
Article:
Purshouse, R.C. orcid.org/0000-0001-5880-1925, Buckley, C. orcid.org/0000-0002-8430-0347, Brennan, A. orcid.org/0000-0002-1025-312X et al. (1 more author) (2021) Commentary on Robinson et al. (2021): Evaluating theories of change for public health policies using computer model discovery methods. Addiction, 116 (10). pp. 2709-2711. ISSN 0965-2140

https://doi.org/10.1111/add.15595

ADDICTION
SSA SOCIETY FOR THE STUDY OF ADDICTION
COMMENTARY

Commentary on Robinson *et al.* (2021): Evaluating theories of change for public health policies using computer model discovery methods

Recent developments in computer modelling—known as model discovery—could help to confirm the mechanisms underpinning Robinson and colleagues' important early findings for the effectiveness of minimum unit pricing, and to test the complete theory of change underpinning this crucial evaluation.

Robinson and colleagues provide important evidence for understanding the short-term impact of minimum unit pricing (MUP) in Scotland [1]. Their finding of a 3.5% reduction in off-trade alcohol sales since the introduction of the policy on 1 May 2018 aligns with previous research reporting a reduction in alcohol purchasing by households in the first 8 months post-implementation [2].

Evaluators increasingly seek evidence on the mechanisms underlying policy effects. Mechanism-focused evidence is important because it helps identify wider secondary effects (positive or negative), helps interpret claims of causality, supports assessments of longer-term effectiveness and can inform the transfer of policies to different contexts [3]. It is reassuring that the present study is part of a much broader MUP evaluation programme examining a variety of mechanisms [4].

The programme is informed by a theory of change that identifies a central pathway anticipated to determine policy effectiveness and additional pathways, which could interact with the policy [4]. The central pathway posits that retailer compliance with MUP legislation increases retail prices of some alcohol products; these price increases lead to reduced purchasing and consumption of alcohol products, which reduces the risk of alcohol-related harm to individuals and society. This pathway aligns with computer model-based appraisals that informed the MUP decision [5,6]. The additional pathways consider market responses to MUP and impacts on the alcohol industry, changes in social norms and attitudes, changes in spending on food and essentials among heavier drinkers and increased demand for specialist alcohol treatment services. The theory of change explicitly acknowledges that MUP impact may also be shaped by external factors, such as changes in disposable income.

One possibility absent from the programme is the use of formal computer modelling to test and confirm the rich set of mechanisms in the MUP theory of change using an approach known as model discovery. Developed in the physical sciences, model discovery combines computer modelling with machine learning to search through the possible explanations for a phenomenon to identify which explanation can best represent the observed data [7]. Model discovery goes beyond best practice approaches for calibrating models to data [8], by identifying not just model parameters, but also model structures (i.e. the formal equations and their corresponding computer code). State of the art model discovery techniques are now moving to investigate social phenomena that involve contested explanations and reflexive human behaviour, including alcohol use [9–11]. Our own approach draws on the work of the American sociologist, James Coleman, who developed a typology of explanatory mechanisms based on individuals and social structures such as norms and institutions [12]. In terms of the MUP evaluation, Coleman's typology suggests we can model how social norms interact with MUP using three mechanism types: situational mechanisms explain how social structures affect individuals (i.e. how social norms are transmitted between and perceived by individuals); action mechanisms explain how perceived norms influence individuals' drinking behaviours; and transformational mechanisms explain how drinking behaviours collectively change norms as social structures. These mechanisms can most naturally be expressed as the 'building blocks' of an agent-based model (ABM)—a computational approach to modelling interacting agents and social structures that is gaining prominence in social psychology and the addictions field [13,14]. Model discovery has already identified competing explanations for the role of social norms in drinking trends [15], using empirical ABMs automatically constructed by machine learning from Coleman-like building blocks [16,17].

The next step for applying model discovery to the MUP evaluation is the development of all the necessary building blocks in the theory of change—some of which do not yet exist. A collective research effort is needed by modellers to develop building block-style ABMs and deliver a richer library of mechanisms. West and colleagues' formal ontology of behavioural theories from psychology offers fertile ground for developing the action mechanisms for such a library [18]. Broader sociological perspectives on substance use are also needed [19].

Model discovery offers the exciting opportunity of identifying the combinations of mechanisms that reproduce the

alcohol sales observations from Robinson *et al.* [1]. Understanding whether and how these combinations align with the MUP theory of change would usefully inform not only the MUP evaluation itself but also theories of change for future policy design, appraisal and evaluation on further key areas of policy debate.

Declaration of interest

None.

Acknowledgements

Computer model discovery research by the authors is funded by the National Institute on Alcohol Abuse and Alcoholism of the National Institutes of Health under Award Number R01AA024443.

Author contributions

Robin Purshouse: Conceptualization; funding acquisition; methodology. **Charlotte Buckley:** Methodology. **Alan Brennan:** Methodology. **John Holmes:** Methodology.

Keywords Agent-based modelling, alcohol, computer modelling, minimum unit pricing, model discovery, policy evaluation.

ROBIN C. PURSHOUSE[1], CHARLOTTE BUCKLEY[1], ALAN BRENNAN[2] & JOHN HOLMES[2]

Department of Automatic Control and Systems Engineering, University of Sheffield[1] and School of Health and Related Research, University of Sheffield[2]

E-mail: r.purshouse@sheffield.ac.uk

Submitted 21 May 2021; final version accepted 27 May 2021

References

1. Robinson et al. 2021.
2. O'Donnell A., Anderson P., Jané-Llopis E., Manthey J., Kaner E., Rehm J. Immediate impact of minimum unit pricing on alcohol purchases in Scotland: controlled interrupted time series analysis for 2015-18. *BMJ* 2019; **366**: l5274.
3. Craig P., Dieppe P., Macintyre S., Michie S., Nazareth I., Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ* 2008; **337**: a1655.
4. Beeston C., Robinson M., Giles L., Dickie E., Ford J., MacPherson M., *et al.* Evaluation of minimum unit pricing of alcohol: a mixed method natural experiment in Scotland. *Int J Environ Res Public Health* 2020; **17**: 3394.
5. Angus C., Holmes J., Pryce R., Meier P., Brennan A. *Model-based appraisal of the comparative impact of Minimum Unit Pricing and taxation policies in Scotland: An adaptation of the Sheffield Alcohol Policy Model version 3*. ScHARR: University of Sheffield; 2016.
6. Katikireddi S. V., Bond L. I., Hilton S. Perspectives on econometric modelling to inform policy: a UK qualitative case study of minimum unit pricing of alcohol. *Eur J Public Health* 2014; **24**: 490–5.
7. Schmidt M., Lipson H. Distilling free-form natural laws from experimental data. *Science* 2009; **324**: 81–5.
8. Cranmer K., Brehmer J., Louppe G. The frontier of simulation-based inference. *Proc Natl Acad Sci* 2020; **117**: 30055–62.
9. Vu T. M., Probst C., Epstein J. M., Brennan A., Strong M., Purshouse R. C. Toward inverse generative social science using multi-objective genetic programming. In: *Genetic and Evolutionary Computation Conference (GECCO'19)*, Vol. **2019**. Prague, Czech Republic: ACM; 2019; 1356–63.
10. Vu T. M., Buckley C., Bai H., Nielsen A., Probst C., Brennan A., *et al.* Multiobjective genetic programming can improve the explanatory capabilities of mechanism-based models of social systems. *Complexity* 2020; **2020**: 8923197.
11. Vu T. M., Davies E., Buckley C., Brennan A., Purshouse R. C. Using multi-objective grammar-based genetic programming to integrate multiple social theories in agent-based modeling. In: Ishibuchi H. *et al.*, editors. *Evolutionary Multi-Criterion Optimization. EMO 2021*, Lecture Notes in Computer Science, Vol. 12654. Cham: Springer International Publishing; 2021, pp. 721–33.
12. Coleman J. S. Social theory, social research, and a theory of action. *Am J Sociol* 1986; **91**: 1309–35.
13. Guest O., Martin A. E. How computational modeling can force theory building in psychological science. *Perspect Psychol Sci* 2021 (OnlineFirst)174569162097058; https://doi.org/10.1177/1745691620970585
14. McGill E., Petticrew M., Marks D., McGrath M., Rinaldi C., Egan M. Applying a complex systems perspective to alcohol consumption and the prevention of alcohol-related harms in the 21st century: a scoping review. *Addiction* 2021 (Early View); https://doi.org/10.1111/add.15341
15. Probst C., Vu T. M., Epstein J. M., Nielsen A. E., Buckley C. B., Brennan A., *et al.* Normative underpinnings of population-level alcohol use: an individual-level simulation model. *Health Educ Behav* 2020; **47**: 224–34.
16. Brennan A., Buckley C., Vu T. M., Probst C., Nielsen A., Bai H., *et al.* Introducing CASCADEPOP: an open-source sociodemographic simulation platform for US health policy appraisal. *Int J Microsim* 2020; **13**: 21–60.
17. Vu T. M., Probst C., Nielsen A., Bai H., Meier P. S., Buckley C., *et al.* A software architecture for mechanism-based social systems modelling in agent-based simulation models. *J Artif Soc Soc Simul* 2020; **23**: 1.
18. West R., Godinho C. A., Bohlen L. C., Carey R. N., Hastings J., Lefevre C. E., *et al.* Development of a formal system for representing behaviour-change theories. *Nat Hum Behav* 2019; **3**: 526–36.
19. Zucker R. A. Alcohol use and the alcohol use disorders: A developmental-biopsychosocial systems formulation covering the life course. In: Cicchetti D., Cohen D. J., editors. *Developmental psychopathology: Risk, disorder, and adaptation*. John Wiley & Sons, Inc.; 2006, pp. 620–56.

