributions show distinct means, and the difference in these means is statistically significant, as indicated by the very low p-value and the non-overlapping confidence intervals. Since changes are significant now, we can accept our assumption made before and conclude that FOPL system in Chile does not work properly. Other factors influence the issue of obesity. Labels alone do not solve it.

Limitations of diff-in-diff strategy

A significant limitation of this research is the lack of explanatory variables beyond the policy shift itself. This constraint can be addressed by incorporating additional explanatory variables related to time and gender disparities. First, by finding an explanatory variable for "available time" or "feeling overworked" in the database, we could better understand the role of time-poverty in food choices (Kalenkoski & Hamrick, 2012). It also would allow us to measure

gender disparity in the allocation of household responsibilities and provide insights into how these responsibilities impact food choices and health, obesity of different genders (Garawi et al., 2014). This might require supplementing the current database with additional data or improving it to include information about the worktime of family members in a household. By measuring the difference-in-differences while controlling time and gender explanatory variables, future research could significantly advance our understanding of the effectiveness of food labelling policies.

One more limitation is the challenge of generalizing the presence or absence of labels across entire categories of food products (Abadie & Cattaneo, 2018). For example, meat can be sold both packaged, with labels, and unpackaged, without labels. The same applies to fish and cheese. This variability within categories can complicate the analysis. If a category is treated as entirely having or not having labels, it might overlook the mixed nature of label presence within that category, potentially leading to inaccurate conclusions about the effect of the labeling policy.

Another limitation is the potential for selection bias arising from the composition of the treatment and control groups (Caputo & Just, 2022). The food categories chosen for the treatment and control groups might inherently differ in ways not accounted for in the analysis. For instance, the treatment group includes items like sugar, jam, honey, chocolate, and confectionery, which could have different baseline consumption trends and health perceptions compared to the control group items like meat, fish, fruit, and vegetables. These intrinsic differences could confound the results, as the observed changes in consumption might reflect these baseline differences rather than the impact of the labeling policy alone.

Moreover, external factors that affect consumption rates might not be evenly distributed across the treatment and control groups (Vartanian et al., 2008). Economic conditions, marketing campaigns, seasonal variations, and changes in consumer preferences can influence food consumption independently of the labeling policy. If such factors disproportionately affect one group, they could confound the results. For example, if there was a simultaneous health campaign specifically targeting the consumption of vegetables (a control group item), it might reduce the apparent impact of the labeling policy on the treatment group.

There is also the possibility of spillover effects, where the introduction of labels in the treatment group indirectly influences the control group (Butts, 2023). For instance, if consumers who purchase both labeled and unlabeled items become more health-conscious due to the labels, their consumption behavior might change for control group items as well. This spillover effect can dilute the estimated impact of the labeling policy, leading to an underestimation or misestimation of its true effect.

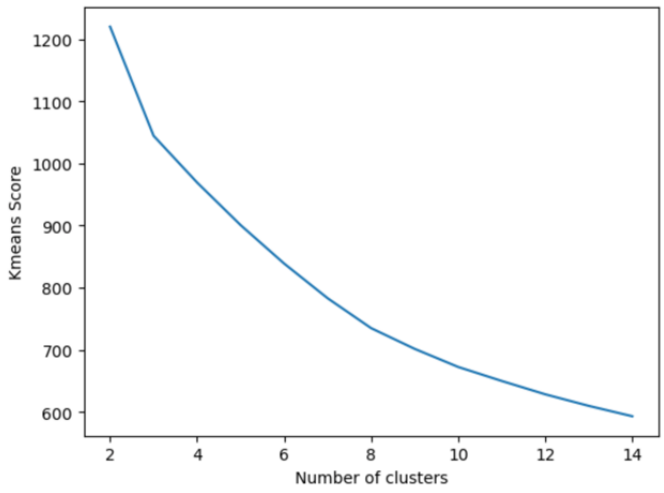
All in all, while the diff-in-diff strategy provided useful insights into the impact of the labeling policy, these limitations highlight the need for cautious interpretation of the results.

Selection bias, the parallel trends assumption, external factors, spillover effects, measurement error, and issues with generalizing label presence across food categories are all potential sources of bias that can affect the validity of the findings. Future research should aim to address these limitations, perhaps by using more granular data, refining the selection of treatment and control groups, or employing additional robustness checks to ensure the accuracy of the conclusions.

Method 2. Clusters analysis

After finding that the application of our diff-in-diff strategy did not yield significant results (1,96% increase in the share of consumption expenses not necessarily regarded as healthy ("the treatment group of expenses") compared with the share of consumption expenses usually regarded as healthy ("the control group of expenses")), we decided to explore alternative analytical methods. In particular, we turned to cluster analysis as a means to gain deeper insights into our dataset. We chose this method because it allows us to uncover hidden patterns within our data by grouping similar observations together into clusters. This approach is valuable when our diff-in-diff analysis did not reveal clear trends or significant effects (MacKinnon et Webb, 2020). Also, by identifying clusters of observations with similar characteristics, we can gain a better understanding of the heterogeneity within our dataset. This helps us move beyond aggregate-level analyses and explore nuanced differences among subgroups (Pesaran, 2006). Finally, cluster analysis is exploratory in nature, meaning it does not rely on pre-defined hypotheses. This flexibility allows us to discover unexpected relationships and patterns that may have been overlooked by traditional analytical methods (Dubes et Jain, 1980).

To implement cluster analysis, we chose the K-means model due to its simplicity and effectiveness in partitioning data into distinct clusters (Piech, 2013). We selected this model because K-means algorithm is computationally efficient and scales well to large datasets. In our case it is one database with 15,239 households, and another with 15,134 households. What makes 30,373 households in total. Thus, K-Means is suitable for our analysis, which involves a significant amount of data spanning multiple years (Farnstrom et al., 2000). Moreover, K-means produces clear and interpretable results, making it easier to understand and communicate the findings to stakeholders. Each cluster represents a distinct group of observations characterized by similar features, facilitating actionable insights (Gjelsvik et Tøndel, 2023). Finally, to determine the optimal number of clusters, we employed elbow method technique. This method helped identify the point at which additional clusters do not significantly improve the clustering quality, thus guiding us in selecting the appropriate number of clusters (Ketchen et al., 1996). In our case it is 3 clusters. Graph 12 demonstrates it:



Graph 12. Optimal number of clusters, elbow method

Findings of clusters analysis

In 2022, our analysis revealed the presence of three distinct consumption groups, with the following distribution:

2022		*2017*	
0	0.556163	0	0.528872
,1	0.323748	,1	0.348704
,2	0.120089	,2	0.122424

Table 3. Distribution of households for three clusters in 2022 and 2017

	bread	meat	fish	milk_eggs	fats	fruit	veget	suger	other	soft_dr	tea_coffe
0	0.191004	0.124463	0.033138	0.140373	0.032044	0.095920	0.128290	0.057130	0.078971	0.097716	0.020951
1	0.167271	0.376831	0.023644	0.091408	0.025706	0.055883	0.097470	0.034419	0.045464	0.068170	0.013734
2	0.522801	0.082495	0.011797	0.080494	0.022170	0.049875	0.070701	0.031455	0.035486	0.082105	0.010621

Table 4. Spendings distribution by food categories within clusters in 2022

	bread	meat	fish	milk_eggs	fats	fruit	veget	suger	other	soft_dr	tea_coffe
0	0.202839	0.132668	0.033033	0.147757	0.029770	0.065822	0.164339	0.055648	0.038227	0.022470	0.107427
1	0.184138	0.362654	0.022504	0.097765	0.023903	0.036496	0.116004	0.033542	0.024986	0.015670	0.082328
2	0.500570	0.094502	0.014088	0.092528	0.022047	0.030355	0.081239	0.035777	0.019687	0.013474	0.095732

Table 5. Spendings distribution by food categories within clusters in 2017

These numbers have the following interpretations. *0 cluster* comprises the largest proportion of households, representing approximately 55.62% of the population. These households exhibit average spending patterns across various food categories, with no specific preferences or notable characteristics. *1 cluster* accounting for approximately 32.37% of households is characterized by a predominant consumption of protein-rich foods, such as meat (highlighted in red). These households allocate a significant portion of their expenditures towards protein foods, reflecting a preference for meat-based diets. Additionally, their spending levels are notably higher compared to other clusters. *2 cluster* represents a smaller segment of the population, comprising approximately 12.01% of households. These households are characterized by minimal spending and a focus on essential food items, particularly bread. With nearly half of their expenditures allocated to bread (highlighted in purple), cluster 2 reflects a population segment facing economic constraints and prioritizing basic sustenance over discretionary spending.

For 2017 numbers stayed almost similar to 2022. *Cluster 0* in 2017 represents the largest proportion of households, with approximately 52.89% of the population. These households exhibit average spending patterns across food categories, mirroring the characteristics of cluster 0 in 2022. In 2017, *cluster 1* also comprises a substantial portion of households, accounting for approximately 34.87% of the population. Similar to 2022, these households prioritize protein-rich foods, with higher spending levels compared to other clusters. *Cluster 2* in 2017 mirrors the characteristics of its 2022 counterpart, representing approximately 12.24% of households. This cluster exhibits minimal spending and a focus on essential food items, particularly bread, indicative of economic constraints.

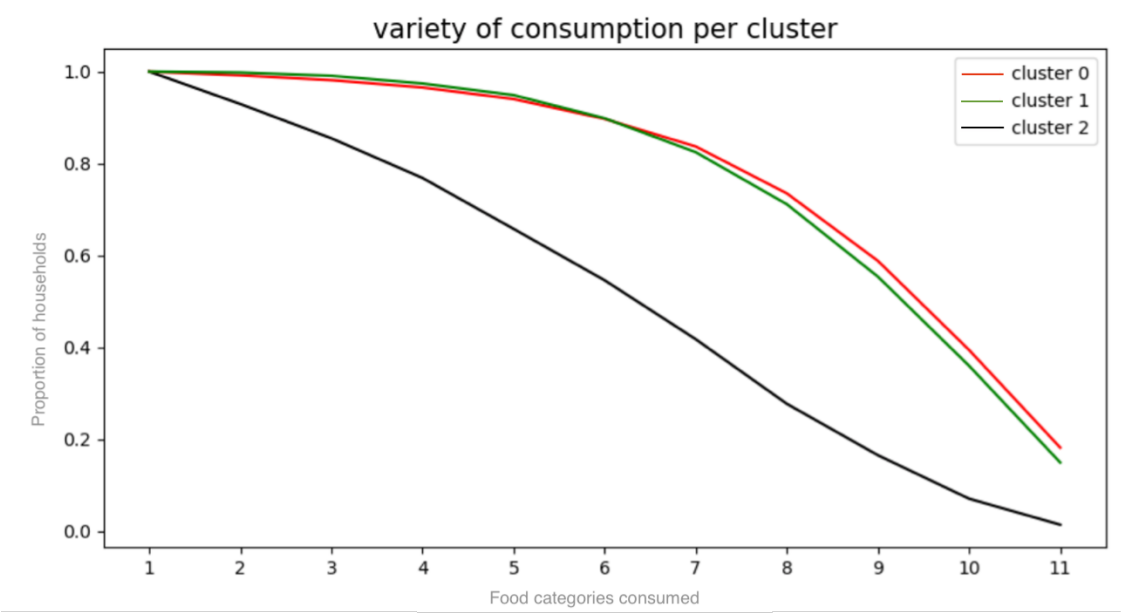
Nevertheless, there are some positive minor improvements in consumption patterns. Speaking about each food category precisely, clusters 0 and 1 showed slight decreases in spendings on bread. Fish, milk, and eggs category saw minor fluctuations, with slight increases in cluster 0's spending on dairies, indicating a possible improvement in dietary quality. In terms of fruits and vegetables, clusters 1 and 2 showed increased spending on "green foods", suggesting better access to and prioritisation of these products. There are also minor variations in sugar expenditure, with cluster 0 decreasing slightly.

Overall, comparing these findings (2022 and 2017 years), it was observed that the distribution among the clusters had remained relatively consistent over the five-year period. This suggests that consumption patterns and spending habits, demand had not significantly changed during this time frame. Since the study sought to investigate the impact of food labeling introduced in 2017, which aimed to highlight products with high calories, sugar, sodium and saturated fat content, despite the implementation of these labels, the analysis indicated that household spending and consumption patterns had not shifted notably over the five-year period. This leads to the conclusion that the

introduction of food labels did not effectively influence dietary choices or spending behaviors among the population.

Relationship with obesity by cluster: application of ANOVA

Following the identification of three distinct consumption clusters through cluster analysis, our focus shifts to exploring the relationship between food expenses and indicators of obesity across these clusters. Utilizing ANOVA (Analysis of Variance), we aim to discern significant differences in spending patterns on various food categories among the identified clusters. This analysis is crucial for understanding how different spending behaviors may correlate with obesity prevalence or BMI within each cluster (Mohamed et al., 2023; Bittner, 2022). One-way ANOVA is chosen as the appropriate statistical tool for comparing means across multiple groups, specifically the three clusters identified through our previous analysis. This methodological choice allows us to test whether there are statistically significant variations in average spending on food items such as meat, fruits, vegetables, and others across the clusters. ANOVA's ability to handle comparisons among more than two groups is particularly advantageous in this context, facilitating a comprehensive examination of spending disparities among diverse socioeconomic groups (Cutler et al., 2011; Danielzik et al., 2004; Dinsa et al., 2012). Our key findings are presented on graph 13.



Graph 13. Variety of food consumption per cluster

We can see the proportion of households within each cluster that consume a specific number of food categories. The food categories are as follows: *1 Bread and cereals, 2 Meat, 3 Fish and seafood, 4 Milk, cheese, and eggs, 5 Oils and fats, 6 Fruit, 7 Vegetables, 8 Sugar, jam, honey,*

chocolate, and confectionery, 9 Food products n.e.c, 10 Coffee, tea, and cocoa, and 11 Mineral waters, soft drinks, fruit and vegetable juices. The x-axis represents the number of food categories consumed, while the y-axis shows the proportion of households, ranging from 0 to 1, where 0 is 0% (none of households) and 1 is 100% (all households).

This graph helps better understand the obesity problem through consumption preferences by highlighting the differences in dietary diversity among various social groups. The steep decline in the black line for cluster 2 indicates that a smaller proportion of households consume a wide variety of food categories. About 40% of households in cluster 2 consume 7 food categories. Only 1% of households in cluster 2 consume all 11 food groups. Limited dietary diversity often leads to nutritional imbalances, as individuals may not receive all essential nutrients. As we have already discussed in literature review section, people in this cluster may prioritize cheaper and quick-to-prepare foods due to time constraints or financial limitations, this could also impact their dietary choices and level of physical activity, potentially leading to obesity due to easier access to high-calorie products (Sepúlveda-Peñaloza et al., 2022).

Clusters 1 and 0 (green and red lines respectively) demonstrate almost similar dietary patterns. The gradual decline in these lines indicates higher dietary diversity and suggests more balanced diets, incorporating fruits, vegetables, proteins, and other essential food groups. Approximately 80% of households in these clusters consume 7 food categories. Consuming a broad range of food categories typically ensures a better balance of essential nutrients, which supports healthier body weight and reduces the risk of obesity (Darmon et Drewnowski, 2008; Mohd Shariff et al., 2015).

Interestingly, all three clusters allocate equal amounts of expenditure towards bread. This suggests that bread is a staple across all socioeconomic groups. While the amount of expenses towards bread is the same, the share of income spent on bread is different. For cluster 2, bread constitutes more than 50% of their total food budget, indicating a heavy reliance on this food category. In contrast, for clusters 1 and 0, bread accounts for less than 20% of their total food spending, showing a more balanced distribution of their food budget across various categories. Although the graph does not explicitly show bread consumption, the overall variety and the information about spending patterns highlight how bread plays a significant role in cluster 2's diet. This heavy reliance on bread, with less spending on other food categories, illustrates the cluster's lower dietary diversity and its potential contribution to obesity. These findings highlight the intricate relationships between socioeconomic factors, spending behaviors, and dietary habits within different clusters. Understanding these patterns is crucial for devising targeted strategies to promote healthier eating habits and mitigate disparities in dietary intake and health outcomes across diverse population segments (Vega-Salas et al., 2021).

Limitations of clusters analysis

The results of cluster analysis are sensitive to the initial conditions or starting points chosen for the algorithm. Different starting points can lead to different final clusters, which may not be stable or reliable (Karam et al., 2002). To solve this problem, we used the k-means initialization method to reduce the influence of initial conditions on the results.

Moreover, interpreting the clusters generated by the analysis is often subjective and may vary depending on the researcher's perspective. It can be challenging to determine the optimal number of clusters or to assign meaningful labels to each cluster (Abadie et al, 2023). Thus, we applied elbow method which provided us with optimal number of clusters. Interpretation was made based on this analysis.

Cluster analysis may face scalability issues when dealing with large datasets, as the computational complexity increases with the number of data points and dimensions. This can make it challenging to apply cluster analysis to big data efficiently (Fretheim et al., 2015). In statistical terms our data is not considered big. Our volume of information does not lead to scalability problems when using standard data analysis methods.

Unlike some statistical techniques that have clear criteria for model selection (e.g., AIC or BIC in regression), cluster analysis lacks deterministic criteria for selecting the optimal number of clusters, making it challenging to assess model fit objectively (Baranwal et Salapak, 2017). Although there is no clear optimal way to select the number of clusters, we used an internal criterion such as the elbow method to decide on the number of clusters.

Results and discussion

1. Findings

Two methods were used to analyze labels on food products with high calories, sugar, sodium, and saturated fat content. The first method employed the Difference-in-Differences strategy, which yielded an estimate of 1.955991. This estimate represents the effect of the intervention, accounting for time trends and other factors that may influence both groups similarly. A positive estimate indicates that the introduction of labels increased consumption rates of products not necessarily regarded as healthy by 1.955991 percentage points more in the treatment group (where labels were introduced) compared to the control group (foods without labels, usually regarded as healthy). Therefore, it can be inferred that the FOPL system in Chile is not functioning effectively.

The second method used was cluster analysis. When comparing the findings from 2022 and 2017, it was observed that the distribution among the clusters remained relatively consistent over the five-year period. This suggests that consumption patterns and spending habits did not significantly change during this time frame. Since the study aimed to investigate the impact of food labeling introduced in 2017, which aimed to highlight products with high calories, sugar, sodium, and saturated fat content, the analysis indicated that household spending and consumption patterns did not notably shift over the five-year period. This leads to the conclusion that the introduction of food labels did not effectively influence spending behaviors among the population.

To better understand dietary choices across clusters and diet composition, we applied the ANOVA method, which highlighted significant differences in consumption and presence of products in meals, particularly eye-catching is cluster 2. This cluster has low penetration and variety in consumption, indicating limited access to nutritious foods and a higher risk of obesity due to nutrient imbalances and overconsumption of less nutritious foods. High bread expenditures and economic constraints in this cluster contribute to obesity risk through the intake of energy-dense carbohydrates and choices of less healthy foods (Mohd Shariff et al., 2015; Darmon and Drewnowski, 2008). Also, what is interesting, before ANOVA analysis cluster 1 could be characterized by high spendings on “2 Meat” food category (table 4), after we compared for means, we noticed that meat is not the main item of the diet (graph 13). Noticeably, this group of households spends the biggest part of the income on meat products, but it does not take the major share of meals. This finding aligns logically with the studied literature. Meat is one of the most expensive products among all food categories, and families which are able to buy meat and at the same time have a balanced and various diet, constituted as well as from vegetables, fruits, milk, sugar, etc. are the high-income families (Food and Fertilizer Technology Center, 2024).

2. Policy recommendations

Since FOPL did not effectively address the issue of obesity, we propose the following recommendations that can have a positive impact on the problem (reduce obesity rates in Chile). We suggest focusing on the food environment, cultural factors, and eating patterns. Our 1st recommendation is to prohibit the promotion of unhealthy food and drinks, particularly those high in fat, sugar, and salt, on public transportation systems such as buses, subways, and trains within urban areas. This approach, which has shown success in London by reducing the consumption of unhealthy foods, involves restricting the advertising of these products in public transport settings (Holland, 2019). This recommendation can be implemented through policy transfer from the ban on marketing unhealthy food and beverages across public transport in London, UK (Halliday et al., 2019). The stakeholders involved in implementing this recommendation include regional or local government bodies, the Ministry of Transportation, public health organizations, the private sector, and universities.

2nd recommendation is to implement free and safe drinking water fountains in and around schools and public spaces, while also enhancing the infrastructure of local fresh food markets. It can significantly improve access to healthy food and beverages for children and families. This initiative should involve collaboration between the regional or local government, the Ministry of Housing and Urban Planning, the Ministry of Education, and the private sector. Taking inspiration from successful examples such as the Refill revolution in London, UK (Reynolds et al., 2019), and the Mejora del Mercado Agrícola de Montevideo in Uruguay (Mercado Agrícola de Montevideo, 2020), this combined effort aims to promote healthier lifestyles and better access to essential resources for communities.

3rd involves adopting policies from Buenos Aires, Argentina, which is recognized for its efforts in promoting healthy eating, and Splash Jam, Lexington, USA, which concentrates on encouraging healthy lifestyles through public events. This recommendation targets regional or local governments. By drawing inspiration from effective programs in other areas, local governments can adjust and apply comparable approaches to encourage healthy eating and physical activity within their own communities. These initiatives could be integrated into urban planning, public health programs, and community development efforts, ultimately leading to a healthier and more vibrant local environment. While the private sector could also play a role in supporting these initiatives, the primary responsibility for implementing such policies and programs typically lies with the regional or local government and relevant ministries. (Buenos Aires Ciudad, 2023; Splash Jam, 2023).

4th recommendation introduces mobile farmers' markets in distant regions to guarantee availability of fresh and nutritious food (Buenos Aires Ciudad, 2023). This can be efficiently

executed through subsidy or grant programs, along with partnerships between local or regional government bodies, the Ministry of Social Development, the Ministry of Housing and Urban Planning, local fresh produce markets, and private enterprises. This collaboration will aid in obtaining resources, permits, logistical support, financial aid for modifying vehicles, procuring fresh produce, and managing operational expenses.

Conclusion

This paper set out to investigate the role of food labelling in enhancing food security and addressing obesity in Chile, focusing on the impact of the comprehensive food labels introduced under Law 20.606. The research aimed to assess whether these regulatory measures contribute to increased consumer awareness, healthier food choices, and improved health outcomes. The findings from the mixed-methods approach, which included literature review, econometric modelling with consumer surveys, difference-in-differences strategy and cluster analysis provide the following insights. While labels provide transparency about the contents of food products, including ingredients, nutritional information, allergens, and any additives or preservatives, Chilean consumers do not really pay attention to them. To be more precise, our first hypothesis was not fully confirmed. The data revealed that spendings on all food categories ("Bread and cereals", "Meat", "Fish and seafood", "Milk, cheese and eggs", "Oils and fats", "Fruit", "Vegetables", "Sugar, jam, honey, chocolate and confectionery", "Food products n.e.c", "Coffee, tea and cocoa") except "Mineral waters, soft drinks, fruit and vegetable juices" increased. This small deviation from the general trend presented by beverages group can give us little hope for the future improvement on consumption behavior. However, in this research we also applied "Difference-in-Difference Strategy" method which ended up with the 1,955991coefficient. A positive estimate indicates a favorable impact of the intervention on the result, meaning that the labelling policy boosted consumption rates by 1,955991 percentage points more in the treatment group (where labels were implemented) compared to the control group (foods without labels). In other words, we have an increase in the share of consumption expenses not necessarily regarded as healthy ("the treatment group of expenses") compared with the share of consumption expenses usually regarded as healthy. Thus, we can infer that the FOPL system in Chile is not functioning effectively.

Furthermore, we were not satisfied with this result and decided to go deeper in consumption patterns via clusters analysis. Unfortunately, it revealed that consumption habits remained largely the same. Households were segmented into three clusters based on spending patterns, with cluster 0 being the largest and showing average spending, maintaining a balanced approach to their food expenditures. Cluster 1 prioritizes protein-rich foods with higher spending, allocating a larger portion of their budget to items like meat, poultry, and dairy products. Finally, cluster 2 focused on minimal spending on essential items, particularly bread, indicating a preference for basic staples over other food categories. The distribution among these clusters remained consistent between 2017 and 2022, indicating that the introduction of food labels in 2017 did not significantly impact household spending and consumption patterns.

To understand better how spendings within clusters interact with each other, what diet composition households have, we applied ANOVA method. It highlighted the main problem for us. The issue is differences between consumption and availability of goods among different social groups, especially in the context of cluster 2. This cluster has low penetration and less variety of consumption, which may indicate limited access to nutritious and varied foods. In contrast, clusters 1 and 0 consume a greater variety of foods, which may reflect their better access to quality food and healthy eating information. Thus, cluster 2, which prefers cheaper and less varied foods, may be at risk of obesity due to nutrient imbalances and overeating less nutritious foods (Mohd Shariff et al., 2015). High bread expenditures in this cluster may contribute to obesity through the consumption of energy-dense carbohydrates unaccompanied by appropriate control of total energy intake. Economic constraints of household forming this cluster can also lead to choices for fast and affordable but less healthy foods, increasing the risk of obesity (Darmon et Drewnowski, 2008).

All these findings were proved with OECD 2023 statistics highlighting that Chile faced a concerning obesity prevalence rate of 26.4%, which surpassed the OECD average of 18.4% (OECD, 2023), as well as BMI increasing over the years. Thus, our second hypothesis also failed to be confirmed. To explain this phenomenon, we are of the opinion that the obesity problem is less related to food labels, but depends on other factors such as food environment, education, awareness, personal preferences, time-poverty (Muzzioli et al., 2022). Moreover, the impact of Law 20.606 may be less direct and requires time to fully assess its impact on consumer behaviour. It is also worth considering that socioeconomic factors may be interrelated with other variables that were not taken into account in the study. This notion is a direction for future research of labels phenomenon.

Contribution of this paper are findings described above and policy recommendations which aim to reduce obesity rates in Chile by focusing on the food environment, cultural factors, and eating patterns. They include prohibiting the promotion of unhealthy food and drinks on public transportation, implementing free and safe drinking water fountains, applying policy transfer from successful initiatives in other regions, and deploying mobile farmers markets in remote areas, involving collaboration between government bodies, ministries, private sector, and local communities.

References

1) Abadie, A., Athey, S., Imbens, G. W., & Wooldridge, J. M. (2023). When should you adjust standard errors for clustering? The Quarterly Journal of Economics, 138(1), 1–35. https://doi.org/10.1093/qje/qjac038

2) Abadie, A., Cattaneo, M. (2018). Econometric methods for program evaluation. Annual Review of Economics, 10(1), 465–503. https://doi.org/10.1146/annurev-economics-080217-053402\

3) Aggarwal, A., Monsivais, P., Cook, A. J., Drewnowski, A. (2014). Positive attitude toward healthy eating predicts higher diet quality at all cost levels of supermarkets. Journal of the Academy of Nutrition and Dietetics, 114(2), 266-72.

4) Aguilar, C., Jedlicki, M., Correa, T., Stoltze, F., Fuentealba, N. (2016). Law of Food Labeling and Advertising. Global Food Research Program. https://www.globalfoodresearchprogram.org/where-we-work/chile/

5) Alotaibi, N., Alshammari, G., Alabdulkarem, K., Alotaibi, A., Mohammed, M., Yahya M. (2023). A Cross-Sectional Study of Gender Differences in Calorie Labeling Policy among Students: Dietary Habits, Nutritional Knowledge and Awareness. Nutrients;15(4):879. doi: 10.3390/nu15040879. PMID: 36839237; PMCID: PMC9958862.

6) Anastasiou, K., Miller, M. & Dickinson, K. (2019). The relationship between food label use and dietary intake in adults: A systematic review. Appetite, 138, 280-291

7) Ameye, H., & Swinnen, J. (2019). Obesity, income and gender: The changing global relationship. Global Food Security, 23, 267-281. doi: 10.1016/j.gfs.2019.09.003

8) Araya S., Elberg, A., Noton C., Schwartz, D. (2021). Identifying food labeling effects on consumer behavior. Santiago: Pontificia Universidad Católica de Chile.

9) Ares, G., Antúnez, L., Cabrera, M., Thow, A. (2021). Analysis of the policy process for the implementation of nutritional warning labels in Uruguay. Public Health Nutr; 24(17):5927-5940. doi: 10.1017/S1368980021002469.

10) Arrúa, A., Curutchet, M., Rey, N. (2017). Impact of front-of-pack nutrition information and label design on children's choice of two snack foods: Comparison of warnings and the traffic-light system. Appetite, 116:139-146.

11) Bablani, L., Ni Mhurchu, C., Neal, B., Skeels, C., Staub, K., Blakely, T. (2020). The impact of voluntary front-of-pack nutrition labelling on packaged food reformulation: A difference-in-differences analysis of the Australasian Health Star Rating scheme. PLoS Med.; 17(11):e1003427. doi: 10.1371/journal.pmed.1003427.

12) Ball, K., Crawford, D. (2005) Socioeconomic status and weight change in adults: a review. Soc Sci Med 60, 1987–2010.

13) Baranwal, M., Salapaka, S. (2017). Clustering with capacity and size constraints: A deterministic approach. 251-256. 10.1109/INDIANCC.2017.7846483.

14) Bittner, A. (2022). Analysis-of-variance (ANOVA) Assumptions Review: Normality, Variance Equality, and Independence. 28-33. 10.47461/isoes.2022_bittner.

15) Bollard, T., Maubach, N., Walker, N., Ni Mhurchu, C. (2016). Effects of plain pack- aging, warning labels, and taxes on young people's predicted sugar- sweetened beverage preferences: An experimental study. Int J Behav Nutr Phys Act, 13(1):95.

16) Bouis, H., Eozenou, P. and Rahman, A. (2011). Food prices, household income, and resource allocation: socioeconomic perspectives on their effects on dietary quality and nutritional status. Food and Nutrition Bulletin, 32(1), S14–S23.

17) Brazil Ministry of Health. (2014). Guia alimentar para a populacao Brasileira.

18) Buenos Aires Ciudad. (2023). Estaciones Saludables. Vamos Buenos Aires. https://buenosaires.gob.ar/vicejefatura/bienestar-integral/puntos-de-bienestar/estaciones-saludables

19) Buenos Aires Ciudad. (2023). Ferias de abastecimiento barrial. Vamos Buenos Aires. https://buenosaires.gob.ar/espaciopublicoehigieneurbana/ferias-de-abastecimiento-barrial

20) Buijzen, M., Schuurman, J., Bomhof, E. (2008). Associations between children's television advertising exposure and their food consumption patterns: A household diary–survey study. Appetite, 50(2-3): 231-239.

21) Butts, K. (2023). Difference-in-Differences with Spatial Spillovers. University of Colorado Boulder, Economics Department.

22) Campbell, M. (2022). Chile: Front-of-Package Warning Labels and Food Marketing. Journal of Law, Medicine & Ethics, 50(2), 298–303. doi:10.1017/jme.2022.55

23) Caputo, V., Just, D. (2022). The economics of food related policies: Considering public health and malnutrition. Handbook of Agricultural Economics, Elsevier, Volume 6, pages 5117-5200, doi.org/10.1016/bs.hesagr.2022.03.008.

24) Castronuovo, L., Tiscornia, M., Guarnieri, L., Martins, E., Gomes, F., Allemandi, L. (2022). Efficacy of different front-of-package labeling systems in changing purchase intention and product healthfulness perception for food products in Argentina. Rev Panam Salud Publica. 46:e137. doi:10.26633/RPSP.2022.137.

25) Codex Alimentarius. (2024). International Food Standards. FAO, WHO. https://www.fao.org/fao-who-codexalimentarius/about-codex/en/#c453333

26) Contreras-Manzano, A., Cruz-Casarrubias, C., Munguía, A., Jáuregui, A., Vargas-Meza, J., Nieto, C., Tolentino-Mayo, L., Barquera, S. (2022). Evaluation of the Mexican warning label nutrient profile on food products marketed in Mexico in 2016 and 2017: A cross-sectional analysis. PLoS Med; 19(4):e1003968. doi: 10.1371/journal.pmed.1003968.

27) Corvalán, C., Reyes, M., Garmendia, M., Uauy., R. (2018). Structural responses to the obesity and non-communi- cable diseases epidemic: Update on the Chilean law of food labelling and advertising. Obesity Reviews, 1–8.

28) Cutler, G. J., Flood, A., Hannan, P., Neumark-Sztainer, D. (2011). Multiple socio demographic and socio environmental characteristics are correlated with major patterns of dietary intake in adolescents. Journal of the American Dietetic Association, 111(2), 230–240.

29) Danielzik, S., Czerwinski-Mast, M., Langnäse, K., Dilba, B., Müller, M. J. (2004). Parental overweight, socioeconomic status and high birth weight are the major determinants of overweight and obesity in 5–7 y-old children: baseline data of the Kiel Obesity Prevention Study (KOPS). International journal of Obesity, 28(11), 1494–1502.

30) Darmon, N., Drewnowski, A. (2008). Does social class predict diet quality? Am J Clin Nutr.; 87:1107–1117.

31) Departamento de Nutrición y Alimentos. (2016). Ley 20.606 "Sobre composición nutricional de los alimentos y su publicidad". Subsecretaria de Salud Publica – DIPOL. https://www.achipia.gob.cl/wp-content/uploads/2016/06/1-MINSAL-Ley-20.606-Dra.-Silvia-Baeza.pdf

32) Diadio oficial de la Republica de Chile. (2015). Modifica Decreto Supremo №977, de 1996, Reglamento Sanitario de los Alimentos. https://www.minsal.cl/wp-content/uploads/2015/08/decreto_etiquetado_alimentos_2015.pdf

33) Dinsa, G., Goryakin, Y., Fumagalli, E. (2012) Obesity and socioeconomic status in developing countries: a systematic review. Obesity Reviews 13, 1067–1079.

34) Drèze, J., Sen, A. (1991). Endemic Hunger. The Political Economy of Hunger. Clarendon Press, Oxford University Press. Volume 3.

35) Drewnowski, A., & Popkin, B. M. (1997). The nutrition transition: new trends in the global diet. Nutrition reviews, 55, 31–43.

36) Dubes, R., Jain, A.K. (1980). Clustering Methodologies in Exploratory Data Analysis. Advances in Computers, Elsevier, volume 19, pages 113-228, ISSN 0065-2458, ISBN 9780120121199, https://doi.org/10.1016/S0065-2458(08)60034-0.

37) Economic Commission for Latin America and the Caribbean (ECLAC) (2022). Social Panorama of Latin America, 2021 (LC/PUB.2021/17-P), Santiago. Available online at: https://repositorio.cepal.org/bitstream/handle/11362/47719/1/ S2100654_en.pdf (accessed April 12, 2024).

38) FAO. (1996). Rome Declaration on World Food Security. Rome. 13 November 1996.

39) FAO. (2011). The state of food and agriculture 2010–2011: women in agriculture: closing the gender gap for development. Rome: FAO.

40) FAO. (2013). Synthesis of guiding principles on agriculture programming for nutrition. Rome: FAO.

41) FAOSTAT. (2023). Suite of Food Security Indicators. In: FAO. Rome. [Cited July 2023]. https://www.fao.org/faostat/en/#data/FS

42) FAO, IFAD, PAHO, UNICEF & WFP. 2023. Latin America and the Caribbean – Regional Overview of Food Security and Nutrition 2023: Statistics and trends. Santiago. https://doi.org/10.4060/cc8514en

43) FAO. (2024). Food Labelling. https://www.fao.org/food-labelling/en/#:~:text=The%20Codex%20Alimentarius%20guidelines%20recommend,Nutrition%20Claims%20and%20Health%20Claims

44) FAO. (2024). World Bank Group. Prevalence of moderate or severe food insecurity in the population (%) – Argentina. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?locations=AR

45) FAO. (2024). World Bank Group. Prevalence of moderate or severe food insecurity in the population (%) – Brazil. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?locations=BR

46) FAO. (2024). World Bank Group. Prevalence of moderate or severe food insecurity in the population (%) – Chile. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?locations=CL

47) FAO. (2024). World Bank Group. Prevalence of moderate or severe food insecurity in the population (%) – Ecuador. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?locations=EC

48) FAO. (2024). World Bank Group. Prevalence of moderate or severe food insecurity in the population (%) – Uruguay. https://data.worldbank.org/indicator/SN.ITK.MSFI.ZS?locations=UY

49) Farnstrom, F., Lewis, J., Elkan, C. (2000). Scalability for Clustering Algorithms Revisited. SIGFDD Explorations. Volume 2, Issue 1, pages 51-57.

50) Food and Fertilizer Technology Center. (2024). How meat consumption differs among different income groups in Nay Pyi Taw, Maynmar. Agricultural Policy Platform. https://ap.fftc.org.tw/article/3391#:~:text=The%20calculated%20per%20capita%20consumption,and%200.32%20kg%20per%20month

51) Food Standards Agency. (2020). Packaging and labelling. https://www.food.gov.uk/business-guidance/packaging-and-labelling

52) Fretheim, A., Zhang, F., Ross-Degnan, D., Oxman, A, Cheyne, H., Foy, R., Soumerai, S. (2015). A reanalysis of cluster randomized trials showed interrupted time-series studies were valuable in health system evaluation. Journal of Clinical Epidemiology, 68(3), 324–333. https://doi.org/10.1016/j.jclinepi.2014.10.003

53) Gao, Z., Yu, X., Lee, J-Y. (2013). Consumer demand for diet quality: Evidence from the healthy eating index. The Australian Journal of Agricultural and Resource Economics. 57. 10.1111/j.1467-8489.2012.00619.x.

54) Garawi, F., Devries, K., Thorogood, N., & Uauy, R. (2014). Global differences between women and men in the prevalence of obesity: is there an association with gender inequality? *European Journal of Clinical Nutrition, 68*, 1101–1106. doi:10.1038/ejcn.2014.86

55) Giskes, K., van Lenthe, F. J., Brug, J., Mackenbach, J. P., Turrell, G. (2007). Socioeconomic inequalities in food purchasing: the contri- bution of respondent-perceived and actual (objectively measured) price and availability of foods. Preventative Medicine, 45(1), 41–48.

56) Gjelsvik, E., Tøndel, K. (2023). Increased interpretation of deep learning models using hierarchical cluster-based modelling. PLoS One. 18(12):e0295251. doi: 10.1371/journal.pone.0295251.

57) Global Data Report. (2023). Chile Foodservice Market Size and Trends by Profit and Cost Sector Channels, Players and Forecast to 2027. GDFS230025CS-ST. https://www.globaldata.com/store/report/chile-foodservice-market-analysis/

58) Goettler, A., Grosse, A., & Sonntag, D. (2017, October). Productivity loss due to overweight and obesity: a systematic review of indirect costs. BMJ open, 7(10), e014632.

59) Gormaz, T., Cortés, S., Tiboni-Oschilewski, O., Weisstaub, G. (2022). The Chilean Diet: Is It Sustainable? Nutrients 14, 3103. https://doi.org/10.3390/nu14153103

60) Gough, M., Lippert, A., Martin, M. (2019). The Role of Time Use Behaviors in the Risk of Obesity among Low-Income Mothers. Womens Health Issues; 29(1):23-30. doi: 10.1016/j.whi.2018.10.002. Epub 2018 Nov 13. PMID: 30446329; PMCID: PMC6295251.

61) Grunert, K.. (2005). Food Quality and Safety: Consumer Perception and Demand. European Review of Agricultural Economics. 32. 369-391. 10.1093/eurrag/jbi011.

62) Halliday, J., Platenkamp, L., Nicolarea, Y. (2019) A menu of actions to shape urban food environments for improved nutrition, GAIN, MUFPP and RUAF.

63) Herforth, A., Ahmed, S. (2015). The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. Food Security. The science, sociology and economics of food production and access to food, ISSN 1876-4517.

64) Herforth, A., Harris, J. (2014). Understanding and applying primary pathways and principles. Brief #1. Improving nutrition through ag- riculture technical brief series. Arlington: USAID/Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project.

65) Hernández-Vásquez, A., Visconti-Lopez, F., Vargas-Fernández, R. (2022). Factors Associated with Food Insecurity in Latin America and the Caribbean Countries: A Cross-

Sectional Analysis of 13 Countries. Nutrients. 14(15):3190. doi: 10.3390/nu14153190. PMID: 35956365; PMCID: PMC9370137.

66) Herrera, M. (2023). Retail Foods, Chile, Santiago. Report CI2023-0015. United States Department of Agriculture. Foreign Agricultural Service. Global Agricultural Information Network.

67) Holland, F. (2019). HFSS sales drop since junk food advertising is banned on London public transport. Food Matters Live. https://foodmatterslive.com/article/hfss-sales-drop-since-junk-food-advertising-is-banned-on-london-public-transport/

68) Instituto Nacional de Estadísticas. (2024). [Encuesta de Presupuestos Familiares] Family Budget Survey. https://www.ine.gob.cl/statistics/social/individual-income-and-expenses/household-budget-survey-(hbs)

69) inflation.eu. (2024) WORLDWIDE INFLATION DATA. Historic inflation Chile - CPI inflation. https://www.inflation.eu/en/inflation-rates/chile/historic-inflation/cpi-inflation-chile.aspx

70) Jaison, I., Asharaf, H., Thimothy, G., George, S., Jose, J., Paily, R., Josey, J., Sajna, S., Radhakrishnan, R. (2024). Psychological impact of obesity: A comprehensive analysis of health-related quality of life and weight-related symptoms. Obesity Medicine, volume 45, 100530, ISSN 2451-8476. https://doi.org/10.1016/j.obmed.2023.100530.

71) Jang, H.-J., & Oh, H. (2021, April). Trends and Inequalities in Overall and Abdominal Obesity by Sociodemographic Factors in Korean Adults, 1998-2018. International journal of environmental research and public health, 18(8).

72) Julia, C., Etilé, F., Hercberg, S. (2018). Front-of-pack Nutri-Score labelling in France: An evidence-based policy. The Lancet Public Health. 3. 10.1016/S2468-2667(18)30009-4.

73) Junta Nacional de Auxilio Escolar y Becas, Departamento de Planificación y Estudios Informe Mapa Nutricional 2016. Junta Nacional de Auxilio Escolar y Becas: Santiago de Chile 2016.

74) Junta Nacional de Auxilio Escolar y Becas (JUNAEB), Departamento de Planificación. (2016). JUNAEB Contra la obesidad estudiantil. Santiago de Chile: Becas JNdAEy (ed.).

75) Jura, M., & Kozak, L. P. (2016, February). Obesity and related consequences to ageing. Age (Dordrecht, Netherlands), 38, 23–23. doi:10.1007/s11357-016-9884-3

76) Kain, J., Hernández, S., Pineda, D. (2014) Obesity prevention in Latin America. Curr Obes Rep 3, 150–155.

77) Kalenkoski, C., Hamrick, K. (2012). How Does Time Poverty Affect Behavior? A Look at Eating and Physical Activity. Applied Economic Perspective and Policy. 35. 89-105. 10.1093/aepp/pps034.

78) Kanter, R., & Caballero, B. (2012). Global gender disparities in obesity: a review. Advances in nutrition (Bethesda, Md.), 3(4), 491-8.

79) Kanter, R., Reyes, M., Corvalan, C. (2017) Implementation of the Advertising and Labelling Law in Chile: Early Results of Impact on Food Reformulation (Abstract). IUNS 21st International Congress of Nutrition. Buenos Aires, Argentina: Annals of Nutrition and Metabolism.

80) Kanter, R., Villagra, M., Azúa, V., Herrera, N. (2019). Using Healthy and Sustainable Traditional Culinary Preparations to Improve Diets and Food Choices in Poor Areas of Chile's Metropolitan Region (P10-036-19), Current Developments in Nutrition, Volume 3, Supplement 1. nzz034.P10-036-19, ISSN 2475-2991, https://doi.org/10.1093/cdn/nzz034.P10-036-19

81) Karam, O., Hamad, A., Moussa, S. (2002). Determining initial starting conditions for documents clustering. Karam, O., Hamad, A., Moussa, S. (2002). Determining initial starting conditions for documents clustering. University of Illinois Urbana-Champaign.

82) Kelly, B., Jewell, J. (2019). Front-of-pack nutrition labelling in the European region: identifying what works for governments and consumers. Public Health Nutr. 22(6):1125-1128. doi: 10.1017/S1368980018003737.

83) Ketchen, D., Shook, C.(1996). The application of cluster analysis in Strategic Management Research: An analysis and critique. Strategic Management Journal. 17 (6): 441–458. doi:10.1002/(SICI)1097-0266(199606)17:6<441::AID-SMJ819>3.0.CO;2-G

84) Khanna, D., Peltzer, C., Kahar, P., Parmar, M. (2022) Body Mass Index (BMI): A Screening Tool Analysis. Cureus 14(2): e22119. doi:10.7759/cureus.22119

85) Kimenju, S. C., Rischke, R., Klasen, S., & Qaim, M. (2015). Do supermarkets contribute to the obesity pandemic in developing countries? Public Health Nutrition, 18, 3224–3233. doi:10.1017/S1368980015000919

86) Le Coq J.-F., Grisa C., Guéneau S., Niederle P. (2022). Public policies and food systems in Latin America. Versailles, Quæ, 227-243, 339-419 p.

87) Lexington. (2023). Lexington-Fayette Urban County Government. Lexington KY, Horse Capital of the World. https://www.lexingtonky.gov/news/07-18-2017/splashjam-back-summer

88) Logue, J., Murray, H. M., Welsh, P., Shepherd, J., Packard, C., Macfarlane, P., Sattar, N. (2011). Obesity is associated with fatal coronary heart disease independently of traditional risk factors and deprivation. Heart (British Cardiac Society), 97(7), 564-8.

89) Lupton, J., Balentine, D., Black, R., Hildwine, R., Ivens, B., Kennedy, E., Packard, P., Sperber, B., Steffen, D., Story, M. (2010). The Smart Choices front-of-package nutrition labeling program: rationale and development of the nutrition criteria. The American Journal of Clinical Nutrition. Volume 91, Issue 4, pages 1078S-1089S. https://doi.org/10.3945/ajcn.2010.28450B.

90) MacKinnon, J., Webb, M. (2020). Randomization inference for difference-in-differences with few treated clusters. Journal of Econometrics, 218(2), 435–450. https://doi.org/10.1016/j.jeconom.2020.04.024

91) Mais, L., Borges, C., Khandpur, N., Duran, Martins, A. (2022). Brazil's nutrition labeling regulation: Challenges ahead on the path to guaranteeing consumer's right to adequate information. Frontiers in Nutrition. 9. 921519. 10.3389/fnut.2022.921519.

92) Martini, D., Menozzi, D. (2021). Food Labeling: Analysis, Understanding, and Perception. Nutrients. 13(1):268. doi: 10.3390/nu13010268. PMID: 33477758; PMCID: PMC7832259.

93) Matthew, R. F. (2017). Environmental Biology. Chapter 8.1 : Food Security. Open Oregon Educational Resources.

94) Menú McDonald's, Santiago, Chile. (2024). Menú Completo. https://www.mcdonalds.cl/menu

95) Mercado Agrícola de Montevideo. (2020). https://www.mam.com.uy

96) McLaren, L. (2007) Socioeconomic status and obesity. Epidemiol Rev 29, 29–48.

97) Mohamed, N. A., Alanzi, A. R. A., Azizan, N. A., Azizan, S. A., Samsudin, N., Jenatabadi, H. S. (2023). Evaluation of depression and obesity indices based on applications of ANOVA, regression, structural equation modeling and Taguchi algorithm process. *Frontiers in psychology*, *14*, 1060963. https://doi.org/10.3389/fpsyg.2023.1060963

98) Mohd Shariff, Z., Lin, K. G., Sariman, S., Lee, H. S., Siew, C. Y., Mohd Yusof, B. N., Mun, C. Y., Mohamad, M. (2015). The relationship between household income and dietary intakes of 1-10 year old urban Malaysian. Nutrition research and practice, 9(3), 278–287. https://doi.org/10.4162/nrp.2015.9.3.278

99) Monteiro, C., Moura, E., Conde, W. (2004) Socioeconomic status and obesity in adult populations of developing countries: a review. Bull World Health Organ 82, 940–946.

100) Miquel, J. (2021). Impact of Chile's food labelling and advertising law on unhealthy food consumption and body mass index in children and adolescents: A longitudinal study. The Lancet Planetary Health, 5(10), e493-e503. doi:10.1016/S2542-5196(21)00172-8

101) Ministerio de Salud, Subsecretaría de Salud Pública. (2012) Ley 20.606 Firma Electrónica Sobre Composición Nutricional de los Alimentos y su Publicidad. https://www.bcn.cl/leychile/navegar?idNorma=1041570

102) Ministerio de Salud. Subsecretaría de Salud Pública. (2015). Decreto 13. Modifica decreto supremo nº 977, de 1996, reglamento sanitario de los alimentos. https://www.bcn.cl/leychile/navegar?i=1078836

103) Ministerio de Salud (Ed). (2015). LEY 20869 SOBRE PUBLICIDAD DE LOS ALIMENTOS. Santiago de Chile: Ministerio de Salud (ed.).

104) Ministerio de Salud de Chile. (2017). Informe de Evaluación de la Implementación de la Ley sobre composición nutricional de los alimentos y su publicidad. Chile, 77.

105) Ministerio de Salud. Decreto número 1, de 2017. (2017). Determina características del mensaje que promueve hábitos de vida saludable contenido en la publicidad de los alimentos que indica. Salud Md (ed.). CVE 1315884.

106) Mulder, C., Kain, J., Uauy, R., Seidell, J. (2009). Maternal attitudes and child-feeding practices: relationship with the BMI of Chilean children. Nutr ;8:37. doi: 10.1186/1475-2891-8-37. PMID: 19678925; PMCID: PMC2736172.

107) Muzzioli, L., Penzavecchia, C., Donini, L. M., & Pinto, A. (2022). Are Front-of-Pack Labels a Health Policy Tool?. Nutrients, 14(4), 771.

108) Néron, M., Mateluna, P. (2022). Public policies and the food system in Chile. In: Le Coq JF, Grisa C, Guéneau S, et al., editors. Public Policies and Food Systems in Latin America [Internet]. Versailles (FR): Éditions Quae. Chapter 8. https://www.ncbi.nlm.nih.gov/books/NBK592182/

109) Ochulor, C., Onyeaka, H., Njoagwuani, E., Mazi, I., Oladunjoye, I., & Akegbe, H., Omotosho, A., Odeyemi, O., Nwaiwu, O., Tamasiga, P. (2022). Improper Food Labeling and Unverified Food Claims: Food Safety Implications. American Journal of Food Sciences and Nutrition. 4. 9 - 23. 10.47672/ajfsn.1225.

110) OECD. (2023). Health at a glance 2023 country note, Chile. https://www.oecd.org/chile/health-at-a-glance-Chile-EN.pdf

111) Oswald, C., Adhikari, K., Mohan, A. (2022). Effect of front-of-package labels on consumer product evaluation and preferences. Current Research in Food Science. Volume 5, pages 131-140, ISSN 2665-9271. https://doi.org/10.1016/j.crfs.2021.12.016

112) Palmeira, P. A., Salles-Costa, R., and Pérez-Escamilla, R. (2020). Effects of family income and conditional cash transfers on household food insecurity: evidence from a longitudinal study in Northeast Brazil. Public Health Nutr.23, 756–767. doi: 10.1017/S1368980019003136

113) Paraje, G. (2016). The effect of price and socio-economic level on the consumption of sugar-sweetened beverages (SSB): the case of ecuador. PLoS ONE 11 (3) ARTN e0152260 10.1371/journal.pone.0152260.

114) Perumal, K., Balakrishnan, B., Idris, M. Z. (2022). Food labelling from consumers' perspectives: a review. Muallim Journal of Social Science and Humanities. 80-88. 10.33306/mjssh/206

115) Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica, 74(4), 967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x

116) Piech, C. (2013). K Means. Based on a handout by Andrew Ng. Stanford.

117) Pinheiro, A., Quintiliano-Scarpelli, D., Araneda, J., Alvarez, C., Suárez.Reyes, M., Palacios, J. (2022). Food availability in different food environments surrounding schools in a vulnerable urban area of Santiago, Chile: exploring socioeconomic determinants. Foods. 11, 901. doi: 10.3390/foods11070901

118) Popkin, B. M. (2006). Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. The American Journal of Clinical Nutrition, 84, 289-298. doi:10.1093/ajcn/84.2.289

119) Rebolledo, N., Bercholz, M., Adair L., Corvalán, C., Wen Ng, S., Taillie, L. (2023). Sweetener Purchases in Chile before and after Implementing a Policy for Food Labeling, Marketing, and Sales in Schools. Current Developments in Nutrition 7, 100016

120) Reyes, M., Corvalán, C., Correa, T. (2017). The Chilean Experience of FOP Development, Implementation and Impact. Buenos Aires, Argentina: IUNS 21st International Congress of Nutrition.

121) Reynolds, B., Burgess, R., and Harrison, M. (2019). Drinking Water Fountains. A How To Guide. A Sustain and City to Sea publication.

122) Swinburn, B., Dominich, C. H., & Vandevijvere, S. (2014). Benchmarking food environments: experts' assessments of policy gaps and priorities for the New Zealand government. Auckland: University of Auckland.

123) Taillie, L., Hall, M., Popkin, B., Ng, S., Murukulta, N. (2020). Experimental studies of front-of-package nutrient warning labels on sugar-sweetened beverages and ultra-processed foods: a scoping review. Nutrients, 12, 569.

124) Thompson, C., Adams, J., Vidgen, H. (2023). Food literacy, food environments and monitoring and surveillance in public health. Queensland University of Technology, Kelvin Grove, Australia, University of Cambridge, United Kingdom, Queensland University of Technology, Australia. Popul. Med.5 (Supplement): A1837

125) Timmer, P. (2010). Reflections on food crises past. Food Policy, 35–1, 1–11.

126) Saavedra-Garcia, L., Taboada-Ramirez, X., Hernández-Vásquez, A., Diez-Canseco, F. (2022). Marketing techniques, health, and nutritional claims on processed foods and beverages before and after the implementation of mandatory front-of-package warning labels in Peru. Front Nutr; 9:1004106. doi: 10.3389/fnut.2022.1004106.

127) Sarasty, O., Carpio, C., Cabrera, T. (2023). Effect of the traffic-light system on nutrition labeling in processed food products in the Ecuadorian population. Oxford University Press, Q Open 3, 1–19 https://doi.org/10.1093/qopen/qoad018

128) Scarpelli, D., Pinheiro, A.C., Osiac, L., Quevedo, T. (2020). Changes in Nutrient Declaration after the Food Labeling and Advertising Law in Chile: A Longitudinal Approach. Nutrients;12(8):2371. doi: 10.3390/nu12082371. PMID: 32784370; PMCID: PMC7468860.

129) Sepúlveda-Peñaloza, A., Cumsille, F., Garrido, M., Matus, P., Vera-Concha, G., Urquidi, C. (2022). Geographical disparities in obesity prevalence: small-area analysis of the Chilean National Health Surveys. *BMC public health*, *22*(1), 1443. https://doi.org/10.1186/s12889-022-13841-2

130) Shah S. (2023). Easiest Way to Know Everything about Front of Pack Labelling Models in India and International Markets. Food Label Solutions. The Nutrition Alchemy

131) Shangguan, S., Afshin, A., Shulkin, M., Ma, W., Marsden, D., Smith, J., Saheb-Kashaf, M., Shi, P., Micha, R., Imamura, F., Mozaffarian, D., & Food PRICE (Policy Review and Intervention Cost-Effectiveness) Project (2019). A Meta-Analysis of Food Labeling Effects on Consumer Diet Behaviors and Industry Practices. *American journal of preventive medicine*, *56*(2), 300–314. https://doi.org/10.1016/j.amepre.2018.09.024

132) Signal, L., Lanumata, T., Ni Mhurchu, C., Gorton, D. (2012). Front-of-pack nutrition labelling in New Zealand: an exploration of stakeholder views about research and implementation. Health Promot J Austr; 23(1):48-51. doi: 10.1071/he12048.

133) Singh, K., Xie, M. (2010). Bootstrap Method. International Encyclopedia of Education (Third Edition), Elsevier, pages 46-51, ISBN 9780080448947. doi.org/10.1016/B978-0-08-044894-7.01309-9.

134) Sobaih, A. E. E., Abdelaziz, A. S. (2022). The Impact of Nutrition Labelling on Customer Buying Intention and Behaviours in Fast Food Operations: Some Implications for Public Health. International journal of environmental research and public health, 19(12), 7122. https://doi.org/10.3390/ijerph19127122

135) Song, J., Brown, M., Tan, M., MacGregor, G., Webster, J., Campbell, N., Trieu, K., Mhurchu, C., Cobb, L., He, F. (2021). Impact of color-coded and warning nutrition labelling schemes: A systematic review and network meta-analysis. PLOS Medicine. 18. e1003765. 10.1371/journal.pmed.1003765.

136) Sousa, L., Ville, A., Samayoa-Figueroa, L., Melgar-Quiñonez, H. (2019). Changes in food security in Latin America from 2014 to 2017. Food Security. 11. 10.1007/s12571-019-00931-0.

137) Statista. (2024). Gross domestic product (GDP) in current prices in Chile from 2007 to 2029(in billion U.S. dollars). https://www.statista.com/statistics/1391981/gross-domestic-product-gdp-in-current-prices-chile/

138) Statista. (2024). Minimum monthly wage in selected Latin American countries in 2024 (in U.S. dollars). https://www.statista.com/statistics/953880/latin-america-minimum-monthly-wages/

139) Statutory Instruments. (2014). The Food Information Regulations - 2014 No. 1855. TSO, Blackwell and other Accredited Agents. http://www.legislation.gov.uk/id/uksi/2014/1855

140) Stoltze, F., Barker, J., Kanter, R. (2018). Prevalence of child-directed and general audience marketing strategies on the front of beverage pack- aging: The case of Chile. Public Health Nutr.. 21(03):454-464.

141) Storcksdieck Genannt Bonsmann, S., Wills, J. (2012). Nutrition Labeling to Prevent Obesity: Reviewing the Evidence from Europe. Curr Obes Rep. 1(3):134-140. doi: 10.1007/s13679-012-0020-0. Epub 2012 Jun 26. PMID: 22924157; PMCID: PMC3410024.

142) Swetha, K. (2018). Food Label and its influence on Consumer Buying Behavior: A Review of Research Studies. International Journal of Science and Research (IJSR).

143) Ramírez, R., Sternsdorff, N., Pastor, C. (2016). Chile's law on food labelling and advertising: a replicable model for latin america? Special Report. Developing Ideas, Llorente & Cuenca

144) Reyes, M., Garmendia, M.L., Olivares, S., Aqueveque C., Zacarías I., Corvalán C. (2019). Development of the Chilean front-of-package food warning label. BMC Public Health 19, 906.

145) United Nations. (2024). Department of Economic and Social Affairs. Sustainable Development. Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture. https://sdgs.un.org/goals/goal2

146) Vartanian, L., Herman, C., Wansink, Brian. (2008). Are We Aware of the External Factors That Influence Our Food Intake?. Health psychology : official journal of the Division of Health Psychology, American Psychological Association. 27. 533-8. 10.1037/0278-6133.27.5.533.

147) Vega-Salas, M.J., Caro, P., Johnson, L., Armstrong, M., Papadaki, A. (2021). Socioeconomic Inequalities in Physical Activity and Sedentary Behaviour among the Chilean Population: A Systematic Review of Observational Studies. *International Journal of Environmental Research and Public Health*; 18(18):9722. https://doi.org/10.3390/ijerph18189722

148) World Food Programme. (2024). The Sustainable Development Goals (SDGs). https://sdgs.un.org/2030agenda

149) WHO. (2024). Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight#:~:text=For%20adults%2C%20WHO%20defines%20overweight,than%20or%20equal%20to%2030.

150) Winkler, E., Turrell, G., and Patterson, C. (2006). Does living in a disadvantaged area entail limited opportunities to purchase fresh fruit & vegetables in terms of price, availability, variety? Findings from the Brisbane Food Study. Health Place,12, 741–748.

151) World Obesity. (2024). Global Obesity Observation. https://data.worldobesity.org/country/chile-41/#data_trends

152) Zafar, M. Z., Shi, X., Yang, H., Abbas, J., & Chen, J. (2022). The Impact of Interpretive Packaged Food Labels on Consumer Purchase Intention: The Comparative Analysis of Efficacy and Inefficiency of Food Labels. International journal of environmental research and public health, 19(22), 15098. https://doi.org/10.3390/ijerph192215098

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
Faculté des bioingénieurs
Croix du Sud, 2 bte L7.05.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/agro**