Advancing Child and Maternal Health: A System Dynamics Exploration of Policy Interventions to Tackle Socioeconomic Disparities

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***Abstract*—This study delves deep into the multifaceted child and maternal health domain, focusing on policy interventions to mitigate socioeconomic disparities. Utilizing a system dynamics approach, we have integrated various factors such as "Universal Healthcare Access", "Income Support Programs", and "Education Equity Initiatives". We have meticulously analyzed the complex relationships among these elements by investigating dynamic feedback loops. The striking results show the potential for well-designed policy interventions to improve maternal and child health significantly and the reduction of health disparities. Our findings underline the necessity of holistic and multi-pronged approaches to address socioeconomic disparities within the healthcare system, thus promoting the well-being of both mothers and children. This research provides valuable insights for policymakers, researchers, and healthcare professionals seeking effective strategies for achieving equitable child and maternal health outcomes.**

***Index Terms*—Socioeconomic disparities, Policy interventions, Child and maternal health (CMH), Feedback loops, and System dynamics (SD).**

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I. Introduction

A. Overview

In recent years, numerous initiatives have aimed to enhance maternal health by dismantling obstacles that hinder the accessibility and utilization of healthcare services. A significant among these initiatives is the advocacy for universal health coverage (UHC), as outlined by the World Health Organization (WHO), signifying a state where individuals and communities can access necessary healthcare services without experiencing financial burdens [27]. Although promoting UHC in industrialized countries is a novel strategy, significant efforts are required to remove the barriers that limit healthcare access and utilization, particularly for underprivileged populations. Data shows that poor nations with undeveloped healthcare systems have severe socioeconomic gaps [37]. Economic inequalities in the utilization of maternity healthcare services in low and middle-income nations underscore the expanding disparities in maternity care associated with wealth in multiple developing countries [39].

Differences in health across different socioeconomic groups, assessed factors such as income, education, occupation, housing, and healthcare access, pose a significant public health challenge [34]. The extent to which these disparities can be modified remains unclear. International comparative studies can be crucial in identifying opportunities for mitigating health inequalities. Hence, the imperative for comprehensive and enduring initiatives to tackle the root causes and consequences of unfavorable maternal health outcomes remains of utmost importance [37]. Enhancing maternal and child health is a vital element of developmental concerns in every society. Numerous ongoing endeavors exist to mitigate the global, regional, and local maternal mortality challenges. Apparent evidence highlights the escalating disparities in healthcare access to promote maternal well-being within and among developing nations [2]. Improving maternal health continues to be a prominent concern within global public health. The Sustainable Development Goals (SDGs), which succeeded the Millennium Development Goals (MDGs), encompass maternal health and healthcare as pivotal objectives. Furthermore, the SDGs underscore that no individual should be excluded from pursuing these objectives [1].

The health and development of children are intricately linked to socioeconomic status (SES) indicators in the population, which include factors such as household wealth, income, parental education, and occupation [14]. A substantial number of healthcare professionals have firmly believed that inequalities in healthcare access among different socioeconomic groups are the primary cause of significant health disparities between affluent and less affluent individuals. Conversely, some have contended that many factors contribute significantly to these obstacles and that solely addressing financial barriers to healthcare may have a limited impact on reducing disparities in health status. The competitive pressures

within the contemporary healthcare landscape raise concerns about the potential for socioeconomic groups, particularly the insured and uninsured, to become more disparate. Nevertheless, recent state initiatives, notably the State Child Health Insurance Program, serve as impactful instances of healthcare insurance expansion. These initiatives offer valuable insights for policymakers at all levels regarding the surveillance and mitigation of socioeconomic disparities [4].

B. Research Motivation

This research is motivated by the pressing need to address socioeconomic disparities impacting child and maternal health (CMH) outcomes. These disparities, deeply rooted in socioeconomic factors, result in unequal health outcomes among different population groups. Understanding these dynamics is crucial for achieving health equity, enhancing preventive care, optimizing resource allocation, and mitigating the long-term effects of CMH disparities. By examining this complex web of factors, the research seeks to contribute to more equitable and effective strategies for improving CMH outcomes in diverse populations.

C. Research Questions

The following research questions provided the basis for the research:

1) What are the key socioeconomic factors that most significantly influence child and maternal health outcomes, and how do they interact with each other within a dynamic system?
2) How can the causal model help us better understand the complex feedback loop and relationships between socioeconomic disparities, policy interventions, and CMH outcomes?
3) What role do feedback loops play in perpetuating or mitigating CMH disparities, and how can we design policies that break negative feedback loops and reinforce positive ones?

D. Research Objectives

This study investigates how socioeconomic disparities, policy interventions, and child and maternal health outcomes are dynamically interconnected. Specifically, the research aims to achieve the following:

I. Obtain a deep understanding of the system's intricate relationships and feedback loops, including socioeconomic disparities, policy interventions, and CMH.
II. Assess the impact of various policy interventions on critical determinants of CMH, such as income, education, healthcare access, and housing conditions.
III. A feedback loop ensures research informs policies, leading to improved maternal and child health, further reducing disparities, and strengthening public health initiatives.

E. Research Hypothesis

The hypotheses for this research are as follows:

1) The causal model will reveal that socioeconomic disparities, including income inequality, education gaps, and healthcare access disparities, significantly drive differential CMH outcomes.
2) Policy interventions targeting income support programs, education equity initiatives, and universal healthcare access will have a measurable and positive impact on improving CMH outcomes and reducing disparities.
3) Causal modeling, when integrated with real-world data, will provide accurate and reliable predictions of CMH outcomes, supporting the development of effective policy strategies.

F. Research Contributions

This research makes substantial contributions by unraveling the intricate relationship between socioeconomic disparities, policy interventions, and child and maternal health (CMH) within a system dynamics framework. It deepens our understanding of the complex dynamics, allowing for evidence-based policymaking. By quantifying policy impacts and providing long-term projections, it aids in resource allocation and anticipates sustained CMH improvements. Lessons from successful initiatives guide effective strategies, while model validation enhances predictive accuracy.

G. Organization

II. Literature Review

This section encompasses the problem statement, delves into the research context, and examines the relevant studies conducted by other scholars. It offers the foundational context for the research and underscores the importance of addressing the impact of socioeconomic inequalities.

A. Problem Statement

The problem statement for the impact of policy interventions on child and maternal health while addressing socioeconomic disparities can be framed as follows: Historically, public health statistics in the United States have been categorized and reported based on racial or ethnic groups [29]. Health disparities across groups defined by socioeconomic factors, often based on income or educational attainment, have received comparatively less attention in historical public health studies [30]. In many regions, persistent socioeconomic disparities pose significant health challenges for mothers and children. Policy interventions aim to mitigate these disparities, but their effectiveness and intricate interactions within this complex system require breakdown. This research delves into the causal interplay between policies and socioeconomic inequalities in child and maternal health. Addressing this multifaceted issue is crucial for fostering a healthier and more equitable future.

In a review of over 20 publications from the National Center for Health Statistics (NCHS) dating back to 2009, which

focused on health status and health-related behaviors and are accessible on the NCHS website, it was evident that while the majority of these studies investigated health disparities by race or ethnicity, fewer than half of them explored disparities based on income or education. Moreover, among those considering these socioeconomic factors, most studies only examined up to three distinct categories [21]. To illustrate this point, we can look at the most recent edition of "Health, United States", the annual health statistics report from the US Department of Health and Human Services. Out of its 151 tables, 93 tables provide information on health disparities based on race or Hispanic origin, 34 tables focus on inequalities related to income (expressed as a percentage of poverty), and 16 tables examine differences based on education levels. Except the 1998 edition's Socioeconomic Status and Health Chartbook [15], "Health, United States" typically restricts its comparisons to a maximum of three income groups (the "poor" - those with incomes below 100% of the poverty threshold, the "near poor" - incomes ranging from 100% up to 200% of poverty, and all higher-income individuals combined) and three education groups (individuals who have not completed high school, high school graduates, and those with at least some postsecondary education). Several exceptions in routine public health data reports delve into disparities across four or five socioeconomic groups. These include the Socioeconomic Status and Health Chartbook, the National Health Interview Survey (NHIS) series 10 reports, and the Agency for Healthcare Research and Quality (AHRQ) national healthcare disparities reports [7].

The absence of regular reporting on health disparities linked to social and economic factors in the United States carries significant public health implications. Examining how social patterns influence health inequalities can enhance our understanding of their underlying nature and guide more effective strategies for addressing them [33]. Health disparities that exhibit a distinct socioeconomic threshold, particularly around or near the poverty line, such as significantly higher rates of a specific illness among impoverished individuals compared to more favorable and consistent rates among other income groups, can provide compelling evidence for implementing particular policies. These policies should tackle deprivation-related issues, like substandard housing and hazardous work conditions, which the most marginalized and disadvantaged individuals disproportionately experience [7].

Their objective was to characterize the variations in socioeconomic disparities across a comprehensive set of significant health measures in the United States, encompassing children and adults and distinct racial or ethnic groups. While several studies in the US have demonstrated gradient patterns in adult health metrics [26], they are not aware of any US studies or regular reports since "Health, United States, 1998" that have achieved the following: Assessed socioeconomic disparities across a broad spectrum of health-related indicators for both children and adults Examined a sufficient number of income or education categories to distinguish variations in health within subgroups of the nonpoor (or individuals with at least a high school education) They simultaneously analyzed health disparities concerning socioeconomic and racial or ethnic factors [7].

B. Comprehending Healthcare Socioeconomic Disparities and Policy Interventions

Pursuing the highest level of health for all individuals requires a comprehensive understanding and identification of how disparities impact the health of entire populations within communities, states, and the nation. This involves recognizing and addressing socioeconomic, educational, and access-related disparities to ensure equitable health opportunities and outcomes for everyone [16].

Socioeconomic factors profoundly influence health outcomes. Income distribution, wealth inequality, housing quality, education, employment, and healthcare access are vital in shaping health. Income inequality and its psychosocial impacts are particularly notable. Addressing these disparities is crucial for promoting health equity and improving public health, as shown in Figure 1.

1) Income Inequality: Income has a notable impact on health, but the health improvements per additional dollar diminish (concave relationship), holding significant implications for overall health outcomes, as noted by Rodgers [42]. Over the past three decades, many developed nations, including the United States, have witnessed a significant increase in income inequality. For instance, when we adjust for inflation, the average annual salary in the United States grew from $32,522 in 1970 to $35,864 in 1999, marking a relatively modest 10% increase over those thirty years. In stark contrast, during the same period, the average annual compensation for the top 100 chief executive officers surged from $1.3 million (equivalent to 39 times the average worker's pay) to an astounding $37.5 million (surpassing 1,000 times the average worker's salary) [31]. Wealth inequality trends have also been noteworthy. The net worth of families in the top 10% of income earners escalated by 69%, reaching $833,600 in 2001, up from $493,400 in 1998. In comparison, during this same period, the net worth of families in the lowest fifth-income earners increased by 24%, reaching $7,900. Throughout the 1990s, the median accumulated wealth of families in the top 10 percent income bracket was 12 times greater than that of lower-middle-income families. However, by 2001, the median net worth of the top earners was approximately 22 times as substantial [3]. Financial constraints due to lower incomes often lead to delayed or forgone medical care. This can result in delayed diagnoses and inadequate management of health conditions, ultimately affecting health outcomes as mentioned in Figure 1.

2) Housing and Neighborhood Environment: Low-income families face challenges securing affordable, quality, and secure housing in safe neighborhoods. The recent housing crisis has emphasized the critical role of housing and communities in children's well-being [10].

In 2003, 70% of low-income families grappled with housing cost burdens, spending over 30% of their income on housing [46]. The stability and type of housing are intertwined with housing expenses. Escalating home prices and rents during the late 1990s and early 2000s resulted from increased demand and rising family incomes [40]. Housing quality and safety are pivotal aspects of families' living conditions [36]. Low-income families in the United States often experience housing problems like structural issues, utility problems, and environmental concerns such as pests, mold, and insufficient lighting [6]. Inadequate or unstable housing conditions can expose individuals to environmental hazards and chronic stress, both detrimental to health. Unsafe and unsanitary living environments can also lead to health problems, as shown in Figure 1.

3) Education: Public health initiatives must prioritize educational programs and policies. Empirical research proving the inextricable links between education and health and the importance of social connections, comprehension, reasoning, and emotional control in well-being lend confidence to these claims [20]. The social influence of education on health emphasizes the importance of education in promoting public health. Programs targeting achievement gaps among various groups are required to minimize disparities and advance health equity. This calls for cooperation between health and education partners to carry out evidence-based initiatives with unmistakable public health advantages [20]. Limited health literacy from lower educational levels can lead to misunderstandings about healthcare, treatment options, and preventive measures. This can hinder individuals from making informed decisions about their health. as shown in Figure 1.

4) Employment and Working Conditions: Balancing parental responsibilities and employment can be demanding for many parents, especially when caring for a child with special healthcare needs (CSHCN) [38]. These challenges can lead to increased absenteeism, decreased work productivity, and fatigue due to caregiving duties, potentially impacting paid work hours. In some cases, this may result in reduced work hours or even a cessation of paid employment, temporarily or for an extended period [13]. Balancing work and family is a significant challenge for parents, especially those caring for children with special healthcare needs. Caregiving can lead to fatigue, reduced work productivity, and increased absenteeism, affecting family income as some may work fewer hours or even lose their paid employment, as shown in Figure 1.

5) Healthcare Access: The Affordable Care Act (ACA) highlights that the United States has the most substantial socioeconomic disparities in healthcare access compared to other prosperous nations [19]. The leading cause of the notable health status differences between wealthy and poor people is believed by many healthcare professionals to be gaps in access to health care across socioeconomic categories. Others, however, contend that various factors combine to impede

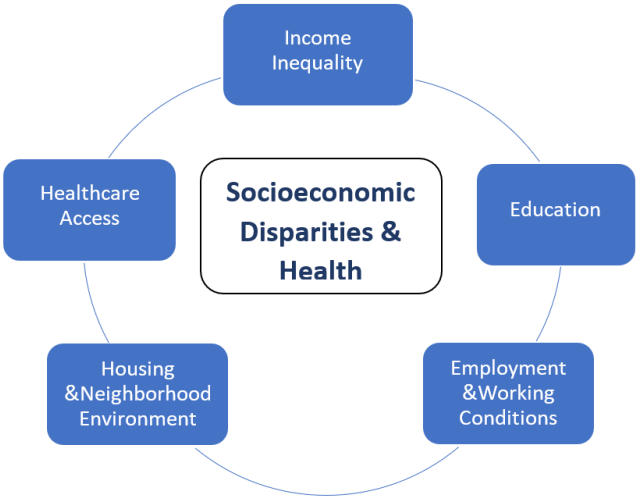

Fig. 1. The Socioeconomic Disparities Visualization

access to care significantly and that lowering or eliminating financial barriers will have minimal impact on the disparities in health status [4]. As mentioned in figure 1, Healthcare access in the United States is characterized by significant socioeconomic gaps, which result in different access for affluent and disadvantaged populations. These differences are the leading cause of health inequality. At the same time, some contend that several variables make access to healthcare more complex, meaning that removing financial obstacles alone may not greatly diminish gaps in health status.

"Policies" refer to legal, administrative, and regulatory measures shaping physical exercise behaviors. They stem from government actions or organizational regulations that guide conduct and can produce intended or unintended effects. Policies, as sociocultural influences, often arise in response to societal demands and preferences, influencing exercise practices on local, state, or national levels [28]. Policy interventions can play a crucial role in reducing socioeconomic disparities in maternal and child health. Several key strategies have been proposed and implemented as shown in Figure 2:

6) Income Support Programs: Policies such as the Earned Income Tax Credit (EITC) and Temporary Assistance for Needy Families (TANF) provide financial assistance to low-income families. These programs help alleviate poverty and improve the economic well-being of families, ultimately benefiting CMH outcomes [25].

7) Education Equity Initiatives: Policies aimed at improving educational opportunities for disadvantaged children can have long-term effects on health [22]. Early childhood education programs, improved school quality, and interventions to reduce the achievement gap can positively impact CMH.

8) Universal Healthcare Access: Expanding access to healthcare through policies like the ACA can reduce disparities in access to medical services. Ensuring all pregnant women

and children access essential healthcare services is critical for improving CMH outcomes [18].

9) Nutrition Programs: Policies that support access to nutritious food, such as the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), can positively impact child nutrition and health [8].

10) Workplace Reforms: Policies that promote job security, fair wages, and family-friendly workplaces can reduce the stress and financial insecurity associated with employment disparities. These reforms can benefit maternal and child well-being [12].

11) Mental Health Services: Policies that improve access to mental health services can address the psychological stressors associated with socioeconomic disparities. Maternal mental health is closely linked to CMH outcomes [35].

12) Community Development Efforts: Targeted investments in disadvantaged communities can improve housing conditions, reduce exposure to environmental hazards, and enhance overall community well-being [11]

These interconnected policy interventions can work synergistically to reduce socioeconomic disparities and improve CMH outcomes. Understanding how these policies interact within a dynamic system is essential for crafting effective strategies.

III. Material and Methodology

The intricate challenges posed by dynamic complexity in public health can often find practical solutions by applying the system dynamics methodology. This approach entails the creation of causal diagrams and policy-driven computer-to-interplay models tailored to the specific circumstances of each problem. Computer visionary Jay W. Forrester formulated the process in the mid-1950s and initially comprehensively expounded upon it in his publication, "Industrial Dynamics" [17]. The International System Dynamics Society was founded in 1983, and a particular interest group focusing on health issues was formed within the society in 2003 [24]. A core principle of system dynamics posits that the intricate behaviors observed in organizational and social systems stem from continuous accumulations—people, resources, information, or even biological and psychological states. Amplification and balancing feedback mechanisms both have an impact on these dynamics. The notions of accumulation and feedback have been discussed in various incarnations for centuries [41]. System dynamics offers a distinctive practical manifestation of these concepts through computerized models. These models enable systematic testing of alternative policies and scenarios, providing answers to both "what if" and "why" questions in a structured manner [48].

Jay Forester (1961) introduced the idea of Causal Loop Diagrams (CLD) in the 1960s [17], and other scholars, including Rosnay (1979) [43], Richardson and Puch (1981) [41], Senge (1990) [45], and Sterman (2000) [47] expanded on it. CLDs are used to map out the feedback and structure of a system to comprehend its feedback mechanisms. The purpose of the CLDs is to help us establish strategies to either work with or oppose the behavior by helping us understand how the behavior has been presenting itself in the system. We also want to discover how and to what degree the issue is related to other "systems".

Addressing Socioeconomic Disparities and Improving Child and Maternal Health Through Policy Interventions	
Policy Interventions	**Socioeconomic Disparities**
Income Support Programs	Improved Income
Education Equity Initiative	Enhanced Education
Affordable Housing Policies	Better Housing Conditions
Universal Healthcare Access	Improved Healthcare Access
Nutrition Programs	Enhanced Nutrition
Workplace Reforms	Stable Employment
Mental Health Services	Improved Mental Health
Community Development Efforts and Social Support	Improved Housing, Nutrition and, Health Knowledge

Fig. 2. The Socioeconomic Disparities and Policy Intervention Visualization

Causal models are used within systems thinking and system dynamics and have been utilized in population health since the 1970s. The focal areas of application have encompassed the following:

- Interactions between the capacity of healthcare systems or public health infrastructure and the epidemiology of diseases [23].
- The capacity and delivery of healthcare services in various domains, including population-based health maintenance organization planning, mental health, and the impact of natural disasters or acts of terrorism [32].
- The movement of patients within emergency and extended care settings [44].

IV. Results and Discussions

Addressing the impact of socioeconomic factors on child and maternal health requires a multifaceted approach that includes policy interventions, improved access to healthcare and education, social support programs, and efforts to reduce income inequality. By addressing these disparities, societies can work towards ensuring that all children and mothers have the opportunity to lead healthy and fulfilling lives, as shown in Figure 2.

A. Exploring how policy interventions and socioeconomic factors interact to influence the health outcomes of both mothers and children.

The complexity of health systems results from the sheer number of people, resources, and processes that make them up. The complex relationships between these elements, which are numerous and varied, also add to the complexity of health

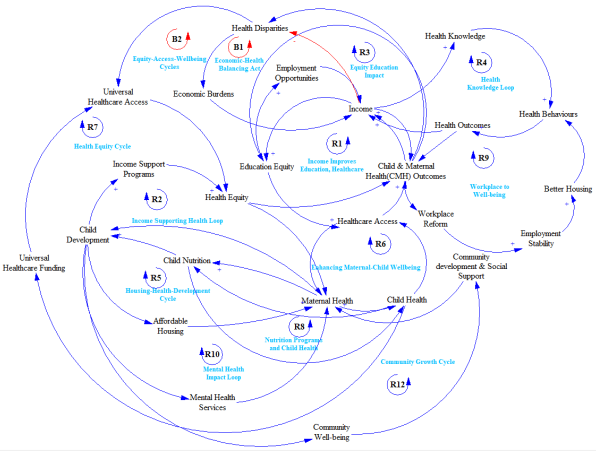

Fig. 3. The Interplay of Causal Loop Diagram for Policy Interventions and Socioeconomics Factors Visualization

systems [5]. Causal loop diagrams (CLDs), a systems thinking technique, offer a valuable tool for understanding complex health system behavior. They can be applied retrospectively and prospectively to identify the causes and consequences of healthcare regulations and initiatives to enhance healthcare delivery. These diagrams serve as a means to educate policymakers and stakeholders about potential solutions to address sub-optimal healthcare outcomes [9]. Therefore, developing health system treatments and assessing their outcomes must be guided by tools created to manage and analyze complicated behavior.

Figure 3 demonstrates the causal loop diagram illustrating how socioeconomic factors and policy interventions interact in the model. This figure shows potential reinforcing and balancing loops resulting from these interactions.

1) Income Improves Education, Healthcare (R1): This loop demonstrates the vital role of income in supporting education and healthcare access, ultimately contributing significantly to the well-being of CMH. Higher income promotes equitable education, leading to improved healthcare access, and positively impacts CMH outcomes, emphasizing the interconnectedness of these factors.

2) Income Supporting Health Loop (R2): This reinforcing loop exemplifies the connection between income support programs and health equity, influencing maternal health and well-being. Policies that enhance health equity may include income support programs, creating a self-reinforcing cycle that contributes to better maternal health, and increasing support for such procedures. This loop underscores the significance of income support in promoting health equity and maternal health development.

3) Equity Education Impact (R3): This reinforcing loop illustrates the positive relationship between education equity, employment opportunities, income, and CMH outcomes. Education equity leads to improved job opportunities and revenue, which, in turn, enhance CMH outcomes. These improved health outcomes reinforce the importance of promoting education equity to achieve better CMH.

4) Health Knowledge Loop (R4): This loop underscores the pivotal role of income in improving child and maternal health. As income rises, it boosts health knowledge, encourages healthier behaviors, and ultimately leads to better health outcomes for both children and mothers.

5) Housing-Health-Development Cycle (R5): This reinforcing loop emphasizes the interplay between affordable housing, maternal health, child nutrition, and child development. Improved access to affordable housing positively influences maternal health and child nutrition. Enhanced child nutrition fosters child development, contributing to the overall well-being of mothers and children. Better child development reinforces the need for continued investment in affordable housing, creating a self-reinforcing cycle that benefits child and maternal health.

6) Enhancing Maternal-Child Wellbeing (R6): This loop demonstrates the positive impact of universal healthcare access fosters maternal health and, consequently, child health, establishing a reinforcing loop. This feedback mechanism improves overall healthcare access and emphasizes its crucial role in enhancing the well-being of both mothers and children.

7) Health Equity Cycle (R7): This complex feedback loop highlights the interdependence of policy, universal healthcare access, health equity, maternal health, child health, and funding. Health equity is promoted through universal access to healthcare, which improves maternal and child health and highlights the need for universal healthcare spending. The existence of funds creates an autonomous system by ensuring continued access to healthcare. It highlights how vital equitable and open access to healthcare is to improving mother and child health.

8) Nutrition Programs and Child Health (R8): This loop underlines the significance of nutrition programs, initiatives, and policies to ensure children access proper nutrition. Doing so contributes to improved child health, which has long-term implications for the overall well-being of individuals and societies.

9) Workplace to Well-being (R9): The loop begins with "Workplace Reform", which positively influences "Employment Stability", leading to "Better Housing". Improved housing enhances "Healthcare Access", which positively affects "Health Behaviors", resulting in better "Health Outcomes". Ultimately, these positive changes benefit "Child and Maternal Outcomes", creating a reinforcing loop that underscores the significance of workplace reform in promoting overall well-being, especially for children and mothers.

10) Mental Health Impact Loop (R10): This loop illustrates the impact of mental health services on maternal health, which, in turn, influences child development. Improved maternal mental health fosters positive child development, creating a beneficial cycle. Conversely, a lack of mental health services can lead to maternal mental health issues, negatively affect-

ing child development. This underscores the significance of accessible mental health support for mothers and children.

11) Community Growth Cycle (R11): This reinforcing loop illustrates how community development and social support can positively impact maternal health, which, in turn, influences child development. Child development contributes to the community's overall well-being, reinforcing the importance of ongoing community development and social support. The loop highlights the interconnectedness of these elements and their collective role in fostering community well-being.

12) Economic-Health Balancing Act (B1): The loop implies that economic stability, driven by income, plays a vital role in addressing health disparities and financial burdens. For child and maternal health, this loop underscores that improving income and reducing health disparities can lead to better access to healthcare services and overall well-being. When individuals have the financial means to access healthcare, it positively impacts child and maternal health outcomes. In contrast, if economic burdens and health disparities persist, it can hinder access to essential healthcare services, potentially leading to adverse health outcomes for mothers and children. Therefore, interventions that break this balancing loop by reducing health disparities and promoting economic stability can positively influence child and maternal health outcomes.

13) Equity-Access-Wellbeing Cycle (B2): In this balancing loop, addressing health disparities leads to establishing universal healthcare access, resulting in health equity. Improved health equity positively influences child and maternal outcomes, completing the cycle. The loop emphasizes the significance of eliminating health disparities for the overall well-being of children and mothers.

V. Conclusion and Future Research

A system dynamics exploration of policy interventions to tackle socioeconomic disparities provides a comprehensive understanding of the complex web of factors influencing child and maternal health. Causal modeling has allowed us to visualize and analyze how various policy interventions can have far-reaching effects on these health outcomes, particularly in addressing socioeconomic disparities. In conclusion, the study highlights the intricate relationships and interdependencies among income, education, healthcare access, health equity, and many other factors. It demonstrates that addressing these factors through well-designed policy interventions can significantly improve child and maternal health. The study also underscores the importance of considering feedback loops and unintended consequences when formulating and implementing policies.

As part of the future research, a system dynamics model can be developed from the causal model and could be improved and expanded with new variables and interactions to thoroughly analyze the health outcomes for mothers and children. The model then can be populated and validated with empirical data to enhance its accuracy and predictive capabilities, making it a more robust tool for policy analysis.

Furthermore, scenario-based investigations can be conducted to simulate the potential impact of various policy interventions under different conditions, helping policymakers make more informed decisions. The model's sensitivity to different parameters and assumptions can be explored to assess the model's reliability under various conditions. The long-term effects of policy interventions on child and maternal health, including how these interventions affect health outcomes over extended periods can be investigated further as well. In order to be able to acquire a more complete picture of the variables at play both the quantitative model and qualitative research could be integrated in future work. The challenges and barriers that may hinder the successful implementation of policy interventions and potential strategies to overcome them is another area that could be explored extensively.

Continued research in this field is vital for creating evidence-based policies and interventions that effectively tackle socioeconomic disparities and improve child and maternal health outcomes. The system dynamics approach presented here is a valuable tool for policymakers and researchers to explore the intricate dynamics of this complex issue and develop targeted strategies for improvement.

References

[1] Adams, C. A. The sustainable development goals, integrated thinking and the integrated report. *Integrated Reporting (IR)* (2017), 1–52.

[2] Ahmed, S., Creanga, A. A., Gillespie, D. G., and Tsui, A. O. Economic status, education and empowerment: implications for maternal health service utilization in developing countries. *PloS one 5*, 6 (2010), e11190.

[3] Andrews, E. L. Economic inequality grew in 90's boom, fed reports. *New York Times 23*, 01 (2003).

[4] Andrulis, D. P. Access to care is the centerpiece in the elimination of socioeconomic disparities in health. *Annals of internal medicine 129*, 5 (1998), 412–416.

[5] Barasa, E. W., Cloete, K., and Gilson, L. From bouncing back, to nurturing emergence: reframing the concept of resilience in health systems strengthening. *Health policy and planning 32*, suppl_3 (2017), iii91–iii94.

[6] Bradman, A., Chevrier, J., Tager, I., Lipsett, M., Sedgwick, J., Macher, J., Vargas, A. B., Cabrera, E. B., Camacho, J. M., Weldon, R., et al. Association of housing disrepair indicators with cockroach and rodent infestations in a cohort of pregnant latina women and their children. *Environmental health perspectives 113*, 12 (2005), 1795–1801.

[7] Braveman, P. A., Cubbin, C., Egerter, S., Williams, D. R., and Pamuk, E. Socioeconomic disparities in health in the united states: what the patterns tell us. *American journal of public health 100*, S1 (2010), S186–S196.

[8] Carlson, S., and Neuberger, Z. Wic works: addressing the nutrition and health needs of low-income families for more than four decades. *Center on Budget and Policy Priorities* (2021).

[9] Cassidy, R., Borghi, J., Semwanga, A. R., Binyaruka, P., Singh, N. S., and Blanchet, K. How to do (or not to do)… using causal loop diagrams for health system research in low and middle-income settings. *Health policy and planning 37*, 10 (2022), 1328–1336.

[10] Coley, R. L., Kull, M., Leventhal, T., and Lynch, A. D. Profiles of housing and neighborhood contexts among low-income families: Links with children's well-being. *Cityscape 16*, 1 (2014), 37–60.

[11] Davidson, N. M. Reconciling people and place in housing and community development policy. *Geo. J. on Poverty L. & Pol'y 16* (2009), 1.

[12] de Ruijter, E., van der Lippe, T., et al. Effects of work characteristics on household outsourcing as a strategy to combine work and home. *Work and occupations 34*, 2 (2007), 205–230.

[13] DeRigne, L., and Porterfield, S. Employment change and the role of the medical home for married and single-mother families with children with special health care needs. *Social science & medicine 70*, 4 (2010), 631–641.

[14] Durkin, M. S., Maenner, M. J., Meaney, F. J., Levy, S. E., DiGuiseppi, C., Nicholas, J. S., Kirby, R. S., Pinto-Martin, J. A., and Schieve, L. A. Socioeconomic inequality in the prevalence of autism spectrum disorder: evidence from a us cross-sectional study. *PloS one 5*, 7 (2010), e11551.

[15] for Health Statistics (US, N. C., et al. Health, united states, 2011: With special feature on socioeconomic status and health.

[16] for Healthcare Research, A., and Quality. 2021 national healthcare quality and disparities report: Executive summary, 2021.

[17] Forrester, J. W. Industrial dynamics. *Journal of the Operational Research Society 48*, 10 (1997), 1037–1041.

[18] Gaffney, A., and McCormick, D. The affordable care act: implications for health-care equity. *The Lancet 389*, 10077 (2017), 1442–1452.

[19] Griffith, K., Evans, L., and Bor, J. The affordable care act reduced socioeconomic disparities in health care access. *Health Affairs 36*, 8 (2017), 1503–1510.

[20] Hahn, R. A., and Truman, B. I. Education improves public health and promotes health equity. *International journal of health services 45*, 4 (2015), 657–678.

[21] Ham, S. A., and Ainsworth, B. E. Disparities in data on healthy people 2010 physical activity objectives collected by accelerometry and self-report. *American journal of public health 100*, S1 (2010), S263–S268.

[22] Heckman, J. J., and Kautz, T. Fostering and measuring skills: Interventions that improve character and cognition.

[23] Homer, J., and Milstein, B. Optimal decision making in a dynamic model of community health. In *37th Annual Hawaii International Conference on System Sciences, 2004. Proceedings of the* (2004), IEEE, pp. 11–pp.

[24] Homer, J. B., and Hirsch, G. B. System dynamics modeling for public health: background and opportunities. *American journal of public health 96*, 3 (2006), 452–458.

[25] Hoynes, H., Miller, D., and Simon, D. Income, the earned income tax credit, and infant health. *American Economic Journal: Economic Policy 7*, 1 (2015), 172–211.

[26] Kanjilal, S., Gregg, E. W., Cheng, Y. J., Zhang, P., Nelson, D. E., Mensah, G., and Beckles, G. L. Socioeconomic status and trends in disparities in 4 major risk factors for cardiovascular disease among us adults, 1971-2002. *Archives of internal medicine 166*, 21 (2006), 2348–2355.

[27] Khadem Broojerdi, A., Baran Sillo, H., Ostad Ali Dehaghi, R., Ward, M., Refaat, M., and Parry, J. The world health organization global benchmarking tool an instrument to strengthen medical products regulation and promote universal health coverage. *Frontiers in medicine* (2020), 457.

[28] King, A. C., Jeffery, R. W., Fridinger, F., Dusenbury, L., Provence, S., Hedlund, S. A., and Spangler, K. Environmental and policy approaches to cardiovascular disease prevention through physical activity: issues and opportunities. *Health Education Quarterly 22*, 4 (1995), 499–511.

[29] Krieger, N., Chen, J. T., and Ebel, G. Can we monitor socioeconomic inequalities in health? a survey of us health departments' data collection and reporting practices. *Public health reports 112*, 6 (1997), 481.

[30] Krieger, N., and Fee, E. Measuring social inequalities in health in the united states: a historical review, 1900–1950. *International Journal of Health Services 26*, 3 (1996), 391–418.

[31] Krugman, P. For richer. *Critical social issues in American education: Democracy and meaning in a globalizing world 3* (2005).

[32] Levin, G., Roberts, E. B., and Hirsch, G. B. The dynamics of human service delivery. *(No Title)* (1976).

[33] Macintyre, S. Understanding the social patterning of health: the role of the social sciences. *Journal of Public Health 16*, 1 (1994), 53–59.

[34] Marmot, M. Social determinants of health inequalities. *The lancet 365*, 9464 (2005), 1099–1104.

[35] Melville, J. L., Gavin, A., Guo, Y., Fan, M.-Y., and Katon, W. J. Depressive disorders during pregnancy: prevalence and risk factors in a large urban sample. *Obstetrics and gynecology 116*, 5 (2010), 1064.

[36] Newman, S. J. Does housing matter for poor families? a critical summary of research and issues still to be resolved. *Journal of Policy Analysis and Management 27*, 4 (2008), 895–925.

[37] Obiyan, M. O., and Kumar, A. Socioeconomic inequalities in the use of maternal health care services in nigeria: trends between 1990 and 2008. *Sage Open 5*, 4 (2015), 2158244015614070.

[38] of Health, U. D., Services, H., et al. The national survey of children with special health care needs chartbook 2009–2010. *Rockville, MD: US Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau* (2013).

[39] Pulok, M. H., Uddin, J., Enemark, U., and Hossin, M. Z. Socioeconomic inequality in maternal healthcare: An analysis of regional variation in bangladesh. *Health & place 52* (2018), 205–214.

[40] Quigley, J. M., and Raphael, S. Is housing unaffordable? why isn't it more affordable? *Journal of Economic Perspectives 18*, 1 (2004), 191–214.

[41] Richardson, G. P. *Feedback thought in social science and systems theory*. University of Pennsylvania, 1991.

[42] Rodgers, G. B. Income and inequality as determinants of mortality: An international cross-section analysis a. *International journal of epidemiology 31*, 3 (2002), 533–538.

[43] Rosnay, J. d. The macroscope: a new world scientific system. *(No Title)* (1979).

[44] Royston, G., Dost, A., Townshend, J., and Turner, H. Using system dynamics to help develop and implement policies and programmes in health care in england. *System Dynamics Review: The Journal of the System Dynamics Society 15*, 3 (1999), 293–313.

[45] Senge, P. The fifth discipline: The art and practice of the learning organization. new york: Currency doubleday. *SengeThe Fifth Discipline: The Art and Practice of the Learning Organisation1990* (1990).

[46] Sherraden, M., and Barr, M. S. Joint center for housing studies harvard university.

[47] Sterman, J. *Instructor's manual to accompany business dyanmics: systems thinking and modeling for a complex world*. McGraw-Hill, 2000.

[48] Sterman, J. D. System dynamics modeling: tools for learning in a complex world. *California management review 43*, 4 (2001), 8–25.