Hybrid Human Policy Modeling: Enhancing Decision-Making using Social Simulations

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Abstract. Healthcare policy making is complex, requiring both human expertise and data-driven support. Agent-based Social Simulations (ABSS) provide a powerful tool for testing the potential consequences of healthcare policy interventions in a controlled environment. By integrating computational modeling with expert knowledge, ABSS enable hybrid-human policy collaborations, where simulation results support human decision-making. This approach facilitates policy refinement and scenario analysis through participatory modeling, leading to more adaptive and socially sustainable policies. We argue that ABSS enhances decision-making by complementing simulation-based insights with qualitative expertise, enabling more sustainable and evidence-based healthcare policies.

Keywords. Hybrid-Human Policy Collaboration, Healthcare, Agent-based Social Simulation, Human-Centered AI

1. Introduction

Healthcare systems are inherently complex as they include human behavior, emergent social phenomena, constant socio-political and economic fluctuations, as well as institutional constraints. Hence, predicting and understanding potential policy outcomes is challenging [1]. These challenges are further intensified by the high-risk nature of the domain, where real-life trials for assessing the consequences of health policy changes can be unethical and/or politically unpalatable, thus limiting the maneuverability of policy makers [2]. Healthcare and population health are in a state of flux [3]. Health, understood as the complete physical, mental and social well-being, means there is always room for improvement [4]. Thus, there is a constant need for monitoring existing and developing new health policy interventions. In this context, *Agent-based Social Simulation* (ABSS) can provide a unique means for *hybrid-human policy collaboration*.

ABSS is a simulation paradigm that is particularly well-suited for simulating social interactions and adaptive behaviour [5]. In an artificial population, individuals are represented by (autonomous) *agents* with specific characteristics that imitate real-world hu-

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man behaviour. This enables *in silico* experiments in a controlled environment to instigate potential consequences of interventions.

The unique potential of social simulations to facilitate public health policy became apparent during the Covid-19 pandemic, where individual-based epistemic models were used to analyse the potential effects of non-pharmaceutical interventions on the spread of the virus [6]. There are manifold examples of social simulations used to inform public health policy making [7], including SARS [8], chronic diseases and health conditions [9], addiction [10] crisis interventions [11], obesity [12], and organ donation [13]. Moreover, applications exist that illustrate societal challenges such as socio-economic inequalities in health [14] or effects of public health policies on health behaviours and disease prevention [15]. Here, we build on this research and highlight the value of ABSS for collaborative hybrid-human policy modeling in healthcare.

2. Collaborative Hybrid-Human Policy Modeling

Well-informed healthcare policy-making requires both human judgment and data-driven support. ABSS enables a hybrid intelligence approach, where human expertise is enhanced through synthetic data from the simulations, which can provide insights into large-scale interactions, uncover emergent phenomena, and optimize outcomes, therefore improving decision-making processes. Computer simulations provide a valuable alternative to real-world experiments as they use models to create artificial systems that imitate the actions and behaviour of real-world systems over time. Through this, simulations provide a testbed that allows for efficiently conducting *what-if* analyses, enabling more time- and cost-efficient experiments in a safe and controlled environment. Results and insights from this artificial system can then be interpreted by policy actors, enabling a better understanding of the real-world system's behavior. Here, it is of utmost importance to include ethical considerations and qualitative expert knowledge, factors that simulations are not able to capture and provide.

Hybrid-human policy collaboration enables the development of more sustainable policy interventions and strategies. Through continuous adjustments of the model and the investigated scenarios based on real-world observations, developments, and needs, ABSS becomes a mediator between stakeholders and policymakers. This enables a novel future-focused approach to scenario thinking, facilitating risk assessment and identification of potential societal threats.

From a public health perspective, this also provides an innovative approach for considering long-term temporal dynamics including socio-demographic changes such as an aging population, urbanization, migration, lifestyle shifts, epidemics, as well as changing health conditions and habits. It further enables stakeholders to engage in participatory modeling and collaborative future making, ensuring policies are societally acceptable and practically implementable [16]. In summary, we argue that hybrid-human policy collaboration facilitates policies that are more adaptable, resilient, and aligned with societal values.

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References

[1] Burton C, Elliott A, Cochran A, Love T. Do healthcare services behave as complex systems? Analysis of patterns of attendance and implications for service delivery. BMC medicine. 2018;16:1-15.

[2] Fowler EF, Gollust SE. The content and effect of politicized health controversies. The ANNALS of the American Academy of Political and Social Science. 2015;658(1):155-71.

[3] Goldman L, Benjamin G, Hernández S, Kindig D, Kumanyika S, Nevarez C, et al. Advancing the health of communities and populations: a vital direction for health and health care. NAM Perspectives. 2017.

[4] Nobile M. The WHO definition of health: a critical reading. Med & L. 2014;33:33.

[5] Gilbert N. Agent-based social simulation: dealing with complexity. The Complex Systems Network of Excellence. 2004;9(25):1-14.

[6] Lorig F, Johansson E, Davidsson P. Agent-based social simulation of the COVID-19 pandemic: A systematic review. Journal of Artificial Societies and Social Simulation. 2021;24(3).

[7] Tracy M, Cerdá M, Keyes KM. Agent-based modeling in public health: current applications and future directions. Annual review of public health. 2018;39(1):77-94.

[8] Huang CY, Sun CT, Hsieh JL, Lin H. Simulating SARS: Small-world epidemiological modeling and public health policy assessments. Journal of Artificial Societies and Social Simulation. 2004;7(4).

[9] Li Y, Lawley MA, Siscovick DS, Zhang D, Pagán JA. Agent-based modeling of chronic diseases: a narrative review and future research directions. Preventing chronic disease. 2016;13:E69.

[10] Keyes KM, Shev A, Tracy M, Cerdá M. Assessing the impact of alcohol taxation on rates of violent victimization in a large urban area: An agent-based modeling approach. Addiction. 2019;114(2):236-47.

[11] Tucker J, Lorig F. Agent-based social simulations for health crises response: utilising the everyday digital health perspective. Frontiers in Public Health. 2024;11:1337151.

[12] Giabbanelli PJ, Tison B, Keith J. The application of modeling and simulation to public health: Assessing the quality of agent-based models for obesity. Simulation Modelling Practice and Theory. 2021;108:102268.

[13] Fabris B, Tucker J, Lorig F. Using agent-based social simulations to inform organ donation policymaking: adopting the Spanish approach in Sweden. In: The 26th International Workshop on Multi-Agent-Based Simulation (MABS2025); 2025. Available from: `https://urn.kb.se/resolve?urn=urn:nbn:se:mau:diva-75295`.

[14] Boyd J, Wilson R, Elsenbroich C, Heppenstall A, Meier P. Agent-based modelling of health inequalities following the complexity turn in public health: a systematic review. International journal of environmental research and public health. 2022;19(24):16807.

[15] Nianogo RA, Arah OA. Impact of public health interventions on obesity and type 2 diabetes prevention: a simulation study. American journal of preventive medicine. 2018;55(6):795-802.

[16] Strange M, Tucker J. Collaborative Future-Making: Bridging the Everyday and the Global Political Economy of Automated Health. The De Gruyter Handbook of Automated Futures: Imaginaries, Interactions and Impact. 2024;2:223.