PHI UK | Policy Modelling for Health

Briefing Paper

July 2025

What makes a good model?

Recommendations for policy simulation modelling

Dr Lisa Garnham[1], Dr Clementine Hill O'Connor[2], Prof Gerard McCartney[2], Prof Katherine Smith[1]

[1] University of Strathclyde [2]University of Glasgow

Policy Modelling for Health, School of Health and Wellbeing, University of Glasgow, Clarice Pears Building 90 Byres Road, Glasgow, G12 8TB

Email: healthmod@glasgow.ac.uk

www.phiuk.org/policy-modelling-for-health

This briefing paper outlines the findings of a systematic review of the academic and policy literature on policy simulation modelling. It synthesises the recommendations offered by 36 papers on best practice for developing computational models for use in social and economic policy settings.

Methods

This review was conducted by four academics at the University of Strathclyde and the University of Glasgow, as part of the PHI UK Policy Modelling for Health Consortium.

We undertook a systematic search of two academic databases, as well as searching policy literature for relevant papers via policy publication databases and our policy networks. We undertook two rounds of reference tracing of the papers identified through these searches and then cross-checked our searches using AI search tool Elicit. Two reviewers screened and extracted from each of the papers included in the review.

A list of the papers included in this review is provided at the end of this briefing paper. A fuller version of this review, including a detailed methodology, has also been submitted for peer reviewed academic publication and conforms to PRISMA reporting guidelines.

Recommendations

Two sets of recommendations were identified.

The first six recommendations describe **characteristics of models** that affect their **usability** in policy settings; these unpin the quality of the models as evidence tools. They are that models should:

- Be as **simple** as possible
- Use the highest **quality data** available, which may be qualitative
- Have undergone extensive **verification, sensitivity and robustness** checks
- Have had their outputs **validated**, either quantitatively or qualitatively
- Be **compatible**, in terms of software and hardware, with policy users' systems
- By supported by thorough **documentation** in varying levels of detail for different audiences

The second five describe aspects of the model development process and affect the **usefulness** of models in policy settings because they underpin the relevance of the model to real-world problems. They are that model development should involve:

- **Collaboration** with model users and other stakeholders
- **Framing** models in a way that is coherent with model users' perspectives
- Being **responsive** to changes in the real-world being modelled and the policymaking context
- **Scrutiny** by external experts, stakeholders and publics
- **Embedding** within policy settings, including training and plans for ongoing maintenance

This briefing paper includes further details on these recommendations – See **Detailed recommendations on what makes a 'good' policy simulation model.**

An online interactive map of these recommendations is available. Visit - What makes a 'good' policy simulation model? Findings of a systematic literature review.

Conclusions

These recommendations describe models that have **utility, transparency and credibility** as part of the policy process. They also incorporate learning from two overarching debates within the literature on this topic.

First, more than half of the papers in this review criticised **models being used for purposes for which they were not designed**. Specifically, they cautioned against presenting the outputs of models that were designed to explore theories of cause and effect or to illustrate possible impacts of policy intervention as numbers that predict what will happen in future, if a particular policy is implemented. Many also noted that models that incorporate social processes (such as policy simulation models) are typically not accurate predictors and are more useful as exploration tools.

Second, the **involvement of publics** in the development and use of models in policymaking was highlighted as an issue of longstanding concern by a number of papers in this review. They criticised the lack of involvement of members of the public in modelling, especially those who are affected by the policy decisions informed by models and their outputs.

Limitations

It has not been possible within this review to assess whether there are any **trade-offs** between these recommendations. For example, to what extent does a deep process of collaboration with a wide range of stakeholders inhibit a model's responsiveness to changing policy priorities?

It has also not been possible to explore the extent to which model users would **prioritise** any of the features or qualities of models or the model development process over others. This is because the papers in this review were largely based on single case studies or commentaries by experienced, academic model developers and very few gathered the perspectives of policy analysts or decision makers.

Next Steps

This literature review will be complemented by a series **of interviews and workshops** with policy decision-makers who use models and model outputs in their work, as well as model developers.

The aim of this future work is to deepen our understanding of these findings and establish how they relate to the use of models in social, economic and public health policy decision-making in a UK context. It will explore both the **technical trade-offs** between these recommendations and models **user's preferences and priorities**.

The next phase of this work will be undertaken over 2025/2026.

Detailed recommendations on what makes a ‘good’ policy simulation model

These six recommendations describe **characteristics of models** that affect their **usability** in policy settings; these unpin the quality of the models as evidence tools.

1. **Model simplicity**

   What does best practice look like? Designing models that are as simple as possible while still capturing the essential components needed for their intended purpose.

   Why is it important? Simpler models support usability, transparency, and communication, especially when integrated with or compared against other models to build confidence. When aligned with purpose, it helps balance explanatory power with practical utility.

   What are the challenges? Oversimplification can exclude critical system behaviours, undermining a model’s usefulness for insight or complex analysis. Determining the right level of simplicity requires careful judgment and depends heavily on the model's intended use and audience.

2. **Data quality**

   What does best practice look like? Using robust, well-documented data and being transparent about its provenance, quality, and limitations. Where high-quality quantitative data is unavailable, alternative strategies such as expert elicitation, uncertainty modelling, and collaborative reflection can be used to address gaps.

   Why is it important? Data quality directly affects the credibility, reliability, and outcomes of models, making it essential for informed decision-making and user trust.

   What are the challenges? There is limited consensus on what constitutes ‘quality’ data in practice, and tensions may arise between technical standards and user preferences. Addressing data scarcity or questionable quality requires judgement, iteration, and negotiation, with few established criteria for when alternatives should be pursued.

3. **Model testing: verification, sensitivity and robustness**

   What does best practice look like? Verifying a model's internal logic and code to check for errors, followed by sensitivity and robustness checks tailored to the model's purpose. These help identify overly influential variables, test performance under extreme conditions, and can be guided by structured frameworks or checklists specific to the model's type and purpose.

   Why is it important? Validation, sensitivity, and robustness testing support user confidence, clarify limitations, and help defend the model's use in public or policy-facing settings.

   What are the challenges? Determining how much testing is sufficient depends on the model's purpose and the expectations of users or policymakers. These processes can be technically complex and time-consuming, requiring careful documentation and expert judgment.

4. **Validation of model outputs**

   What does best practice look like? Validation is the process through which a model's outputs are assessed as plausible and should be guided by the model's intended use, with flexible criteria rather than binary judgments. It may be carried out by comparison with real-world data or through expert appraisal of outputs.

   Why is it important? Validation helps to assess whether or not a model is credible and suitable for its applied context. However, it should be noted that no model can ever be proven to be completely 'correct', even with thorough validation processes in place.

   What are the challenges? There is no single validation method suitable for all models or purposes. Strict validation standards can be misleading and applying them without regard to model purpose risks inappropriate rejection or overconfidence.

5. **Technical compatibility**

   What does best practice look like? Ensuring models align with users' hardware, software, data systems, and workflows. Interfaces should be intuitive, compatible with existing infrastructure, and require minimal training or specialist support.

Why is it important? Technical compatibility ensures models are usable in real-world policy settings by supporting adoption, autonomy, and long-term integration into decision-making processes. Without it, even technically sound models may be ignored or misused.

What are the challenges? Government departments often face hardware constraints and limited technical capacity, making it difficult to implement complex or resource-intensive models. Overly technical interfaces or reliance on external consultants can undermine user confidence and reduce sustainable model use.

6. Documentation

What does best practice look like? Clear, comprehensive, and regularly updated documentation tailored to developers, analysts, policymakers, and the public. It should detail model purpose, assumptions, limitations, uncertainties, and processes in accessible formats using consistent structure and visual aids.

Why is it important? Documentation facilitates transparency, trust, and informed use by making model structure and reasoning visible, rather than a 'black box'. It also preserves institutional memory around models and allows for scrutiny, reuse, and responsible integration into policy.

What are the challenges? It is time-consuming and technically demanding to write, requiring careful balance between clarity and accuracy, especially when communicating with non-experts. Risks include oversimplification, loss of institutional knowledge due to poor version tracking, and misinterpretation of outputs if documentation is incomplete or unclear.

These five aspects of the model development process affect the **usefulness** of models in particular policy settings; these underpin the relevance of the model to real-world problems:

1. Collaboration

What does best practice look like? The active, iterative involvement of model users throughout the entire modelling process, from design to deployment

and maintenance. Clear roles, open communication, mutual learning, and dialogue between developers and users are key.

Why is it important? Effective collaboration enhances model quality, prevents misuse, supports interface design, and increases uptake by making the model meaningful to all stakeholders. It ensures models are relevant, credible, and aligned with real-world decision-making needs, while fostering user understanding, trust, and ownership.

What are the challenges? Collaboration requires time, resources, and specialised communication skills, and can be hindered by technical language, power imbalances, or unclear expectations. Ensuring all voices are heard and changes are transparently communicated is essential to avoid tokenism and build genuine, productive partnerships.

2. Framing and coherence

What does best practice look like? Framing refers to how a policy problem is understood by model users, which should shape what a model includes, how it behaves, and how its outputs are presented. Best practice involves exploring existing problem understandings, aligning models with users' knowledge and terminology, and making underlying assumptions and value frames transparent in presenting model outputs.

Why is it important? Coherence between the model's frame and the perspectives of its intended users is essential for model credibility, relevance, and uptake in policy settings. Where multiple or conflicting stakeholder views exist, using diverse models or facilitating explicit deliberation of assumptions helps preserve the scientific integrity and ethics of the development process.

What are the challenges? Identifying which stakeholders to involve in framing, reconciling diverse or conflicting frames, and addressing power imbalances in whose perspectives dominate the modelling process. Publics are often under-represented, despite the impact models have on them and their potential role in improving model legitimacy and acceptance.

3. Responsiveness

What does best practice look like? Responding to evolutions in the policy landscape during model development, building flexibility for future

adaptation into models, and continuously reassessing model relevance and assumptions during use. Ensuring the models and model outputs are delivered in a timely way, so as not to overshoot crucial policy decision-making windows.

Why is it important? Responsiveness ensures models remain relevant, timely, and valuable across different stages of policy decision-making.

What are the challenges? Balancing flexibility with credibility and the need for timely model outputs, and ensuring resources are available for ongoing model maintenance and updates.

4. Scrutiny

What does best practice look like? Initiating scrutiny throughout a model's lifecycle, open sharing of code, transparent documentation, and creating spaces for qualitative interrogation. Inviting both external experts and members of the public affected by the policies that models will influence to challenge a model, in a process distinct from internal testing.

Why is it important? To enhance both the technical quality and the democratic legitimacy of models and their outputs. Scrutiny strengthens model credibility, reveals limitations, reduces bias, and ensures model outputs are robust and defensible in policy settings.

What are the challenges? The technical complexity and opacity of models, which can hinder understanding and meaningful critique, especially by non-experts. Scrutiny may also be constrained by reputational risks, technical barrier to accessing models, and a lack of structured, open processes for review and improvement.

5. Embedding and maintenance

What does best practice look like? Identifying model champions, providing tailored training, designing user-friendly interfaces for different types of user, and planning for ongoing model maintenance and appraisal from the outset.

What is it and why is it important? Embedding models in policy settings ensures their sustained use, supports informed decision-making, and

enhances institutional trust in model outputs. Without these practices, models risk being underused, misunderstood, or becoming obsolete.

What are the challenges? Securing long-term resources for maintenance, adapting training for diverse user needs, and balancing interface simplicity with flexibility. Organisational turnover, shifting policy priorities, and limited technical capacity can also undermine consistent use and evaluation.

References

1. Aodha, L. n., Edmonds, B., & Meyer, R. (2017). Some Pitfalls to Beware When Applying Models to Issues of Policy Relevance. *Simulating Social Complexity: A Handbook*, 801-822. https://doi.org/10.1007/978-3-319-66948-9_29
2. Arhweiler, P., & Gilbert, N. (2015). The Quality of Social Simulation: An Example from Research Policy Modelling. In M. Janssen, M. A. Wimmer, & A. Deljoo (Eds.), *Policy practice and digital science: integrating complex systems, social systems, social simulation and public adminstration in policy research* (Vol. 10, pp. 35-55). https://doi.org/10.1007/978-3-319-12784-2_310.1007/978-3-319-12784-2
3. Calder, M., Craig, C., Culley, D., de Cani, R., Donnelly, C. A., Douglas, R., Edmonds, B., Gascoigne, J., Gilbert, N., Hargrove, C., Hinds, D., Lane, D. C., Mitchell, D., Pavey, G., Robertson, D., Rosewell, B., Sherwin, S., Walport, M., & Wilson, A. (2018). Computational modelling for decision-making: Where, why, what, who and how. *R. Soc. Open Sci.*, *5*(6). https://doi.org/10.1098/rsos.172096
4. Di Fiore, M., Kuc-Czarnecka, M., Piano, S. L., Puy, A., & Saltelli, A. (2023). Mind the framing: Match purpose and context. *The Politics of Modelling: Numbers Between Science and Policy*, 37-50.
5. Edmonds, B., Le Page, C., Bithell, M., Chattoe-Brown, E., Grimm, V., Meyer, R., Montanola-Sales, C., Ormerod, P., Root, H., & Squazzoni, F. (2019). Different Modelling Purposes. *Journal of Artificial Societies and Social Simulation*, *22*(3), 6. https://doi.org/10.18564/jasss.3993
6. Feenstra, T., Corro-Ramos, I., Hamerlijnck, D., van Voorn, G., & Ghabri, S. (2022). Four Aspects Affecting Health Economic Decision Models and Their Validation. *Pharmacoeconomics*, *40*(3), 241-248. https://doi.org/10.1007/s40273-021-01110-w
7. Gaber, N., Pascual, P., Foley, G., Stiber, N., & Sunderland, E. (2006). A protocol for the development, evaluation and application of environmental models in decision making. *Proc. iEMSs Bienn. Meet.,"Summit Environ. Model. Softw."*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84858673048&partnerID=40&md5=45081e090201bc84d7f58896ad8b99ec
8. Gilbert, N., Ahrweiler, P., Barbrook-Johnson, P., Narasimhan, K. P., & Wilkinson, H. (2018). Computational modelling of public policy: Reflections on practice. *JASSS*, *21*(1). https://doi.org/10.18564/jasss.3669
9. Greenberger, M., Crenson, M. A., & Crissey, B. L. (1976). *Models in the policy process*. Russell Sage Foundation.

10. Grimm, V., Johnston, A. S. A., Thulke, H. H., Forbes, V. E., & Thorbek, P. (2020). Three questions to ask before using model outputs for decision support. *Nature Communications*, *11*(1), 4959. https://doi.org/10.1038/s41467-020-17785-2
11. Hartley, K., & Kirchherr, J. (2023). Circular economy: Trust the models? *Resources, Conservation and Recycling*, *190*, 106793. https://doi.org/10.1016/j.resconrec.2022.106793
12. Jakeman, A. J., Letcher, R. A., & Norton, J. P. (2006). Ten iterative steps in development and evaluation of environmental models.
13. Kolkman, D. (2015). *Models in Policy Making*
14. Kolkman, D. A., Campo, P., Balke-Visser, T., & Gilbert, N. (2016). How to build models for government: criteria driving model acceptance in policymaking. *Policy Sciences*, *49*(4), 489-504. https://doi.org/10.1007/s11077-016-9250-4
15. Lotzmann, U., & Wimmer, M. A. (2013). TRACEABILITY IN EVIDENCE-BASED POLICY SIMULATION. *PROCEEDINGS 27TH EUROPEAN CONFERENCE ON MODELLING AND SIMULATION ECMS 2013*, 696-+. https://doi.org/10.7148/2013-0696
16. Majstorovic, D., Wimmer, M. A., Lay-Yee, R., Davis, P., & Ahrweiler, P. (2015). Features and Added Value of Simulation Models Using Different Modelling Approaches Supporting Policy-Making: A Comparative Analysis. *Public Adm. Inf. Technol.*, *10*, 95-123. https://doi.org/10.1007/978-3-319-12784-2_6
17. Metcalf, C. J. E., Edmunds, W. J., & Lessler, J. (2015). Six challenges in modelling for public health policy. *EPIDEMICS*, *10*, 93-96. https://doi.org/10.1016/j.epidem.2014.08.008
18. Parker, P., Letcher, R., Jakeman, A., Beck, M. B., Harris, G., Argent, R. M., Hare, M., Pahl-Wostl, C., Voinov, A., Janssen, M., Sullivan, P., Scoccimarro, M., Friend, A., Sonnenshein, M., Barker, D., Matejicek, L., Odulaja, D., Deadman, P., Lim, K., . . . Bin, S. (2002). Progress in integrated assessment and modelling: Summary of a workshop on Integrated Assessment and Modelling, held at EcoSummit 2000, Integrating the Sciences, Halifax, June 18–22, 2000. See Costanza and Jorgensen (2001) for a further report on Ecosummi. *Environmental Modelling & Software*, *17*(3), 209-217. https://doi.org/https://doi.org/10.1016/S1364-8152(01)00059-7
19. Parker, W. S. (2020). Model Evaluation: An Adequacy-for-Purpose View. *Philosophy of Science*, *87*(3), 457-477. https://doi.org/10.1086/708691
20. Perello-Moragues, A., Noriega, P., Popartan, L. A., & Poch, M. (2021). On Three Ethical Aspects Involved in Using Agent-Based Social Simulation for Policy-Making. *Springer Proc. Complex.*, 415-427. https://doi.org/10.1007/978-3-030-61503-1_40
21. Piano, S. L., Sheikholeslami, R., Puy, A., Saltelli, A., & Di Fiore, M. (2023). Sensitivity auditing: A practical checklist for auditing decision-relevant models. *The Politics of Modelling: Numbers Between Science and Policy*, 121-136.
22. Responsibility, O. f. B. (2015). *Office for budget responsibility: forcast evaluation report*. Williams Lea Group on behalf of the Controller of Her Majesty's Stationery Office. https://obr.uk/docs/dlm_uploads/FER2015_____web.pdf
23. Risbey, J., van der Sluijs, J., Kloprogge, P., Ravetz, J., Funtowicz, S., & Corral Quintana, S. (2005). Application of a checklist for quality assistance in environmental modelling to an energy model. *Environmental Modeling & Assessment*, *10*(1), 63-79. https://doi.org/10.1007/s10666-004-4267-z
24. Saltelli, A., Bammer, G., Bruno, I., Charters, E., Fiore, M. D., Didier, E., Espeland, W. N., Kay, J., Piano, S. L., Mayo, D., Pielke, R. J., Portaluri, T., Porter, T. M., Puy, A., Rafols, I., Ravetz, J. R., Reinert, E., Sarewitz, D., Stark, P. B., . . . Vineis, P. (2020). COMMENT: Five ways to ensure that models serve society: a manifesto. *Nature*, *582*, 482-484. https://doi.org/10.1038/d41586-020-01812-9

25. Saltelli, A., & Funtowicz, S. (2014). When All Models Are Wrong. *Issues Sci. Technol., Fall*, *2013*.
26. Schmolke, A., Thorbek, P., DeAngelis, D. L., & Grimm, V. (2010). Ecological models supporting environmental decision making: a strategy for the future. *Trends in Ecology & Evolution*, *25*(8), 479-486. https://doi.org/10.1016/j.tree.2010.05.001
27. Squires, H., Chilcott, J., Akehurst, R., Burr, J., & Kelly, M. P. (2016). A Framework for Developing the Structure of Public Health Economic Models. *Value Health*, *19*(5), 588-601. https://doi.org/10.1016/j.jval.2016.02.011
28. Stirling, A., Saltelli, A., & Di Fiore, M. (2023). Mind the unknowns: Exploring the politics of ignorance in mathematical models. *The Politics of Modelling: Numbers Between Science and Policy*, 99-118.
29. Syme, G. J., Bennett, D., Macpherson, D. K., & Thomas, J. F. (2011). Guidelines for policy modellers-30 years on: New tricks or old dogs? *19TH INTERNATIONAL CONGRESS ON MODELLING AND SIMULATION (MODSIM2011)*, 2948-2953.
30. Technology, G. O. f. S. a. (2018). *Computational modelling: technological futures*.
31. Thompson, E. (2022). *Escape from Model Land: how mathematical models can lead us astray and what we can do about it*. Basic Books.
32. Thompson, J., McClure, R., Scott, N., Hellard, M., Abeysuriya, R., Vidanaarachchi, R., Thwaites, J., Lazarus, J. V., Lavis, J., Michie, S., Bullen, C., Prokopenko, M., Chang, S. L., Cliff, O. M., Zachreson, C., Blakely, A., Wilson, T., Ouakrim, D. A., & Sundararajan, V. (2022). A framework for considering the utility of models when facing tough decisions in public health: a guideline for policy-makers. *Health Res. Policy Syst.*, *20*(1). https://doi.org/10.1186/s12961-022-00902-6
33. Treasury, H. (2013). *Review of quality assurance of Government analytical models: final report*. Retrieved from https://assets.publishing.service.gov.uk/media/5a7c7363e5274a5590059f36/review_of_qa_of_govt_analytical_models_final_report_040313.pdf
34. Treasury, H. (2015). *The Aqua Book: guidance on producing quality analysis for government*. London: Crown Retrieved from https://assets.publishing.service.gov.uk/media/5a7f3bb8e5274a2e87db49be/aqua_book_final_web.pdf
35. van Delden, H., Seppelt, R., White, R., & Jakeman, A. J. (2011). A methodology for the design and development of integrated models for policy support. *Environmental Modelling & Software*, *26*(3), 266-279. https://doi.org/https://doi.org/10.1016/j.envsoft.2010.03.021
36. Watson, M. (2024). 'Let me tell you a story': the politics of macroeconomic models. *New Political Economy*, 1-13. https://doi.org/10.1080/13563467.2024.2359964

This work was supported by UK Research and Innovation funding for the Policy Modelling for Health consortium (MR/Y030656/1) which is part of Population Health Improvement UK (PHI UK), a national research network which works to transform health and reduce inequalities through change at the population level.