Childhood Obesity: Designing Evidence-based Prevention Policies Using Network Analysis

Abstract

Childhood obesity is a global socio-economic burden affecting millions of children and projected to rise in almost every country. Its consequences mostly appear in adult age, and, besides health, they entail heavy care expenses esteemed to reach 3% of nations' GDP by 2030. In Italy care costs for consequences of obesity are esteemed to 13B€/year while prevention policies are founded for just 2M€/year, that is 0.2%, figures that highlight the low level of the issue's priority into political agenda. The research aims to find an empirical way to keep together the obesogenic factors, and it can't be tackled but using a holistic and multidisciplinary approach. Among the quantitative methods, Network Analysis (NA) has been chosen to achieve the goal of the construction of a unique risk index that predicts the emergence of obesity of a newborn child in adult age.

NA application is wide and, when applied to social issues, showed its resolving power. The research paves the way to a comprehensive framework able to empirically show the multifactorial aspect of CO and keeps together five families of influences: genetics, socioeconomic status, social network, environment and impact of policies. In particular, using the bi-partite network technique it is possible to visualize not only the directly responsible factors of CO but also their secondary causes and, overall, to get a clear image of how these factors simultaneously interact.

Unlike almost every study on CO, this approach, based on an extensive literature review, experts' interviews, and a specifically made survey, produced a visual result that gives the scientist the possibility to communicate complexity in a simplified way inside and outside academic context. This technique is particularly useful when prevention policies need to be designed or evaluated, since it gives the possibility to create simulation models based on system dynamics, such as Causal Loop Diagrams or Agent Based Models.

Once the data have been collected and graph was created, results confirmed not only the presence of diverse families of influencing factors but also how they are intertwined, demonstrating how the whole is different from the sum of its parts. Beyond genetic predisposition, an obese children is the result of a lifestyle characterized by: unbalanced diet, particularly made of carbohydrates,

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olive oil, fruit and sugar-added yogurt; frequent use of screen, both in mothers than children, highlighting the transmission of a bad habit throughout generations; a weak correlation with socio-economic status, conversely to what most of the literature states; semi-marginal environment, this is where policies most affect the growing of the problem since children living in city suburbs must face both with the insecurity of big cities and the lack of services of small towns.

Briefly it can be said that CO obesity is the result of the lack of appropriate attention to children's health, firstly into the families and then from the policy makers. The greatest difference between the few countries where obesity started to decrease and others, indeed, is the policy approach, made of a strong contrast to food industry lobbying and investments on parents' awareness.

Introduction

Spread of Obesity and its Costs

"Can a butterfly wing flap in Brazil cause a hurricane in Texas?"

This question, posed by meteorologist Edward Lorenz,

perfectly encapsulates complexity theory: the idea that systems are defined not by isolated elements, but by the dynamic interactions between them. Often mislabeled as a static medical issue, Childhood obesity is better understood if names as a "Culturally Communicable Disease"-a phenomenon resulting from the intricate interplay of genetics, economy, culture, and family habits passed down through generations.

To analyze such a multifaceted problem through a single scientific discipline is akin to "trying to paint a big wall using small brushes" held by people who are not communicating with one another; the result is a fragmented picture that fails to capture the totality of the issue.

Today, childhood obesity represents a global socio-economic burden affecting millions of people and is projected to rise in almost every country; indeed, forecasts suggest that by 2050, one in six children will be obese or overweight [1]. This phenomenon, which has been described as a "silent pandemic," has grown alongside the economic stabilization and proliferation of ultra-processed foods that characterized the post-World War II era, leading to a continuous rise in chronic diseases and healthcare expenditures [2].

The consequences of this trend are profound, affecting both personal health and national productivity. In 2019, the economic impact of overweight and obesity was estimated at 2.19% of global GDP, a figure projected to rise to 3.29% by 2060 if current trends persist. The situation is particularly paradoxical in Italy, the cradle of the Mediterranean Diet, where the prevalence of overweight and obesity among children aged 3 to 5 years was estimated at 33.8% in 2023. The associated economic costs are staggering: direct and indirect consequences of obesity in Italy were estimated at approximately 13.3 billion euros in 2020, equivalent to 0.8% of the national GDP [3]. Despite these alarming figures, Italian investments in prevention remain negligible, accounting for merely 0.01% of care costs [4].

Effective Policies in France and Spain

While the global trajectory of obesity appears relentless, specific national cases demonstrate that the phenomenon is reversible through political willingness and the implementation of evidence-based, multi-level policies. Spain and France serve as virtuous examples of how integrated interventions can succeed where isolated efforts fail.

In 2007, Spain launched the Thao Child Health Programme, a community-based intervention that engaged municipalities, families, and multidisciplinary teams to foster balanced diets and physical activity [5]. By coordinating city councils, health centers, markets, and educators, Spain managed to become one of the few countries capable of reversing the obesity trend [6].

Similarly, France adopted the National Nutrition and Health Program (PNNS), known as "Bouger, Manger" (Move, Eat), which focused on reducing health inequalities and managing nutritional disorders [7]. A pivotal advancement in the French strategy was the 2017 adoption of Nutri-Score [8], a labeling system providing immediate information on food salubrity, which incentivized healthier consumer choices and product reformulation by the agro-industry [9].

The Problem of Mono-disciplinary Approach

Despite the success of integrated programs elsewhere, the general scientific and political approach to obesity often suffers from a narrow perspective, leading to ineffective solutions. Analyzing childhood obesity through a mono-disciplinary lens is metaphorically akin to "trying to paint a big wall using small brushes in the hand of people not talking to each other".

Most current literature approaches the topic from specialized perspectives, often ignoring the complex interaction of influencing factors; for instance, while genetic predisposition plays a role, obesity is also the result of a "cultural heritage" or lifestyle that is unconsciously learned. As Ulrick Beck (1992) asserted in his book Risk Society: Towards a New Modernity, as science becomes more specialized, it risks becoming a problem rather than a solution because it fails to capture the totality of the phenomenon. This fragmentation results in an incapacity to describe the issue coherently, often leading researchers to conclude that "there are other factors" without investigating the interrelation among them, thus failing to see that the whole is different than the sum of its parts.

The Solution: Interdisciplinary Approach Through Network Analysis

To address the limitations of reductionism, this research adopts a framework based on complexity theory and holism. Complexity theory posits that in a system, every component interacts with others, receiving and producing influence simultaneously; applied to social systems, this necessitates looking not a single elements but at the relations between them.

Network Analysis offers the necessary "big brush" to paint this picture, providing an integrated framework to analyze these complex structures. By utilizing graph theory-originating from Euler's work on connectivity-sociological structures can be mapped to reveal how different determinants (nodes) are connected (edges) and which factors hold the most influence [10]. This method allows for the empirical highlighting of multifactoriality, transforming theoretical assumptions into visible, interconnected data, functioning like an "impressionist painting" where the image only becomes clear when one steps back to view the connections rather than the isolated dots.

Methodology

From Survey to Graph

The study utilized a semi-structured survey administered to mothers of children aged 3 to 5 years, designed based on a literature review and expert interviews that categorized determinant factors into five families: Genetics, Lifestyle, Socioeconomic Status, Environment, and Social Network.

The data processing involved several sophisticated steps to translate survey responses into a visual network:

1. Data Collection: The survey produced a data matrix (41 respondents, 81 variables) which was cleaned and standardized.

2. Incidence Matrix: Data were converted into an incidence matrix where connections were established based on standardized variable values.

3. Bipartite Network: A bipartite network was created linking statistical units (IDs) to variables; this was subsequently filtered to focus on the top 10 IDs with the highest Child Body Mass Index (CBMI) to isolate factors specifically co-occurring with obesity.

4. Projections and Community Detection: The bipartite network was projected to show relationships between variables, and community detection algorithms were applied to group tightly connected nodes based on the weight of their edges.

Results

The analysis resulted in a weighted, undirected graph (Figure 1) that visualizes the co-occurrence of variables within the high CBMI demographic.
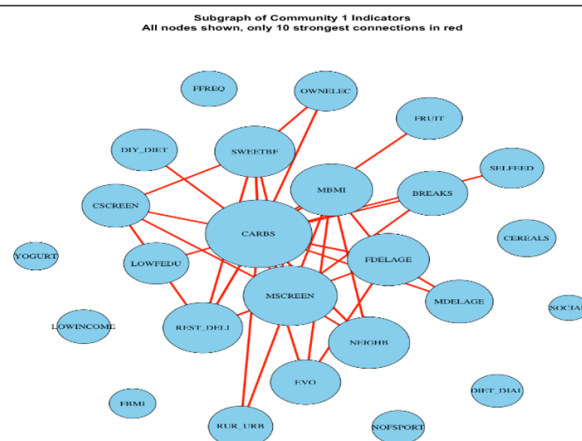

Figure 1: Subgraph of community 1 Indicators all nodes shown, only 10 strongest connections in red

The graph reveals several central nodes and strong connections that characterize the "obesogenic" profile:

- **Unbalanced diet:** A central cluster involves the high consumption of flour-based products (CARBS), extra-virgin olive oil (EVO), and fruit, combined with a sweet breakfast (SWEETBF) and frequent snacking (BREAKS). This suggests that even foods perceived as healthy contribute to obesity when part of a hyper-caloric, unbalanced diet.

- **Media influence:** Maternal screen time (MSCREEN) emerged as a central variable strongly connected to the child's screen time (CSCREEN) and the possession of personal electronic devices (OWNELEC). This confirms the transmission of sedentary habits and "cultural heritage" from parent to child.

- **Environment:** The analysis highlights "City Suburbs" (RUR_URB) as a prevalent environment for high

CBMI, characterized by frequent interactions with neighbors (NEIGHB) but potentially lacking in quality services or safe outdoor spaces.

Conclusion

According to Ulrich Beck, as science becomes increasingly specialized, it risks becoming a problem rather than a solution, and this paradox is strikingly evident in the context of childhood obesity. Despite the existence of boundless empirical evidence and research, indeed, the phenomenon continues to grow in almost every country. This persistence can be attributed to two primary failures: a lack of political willingness to prioritize health over economic paradigms, and the fragmentation of scientific disciplines, which results in an incapacity to describe the issue through a coherent, unified narrative. To address a complex social phenomenon that cannot be isolated within a laboratory, a holistic approach-comprising multidisciplinary scientific analysis and multi-stakeholder engagement-is not just beneficial but required.

This research demonstrates that Network Analysis serves as an effective "big brush" capable of painting the "big wall" of childhood obesity. The utility of this methodological approach lies in its ability to highlight multifactoriality empirically, transforming theoretical assumptions about the interconnectivity of variables into visible data. The resulting graph functions as an "impressionist painting": if one stands too close, they see only isolated dots (specialized data points) surrounded by white space; however, by stepping back to the appropriate distance provided by Network Analysis, the dots merge to reveal the shape and colour of the problem. Under this lens, the determinants of obesity are not isolated causes but pieces of a "mosaic" that interact to create an obesogenic atmosphere.

The application of this analysis has clarified the profile of the "obesogenic" family unit. Contrary to the assumption that obesity is solely driven by "junk food," the results highlight the critical role of an "unbalanced diet". An obese child in this study frequently consumes flour-based products, sweet breakfasts, and multiple snacks, but also significant amounts of foods perceived as healthy, such as extra-virgin olive oil and fruit, while lacking legumes and vegetables. This stems from misconceptions about food healthiness and a lack of time dedicated to food preparation, which is strictly linked to the second major factor: media consumption.

The analysis reveals a strong connection between the time mothers spend in front of screens and the time their children do. Excessive parental media consumption correlates with a reliance on food delivery and ready-to-eat meals, while simultaneously "nudging" children toward sedentary behaviour through the provision of personal electronic devices. Thus, the "cultural heritage" of the family-defined by sedentary habits and distracted parenting-acts as a primary transmission vehicle for obesity risks.

A significant finding of this research concerns the socio-environmental context. While many studies associate childhood obesity strictly with low Socioeconomic Status (SES), this research suggests that in the Italian context, low income and parental education have a weaker influence than expected. Instead, the environment plays a pivotal role. The prevalent setting for high childhood BMI in this study is the "city suburbs". These areas represent a "worst of both worlds" scenario: they possess the insecurity and traffic of big cities (preventing outdoor play) combined with the lack of quality services typical of small towns. In these suburbs, families often face a landscape of low-quality grocery options and fast food, confirming that the emergence of obesity is inextricably linked to political decisions regarding urban planning and infrastructure.

Ultimately, this research confirms that obesity in children is an indicator of a lack of appropriate attention-both within the family regarding habits and externally regarding environmental conditions. To effectively prevent childhood obesity, policymakers must move beyond the "blame the individual" narrative and address the complex system of interactions revealed by the network graph.

The advantage of using Network Analysis is that it facilitates communication outside the academic world, allowing scientists to present a comprehensive framework to decision-makers. A multidisciplinary approach utilizing these tools could lead to the development of a predictive "obesity risk index" that accounts for genetic, epigenetic, and environmental factors. Such an index would allow for intervention before the problem manifests, thereby lightening the burden on national economies, public health systems, and, most importantly, the children themselves.

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