Microsimulation as a flexible tool to evaluate policies and their impact on socioeconomic inequalities in health

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The Lancet Regional Health - Europe 2023;34: 100758

Published Online 18 October 2023

https://doi.org/10.1016/j.lanepe.2023.100758

Health inequalities are a global concern.[1] They are socially produced, potentially avoidable, and widely considered unacceptable in civilised societies. Reducing them remains a public health policy priority in many countries, especially in light of the unequal impact of the COVID-19 pandemic.[2]

Social, economic, and commercial determinants (collectively called the social determinants of health) have been demonstrated to be important drivers for health inequalities across multiple health outcomes, including morbidity, mortality, and mental health, across many countries and over time.[3–5] Furthermore, a substantial body of evidence suggests a causal relationship between social determinants and health outcomes, although the extent and direction of effects may vary across institutional settings, life stages, and specific health conditions.[6] Taken together, the existing evidence strongly indicates that there is potential for a significant reduction in health inequalities by implementing policies targeting social determinants pathways.[7]

However, progress in addressing health inequalities through policy interventions has been hindered by a lack of actionable research into the health effects of social and economic policies, such as increased social security payments or job retention schemes during labour market crises. This is partly due to practical and ethical constraints limiting the feasibility of large-scale and real-world experiments. However, without research that can directly inform policymaking, the field of health inequalities risks stagnation, reaffirming the same patterns with updated data. Therefore, providing evidence informing change across different policy domains is imperative, necessitating innovative approaches and new methodological tools.

One such tool is microsimulation.[8] Microsimulations simplify the real world by synthesising the best available evidence, theories, and data to project an initial population of micro-units, such as individuals or households, over time. In microsimulations, micro-units are cycled through a series of processes that each predict a specific outcome. The transitions between different states are based on evidence of key modifiable pathways and the application of custom policy scenarios. These models can be tailored to specific contexts and policy needs, making them highly adaptable. They are particularly well-suited for three tasks: quantification of the effects of secular trends on health inequalities, such as population ageing, increasing levels of schooling, or changing household structure; *ex-post* evaluation of the benefits of implementing policies against counterfactual scenarios where the policy is not introduced; and *ex-ante* assessment of policy proposals, before their implementation, which is particularly valuable when empirical evaluations of health impacts are either unavailable

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or when the evidence would take many years to emerge.[9]

Microsimulation also offers a more detailed representation of policy responsiveness than models frequently used to assess medical technology cost-effectiveness, such as cohort-based state transition models. It can model policy interactions and effects that are rule-based (e.g., caps on total social security payments) and behavioural (e.g., high-income taxes reducing labour supply). Additionally, microsimulation models can incorporate dynamic and spatial aspects and provide a detailed description of the tax and benefit system.[10] Moreover, since any combination of individual characteristics can disaggregate simulated output, microsimulation modelling is particularly well-suited to distributional analyses of intersecting inequalities along multiple axes.

Furthermore, policy interventions targeting health inequalities can be costly and challenging to implement and evaluate. Microsimulation provides a cost-effective tool for identifying promising interventions and optimising policy design. While robust ex-post evaluations of real-world policies remain essential, microsimulation can guide the allocation of resources towards policies likely to impact population health and health inequalities.

The authors identify six priority areas particularly suitable for microsimulation analysis in the context of health inequalities: 1) *regulatory policies*, assessing how taxes, minimum pricing, or restrictions on promoting unhealthy goods reduce health inequalities; 2) *healthcare policies*, investigating how different funding mechanisms impact health service access; 3) *social security policies*, identifying the optimal mix of income maintenance, cash transfers, and housing policies to prevent poor health outcomes resulting from relative poverty; 4) *tax regimes*, examining the influence of direct and indirect taxes on health outcomes through changes in labour supply and consumption; 5) *crisis policy responses*, identifying a range of policies to protect population health during crises such as pandemics, recessions, and environmental emergencies; 6) *improving life opportunities*, supporting employability, educational outcomes, and lifelong learning.

Reducing health inequalities is arguably the 'holy grail' of public health. However, there is an urgent need to bridge the gap between research and policy, and policymakers and stakeholders have repeatedly called for actionable evidence to address socioeconomic inequalities in health.[8] While the development of microsimulation models can be hampered by data complexity and high resource demands, these factors are likely to diminish as the adoption of microsimulation models widens and open-source release becomes more widespread. Ultimately, microsimulation offers the opportunity to shift from describing health inequalities to addressing their creation and evolution. Its broader adoption could drive important progress towards better equitable public health policy decisions. The authors welcome collaboration with researchers and policymakers aiming to reduce health inequalities by utilising this emerging tool for epidemiological and public health research.

Contributors
TAE, JVS, and SVK developed the initial idea for the study. DK, JVS, SVK, and TAE wrote the first draft of the manuscript. PB, MR, MC, SA, KEF, CB, HH, IB, and MB provided critical feedback (comments and edits). IB provided managerial support and coordination. The corresponding authors had final responsibility for the decision to submit for publication.

Declaration of interests
DK and SVK acknowledge funding from the Medical Research Council (MC_UU_00022/2), the Scottish Government Chief Scientist Office (SPHSU17) and the European Research Council (949582). The authors declare no other competing interests.

Acknowledgements
The opinions expressed, and arguments used herein are solely those of the authors and do not necessarily reflect the official views of the institutions to which they are affiliated or of the institutions' stakeholders. For open access, the author(s) has applied a Creative Commons Attribution (CC BY) license to any Author Accepted Manuscript version arising from this submission.

Funding: This study was conducted as part of the Centre for Global Health Inequalities Research (CHAIN), funded by the Norwegian Research Council (project number: 288638) and by the European Research Council, grant number 949582. The funding sources have not been involved in writing the commentary and in the decision to submit the article for publication.

References
1 Friel S, Marmot MG. Action on the social determinants of health and health inequities goes global. *Annu Rev Public Health*. 2011;32(1):225–236.
2 Bambra C, Riordan R, Ford J, Matthews F. The COVID-19 pandemic and health inequalities. *J Epidemiol Community Health*. 2020;74(11):964.
3 Mackenbach JP, Kulhánová I, Bopp M, et al. Variations in the relation between education and cause-specific mortality in 19 European populations: a test of the "fundamental causes" theory of social inequalities in health. *Soc Sci Med*. 2015;127:51–62.
4 Rydland HT, Solheim EF, Eikemo TA. Educational inequalities in high- vs. low-preventable health conditions: exploring the fundamental cause theory. *Soc Sci Med*. 2020;267:113145.
5 Allen J, Balfour R, Bell R, Marmot M. Social determinants of mental health. *Int Rev Psychiatry*. 2014;26(4):392–407.
6 Lundberg O. Is lack of causal evidence linking socioeconomic position with health an 'inconvenient truth'? *Eur J Public Health*. 2020;30(4):619.
7 Eikemo TA, Hoffmann R, Kulik MC, et al. How can inequalities in mortality be reduced? A quantitative analysis of 6 risk factors in 21 European populations. *PLoS One*. 2014;9(11):e110952.
8 Rutter CM, Zaslavsky AM, Feuer EJ. Dynamic microsimulation models for health outcomes. *Med Decis Making*. 2011;31(1):10–18.
9 Schofield DJ, Zeppel MJB, Tan O, Lymer S, Cunich MM, Shrestha RN. A brief, global history of microsimulation models in health: past applications, lessons learned and future directions. *Int J Manag*. 2018;11(1):97–142.
10 Bronka P, Richiardi M, van de Ven J. *SimPaths: an open-source microsimulation model for life course analysis. CeMPA working paper series CEMPA6/23 2023*. 2023.