A framework for developing open source economic models of mental health systems

Matthew P Hamilton[1,*] Caroline X Gao[1,2,3] Glen Wiesner[4] John Gillam[2] Kate M Filia[1,2] Jana M Menssink[1,2] Petra Plencnerova[5] David Baker[1,2] Patrick D McGorry[1,2] Alexandra Parker[6] Jonathan Karnon[7] Sue M Cotton[1,2] Cathrine Mihalopoulos[3]

Abstract

Summary: There is strong in principle support for open source health economic models, but practical barriers limit their availability. We propose a set of principles and standards for the implementation of open source health economic models that are TIMELY - Transparent, Iterative, Modular, Epitomised and Yielding. We then describe a software framework that we have developed for developing TIMELY models in youth mental health and illustrate this framework with an open source utility mapping project.

Data: Data

[1] Orygen, Parkville, Australia
[2] Centre for Youth Mental Health; University of Melbourne, Parkville, Australia
[3] School of Public Health and Preventive Medicine, Monash University, Clayton, Australia
[4] Heart Foundation, Melbourne, Australia
[5] headspace National Youth Mental Health Foundation, Melbourne, Australia
[6] Victoria University, Footscray, Australia
[7] Flinders University, Adelaide, Australia

[*] Correspondence: Matthew P Hamilton <matthew.hamilton@orygen.org.au>

1 Introduction

Computational models have become an essential tool for healthcare policy development [1]. Although influential and widely used, these models routinely contain errors [2], are often poorly reproducible [3,4] and may be infrequently updated or revised [5]. To address these issues, there is increasing in principle support for open source health economics models (OSHEMs) that grant open access to and liberal permission to re-use model source code [6]. However, in-practice implementation of OSHEMs remains rare [7]. Some resistence to adoption centers on.... [8] .

A major shift in how health economic models are implemented.....They may also have educational value in developing the health systems modelling field [9]. However, open source computational models also present a range of conceptual, technical, legal and resourcing issues compared to more traditional approaches to model development.

The health economics field i

copyrights, model misuse, confidential data, software, and time/resources [10] cooperation [11] coding framework / guidance [12] 10 rules [1] Sys review Over the last decade there have been the potential to increase the transparency, reproducibility and reuse of health economic analyses.

Open source frameworks, which have been recommended for the development of mental health modelling field [13], have the potential to help address a number of these challenges. Open source approaches can promote common standards and interoperability, improve model transparency and facilitate routine updates to rectify errors, update data and add features.

- Our project - readyforwhatsnext : open source model of the systems shaping the mental health of young people
- Lack of guidance on open source health economic models and in particular on recommended frameworks for implementing the computational model.
- Focus computational model. Most in need of novel guidance. Also: Of the three components that comprise a mental health computer simulation model - the conceptual model, the mathematical model and the computational model - only the first two are typically developed and reported in a manner that facilitates reuse, refinement and extension by others. This is problematic as the code implementation is where the theory represented by a simulation model is most fully elaborated.

In this article, we aim to:

i. Describe a suggested framework for implementing open source mental health systems models comprised of a foundation set of modelling principles and standards and a software development toolkit.

ii. Provide a worked example of applying the framework to developing open source models for mapping psychological measures to health utility in young people.

2 Motivation

Mental disorders impose high health, social and economic burdens worldwide [14,15]. Much of this burden is potentially avertable [16], but poorly financed and organised mental health systems are ill-equiped for this challenge[17,18]. The large and widespread additional mental health burdens recently observed during the COVID pandemic[19] and predicted as a potential future consequence of global heating [20], highlight the need to improve the resilience and adaptability of these systems. To help stem growing demand for mental health services, policymakers have also been encouraged to place greater emphasis on tackling the social determinants of mental disorder[21].

Realising significant improvements in population mental health may in part depend on gaining better understanding of the systems in which mental disorder emerges and is treated [22]. Currently, the theoretical basis for understanding these systems is weak [23]. Strikingly, it remains unclear why increased investments in mental health care have yet to discernably reduce the prevalence and burden of mental disorders[24]. The literature about how the requirements, characteristics and performance of mental health services are shaped by spatiotemporal context is underdeveloped [25]. There is insufficient evidence to identify the social determinants of mental disorders most amenable to preventative interventions, and for which population sub-groups such interventions would be most effective [26].

Mental health simulation studies rarely explore the features and behaviours of complex systems [13], with mental health economic models predominantly addressing issues relating to the affordability and value for money of individual programs [27]. Single purpose models that assume static systems, even when sufficiently robust to be formally incorporated into Government resource planning processes, may be inadequate for the decision support needs of policymakers and service planners seeking to successfully identify, prioritise, sequence and target multiple elements of complex reform programs [28].

Multi-application, dynamic systems modelling approaches can provide insights about inter-dependencies between candidate policy settings that static models of isolated scenarios cannot [29]. However, greater use of these types of models may require adaptation on the part of funders, modellers and decision-makers. The complexity of multi-application systems models may make them particularly prone to errors [30], thus requiring greater investments in model transparency and validation [31]. These types of models can be highly

resource intensive to develop and may also never be truly "finished", instead requiring ongoing updates to remain relevant to evolving decision contexts [32] and to meet additional feature requests from end-users. The development, validation and maintenance of these types of models may be simply too onerous and long term a burden to remain the responsibility of a single modelling team and might benefit from collaborations across multiple modelling teams, and perhaps the general mental health modelling field. Similarly, more attention to developing partnerships between modellers and decision-makers across the life-cycle of a modelling project can help ensure multi-purpose models can address priority decision topics and have user-interfaces that meet the needs of non-technical users.

3 TIMELY principles and standards

4 ready4 Framework

5 Application

5.1 readyforwhatsnext

5.2 Worked example

6 Discussion

Availability of data and materials

Ethics approval

Details on ethics approvals go here.

Funding

The study was funded by Orygen, VicHealth and Victoria University.

Conflict of Interest

None declared.

References

1. Erdemir A, Mulugeta L, Ku JP, Drach A, Horner M, Morrison TM, et al. Credible practice of modeling and simulation in healthcare: Ten rules from a multidisciplinary perspective. Journal of translational medicine. 2020;18: 369. doi:10.1186/s12967-020-02540-4
2. Radeva D, Hopkin G, Mossialos E, Borrill J, Osipenko L, Naci H. Assessment of technical errors and validation processes in economic models submitted by the company for NICE technology appraisals. International Journal of Technology Assessment in Health Care. 2020;36: 311–316. doi:10.1017/S0266462320000422
3. Jalali MS, DiGennaro C, Guitar A, Lew K, Rahmandad H. Evolution and reproducibility of simulation modeling in epidemiology and health policy over half a century. Epidemiologic Reviews. 2021;43: 166–175. doi:10.1093/epirev/mxab006
4. McManus E, Turner D, Gray E, Khawar H, Okoli T, Sach T. Barriers and facilitators to model replication within health economics. Value Health. 2019;22: 1018–1025. doi:10.1016/j.jval.2019.04.1928
5. Sampson CJ, Wrightson T. Model registration: A call to action. PharmacoEconomics - Open. 2017;1: 73–77. doi:10.1007/s41669-017-0019-2
6. Pouwels X, Sampson CJ, Arnold RJG. Opportunities and barriers to the development and use of open source health economic models: A survey. Value Health. 2022;25: 473–479. doi:10.1016/j.jval.2021.10.001
7. Emerson J, Bacon R, Kent A, Neumann PJ, Cohen JT. Publication of decision model source code: Attitudes of health economics authors. PharmacoEconomics. 2019;37: 1409–1410. doi:10.1007/s40273-019-00796-3
8. Padula WV, McQueen RB, Pronovost PJ. Can economic model transparency improve provider interpretation of cost-effectiveness analysis? Evaluating tradeoffs presented by the second panel on cost-effectiveness in health and medicine. Medical Care. 2017;55. Available: https://journals.lww.com/lww-medicalcare/Fulltext/2017/11000/Can_Economic_Model_Transparency_Improve_Provider.2.aspx
9. Dunlop WCN, Mason N, Kenworthy J, Akehurst RL. Benefits, challenges and potential strategies of open source health economic models. PharmacoEconomics. 2017;35: 125–128. doi:10.1007/s40273-016-0479-8
10. Wu EQ, Zhou Z-Y, Xie J, Metallo C, Thokala P. Transparency in health economic modeling: Options, issues and potential solutions. PharmacoEconomics. 2019;37: 1349–1354. doi:10.1007/s40273-019-00842-0
11. Arnold RJG, Ekins S. Time for cooperation in health economics among the modelling community. PharmacoEconomics. 2010;28: 609–613. doi:10.2165/11537580-000000000-00000
12. Alarid-Escudero F, Krijkamp EM, Pechlivanoglou P, Jalal H, Kao S-YZ, Yang A, et al. A need for change! A coding framework for improving transparency in decision modeling. PharmacoEconomics. 2019;37: 1329–1339. doi:10.1007/s40273-019-00837-x
13. Long KM, Meadows GN. Simulation modelling in mental health: A systematic review. Journal of Simulation. 2017; doi:10.1057/s41273-017-0062-0
14. Bloom DE, Cafiero ET, Jané-Llopis E, Abrahams-Gessel S, Bloom LR, Fathima S, et al. The global economic burden of noncommunicable diseases. 91-93 route de la Capite,CH-1223 Cologny/Geneva,Switzerland: World Economic Forum.; 2011.
15. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990–2019: A systematic analysis for the global burden of disease study 2019. The Lancet Psychiatry. 2022;9: 137–150. doi:10.1016/S2215-0366(21)00395-3
16. Chisholm D, Sweeny K, Sheehan P, Rasmussen B, Smit F, Cuijpers P, et al. Scaling-up treatment of depression and anxiety: A global return on investment analysis. The Lancet Psychiatry. 2016; doi:10.1016/s2215-0366(16)30024-4

17. Saxena S, Thornicroft G, Knapp M, Whiteford H. Resources for mental health: Scarcity, inequity, and inefficiency. The Lancet. 370: 878–889. doi:10.1016/S0140-6736(07)61239-2

18. Whiteford H, Ferrari A, Degenhardt L. Global burden of disease studies: Implications for mental and substance use disorders. Health Affairs. 2016;35: 1114–1120. doi:10.1377/hlthaff.2016.0082

19. Santomauro DF, Mantilla Herrera AM, Shadid J, Zheng P, Ashbaugh C, Pigott DM, et al. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. The Lancet. 2021;398: 1700–1712. doi:https://doi.org/10.1016/S0140-6736(21)02143-7

20. Page LA, Howard LM. The impact of climate change on mental health (but will mental health be discussed at copenhagen?). Psychological Medicine. Cambridge University Press; 2010;40: 177–180. doi:10.1017/S0033291709992169

21. Organization WH, Foundation CG. Social determinants of mental health. Geneva: World Health Organization; 2014.

22. Fried EI, Robinaugh DJ. Systems all the way down: Embracing complexity in mental health research. BMC Medicine. 2020;18: 205. doi:10.1186/s12916-020-01668-w

23. Langellier BA, Yang Y, Purtle J, Nelson KL, Stankov I, Diez Roux AV. Complex systems approaches to understand drivers of mental health and inform mental health policy: A systematic review. Administration And Policy In Mental Health. 2018; doi:10.1007/s10488-018-0887-5

24. Jorm AF, Patten SB, Brugha TS, Mojtabai R. Has increased provision of treatment reduced the prevalence of common mental disorders? Review of the evidence from four countries. World psychiatry : official journal of the World Psychiatric Association (WPA). 2017;16: 90–99. doi:10.1002/wps.20388

25. Furst MA, Gandré C, Romero López-Alberca C, Salvador-Carulla L. Healthcare ecosystems research in mental health: A scoping review of methods to describe the context of local care delivery. BMC Health Services Research. 2019;19: 173. doi:10.1186/s12913-019-4005-5

26. Alegría M, NeMoyer A, Falgàs Bagué I, Wang Y, Alvarez K. Social determinants of mental health: Where we are and where we need to go. Current Psychiatry Reports. 2018;20: 95–95. doi:10.1007/s11920-018-0969-9

27. Knapp M, Wong G. Economics and mental health: The current scenario. World Psychiatry. 2020;19: 3–14. doi:10.1002/wps.20692

28. Commission P. Mental health: Productivity commission inquiry report [Internet]. Productivity Commission; 2020. Available: https://apo.org.au/node/309475

29. Occhipinti JA, Skinner A, Doraiswamy PM, Fox C, Herrman H, Saxena S, et al. Mental health: Build predictive models to steer policy. Nature. 2021;597: 633–636. doi:10.1038/d41586-021-02581-9

30. Saltelli A. A short comment on statistical versus mathematical modelling. Nature Communications. 2019;10: 3870. doi:10.1038/s41467-019-11865-8

31. Eddy DM, Hollingworth W, Caro JJ, Tsevat J, McDonald KM, Wong JB. Model transparency and validation: A report of the ISPOR-SMDM modeling good research practices task force-7. Med Decis Making. 2012;32: 733–43. doi:10.1177/0272989x12454579

32. Jenkins DA, Martin GP, Sperrin M, Riley RD, Debray TPA, Collins GS, et al. Continual updating and monitoring of clinical prediction models: Time for dynamic prediction systems? Diagnostic and Prognostic Research. 2021;5: 1. doi:10.1186/s41512-020-00090-3

A Appendix