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System Dynamics Modeling of Preventive Care Strategies for Addressing Obesity and Healthcare Expenditures in the United States

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ABSTRACT

This study examines the impact of preventive care strategies on obesity prevalence and associated healthcare expenditures in the United States using system dynamics modeling. Obesity is a multifaceted public health challenge involving interdependent behavioral, biological, economic, and systemic factors that interact nonlinearly and evolve, which are characteristics of a complex system. To better understand these dynamics, we developed causal loop diagrams (CLDs) based on a rapid literature review, which mapped the feedback structures among key variables, including dietary behavior, physical activity, healthcare access, and the progression of obesity-related illnesses. The resulting CLDs identify both reinforcing and balancing feedback loops that govern transitions across population health states (healthy, pre-obese, obese, and chronically ill), as well as resource allocation dynamics within the healthcare system. This study makes a unique contribution by developing a comprehensive conceptual model that maps preventive care strategies using system dynamics feedback structures. Unlike prior models that focus narrowly on either physiological or behavioral factors, our model integrates multi-level pathways – behavioral, clinical, and economic – highlighting leverage points for policy intervention. The model reveals leverage points where upstream interventions, such as improving dietary behavior or increasing access to primary care, may disrupt harmful cycles and reduce long-term healthcare costs. These findings offer policymakers a systems-oriented perspective on where and how to intervene to curb the obesity epidemic and its associated economic burden.

Keywords

System dynamics, Obesity, Healthcare cost, Health policy, Preventive care, Causal loop diagram.

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1. Introduction

Obesity is a major contributor to the exorbitant healthcare expenses in the United States. According to the Centers for Disease Control and Prevention (CDC), the healthcare system in the USA spends a staggering $173 billion annually due to obesity-related issues (CDC, 2022). The burden of obesity on the healthcare system is escalating, and it becomes disproportionately high for the most obese portion of the U.S. population (Williams et al., 2015). Between 2000 and 2018, the prevalence of obesity among adults increased by nearly 10% (Hales, 2020). A comprehensive review of the literature on the causal effects of obesity on economic outcomes reveals that it escalates medical care expenses, diminishes the likelihood of finding employment, and reduces earnings and wages (Biener et al., 2018; Lee et al., 2017; Yusefzadeh et al., 2019). Some researchers suggest that the prevention of obesity could potentially result in substantial healthcare cost savings (Avenell et al., 2004; Cawley et al., 2015; Gortmaker et al., 2015).

In addition, obesity is associated with a range of health problems, including cardiovascular disease, hypertension, diabetes, and certain cancers (Aballay et al., 2013; Mozaffarian, 2016; Pi-Sunyer, 2009). Consequently, the progression of obesity into other diseases is associated with increased utilization of healthcare services, increased medication use, and higher rates of hospitalization and emergency room visits, all of which contribute to higher healthcare costs for obese individuals (Cecchini, 2018; Must et al., 1999; Suehs et al., 2017). One study found that healthcare costs for obese individuals were 42% higher than for individuals with a healthy weight (Finkelstein et al., 2009).

Obesity is a pressing public health predicament that has reached epidemic proportions globally (James et al., 2001). In the United States, the incidence of obesity has increased significantly across all demographic groups, primarily due to changes in dietary patterns and advancements in technology that have reduced physical exertion in labor-intensive occupations (Selvin et al., 2014). Overweight and obesity are linked to a heightened risk of multiple ailments and conditions (GBD 2015 Obesity Collaborators, 2017). Adults with obesity are more likely to develop heart disease, type 2 diabetes, and certain forms of cancer, which can result in elevated morbidity and mortality (Aballay et al., 2013). In general, obesity increases the likelihood of contracting other illnesses, thereby increasing healthcare utilization and expenses, while concurrently reducing life expectancy. Overall, obesity is a significant contributor to morbidity and mortality, as well as high medical expenses (Lehnert et al., 2013; Abdelaal et al., 2017). As depicted in Figure 1, healthcare costs in the US are also increasing rapidly, with a significant portion of this growth attributable to obesity (Thorpe et al., 2004). Therefore, the problem that needs to be addressed is how to understand pathways for reducing the prevalence of obesity and associated healthcare costs.

To deepen the understanding of the economic ramifications of obesity, it is essential to consider the broader societal costs beyond direct healthcare expenses. These include indirect costs such as lost productivity, absenteeism, and presenteeism. Research indicates that obese individuals are more likely to miss work due to health-related issues. When they do work, their productivity can be lower due to obesity-related complications (Trogdon et al., 2008). It not only affects individuals but also places a strain on employers and the economy as a whole.

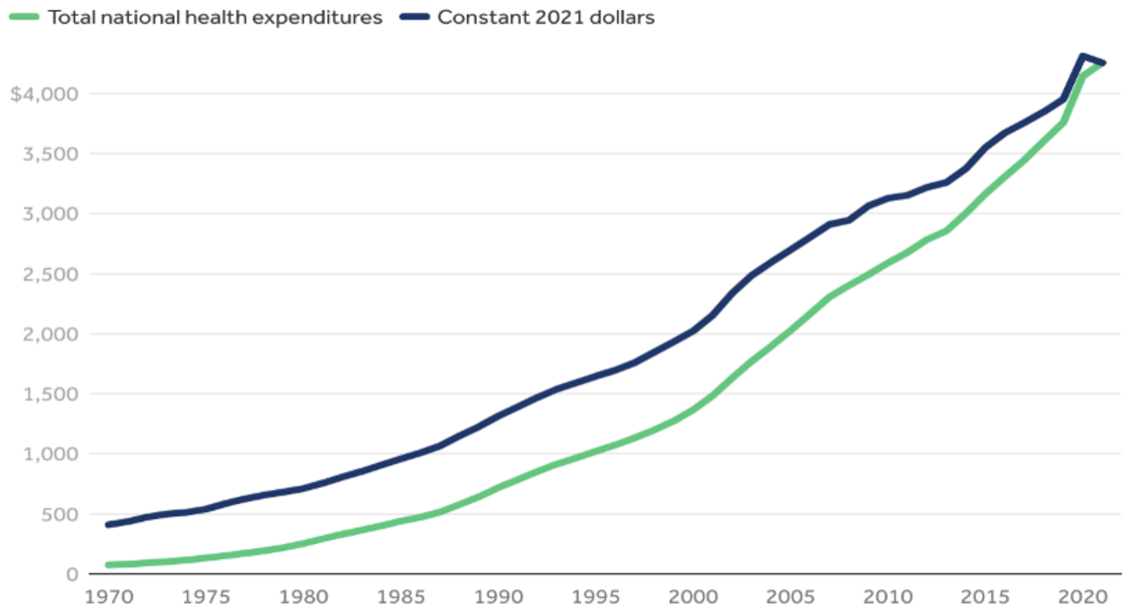

Figure 1. Annual national healthcare expenditures (in billion dollars) (Source: Kaiser Family Foundation)

Furthermore, the psychosocial impact of obesity cannot be overlooked. Obesity often leads to stigmatization and discrimination, which can exacerbate mental health issues such as depression and anxiety (Papadopoulos and Brennan, 2015). These mental health challenges, in turn, can further reduce the quality of life and increase healthcare costs due to the need for mental health services (Puhl and Heuer, 2009). Addressing obesity, therefore, requires a systems approach that encompasses physical, cognitive, and social health dimensions (Bagnall et al., 2019; Finegood, 2012; Lee et al., 2017).

Preventive measures play a critical role in addressing the obesity epidemic (World Health Organization, 2000). Public health interventions that promote healthy eating, physical activity, and behavioral changes are essential in preventing obesity from an early age. Policies that create healthier food environments, such as taxation on sugary beverages, subsidization of nutritious foods, and regulations on food marketing to children, have shown promise in reducing obesity rates (Mozaffarian, 2016). Additionally, community-based programs that encourage physical activity through infrastructure improvements, such as the creation of parks and pedestrian-friendly urban designs, are crucial in fostering an environment conducive to maintaining a healthy weight.

The healthcare system itself must also adapt to better manage obesity. Integrating weight management programs into primary care, improving access to nutrition and physical activity counseling, and providing support for bariatric surgery where appropriate are important strategies. These healthcare interventions should be complemented by policies that address socioeconomic determinants of health, including education, income, and access to healthy foods and safe environments for physical activity (Kumanyika, 2019).

Moreover, the influence of digital technology and media on dietary habits and physical activity levels needs to be addressed. The rise of sedentary lifestyles due to increased screen time and the pervasive marketing of unhealthy foods through digital platforms significantly contributes to the obesity epidemic (Golod, 2021). Initiatives that promote digital wellness and responsible media consumption, alongside stricter regulations on the digital advertising of unhealthy foods, are necessary to combat this trend.

System dynamics is a methodology for understanding the behavior of complex systems over time (Forrester, 1994; Sterman, 1994). By utilizing feedback loops, stock and flow diagrams, and differential equations, it models the dynamic interactions within a system. Developed by Jay W. Forrester in the 1950s, this approach is invaluable in public health for simulating the impact of various interventions and identifying leverage points within complex issues such as obesity (Aguiar et al., 2023). System dynamics offers a comprehensive understanding of the multifaceted factors contributing to obesity, facilitating the design of more effective and sustainable interventions (Xue et al., 2018).

A key tool in system dynamics is the causal loop diagram (CLD), which graphically represents the feedback loops and causal relationships within a system. CLDs use variables connected by arrows to indicate the direction and nature of influence (positive or negative). In addressing obesity, CLDs can map the interactions between dietary habits, physical activity, genetic predispositions, psychological factors, and socioeconomic conditions. By visualizing these relationships, CLDs help identify critical intervention points, allowing policymakers to disrupt negative feedback loops and promote positive change. This systematic approach is crucial for addressing the complexity of obesity, enabling more informed and effective decision-making.

To that end, the objective of this research is twofold. First, we develop a conceptual model to assess the impact of obesity and related complications on healthcare expenditures. Second, using CLDs, we examine how preventive care can help mitigate the costs associated with obesity. We contend that the findings of this research will provide valuable insights to healthcare policymakers in designing effective population-level interventions to address the rising prevalence of obesity. These insights could pave the way for comprehensive strategies that not only reduce obesity rates but also alleviate the associated economic burden on the healthcare system.

2. Methodology

We begin our study by conducting a rapid literature review on the topic of obesity and its impact on healthcare expenditure in the United States. For this literature search, we utilized three comprehensive databases: Scopus, Web of Science, and PubMed. These databases were chosen due to their extensive coverage of peer-reviewed journals and high-quality research articles relevant to our study. The literature review aimed to gather insights into the direct and indirect costs associated with obesity, the healthcare burden it imposes, and the effectiveness of various interventions aimed at mitigating these costs. This foundational step was crucial in understanding the current state of knowledge and identifying gaps that our research could address.

Based on the insights gleaned from this extensive literature review, we brainstormed the key variables that influence the relationship between obesity and healthcare expenditure. These variables were identified through a combination of empirical evidence from existing studies and theoretical considerations. Our brainstorming sessions included multidisciplinary perspectives to ensure a holistic understanding of the problem. By integrating these variables with our existing mental models, we developed CLDs, a widely used tool in system dynamics modeling. CLDs are instrumental in illustrating the feedback loops and complex interactions within a system, demonstrating how the escalating prevalence of obesity could potentially influence healthcare expenses over time.

The development of the CLDs was an iterative process that involved multiple refinements to accurately capture the dynamics of obesity and healthcare costs. Each iteration incorporated feedback from domain experts and refinements based on the latest empirical data. This rigorous process ensured that our final model was robust and reflective of real-world complexities. The resulting causal loop diagrams not only highlight the direct pathways through which obesity impacts healthcare costs but also reveal the underlying feedback mechanisms that sustain or exacerbate this issue. The research framework for our study, which outlines these processes and connections, is depicted in Figure 2 below. This framework serves as the blueprint for our analysis, guiding our exploration of potential interventions to reduce obesity-related healthcare expenditures.

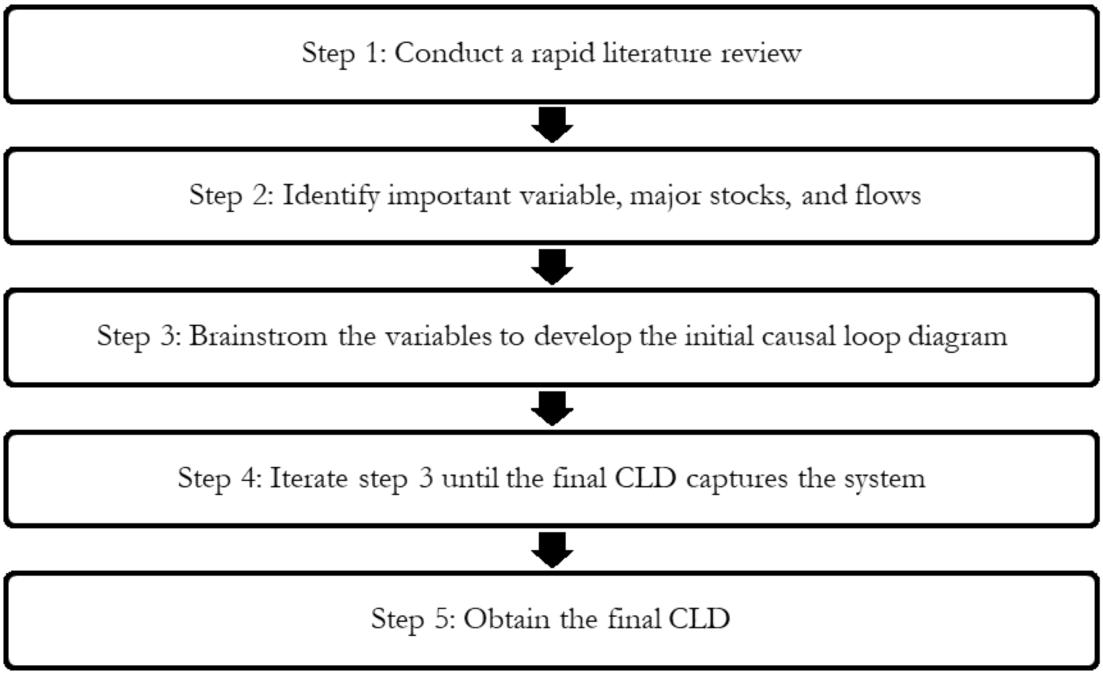

Figure 2. The research framework used in this study

3. Literature review

Numerous studies have established a link between obesity and the imbalance between energy intake and energy expenditure. Obesity occurs when individuals consistently consume more energy than they expend, leading to the accumulation of excess body fat (Abdel-Hamid, 2002; Abidin et al., 2014). Factors contributing to high energy intake include unhealthy eating behaviors such as high sugar consumption, frequent intake of fast foods, and continuous snacking (Mattes, 2014). Conversely, insufficient physical activity, whether through exercise or physical labor, prevents adequate energy expenditure, resulting in an energy imbalance (Fallah-Fini et al., 2014; Roberts et al., 2019). This imbalance increases average weight and consequently raises the body mass index (BMI), a key indicator of obesity. BMI is calculated by dividing a person's weight in kilograms by the square of their height in meters (Cole et al., 1995). According to the CDC, a BMI value of 30 or higher indicates obesity.

The progression from pre-obesity (BMI 25-29.9) to obesity underscores the dynamic nature of this condition. As the number of individuals with pre-obese BMI increases, a portion of this population transitions to obesity, particularly if they do not receive proper treatment (Waterlander et al., 2021). This transition is often accompanied by the onset of comorbidities such as heart disease, high blood pressure, and diabetes, which further burden the healthcare system economically (Brittin et al., 2015). Consequently, addressing obesity is not only a matter of managing weight but also preventing associated health conditions that contribute to escalating healthcare costs.

Recent reviews have highlighted the effectiveness of system dynamics modeling in understanding and addressing chronic diseases, including obesity (Darabi and Hosseinichimeh, 2020; Davahli et al., 2020; Morshed et al., 2019). These studies have explored various strategies for reducing obesity, such as preventive care (Chen et al., 2018), improving access to healthy foods (Chiu et al., 2023), and increasing the prices of unhealthy foods (Guariguata et al., 2022). Community-wide prevention programs have also been examined for their potential to reduce obesity rates (Allender et al., 2015; Crielaard et al., 2020). Additionally, researchers have investigated the economic impact of obesity on healthcare costs, highlighting the significant financial strain it poses (Karanfil et al., 2011).

Preventive care is often posited as a solution to mitigate obesity-related healthcare costs (Homer et al., 2004; Homer et al., 2006; Zare Mehrjerdi, 2012; Jalali et al., 2014; Zainal Abidin et al., 2014). However, some researchers argue that preventive measures alone may not suffice in combating obesity effectively (van Baal et al., 2008). Implementing upstream measures and preventive care requires substantial government funding for pre-obesity interventions. While this could potentially reduce the prevalence of obesity and related healthcare expenditures, it necessitates a reallocation of resources that might be challenging to achieve (Zhao et al., 2008; Thompson and Wolf, 2001).

Overall, the literature underscores the complexity of obesity as a public health issue. It highlights the need for a multifaceted approach that includes preventive care, policy changes, and community interventions to address both the direct and indirect costs associated with obesity. Understanding these dynamics is crucial for developing effective strategies to reduce the prevalence of obesity and alleviate the economic burden on the healthcare system. To that end, this research applies a systems approach – system dynamics – to model the complexity of obesity.

4. System dynamics model

The final system dynamics model, prepared using Vensim PLE (shown in Figure 3), considers six major stocks: average weight, healthy population, pre-obese population, obese population,

population with obesity-related illnesses, and healthcare budget. In our CLD, we identify six balancing loops and six reinforcing loops. The first three balancing loops illustrate how initiatives such as improving physical activity and dietary behaviors can reduce the increase in average weight and prevent people from moving from a healthy state to a pre-obese state. The next three balancing loops demonstrate how allocating appropriate medical resources for treatment can prevent the progression of illness from one stage to a more critical stage. However, as the population moves downstream, the costs and utilization related to treating people with obesity and related illnesses increase.

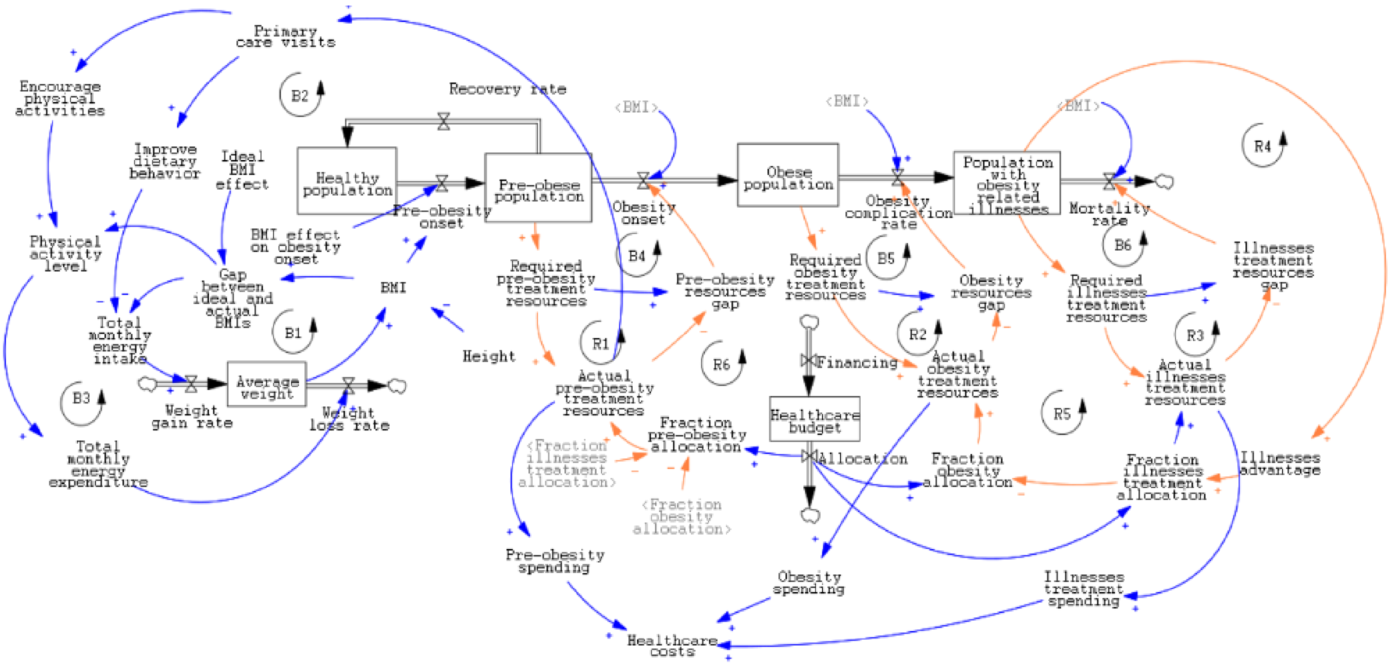

Figure 3. Overall causal loop diagram for preventive care for obesity

As more people become obese and their illness progresses to other types of chronic diseases, the costs and utilization associated with their treatments also increase. For example, as seen in the analysis of reinforcing loop 6, the population with obesity-related illnesses will have a higher priority for treatment, reducing the resources available for the healthy, pre-obese, and obese populations. This situation reinforces obesity rates and their associated illnesses, constantly demanding more resources for treatment and leaving the healthy population and those in the early stages of obesity unattended. The feedback loops are discussed below. Note that the labels B1–B6 and R1–R6 are assigned solely for reference and do not imply any ordering or prioritization of the feedback loops. An overview of the key variables employed in the feedback loops, along with their supporting references from the literature, is presented in Table 1.

Table 1. Mapping of feedback loops to supporting literature

Loop ID	Loop name	Key variables identified	Supporting references
B1	Obesity generation loop	BMI, energy intake, average weight	Abdel-Hamid (2002); Mattes (2014); Roberts et al. (2019)
B2	Prevention via dietary behavior loop	Pre-obese population, primary care visits, dietary behavior, energy intake, BMI	Abidin et al. (2014); CDC (2021); Chen et al. (2018)
B3	Prevention via physical activity loop	Primary care visits, physical activity level, energy expenditure, weight loss rate, BMI	Mozaffarian et al. (2012); Park et al. (2017); Lee et al. (2017)
B4	Pre-obese resource gap loop	Pre-obese population, required resources, actual allocation, resource gap, pre-obesity onset	Suehs et al. (2017); Zare Mehrjerdi (2012); Cecchini (2018)
B5	Obese resource gap loop	Obese population, required and allocated medical resources, resource gap, obesity complication rate	Finkelstein et al. (2009); Cecchini (2018); Fallah-Fini et al. (2014)
B6	Illness resource gap loop	Population with obesity-related illnesses, medical treatment resources, mortality rate	Abdelaal et al. (2017); Mozaffarian (2016); Suehs et al. (2017)
R1	Pre-obesity reinforcement loop	Pre-obese population, resource demand, allocation gap, obesity onset	Abidin et al. (2014); Jalali et al. (2014); Zainal Abidin et al. (2014)
R2	Obesity treatment loop	Obese population, healthcare visits, medication needs, resource allocation gap, obesity complications	Pi-Sunyer (2009); Cecchini (2018); CDC (2022)
R3	Chronic illness care demand loop	Chronic diseases (diabetes, CVD, cancer), hospitalization, medication use, mortality, healthcare costs	Aballay et al. (2013); Must et al. (1999); GBD 2015 Obesity Collaborators (2017)
R4	Illness treatment prioritization loop	Resource prioritization, actual resource allocation, mortality rate	Abdelaal et al. (2017); Cecchini (2018)
R5	Obesity resource reallocation loop	Healthcare budget constraints, allocation shift from obesity to illness treatment, obesity complication rate	Cawley et al. (2015); Zare Mehrjerdi (2012); Zhao et al. (2008)
R6	Pre-obesity resource allocation loop	Allocation shift from pre-obesity to illness care, guidance gap, pre-obesity onset	Park et al. (2017); Kumanyika (2019); Penn Medicine (2014)

4.1. Obesity generation loop – B1

A high BMI means an increased gap between the ideal BMI (according to a person's height) and their actual BMI. The higher gap should reduce the total monthly energy intake by that individual. As the monthly energy intake decreases, it reduces the average weight, and thus the BMI should decrease, completing a balancing feedback loop (Figure 4).

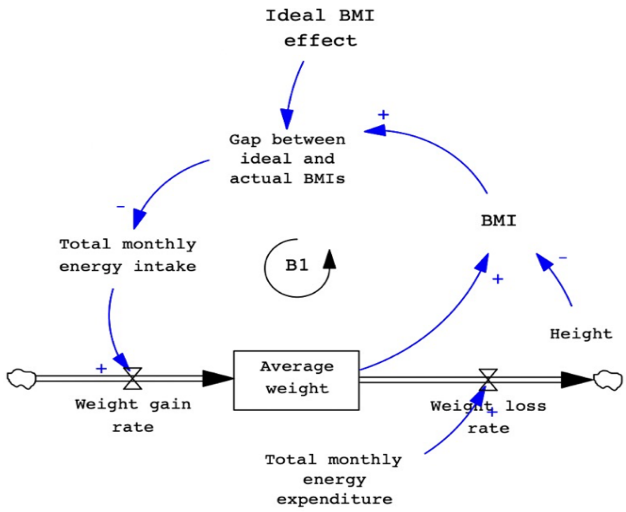

Figure 4. Obesity generation loop (B1)

4.2. Prevention via dietary behavior loop – B2

As the pre-obese population increases, it also increases the required amount of resources (such as treatment, medication, and equipment) for treating that population. It requires a higher actual allocation of pre-obese treatment resources. A higher allocation for such resources will enable a greater number of primary care visits for those individuals. Based on the guidance of primary care physicians (PCPs), the dietary behavior of that population would improve, resulting in a reduction of their monthly energy intake. As the monthly energy intake reduces, it decreases the average weight, and thus the BMI should decrease. A reduced BMI would further delay the onset of pre-obesity and eventually decrease the number of pre-obese individuals who complete a balancing feedback loop for prevention through dietary behavior control (Figure 5).

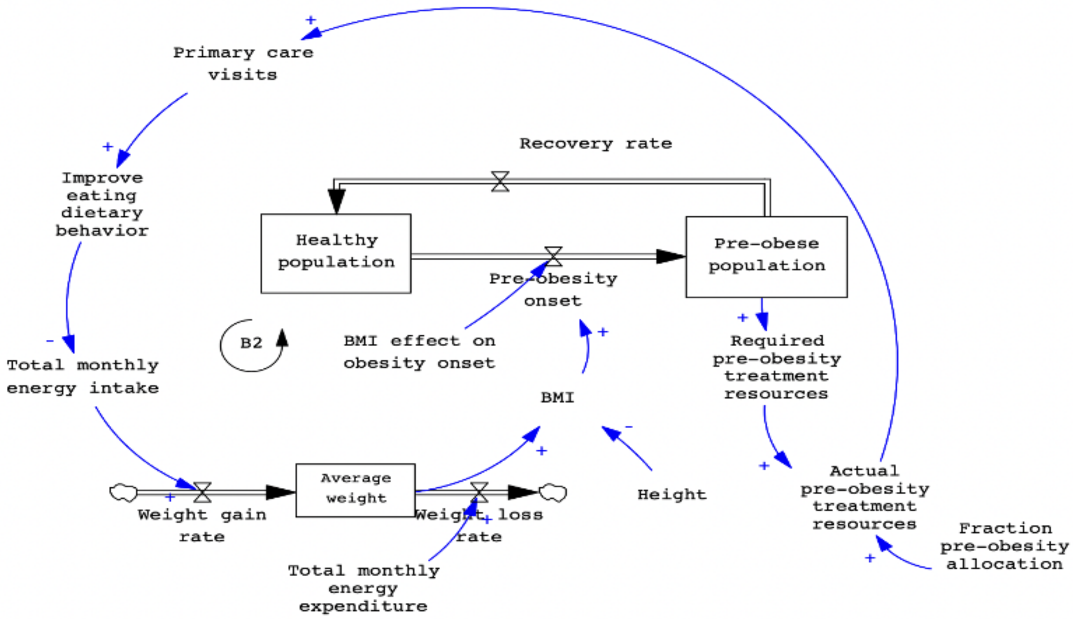

Figure 5. Prevention via dietary behavior loop (B2)

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4.3. *Prevention via physical activity loop – B3*

A similar model behavior can be observed for prevention via physical activity measures, as shown in Figure 6. Increasing the population's access to primary care would likely lead to higher levels of physical activity. Meaning that their total monthly energy expenditure will go down, increasing the weight loss rate. It would reduce the average weight, consequently reducing the BMI, and ultimately decrease the number of individuals in the pre-obese population.

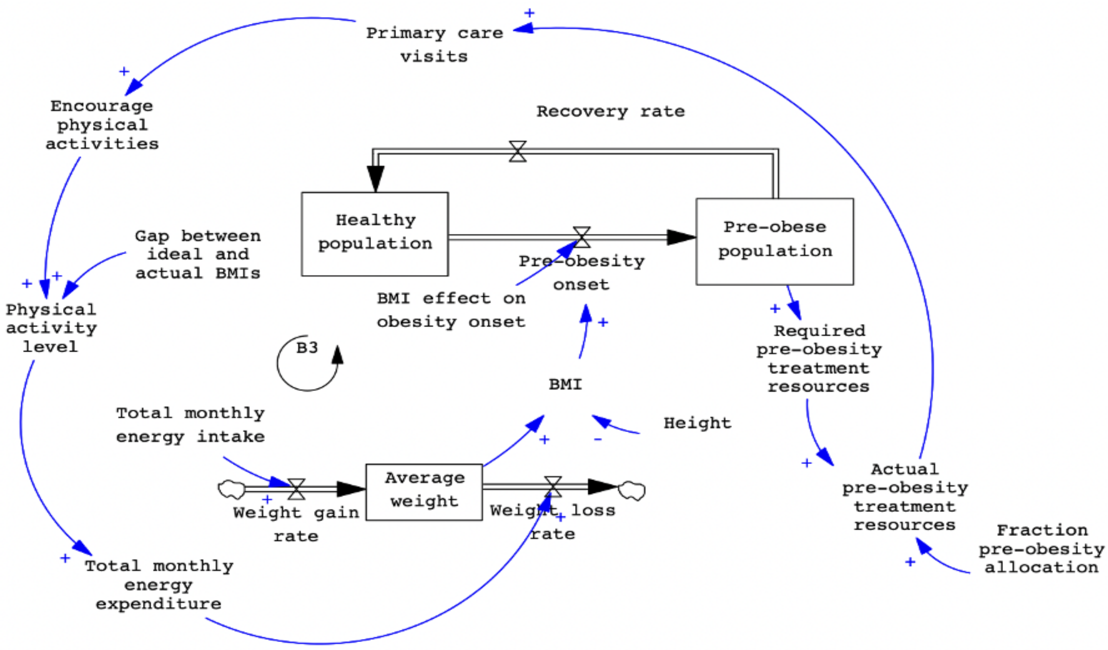

Figure 6. Prevention via physical activity loop (B3)

4.4. *Required resources balancing loops – B4, B5, and B6*

These three balancing loops explain how the pre-obese population, the obese population, and the population with obesity-related illnesses are influenced by the required resources for their corresponding treatment. For example, in the case of the B4 loop, an increased pre-obese population will require a higher amount of resources for treating that population. It would exacerbate the pre-obesity resources gap, which is the difference between the actual resources available and the required resources. A higher resource gap would increase the onset of pre-obesity, thereby reducing the pre-obesity population. The same behavior is also observed for the other two stock variables, as shown in Figure 7.

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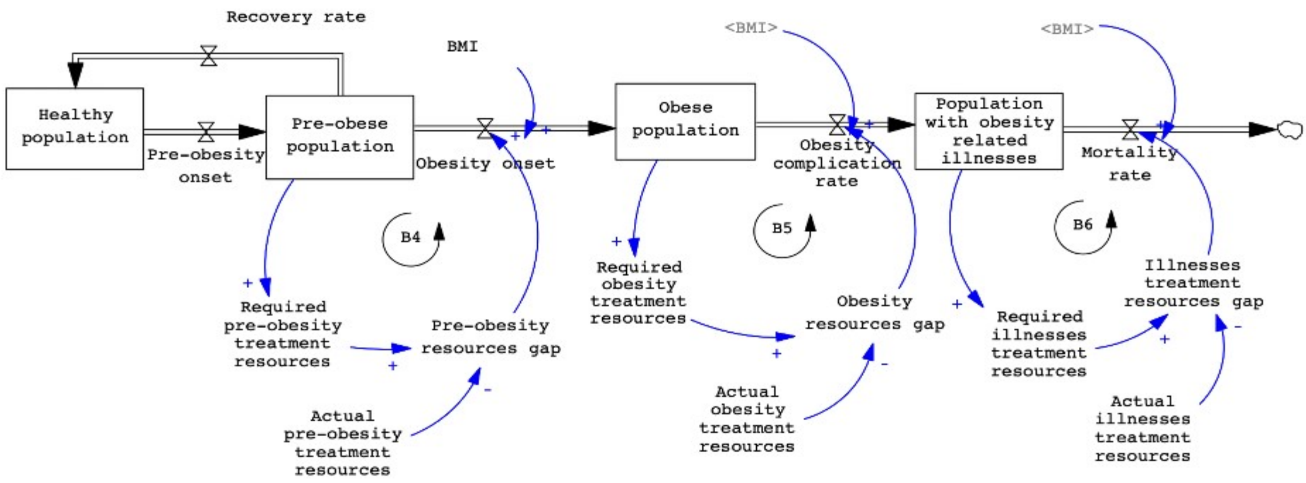

Figure 7. Required resources balancing loops (B4, B5, and B6)

4.5. Reinforcing loops – R1, R2, and R3

The population that moves from a healthy state to a state of pre-obesity begins to demand more resources, such as primary care visits and nutrition counseling, to prevent further weight gain and reduce the risk of developing obesity-related health issues. Based on the population suffering from pre-obesity, the resources required will increase; however, the fraction of the healthcare budget allocated for treating people in this stage may not be sufficient, creating a gap between the actual and required resources. A gap in resources can increase the onset of obesity, with more people reaching the obesity state (as depicted in Figure 8).

The same trend is observed in reinforcing loop 2, where populations that had reached a state of obesity may require more frequent visits to healthcare providers and hospitals for various health issues such as joint pain, sleep apnea, and respiratory problems. In addition, obese individuals may require medications for various obesity-related health issues, such as high blood pressure, high cholesterol, and type 2 diabetes. The gap between the medical services needed and the ones allocated by the healthcare budget can start increasing the obesity complication rate, as people do not receive treatment for their obesity condition. All these services increase healthcare utilization and can lead to higher costs for medical services and procedures.

For reinforcing loop 3, according to the CDC (2022), obesity is associated as a risk factor for several chronic health conditions, such as type 2 diabetes, heart disease, stroke, and certain types of cancer. These conditions require ongoing medical care, including drugs and hospitalizations, increasing the demand for medical resources for treating people with obesity-related illnesses. Once again, if the healthcare budget is not capable of allocating enough resources to cover the medical treatments of people with chronic diseases, the mortality rate among the population can start increasing significantly.

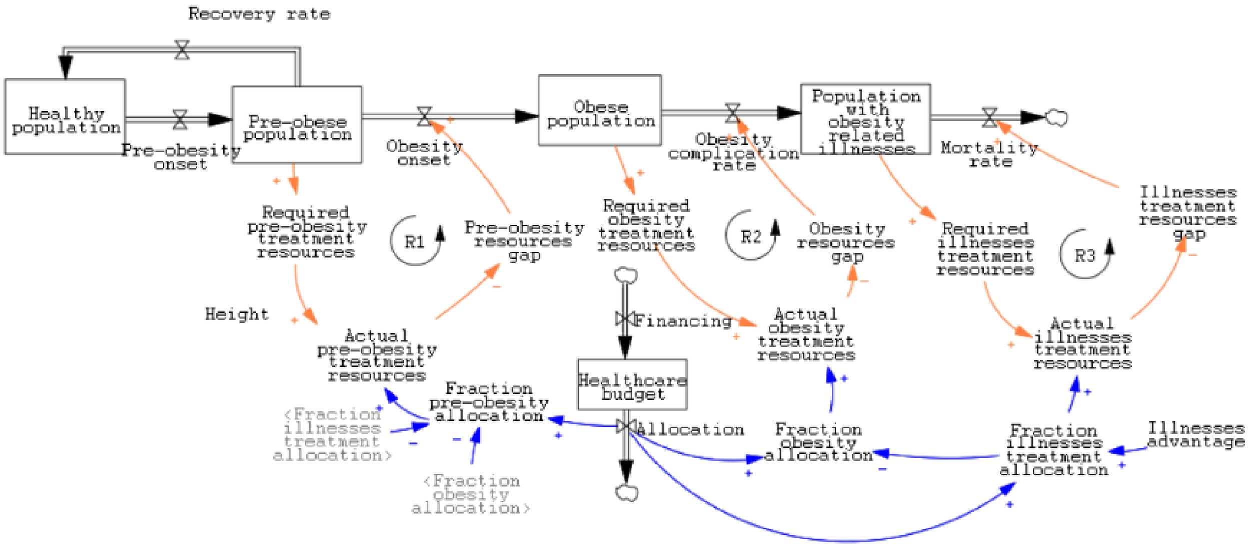

Figure 8. Reinforcing loops (R1, R2, and R3)

4.6. Reinforcing loops – R4, R5, and R6

The population with obesity related illnesses or the population suffering from chronic diseases has a high risk of mortality, which increases the advantage they have for accessing medical treatments, as the allocation of resources will be higher compared to this advantage. An increase in the actual resources for treating the population with obesity-related illnesses will reduce the gap and will reduce the level of mortality (Reinforcing loop 4, shown in Figure 9).

The advantage of the population with obesity-related illnesses has also affected the fraction of resources being allocated for treating the population with obesity. The fraction of obesity allocation is reduced by the fraction of resources earmarked for illness treatment, considering that the healthcare budget is limited. This decrease in the fraction of obesity allocation increases the gap in treating populations with obesity, which in turn increases the obesity complication rate (Reinforcing loop 5, shown in Figure 9). The same trend is observed for reinforcing loop 6, where the two fractions affect the pre-obesity allocation fraction by reducing it and increasing the demand for medical guidance and treatments among the population suffering from pre-obesity, thereby reinforcing the rate of obesity onset.

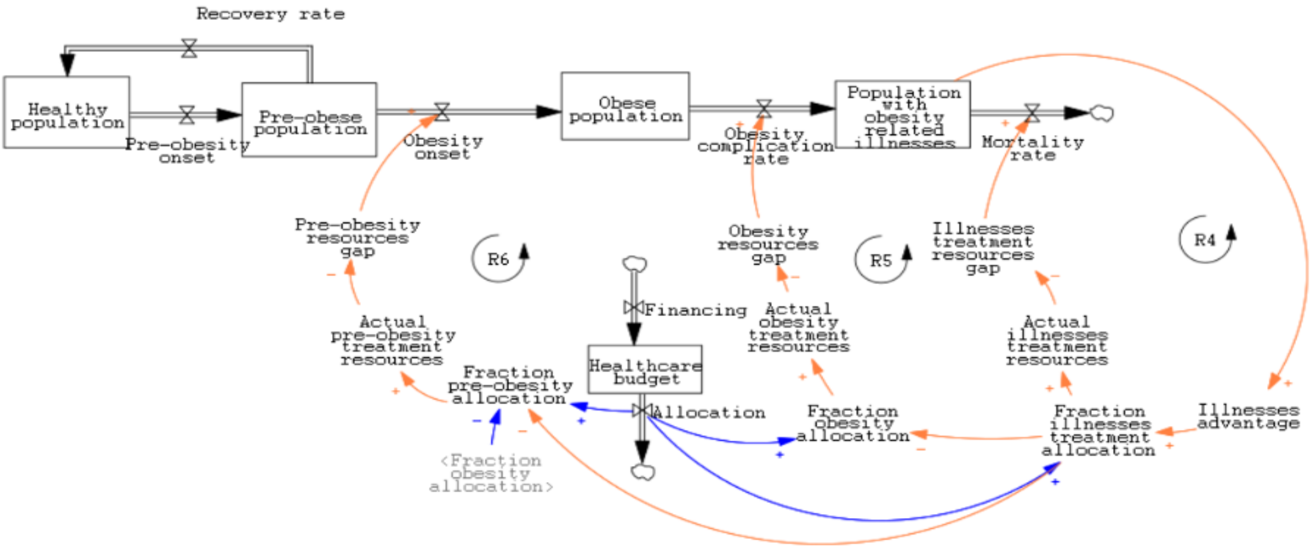

Figure 9. Reinforcing loops (R4, R5, and R6)

5. Policy implications

In terms of policy implications, our conceptual system dynamics model suggests that addressing the healthcare costs associated with obesity in the United States requires a shift towards preventive measures aimed at reducing the prevalence and incidence of obesity and its associated risk factors. Currently, the focus largely remains on managing chronic diseases after they have developed, rather than preventing their onset. This reactive approach results in healthy individuals transitioning to states of obesity or obesity-related illnesses at an alarming rate, underscoring the need for upstream interventions.

The CDC advocates for a multifaceted approach to addressing this issue, emphasizing the importance of creating healthier communities where individuals can make informed decisions about their health. This approach encompasses epidemiological surveillance to track trends and inform action, environmental interventions to promote healthy behaviors, improvements in healthcare systems to facilitate early prevention and management of chronic diseases, and fostering links between communities and clinical settings to support individuals in managing their health conditions.

To promote healthier choices and behaviors among the population, it is imperative to enhance access to primary care services and preventive interventions. Primary care physicians play a pivotal role in guiding individuals toward healthier lifestyles through dietary improvements, increased physical activity, and disease management support (Penn Medicine, 2014).

Furthermore, enhancing the delivery of primary preventive medical services is crucial to laying the foundation for population-wide health improvements.

Community-level initiatives aimed at improving access to healthy foods and discouraging the consumption of unhealthy options, through measures such as taxation, can have a significant impact on dietary habits. Similarly, promoting active mobility and enhancing access to recreational and fitness facilities can encourage physical activity and combat sedentary lifestyles (Park et al., 2017).

Implementing these solutions has the potential to reduce the prevalence of obesity and associated complications, thereby lowering the demand for healthcare resources dedicated to treating these conditions. By reallocating resources towards preventive measures and primary care services, we can enhance population health outcomes and alleviate the strain on the healthcare system. However, it is essential to recognize that the outcomes of these interventions may take time to materialize, necessitating sustained efforts and investments. Additionally, systemic barriers such as the lack of universal health insurance and profit-driven healthcare systems may pose challenges to the widespread adoption of preventive care approaches, necessitating policy reforms and stakeholder engagement to overcome resistance and drive meaningful change.

6. Conclusion and future work

In conclusion, addressing the healthcare costs associated with obesity in the United States necessitates an upstream approach focused on prevention. By promoting measures that encourage healthy lifestyles, fostering community commitment to making healthy choices, and enhancing access to primary care services, we can effectively reduce the onset of obesity and associated illnesses. This proactive approach not only optimizes the utilization of healthcare resources but also fosters a healthier population overall. Through these efforts, the U.S. can exert greater control over the progression of obesity, ultimately leading to a reduction in the number of individuals suffering from obesity-related ailments and an improvement in overall quality of life.

While our conceptual system dynamics model provides valuable insights based on existing literature, future research endeavors could further enhance its efficacy and impact. Integrating data from additional sources, such as expert opinions obtained through interviews and focus group discussions, as well as input from stakeholders like physicians and healthcare organizations, would strengthen the robustness of the model. By incorporating diverse perspectives and real-world insights, we can refine our understanding of the complex dynamics underlying obesity and healthcare expenditures.

Moreover, there is potential for developing a quantitative simulation model to complement our conceptual framework. Such a model could be validated using comprehensive data on obesity rates and associated costs sourced from reliable databases like the CDC and the Kaiser Family Foundation. However, the accuracy and reliability of the model's predictions will hinge on the quality of the input data. Once established, this simulation model could serve as a powerful tool for quantitatively assessing the cost-effectiveness of various preventive care initiatives aimed at reducing obesity prevalence and mitigating long-term healthcare expenditures. Through continued interdisciplinary collaboration and methodological refinement, we can advance our capacity to address the complex challenges posed by obesity and work towards building a healthier future for all.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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