BMJ Open

Microsimulation models on child and adolescent health: a scoping review protocol

Claire de Oliveira [iD] ,[1,2,3] Filipa Sampaio[2,4,5]

¹Campbell Family Mental Health Research Institute and Institute for Mental Health Policy Research, Centre for Addiction and Mental Health, Toronto, Ontario, Canada
²Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden
³Institute of Health Policy, Management and Evaluation, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
⁴Department of Women's and Children's Health, Uppsala University, Uppsala, Sweden
⁵Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Stockholm, Sweden

Correspondence to
Dr Claire de Oliveira;
claire.de.oliveira@uu.se

ABSTRACT

Introduction Microsimulation models are computer-based models, which can be employed to simulate the behaviour of microagents, such as children and adolescents, to understand the potential behavioural and economic effects of health interventions or policies. As a result, these models can be useful tools to help guide decision-making. A comprehensive review of the literature on child and adolescent microsimulation models has yet to be undertaken. Moreover, an evaluation of the quality of the existing models can be useful to understand their strengths and limitations and thus inform the development of future models. The aim of this scoping review will be to retrieve, synthesise and critically appraise the literature on existing microsimulation models focused on child and adolescent health.

Methods and analysis We will conduct a scoping review using established methods. We will search PubMed (until 23 September 2024), Embase (until 18 September 2024), CINAHL (until 9 September 2024), PsycINFO (11 September 2024), EconLit (until 9 September 2024) and Scopus (until 10 September 2024), with an update closer to the time of manuscript submission. We will also undertake snowballing, Google searches and searches on specific journal (eg, *International Journal of Microsimulation*) and websites (eg, https://www.microsimulation.ac.uk/) to complement database searches. We will extract relevant data on all studies retrieved and use the Quality Assessment Reporting for Microsimulation Models checklist to assess the reporting quality of each model. We will use a narrative synthesis with summary tables to describe our findings. Findings will be synthesised by type of health condition, if/where possible.

Ethics and dissemination Given that primary data will not be collected in this study, research ethics approval is not required. We will present our findings at relevant conferences and publish our results in an appropriate peer-reviewed academic journal. In addition, we will use this information to guide the development of a microsimulation model on child and adolescent health for use in the Swedish context.

Registration details https://osf.io/a8txn/

BACKGROUND

There is a vast literature describing the long-lasting effects of poor health in childhood and adolescence. For example, using data from the 1958 longitudinal British birth cohort

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This scoping review will consider studies published in several languages obtained from a variety of academic databases.
⇒ This scoping review will also undertake Google searches (using Google and Google Scholar) and searches on specific journal websites (eg, *International Journal of Microsimulation*) and other relevant websites (eg, https://www.microsimulation.ac.uk/) will be undertaken.
⇒ This scoping review will not consider grey literature.

study, researchers found a strong connection between birth weight and childhood health conditions and later life outcomes, such as educational attainment and labour market outcomes.[1 2] In a systematic review, it was found that childhood circumstances can affect individuals' physical and mental health, cognitive function and social relationships in later adulthood.[3] In most cases, these analyses are possible when individuals can be followed over long periods of time. However, such data are not always readily available, particularly data and evidence on the long-term impact of child and adolescent health-focused policies. Microsimulation models provide an attractive solution to this problem as they can simulate the behaviour of microagents, such as children or adolescents, and thus be used to understand the potential long-term behavioural and economic effects of health interventions/policies. Accordingly, these models can be useful tools to help guide decision-making, particularly in cases where evidence is absent or challenging to obtain.

In a prior systematic review of microsimulation models on mental health, most models focused on the general adolescent and adult populations; only one microsimulation model included children.[4] This model simulated the individual-level disease dynamics of eating disorders (ie, anorexia nervosa, bulimia nervosa, binge eating disorder, and other specified feeding and eating disorders)

from birth to age 40 years.[5] Other work has made use of microsimulation techniques to understand the impact of health and social policies on the public budget. For example, the LifeSim, a dynamic microsimulation model, can be used to model developmental, economic, social and health outcomes from birth to death for each child in the English Millennium Birth Cohort.[6] Additionally, some studies have applied microsimulation to specific health behaviours, such as smoking, among adolescents. Chao and colleagues used an agent-based microsimulation model to explore the impact of social influence of the prevalence of e-cigarette use in peer networks and in the general population on adolescents smoking behaviours.[7] Similarly, the Simulation of Tobacco and Nicotine Outcomes and Policy (STOP) model developed by Reddy and colleagues has been used to project the impact of clinical and public health policies on smoking behaviours and inform the design of tobacco treatment trials.[8] For example, this model was used to estimate the longitudinal transitions in initiation, cessation and relapse of cigarette smoking and e-cigarette use among youth in the USA.[9] Despite this work, a comprehensive review of the literature is required to understand the full scope of the existing microsimulation models on child and adolescent health, including models on physical, mental and behavioural health. Furthermore, to encourage the uptake of microsimulation models by policy makers, it is important that microsimulation models are robust and produce valid outputs. Therefore, it is also important to evaluate the quality of the existing microsimulation models. This scoping review will aim to retrieve, synthesise and critically appraise the literature on existing microsimulation models focused on child and adolescent health.

METHODS AND ANALYSIS

Study design

We propose to undertake a scoping literature review to identify the existing articles on microsimulation models applied to child and adolescent health. Scoping reviews are useful to describe the existing literature on a particular topic, whereas systematic reviews are employed to answer a specific research question.[10] Given that this literature has not yet been comprehensively reviewed, a scoping review was deemed the most appropriate one to undertake.[10] To guide the analysis of the scoping review, we will follow the Joanna Briggs Institute Manual for Evidence synthesis[10] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews.[11] The protocol is registered at Open Science Framework (https://osf.io/a8txn/). We plan to start the analysis on 1 February 2025.

Eligibility criteria

We will employ the Population, Intervention, Control, Outcomes and Study (ie, PICOS) design criteria to guide the development of the search strategy and to inform the inclusion and exclusion criteria. The population of interest will include children and adolescents up to the age of 19 years, in line with child development stages[12] (newborns, infants, toddlers, preschoolers, school-aged children) and the WHO definition of adolescents,[13] while the study design will be a microsimulation model. Microsimulation models that include broader populations will be considered as long as the focus of the model is on children and/or adolescents or produces outputs for these populations. There will be no restrictions on the type of outcomes examined as long as these are health outcomes, including, but not limited to, physical health conditions/disorders, mental health/addiction conditions/disorders and/or neurodevelopmental disorders. The comparison group criterion will not be applicable. We will only consider original studies, but we will undertake snowballing on any relevant related reviews, if/where available, to retrieve studies that are potentially not captured by our search. Study protocols and conference abstracts and/or proceedings will be excluded as we are interested in completed studies describing microsimulation models.

Search strategy

We will search multiple bibliographic databases from database inception: PubMed (until 23 September 2024), Embase (until 18 September 2024), CINAHL (until 9 September 2024), PsycINFO (11 September 2024), EconLit (until 9 September 2024) and Scopus (until 10 September 2024). We will consider all relevant studies published in English, French, German, Chinese, Portuguese and Swedish. We will undertake an update of the search strategy closer to the time of manuscript submission. We will also undertake snowballing (ie, hand searches of references of key articles and reviews), Google searches (using Google and Google Scholar) and searches on specific journal websites (eg, *International Journal of Microsimulation*) as well as other relevant websites (eg, https://www.microsimulation.ac.uk/). Our search will be guided by relevant search terms/strings organised by concepts, as described in table 1 (the full search strategies will be provided as online supplemental materials). The lead investigators (CdO, FS) and a research librarian have developed a structured search strategy reflecting the inclusion and exclusion criteria and tailored these to each database; these search strategies can be found in the online supplemental file.

Study selection

All relevant citations will be uploaded onto Rayan, an online web application for reviews.[14] Following this, duplicate citations will be removed. Two independent reviewers will screen all titles and abstracts, and an additional reviewer will be brought if/where there are disagreements. Subsequently, all relevant articles will be retrieved for full-text review; again, two independent reviewers will review each article, and an additional reviewer will be brought in, if/where necessary, to confirm the final eligibility of the article. In instances where a third reviewer is brought in, the primary reviewers will present their

Table 1 Concepts and search terms used to identify relevant studies

Concept	Search terms
Population	Newborns, infants, toddlers, preschoolers, school-aged children, tweens, teens, teenagers, adolescents, juvenile, youth
Intervention/exposure	Physical health conditions/disorders (allergies, asthma, bronchitis, upper respiratory tract infection, cancer, hypertension, cerebral palsy, congenital heart disease, cystic fibrosis, diabetes, epilepsy, HIV, gastrointestinal disorders, inflammatory bowel disease, irritable bowel syndrome, juvenile arthritis, musculoskeletal disorders, urinary tract infections, urination disorders (anuria, enuresis, glycosuria, haematuria, oliguria, polyuria, proteinuria, incontinence, urinary retention), endocrine disorders, rheumatic disorders, haematological disorders, anaemia, growth disorders, psychosomatic pain, obesity, skin disorders and acne, nutrition disorders (child nutrition disorders, infant nutrition disorders)), mental health/ addiction conditions/disorders (anxiety, depression, eating disorder (anorexia nervosa, bulimia nervosa, binge eating disorder), emotional disorder, post-traumatic stress disorder, PTSD, schizophrenia, psychosis, mood disorder, bipolar disorder, mania, obsessive-compulsive disorder, substance use disorder, smoking, alcohol use, drug use, drug misuse, cannabis use, gambling, suicidal ideation, self-harm, suicide), neurodevelopmental disorders (separation anxiety, attention deficit/hyperactivity disorder, conduct disorder, oppositional defiant disorder, child behaviour disorders, autism spectrum disorder, learning disabilities, developmental disabilities, intellectual disability, tic disorders, Tourette syndrome)
Comparator	n/a
Outcome	n/a
Study design	Microsimulation

n/a - not applicable

reasons for inclusion/exclusion, all three reviewers will discuss the article in question and the third reviewer will ultimately decide on its inclusion.

Data extraction

We will develop a data extraction form, based on the Cochrane good practice data extraction form,[15] which will include the following elements, based on prior related work:[4] study information (author(s), year of publication and country), aim of the model, data source(s) and study population (newborns, infants, toddlers, preschoolers, school-aged children, adolescents), outcomes examined (physical, mental, behavioural and various), type of microsimulation model (static, dynamic and spatial) and description of model and methods, validation (ie, internal validation, where simulated outcomes are compared with actual outcomes and external validation, where model forecasts are compared with other forecasts), robustness checks and model adjustments, such as calibration (ie, parameter adjustments to ensure the model can simulate the distributions of key variables), where applicable, and limitations of the model. Two reviewers will extract and code the data independently. The reviewers will then meet to discuss and resolve any differences in the data extracted. If any disagreements remain, a third reviewer will be brought, if/where necessary, to decide on how best to code the data.

Quality assessment

Critical appraisal of publications is optional when undertaking scoping reviews.[11 16] However, to encourage decision makers to use microsimulation models and their outputs, it is important that these models are robust and of high quality.[17] Therefore, undertaking quality assessment of microsimulation models can be valuable. We will use the Quality Assessment Reporting for Microsimulation Models (QARMM) checklist[4] to assess the quality of the microsimulation models identified in the scoping review. Briefly, the QARMM includes six criteria: purpose of the model, data, transparency, uncertainty, validation and generalisability. The first three criteria relate to the model development and structure; the last three criteria relate to the validity and scope of the results produced by the model. Each item is worth one point (however, half points will be given in cases where the criterion is not fully met). See table 2 for the reporting quality checklist for microsimulation models. Each rating will be done by two independent raters. Raters will meet to resolve any disagreements; in cases where disagreements remain, a third reviewer will be brought in, if/ where necessary. Models with a score >5 will be considered high-quality models, models with a score of 3 or less will be considered low quality and models with scores in between will be classified as medium quality models, as done elsewhere.[3]

Data synthesis

Given the heterogeneity of studies and outcomes examined, undertaking a meta-analysis will not be feasible. Therefore, we will employ a narrative synthesis approach to synthesise the evidence,[18] in line with the approach followed in prior related work.[4] The evidence will be synthesised by model type (eg, static, dynamic) and type of health outcome examined in the model (physical, mental/addiction, neurodevelopmental and various). We will develop tables, which summarise the details around the extracted information, where suitable.

Table 2 The Quality Assessment Reporting for Microsimulation Models (QARMM) checklist

Items	Points
Model development and structure	
Purpose of the model	1
► Are the objectives/goals of the model well defined?	
► Is the target population (ie, individuals with a given mental health condition/disorder) described appropriately?	
Data	1
► Are the data used in the model development representative of the population examined?	
► Are the data sources informing parameter estimations provided?	
► Are the parameters used to populate model frameworks specified?	
Transparency	1
► Is the model structure well described (eg, are assumptions clear, are there choices for the user to make)?	
► Is the time horizon of the model provided?	
► Are all simulated strategies/scenarios specified and/or explained clearly?	
Validity and scope	
Uncertainty	1
► Are model uncertainties discussed?	
► Are sensitivity analyses performed and reported?	
► Is model calibration performed and reported, where required?	
Validation	1
► Is internal and/or external validation performed and reported?	
► Is predictive validation performed and/or attempted?	
Generalisability	1
► Is model generalisability discussed?	
► Are model limitations discussed?	

Patient and public involvement

Patients and/or the public were not involved in this study.

Ethics and dissemination

Given that primary data will not be collected in this study, research ethics approval is not required. We will present our findings at relevant conferences and publish our results in an appropriate peer-reviewed academic journal. In addition, we will use this information to guide the development of a microsimulation model on child and adolescent health for use in the Swedish context.

ORCID iD
Claire de Oliveira http://orcid.org/0000-0003-3961-6008

REFERENCES

1. Currie J, Hyson R. Is the Impact of Health Shocks Cushioned by Socioeconomic Status? The Case of Low Birthweight. *Am Econ Rev* 1999;89:245–50.
2. Case A, Fertig A, Paxson C. The lasting impact of childhood health and circumstance. *J Health Econ* 2005;24:365–89.
3. Parvin MR, Johra FT, Akter F, *et al*. The long-term effects of childhood circumstances on older individuals: A systematic review. *Aging Med (Milton)* 2024;7:239–51.
4. de Oliveira C, Matias MA, Jacobs R. Microsimulation Models on Mental Health: A Critical Review of the Literature. *Value Health* 2024;27:226–46.
5. Ward ZJ, Rodriguez P, Wright DR, *et al*. Estimation of Eating Disorders Prevalence by Age and Associations With Mortality in a Simulated Nationally Representative US Cohort. *JAMA Netw Open* 2019;2:e1912925.
6. Skarda I, Asaria M, Cookson R. LifeSim: A Lifecourse Dynamic Microsimulation Model of the Millennium Birth Cohort in England. *IJM* 2021;14:2–42.
7. Chao D, Hashimoto H, Kondo N. Social influence of e-cigarette smoking prevalence on smoking behaviours among high-school teenagers: Microsimulation experiments. *PLoS One* 2019;14:e0221557.
8. Reddy KP, Bulteel AJB, Levy DE, *et al*. Novel microsimulation model of tobacco use behaviours and outcomes: calibration and validation in a US population. *BMJ Open* 2020;10:e032579.

9 Schwamm E, Noubary F, Rigotti NA, *et al*. Longitudinal transitions in initiation, cessation, and relapse of cigarette smoking and e-cigarette use among US youth and adults: Validation of a microsimulation model. *PLoS One* 2023;18:e0284426.

10 Aromataris E, Lockwood C, Porritt K. In: PillaB, JordanZ, eds. *JBI Manual for Evidence Synthesis*. JBI, 2024.

11 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med* 2018;169:467–73.

12 BalasundaramP. Human growth and development. In: *StatPearls - NCBI Bookshelf*. 2024.

13 World Health Organization (WHO). Adolescent health. Available: https://www.who.int/health-topics/adolescent-health#tab=tab_1 [Accessed 7 Aug 2024].

14 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 2016;5:210.

15 Cochrane. EPOC resources. Cochrane Effective Practice and Organisation of Care. Available: https://epoc.cochrane.org/epoc-resources-old [Accessed 7 Aug 2024].

16 Pham MT, Rajić A, Greig JD, *et al*. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Res Synth Methods* 2014;5:371–85.

17 Sutherland H. Quality Assessment of Microsimulation Models The Case of EUROMOD. *IJM* 2018;11:198–223.

18 Popay J, Roberts HM, Sowden AJ, *et al*. *Guidance on the Conduct of Narrative Synthesis in Systematic Reviews. A Product from the ESRC Methods Programme. Version 1*. 2006.