EDITORIAL

The Human Behaviour-Change Project Phase 2: Advancing behavioural and social sciences through ontology tools

[version 1; peer review: not peer reviewed]

Susan Michie[1], Robert West[2], Janna Hastings[3-5], William Hogan[6], Marta M. Marques[7], Marie Johnston[8], Paulina Schenk[1], Alexander J. Rothman[9]

[1]University College London Centre for Behaviour Change, London, England, UK
[2]University College London Department of Behavioural Science and Health, London, England, UK
[3]Faculty of Medicine, Institute for Implementation Science in Health Care, University of Zurich, Zürich, Zurich, Switzerland
[4]Swiss Institute of Bioinformatics Geneva, Geneva, Geneva, Switzerland
[5]University of St Gallen School of Medicine, St. Gallen, St. Gallen, Switzerland
[6]Data Science Institute, Medical College of Wisconsin, Milwaukee, Wisconsin, USA
[7]Universidade Nova de Lisboa Comprehensive Health Research Centre Escola Nacional Saude Publica, Lisbon, Lisbon, Portugal
[8]Aberdeen Health Psychology Group, University of Aberdeen, Aberdeen, Scotland, UK
[9]Department of Psychology, University of Minnesota Twin Cities College of Liberal Arts, Minneapolis, Minnesota, USA

v1 **First published:** 19 Dec 2024, **9**:730
https://doi.org/10.12688/wellcomeopenres.23520.1
Latest published: 19 Dec 2024, **9**:730
https://doi.org/10.12688/wellcomeopenres.23520.1

Abstract

Changing behaviour at scale is needed to address the major challenges facing humanity: from preventing and treating disease to tackling the climate crisis. Developing effective interventions to achieve this requires efficient generation and use of scientific evidence. The Human Behaviour-Change Project developed an extensive ontology of behaviour change interventions, their contexts and mechanisms of action to organise global evidence about behaviour change and predict intervention outcomes in novel behaviour change scenarios. The APRICOT (Advancing Prevention Research In Cancer through Ontology Tools) project extends this work by developing (i) ontologies covering health-related behaviours, (ii) a Community of Practice for ontologies in the social and behavioural sciences, and (iii) tools and resources to make ontologies more useable and useful. It will also develop methods to apply and integrate ontologies with real-world data related to the social and environmental determinants of health and inequalities, and to facilitate their uptake in behavioural science practice.

Not Peer Reviewed

This article is an Editorial and has not been subject to external peer review.

Any comments on the article can be found at the end of the article.

Keywords
Ontology, Class, Community of Practice, Computer Readable, Interoperable

This article is included in the Human Behaviour-Change Project (including the APRICOT project) gateway.

Corresponding author: Susan Michie (s.michie@ucl.ac.uk)

Author roles: Michie S: Conceptualization, Funding Acquisition, Investigation, Methodology, Project Administration, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **West R**: Conceptualization, Funding Acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing; **Hastings J**: Conceptualization, Funding Acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing; **Hogan W**: Conceptualization, Funding Acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing; **Marques MM**: Conceptualization, Funding Acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing; **Johnston M**: Conceptualization, Funding Acquisition, Methodology, Writing – Review & Editing; **Schenk P**: Conceptualization, Investigation, Methodology, Writing – Review & Editing; **Rothman AJ**: Conceptualization, Funding Acquisition, Writing – Review & Editing

Competing interests: Susan Michie is an unpaid director of the Unlocking Behaviour Change Community Interest Company and a paid advisor to the Godot behavioural science consultancy and intervention development company. Robert West is an unpaid director of the Unlocking Behaviour Change Community Interest Company, an unpaid advisor to the company making the Smoke Free mobile application, and a paid advisor to the Freuds+ Communications Agency, the Public Health Wales behavioural science Team, the Godot behavioural science consultancy and intervention development company, Everyone Health which is a provider of behavioural support commissioned by UK Local Authorities, and Qnovia which is developing a therapeutic nicotine delivery device to aid smoking cessation.

Grant information: This work was supported by Wellcome [201524; an award to the Human Behaviour-Change Project]; and by a National Institutes of Health award 'Advancing Prevention Research in Cancer through Ontology Tools (APRICOT)' [1U01CA291884-01].
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

How to cite this article: Michie S, West R, Hastings J *et al.* **The Human Behaviour-Change Project Phase 2: Advancing behavioural and social sciences through ontology tools [version 1; peer review: not peer reviewed]** Wellcome Open Research 2024, **9**:730 https://doi.org/10.12688/wellcomeopenres.23520.1

First published: 19 Dec 2024, **9**:730 https://doi.org/10.12688/wellcomeopenres.23520.1

The problem: developing and improving behaviour change interventions

Changing behaviour is essential for addressing the major threats facing humankind. These include the climate crisis, anti-microbial resistance and disease. However, despite hundreds of papers being published every month reporting the development or evaluation of behavioural interventions, it is often difficult to identify behaviour change interventions likely to be effective for particular behaviours and contexts (West & Michie, 2023). An important reason for this is the great variation in how interventions and their context are reported and the lack of a shared conceptual and linguistic framework in the field, making integration of research findings across studies and evidence accumulation problematic.

The Human Behaviour-Change Project

The Human Behaviour-Change Project (HBCP) sought to address these limitations (see Michie *et al.*, 2017; www.human-behaviourchange.org). It aimed to support decisions about interventions using cutting-edge ***ontology*** development as a basis for artificial intelligence to collate, synthesise and interpret evidence from behaviour change intervention evaluations (*see* glossary for bold italicised terms in Table 1). This produced the large, semantically rich, Behaviour Change Intervention Ontology (BCIO), enabling precise and shared terms, complex data integration across disciplinary and other silos, and comprehensive, ***computer readable*** intervention descriptions. The HBCP focused on tobacco smoking as its main use case, being one of the most important preventable causes of premature mortality worldwide (GBD 2019 Mental Disorders Collaborators, 2022), but also covered physical activity and developed a highly structured ontology of human behaviour more generally.

The Behaviour Change Intervention Ontology

The BCIO enables the integration of evidence to answer questions posed by policymakers, service planners, clinical and public health practitioners, and researchers of the form: "What works, compared with what, for what behaviours, how well, for how long, with whom, in what setting, and why?" (Michie *et al.*, 2017). It also helps structure empirical research to identify where the main gaps are. For more information see the editorial introducing the HBCP (Michie *et al.*, 2017), and the research articles in this collection.

The BCIO is accompanied by online tools and resources, including training videos, to promote engagement and use (https://www.humanbehaviourchange.org/). However, there is a need to expand the BCIO and upgrade and extend the tools and resources to promote widespread adoption and effective engagement. This editorial introduces a programme of research to do this and to develop a global ***community of practice*** of ontology users to work with us. This will both make the tools and resources as

Table 1. Glossary of terms.

Term	Definition	Source
Class	Ontology classes are representations or types of entities in the world. The term 'class' refers to the relevant representation in the ontology, while 'entity' refers to the type of thing that the class represents.	Arp *et al.*, 2015
Community of practice	A group of individuals who share a common interest (e.g., ontologies) and come together to collaborate, learn and share knowledge.	Alani *et al.*, 2003
Computer readable	A format of data (e.g., text) that has been structured in a way that is supportive of being processed by a computer. The terms 'computer readable' and 'machine readable' are often used interchangeably.	https://opendatahandbook.org/glossary/en/terms/machine-readable/
Interoperable	Two systems (e.g., ontologies) being interoperable refers to the extent that information in one system can be reused by the other system or the two systems can be used together by a third system without conflicts. For example, ontologies are interoperable when they can be used together to organise and integrate data.	http://www.obofoundry.org/principles/fp-010-collaboration.html
Ontology	A standardised representational framework providing a set of terms for the consistent description (or "annotation" or "tagging") of computer-readable data and information across disciplinary and research community boundaries.	Arp *et al.*, 2015

accessible and useable as possible and encourage engagement with them. The programme's title is 'Advancing Prevention Research in Cancer through Ontology Tools' (APRICOT).

The APRICOT project

The APRICOT Project is a collaboration of behavioural scientists, data scientists, and ontology experts that aims to accelerate data integration and knowledge accumulation in the behavioural and social sciences by extending the Behaviour Change Intervention Ontology (BCIO). In doing this, we will (i) improve the precision and shared understanding of terms used to report interventions, their delivery, their mechanisms and their contexts, (ii) develop online toolkits and resources for creating, maintaining and extending ontologies, and for ontology matching and alignment, (iii) build a Community of Practice for ontology users to co-create tools and resources, and to interact with each other and with the project, and (iv) advance the interoperability of the BCIO with clinical and real-world data relevant to social determinants of health.

Whilst the BCIO can apply to all behaviours, we will develop it in depth for two behaviours that are key to preventing cancer and disease more generally: smoking cessation and physical activity.

The key activities involved in extending the BCIO and creating the tools and resources for its use will be:

1. Engaging with a diverse Community of Practice, spanning geography, role, expertise and experience to set up an ongoing and sustainable program to enhance and extend the BCIO, specifically focusing on the behavioral risk factors of tobacco use and physical (in)activity, and including causal relations between intervention components and mechanisms of action (processes of change),

2. Integrating the BCIO with other ontologies capturing 'real-world' data to better address issues relating to the Social and Environmental Determinants of Health (e.g., poverty, educational level, gender identity and sexual orientation, racial and ethnic group, and built environment), and

3. Developing online, accessible tools and resources to promote effective and widespread adoption of the BCIO for writing study reports and protocols, and evidence synthesis for theory building and intervention development.

We will follow FAIR (findable, accessible, ***interoperable*** and reusable) Guiding Principles (Wilkinson *et al.*, 2016) in working with our Community of Practice, and stakeholders more generally, to ensure that the ontology and its tools and resources are developed and implemented in a way that promotes widespread adoption and meets the varied and evolving needs of users. We will work collaboratively with the National Institutes of Health Dissemination and Coordination Center (Bian *et al.*, 2024) and the other funded projects in the Behavioral and Social Science Ontology Development U01 Research Network (Beverley *et al.*, 2024; Duncan & McNeil, 2024; Tao & Bian, 2024).

Deliverables

APRICOT will deliver:

1. Extended ontologies (BCIO, the Addiction Ontology, or AddictO, and the Ontology for Modeling and Representation of Social Entities or OMRSE) including: a) ***classes*** covering details of behavioural outcomes, the social and economic determinants of health, methodological features of intervention evaluation studies, b) causal relations between potential mechanisms of action and intervention components, and c) cross references to important vocabularies e.g., the Unified Medical Language System (Bodenreider, 2004) and alignment of classes and relations between BCIO, AddictO and OMRSE.

2. Updated tools and new toolkits for creating, maintaining and extending ontologies, searching and visualising BCIO and AddictO, ontology matching and alignment.

3. Updated and extended resources, including the Paper and Protocol Authoring and Annotation Tool (PPAT; https://paperauthoringtool.com/), and the Theory and Techniques Tool (TATT; https://theoryandtechniquetool.humanbehaviourchange.org/) linking behaviour change techniques with mechanisms of action.

4. A Behavioural and Social Sciences Ontologies (BSSO) Foundry website (https://www.bssofoundry.org/) as a portal to curated ontologies and resources.

5. A book introducing and enabling use of ontologies for the behavioural and social sciences (OntoGuide).

6. A global, cross-domain Community of Practice of ontology users and a system for the community to co-create tools and resources, increase the adoption and engagement with the BCIO, and interact with each other.

Evaluation

We will evaluate the tools and resources using a mixed methods approach across a range of types of users in terms of their ease of use, engagement and uptake by users and extent of application, for example, to intervention reporting, literature annotation, evidence synthesis, and linking datasets. Community of Practice activities will be evaluated in terms of contributing users' metrics, discussion engagement, knowledge sharing and training uptake. Two other areas of evaluation are methods that we develop for mapping variables and values in datasets onto ontology classes to enhance their logical consistency and interoperability, and for searching, comparing and integrating theories for the purposes of theory testing, development and evaluation. There will be a detailed evaluation plan in the APRICOT project protocol, to be published in the first year of the project.

Conclusions

We are extending the Human Behaviour-Change Project with a 5-year project funded by the US National Institutes of Health to upgrade and extend tools to promote the effective and efficient use of ontologies in the behavioural and social sciences. While the tools will have wide applicability, the ontology classes and properties that we develop will be particularly relevant to research in disease prevention, especially cancer, and more specifically combatting tobacco use and increasing physical activity. A key part of the project is to build an extensive Community of Practice to ensure that ontologies and ontology tools become embedded in behavioural and social scientific practices, and their applications.

Ethics and consent

Ethical approval and consent were not required.

Data availability

Underlying data

No data associated with this article.

Acknowledgements

With thanks to the APRICOT research team: Carolina Silva, Colbie Reed and Maya Braun.

References

Alani H, Dasmahapatra S, O'Hara K, *et al.*: **Identifying communities of practice through ontology network analysis.** *IEEE Intell Syst.* 2003; **18**(2): 18–25.
Publisher Full Text

Arp R, Smith B, Spear AD: **Building ontologies with basic formal ontology.** Mit Press, 2015.
Reference Source

Beverley J, Duncan W, Necka EA: **Promoting Health Aging through Semantic Enrichment of Solitude Research (PHASES).** NIH RePORTER, 2024.
Reference Source

Bian J, Musen MA, Tao C: **ACCELERATE-BASSO: coordinating center for accelerating behavioral and social science through ontology.** NIH RePORTER, 2024.
Reference Source

Bodenreider O: **The Unified Medical Language System (UMLS): integrating biomedical terminology.** *Nucleic Acids Res.* 2004; **32**(Database issue): D267–D270.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Duncan W, McNeil DW: **Developing an ontology for dental care-related fear and anxiety: toward an understanding of problems in dental care utilization.** NIH RePORTER, 2024.
Reference Source

GBD 2019 Mental Disorders Collaborators: **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.** *Lancet Psychiatry.* 2022; **9**(2): 137–150.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Michie S, Thomas J, Johnston M, *et al.*: **The human behaviour-change project: harnessing the power of artificial intelligence and machine learning for evidence synthesis and interpretation.** *Implement Sci.* 2017; **12**(1): 121.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Tao C, Bian J: **Standardizing and harmonizing behavioral and social science research factors in alzheimer's disease through ontology-based approaches.** NIH RePORTER, 2024.
Reference Source

West R, Michie S: **How many papers are published each week reporting on trials of interventions involving behavioural aspects of health?** *Qeios.* 2023.
Publisher Full Text

Wilkinson MD, Dumontier M, Aalbersberg IjJ, *et al.*: **The FAIR guiding principles for scientific data management and stewardship.** *Sci Data.* 2016; **3**(1): 160018.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**