Complex systems, complex practice, complex outcomes: a call for the development of complexity-informed implementation models (CIIM) for traditional, complementary, and integrative medicine.

Kim D. Graham , Hope Foley , Jon Adams , Amie Steel

PII: S1876-3820(23)00090-2
DOI: https://doi.org/10.1016/j.eujim.2023.102314
Reference: EUJIM 102314

To appear in: *European Journal of Integrative Medicine*

Received date: 24 August 2023
Revised date: 25 October 2023
Accepted date: 31 October 2023

Please cite this article as: Kim D. Graham , Hope Foley , Jon Adams , Amie Steel , Complex systems, complex practice, complex outcomes: a call for the development of complexity-informed implementation models (CIIM) for traditional, complementary, and integrative medicine., *European Journal of Integrative Medicine* (2023), doi: https://doi.org/10.1016/j.eujim.2023.102314

Highlights

- The clinical encounter is inherently complex across all systems of medicine.
- Conventional implementation models may be insufficient to meet the needs of real-life clinical practice.
- Complexity science is increasingly being incorporated across all scientific domains.
- A complexity informed implementation model may better reflect the holistic nature of traditional, complementary, and integrative medicine.
- Such a model may prove useful across all systems of medicine.
- We propose a complexity-informed implementation model to better meet the needs of real-life clinical practice.

Title: Complex systems, complex practice, complex outcomes: a call for the development of complexity-informed implementation models (CIIM) for traditional, complementary, and integrative medicine.

Authors:
Kim D. Graham[1*], Hope Foley[1], Jon Adams[1], Amie Steel[1]

[1]Australian Research Centre in Complementary and Integrative Medicine, Faculty of Health, University of Technology, Sydney. NSW, Australia

Dr Kim D. Graham: ORCID ID 0000-0003-3952-8972
Dr Hope Foley: ORCID ID 0000-0003-4901-8300
Distinguished Prof Jon Adams: ORCID ID 0000-0002-9901-5717
A/Prof Amie Steel: ORCID ID 0000-0001-6643-9444

*Corresponding author
Email: kim.graham@uts.edu.au
15 Broadway Ultimo, NSW, Australia 2007

Complex systems, complex practice, complex outcomes: a call for the development of complexity-informed implementation models (CIIM) for traditional, complementary, and integrative medicine.

Abstract

Introduction: Implementation science is the vehicle for ensuring that research evidence informs and shapes clinical practice. However, implementation models structured along linear and mechanistic lines are not necessarily aligned with the complexity of clinical practice. In this article we explore the development and value of a complexity informed implementation model primarily for use in traditional, complementary, and integrative medicine. *Discussion*: Conventional linear mechanistic models of knowledge translation may be insufficient to address the needs of real-life clinical practice. Existing implementation models may pose particular challenges for use in traditional, integrative, and complementary systems of medicine due to their holistic orientation and perspective of human organisms as whole complex systems nested within other complex systems. This paper discusses how a complexity informed implementation model, non-linear in nature and founded on iterative processes, may better reflect the complex nature of the traditional, integrative, and complementary medicine clinical encounter and patient as a complex adaptive system. *Conclusion*: The emergence of complexity science provides an opportunity to re-imagine implementation models and processes to support the translation of evidence into traditional, complementary, and integrative systems of medicine. We propose a complexity-informed implementation model to better meet the complex needs of real-life clinical practice.

Keywords: implementation science; complexity science; traditional, integrative, and complementary medicine; complexity informed implementation models

Word count: 2080 words

Abbreviations:

CIIM – complexity-informed implementation models

IS – implementation science

RCT – randomised controlled trial

TCIM – traditional, integrative, and complementary medicine

Role of funding: the authors declare that no funding was received to support or finance the production of this manuscript.

1. Introduction

1.1 Implementation science and the complexity of clinical practice

The key aim of implementation science (IS) is to ensure research evidence effectively informs and is enacted within practice. A linear and mechanistic framing of this process can, however, present challenges for the complex realities of health care, the clinical encounter, and the research-practice ecosystem [1]. A scoping review by Veziari et al., (2021) [2] concluded that evidence-based practice uptake among traditional, integrative and complementary medicine (TCIM) practitioners largely ignored the complexity of factors inherent within knowledge translation and evidence implementation. Conventional thinking lends itself to implementation models informed by the assumption that research evidence is translated into clinical practice in a rational, phased manner [1]. While this conventional view of evidence translation as a knowledge pipeline is less entrenched than it once was [3], Newtonian linear and reductionist concepts still underpin much of the thinking in IS [4, 5], contextual factors are often overlooked [6] and the entangled nature of subject and context is not recognised [1]. This oversight has prompted calls for more complex, systems-level approaches to IS methods [1] which more accurately reflect clinical practice.

The clinical encounter is inherently complex and uncertain across all systems of medicine [7] and is not necessarily fully served by approaches that do not allow for this [8]. The concept of a knowledge pipeline, where evidence moves from experimental research to clinical practice in a formulaic and staged manner [1], is particularly antithetical to TCIM systems of medicine which by nature are holistic, non-linear, and systems oriented [9]. As such, and in contrast to prevailing IS approaches, the emerging science of systems and complexity provides opportunity to evolve IS models and processes to translate evidence more realistically and effectively into TCIM clinical practice. Distinctions between a conventional IS framework and a complexity informed framework are explored in Table 1.

1.2 Complexity science and implementation science

The transdisciplinary theory of systems, known as *complexity science*, has been evolving over the past 50 to 100 years [10], and while it is increasingly present in many fields of scientific research [11] this is less apparent within biomedical research, education, and application [12-14]. *Complexity science* is founded on a dynamic, relational understanding of phenomena. Rather than static conditions, linear pathways, and a focus on the smallest functional unit, complexity science prompts engagement at the level of the ecosystem, focusing on the interactions within the system and the emergent properties that arise as a result. While conventional assumptions are founded upon classical scientific thinking based on reductionism and determinism, complexity science is founded upon holism [15]. Within holistic paradigms, the whole is perceived as being greater than the sum of its parts due to the interaction of components within and between the system and other systems.

Complexity science provides the theoretical framework, methodology, and tools for exploring and understanding complex systems, including complex adaptive systems. *Complex adaptive systems* are systems that adapt to changing internal and external environments, and exhibit novel properties as an outcome of this adaptive process [16], as exemplified by healthcare organisations, the human organism, and social networks. Complex adaptive systems function in a manner extending beyond the reach of research and translational models that are based upon predictable and repeatable linear cause and effect relationships. We propose that complexity informed implementation models are necessary to meet the health needs of humans as complex adaptive systems, the knowledge needs of holistically oriented systems of medicine, and the communication needs of the complex research-practice ecosystem.

1.3 TCIM, complexity science and implementation

Consistent with its holistic paradigm, most TCIM systems and practices encounter the human organism as a whole complex system. TCIM practitioners, for example, commonly recognise a patient's context as relevant to their health, and perceive TCIM interventions as comprising of specific and non-specific elements [9]. Using naturopathy as a case study, Graham et al. [17] found naturopaths engage with patients as complex adaptive systems – where biochemical processes, internal physiological sub-systems, emotional states, and cognitive processes interact contextually with diet and lifestyle factors and the external environment, and keystone elements provide treatment focal points upon which to leverage positive change. Complexity science provides an opportunity to re-vision IS approaches to more appropriately meet the distinct knowledge translation needs of holistically oriented systems of medicine. In this article we propose a framework for how complexity science concepts might inform implementation models.

2. Discussion

TCIM – and health care more generally – would undoubtedly benefit from a complexity-informed implementation model (CIIM) with relevance to the implementation of evidence-based practices and guidelines, inter-professional shared care models, quality improvement initiatives, and health technology implementation. Leading scholars in IS have identified that a longer-term iterative and recursive process is more realistic and useful than a shorter-term linear one [18], and that iterative, non-linear approaches are particularly suitable when implementation frameworks are adapted for complex interventions [19]. This is particularly pertinent given the increasing global burden of chronic and complex disease [20]. While these existing models do acknowledge complexity, they nevertheless fail to engage substantially and richly with complexity science.

2.1 Visioning a complexity-informed implementation model for TCIM

In a CIIM, non-linearity must be accounted for by i) not expecting the outcome to be proportional to the magnitude of stimulus offered, plus ii) acknowledging the influence of sensitivity to starting conditions [21]. The CIIM must also view cause and effect as being retrospectively revealed and not repeatable, understanding the system to be continuously interacting with the environment [22], and regard context as a key consideration [1]. The context is not merely an inert background but a milieu that feeds, informs, and shapes the system within, in a continuously shifting dynamic. Compared to the linearity of prominent IS frameworks, implementation through a CIIM comprises a circular process tolerating new properties to emerge through processes of adaptation, relational interactions, varying starting conditions, and contextual influences (see Table 1). This type of iterative, interactive, and contextually responsive approach aligns with the emerging understanding of the role and value of traditional knowledge within contemporary TCIM practice. TCIM experts describing traditions as 'living systems' and traditional knowledge requiring a contextual lens to be translated into contemporary practice [23].

2.2 Barriers and opportunities for complexity-informed implementation models

A key challenge with developing CIIMs and implementing research evidence into the complex environment of clinical practice is the primacy and status afforded to randomised controlled trials (RCT) [4, 24]. RCTs do not fully account for a range of factors influencing intervention outcomes, such as health and illness being emergent and relational properties of the patient as a complex adaptive system, clinical uncertainty, context dependency, and sensitivity to initial starting conditions [7]. While RCT outcomes and research conducted in controlled conditions may demonstrate inference level efficacy, they are not necessarily generalisable to real-world clinical practice and patient health needs [24]. Instead, evidence from a range of whole systems research (such as naturalistic observation models, comparative effectiveness studies, and pragmatic trials) and complexity-informed research models [see for example 8] potentially better reflect the complexity of the TCIM clinical encounter and the patient as a complex adaptive system. The value of systems thinking is that it offers a framework cognisant of real-world dynamic contexts and emergent patterns [7] promoting clarity about the condition being treated, the intervention being employed, and the outcomes produced. Beyond an isolated, controlled, linear cause-and-effect paradigm, complexity science supports integration of biographical, biological, and contextual factors [25] to inform individualised, holistic TCIM clinical practice.

TCIM clinical practice is founded upon holistic and complexity principles [9] and the development of a CIIM potentially provides a suitable and sound bridge for the translation of research evidence into clinical practice. TCIM currently functions in a manner that is congruent with complexity science principles [9]. However, beyond preliminary research advances [8, 17, 26, 27] this congruence occurs without fully utilising the language and research capabilities of complexity science, and without comprehensively applying complexity science principles to the knowledge translation process. Until contemporary medical curricula more fully incorporate complexity education, engagement by researchers and practitioners with complexity science concepts and methods may continue to be limited.

TCIM systems are commonly distinguished from biomedicine by their holistic orientation and the manner in which they encounter the human organism as a whole complex system [9]. However, clinical complexity within biomedical clinical practice may also be inadequately accommodated by existing reductionistic and linear models [28]. Evolution of CIIMs, tested and evidenced in the field of TCIM, may have broader benefits within clinical health care. By incorporating the language and methods of complexity science, researchers may be able to better evaluate *actual* treatment outcomes and investigate the benefits and shortfalls of real-world medical interventions and practices, such as exemplified in whole systems research studies. Rather than measuring treatment against an expected outcome determined through linear modelling, we propose evaluation of treatment outcomes would utilise pattern recognition, be recursive and iterative, and engage with emergent properties and diffuse systemic change. In addition, by using a complexity science approach to inform and resource the implementation process, research evidence may be applied in a manner that is more closely aligned with real-world clinical practice in all its complexity.

We propose that complexity science concepts have direct implications for IS, through recognising the health needs of humans as complex adaptive systems and the clinical realities of holistically oriented practice. Complexity science offers a possibility of effectively translating knowledge into safe and efficacious holistic practice beyond the capacity enabled by linear and mechanistic models. In a connected, dynamic, interacting system, it is a fallacy to assume that any intervention will lead to a contained and specific response. We posit that interventions within any complex system can never be expected to function in a targeted and specific manner as assumed within linear and mechanistic models; instead, they have propensity to function as *catalytic probes*. Catalytic probes instigate system wide non-specific and non-linear change. We assert that anticipating linear and specific outcomes from intervening within a complex system – whether that system is the human organism, TCIM systems of medicine, or the research-practice ecosystem – is discordant with the realities of how such systems function. Further, outcome predictability is hampered by the characteristics of complex adaptive systems such as sensitive dependence on starting conditions, emergence, and self-organisation. As a result, we propose complexity cognisant intervention approaches require iterative and recursive elements and counterpoised intervention and evaluative cycles to fully appreciate the quality of the intervention and the extent and nature of response.

2.3 Proposed framework for a complexity informed intervention and evaluation cycle

Catalytic probes may be utilised to investigate and explore a complex adaptive system's activities using a circular recursive and iterative framework, enabling self-organising and emergent properties of the system to be accommodated and explored. We propose a complexity-informed intervention and evaluation cycle comprising: (1) the intervention, (2) time allowed for change process, (3) evaluation of outcome (within a complex system this would be based on pattern recognition), (4) adjustment of intervention, before circling back to (1) implementation of an intervention (although now in a revised form), and repeating the cycle as necessary to attain a suitable outcome (See Figure 1). Each stage of this process is ideally informed by the best available evidence (which may include a variety of information including traditional knowledge or contemporary research) [4], clinical expertise, patient values [29] or experiences [30], and knowledge generated through evaluating the changes catalysed by preceding intervention(s). This model offers an example of how a complexity-informed implementation model might function.

In line with their holistic underpinning, naturopathy, and other TCIM are conceivably a useful testing ground for exploring whether IS models that are informed by complexity science could progress the integration of traditional knowledge, bioscience evidence, clinical expertise, and patient values into clinical decision making and reasoning. By using a complexity science approach to inform and resource the implementation process, research evidence may be translated into practice in a manner that more closely reflects real-world clinical practice across all systems of medicine (whether TCIM or biomedical). A richer understanding of TCIM treatments and their outcomes, and more effective translation of research findings into TCIM practice, may be achieved by evolving IS models to include the language, methods, and framework of complexity science. Such an approach has more authentic alignment with the holistic philosophy of traditional systems of medicine [9].

3. Conclusion

Complexity science provides a framework for engaging with and comprehending the characteristics of complex adaptive systems, such as non-linear dynamics, self-organisation, and emergence. The complexity of the human organism, holistically oriented systems of medicine, and the research-practice ecosystem is more aptly met by knowledge translation approaches that are similarly structured. The evolution of IS that is informed by complexity science has potential to foster the development of more empirically grounded understandings of whole system practice, and increase collaborative discourse between researchers, practitioners, and patients. By accounting for and reflecting the inherent complexity of the clinical encounter, the development of CIIMs may provide benefit beyond TCIM and support health care research, evidence translation, and real-world service provision across all health care practices.

Financial Support

No financial support was received in the preparation of this manuscript.

Data availability

Not applicable for this manuscript as it is a commentary and not research.

Acknowledgements

No acknowledgements to be made.

REFERENCES

1. Braithwaite J, Churruca K, Long JC, Ellis LA, Herkes J: **When complexity science meets implementation science: a theoretical and empirical analysis of systems change**. *BMC Med* 2018, **16**(1).
2. Veziari Y, Kumar S, Leach MJ: **Addressing barriers to the conduct and application of research in complementary and alternative medicine: a scoping review.** . *BMC Complement Med Ther* 2021, **21**:201.
3. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O: **Diffusion of Innovations in Service Organizations: Systematic Review and Recommendations**. *The Milbank Quarterly* 2004, **82**(4):581-629.
4. Adams J, Steel A, Reid R: **A holistic approach to Implementation Science (IS): broadening the IS gaze to traditional, complementary and integrative medicine.** In: *Public health and health services research in traditional, complementary and integrative health care: international perspectives.* edn. Edited by Adams J, Broom A, Sibbritt D, Steel A, Hughes G, Yang W, Filice de Barros N, Sommers E, Bachtiar A, Kusumayati A. Singapore: World Scienctific; 2019: 99-118.
5. Steel A, Rapport F, Adams J: **Towards an implementation science of complementary health care: some initial considerations for guiding safe, effective clinical decision-making**. *Advances in Integrative Medicine* 2018, **5**:5-8.
6. Rogers L, De Brun A, McAuliffe E: **Defining and assessing context in healthcare implementation studies: a systematic review**. *BMC Health Services Research* 2020, **20**(591):1-24.
7. Sturmberg J, Martin C: **How to cope with uncertainty? Start by looking for patterns and emergent knowledge.** *Journal of Evaluation in Clinical Practice* 2021, **27**:1168-1171.
8. Graham KD, Steel A, Wardle J: **Embracing the Complexity of Primary Health Care: System-Based Tools and Strategies for Researching the Case Management Process**. *Journal of Multidisciplinary Healthcare* 2021, **Volume 14**:2817-2826.
9. Graham KD, Steel A, Wardle J: **The intersection between models of health and how healing transpires: a metaethnographic synthesis of complementary medicine practitioners' perceptions**. *Journal of Alternative and Complementary Medicine* 2021, **00**:1-12.
10. Launer J: **Complexity made simple.** . *Postgraduate Medical Journal* 2018, **94**(1116):611-612.
11. Peters DH: **The application of systems thinking in health: why use systems thinking?** *Health Research Policy and Systems* 2014, **12**(1):51.
12. Gustafsson M, Nestor CE, Zhang H, Barabasi AL, Baranzini S, Brunak S, Chung KF, Federoff HJ, Gavin AC, Meehan RR *et al*: **Modules, networks and systems medicine for understanding disease and aiding diagnosis.** . *Genome Medicine* 2014, **6**(10):82.
13. Sturmberg JP, Martin CM, Katerndahl DA: **Systems and Complexity Thinking in the General Practice Literature: An Integrative, Historical Narrative Review**. *The Annals of Family Medicine* 2014, **12**(1):66-74.
14. Tuffin R: **Implications of complexity theory for clinical practice and healthcare organization.** . *BJA Education* 2016, **16**(10):349-352.
15. Heylighen F, Cilliers P, Gershenson C: **Complexity and philosophy**. In: *Complexity, science and society.* edn. Edited by Bogg J, Geyer R. Oxford: Radcliffe Publishing; 2007.
16. Holland JH: **Studying Complex Adaptive Systems**. *Journal of Systems Science and Complexity* 2006, **19**(1):1-8.
17. Graham KD, Steel A, Wardle J: **The converging paradigms of holism and complexity: An exploration of naturopathic clinical case management using complexity science principles**. *Journal of Evaluation in Clinical Practice* 2022.

18. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC: **Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science**. *Implementation Science* 2009, **4**(1):50.
19. Movsisyan A, Arnold L, Evans R, Hallingberg B, Moore G, O'Cathain A, Pfadenhauer LM, Segrott J, Rehfuess E: **Adapting evidence-informed complex population health interventions for new contexts: a systematic review of guidance**. *Implementation Science* 2019, **14**(105):1-20.
20. Murray C, Lopez A: **Measuring the global burden of disease**. *The New England Journal of Medicine* 2013, **369**(5):448-457.
21. Glouberman S, Zimmerman B: **Complicated and complex systems: what would successful reform of Medicare look like?** In., vol. 8: Commission on the Future of Health Care in Canada; 2002.
22. Sturmberg JP, Martin CM: **Complexity and health - yesterday's traditions, tomorrow's future**. *Journal of Evaluation in Clinical Practice* 2009, **15**(3):543-548.
23. Steel A, Foley H, Bugarcic A, Wardle J, Boyd H, Breakspear I, Carlton A-L, Cope G, Dua K, Greenway P *et al*: **Exploring criteria for the translation of traditional knowledge within contemporary clinical practice, research, policy and education: a stakeholder forum**. *Journal of Integrative and Complementary Medicine* 2023.
24. Rapport F, Clay-Williams R, Churruca K, Shih P, Hogden A, Braithwaite J: **The struggle of translating science into action: Foundational concepts of implementation science**. *Journal of Evaluation in Clinical Practice* 2018, **24**(1):117-126.
25. Sturmberg J, Getz L, Upshur R, Mercer S: **Beyond multimorbidity: What can we learn from complexity science?** *Journal of Evaluation in Clinical Practice* 2020, **27**:1187-1193.
26. Steel A, Leach M, Brosnan C, Ward V, Lloyd I: **Naturopaths' mobilisation of knowledge and information in clinical practice: an international cross-sectional survey**. *BMC Complementary Medicine and Therapies* 2021, **21**(1).
27. Graham KD, Steel A, Wardle J: **Primary health care case management through the lens of complexity: an exploratory study of naturopathic practice using complexity science principles**. *BMC Complementary Medicine and Therapies* 2022, **22**(1).
28. Sturmberg J: **Changing the paradigm of research**. *Journal of Evaluation in Clinical Practice* 2023:1-4.
29. Djulbegovic B, Guyatt GH: **Progress in evidence-based medicine: a quarter century on.** *The Lancet* 2017, **390**(10092):415-423.
30. Steel A, Brand S, Leach M, Lloyd I, Ward V: **Patient-shared knowledge and information in clinical decision-making: an international survey of the perspectives and experiences of naturopathic practitioners**. *BMC Complementary Medicine and Therapies* 2023, **23**(1):247.

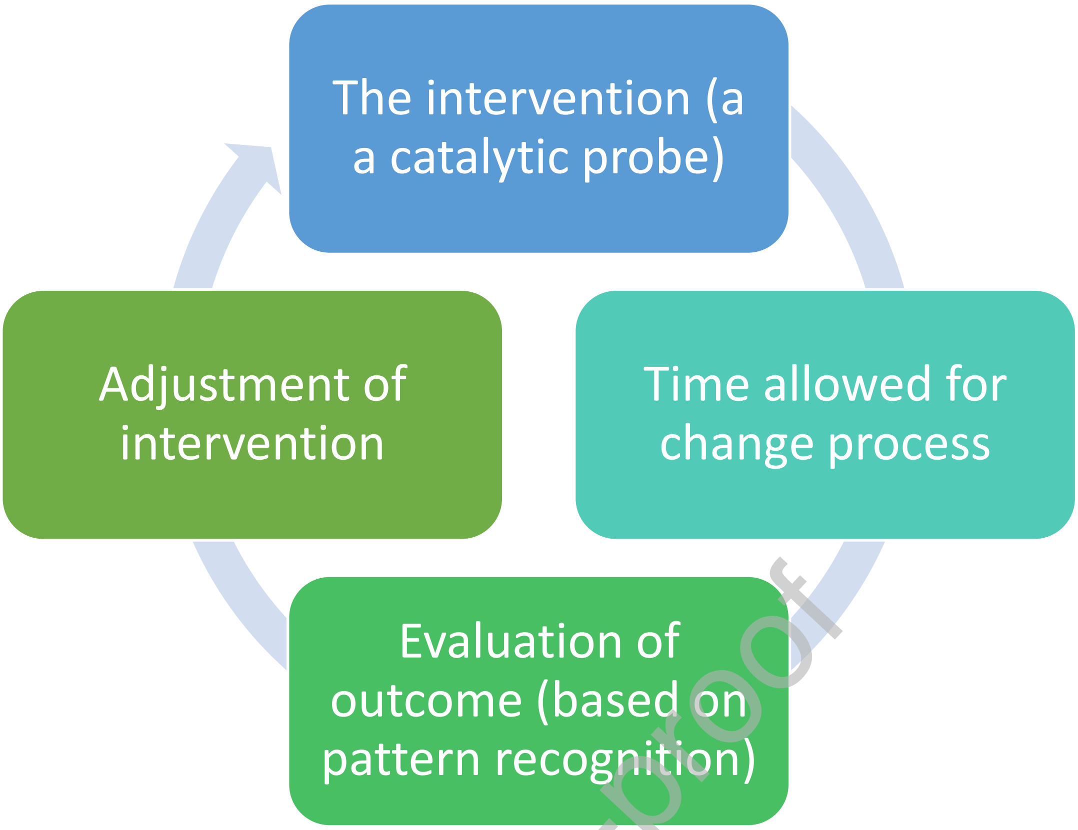

Figure 1: Proposed framework for a complexity informed intervention and evaluation cycle

Table 1: Characteristics of linear and complexity IS approaches

Domain	Conventional, Linear Framework	Complexity Informed Framework
Diagnostic Certainty	Diagnosis and prognosis are knowable	Diagnosis is uncertain and prognosis is obscure
Nature of Intervention	A specific intervention is available, and utilised within a shorter timeframe	Intervention is iterative, recursive, and longer term
Magnitude of Change	Magnitude of input determines magnitude of change	Magnitude of input is not directly correlated to magnitude of change
Role of Environment	Environment is static, and can be discounted	Environment is dynamic, and continuously impacts system
Nature of Causality	Causality is simple	Causality is multigenous
Nature of Evidence	Evidence is founded on reductionism and analysis	Evidence is founded on holism and synthesis
Factors Determining Treatment Choice	Treatment is based on matching diagnosis with proven intervention	Treatment is personalised – devised for the individual patient at a particular point in time
Treatment Evaluation Factors	Evaluation of treatment is based on measurement against expected outcome, as determined by clinical trial data	Evaluation of treatment is based on pattern recognition and awareness of emergent properties of the organism, incorporating patient's health experience and values
Relationship Between Treatment and Outcome	Cause and effect relationship between treatment and outcome are considered repeatable predictable	Cause and effect relationship between treatment and outcome are revealed retrospectively and are not repeatable

[Adapted from 21, 22]

Credit Author Statement:

Kim Graham: conceptualisation; writing – original draft; writing – review and editing. Hope Foley – conceptualisation; writing - review and editing. Jon Adams: conceptualisation, writing - review and editing. Amie Steel: conceptualisation, writing - review and editing.

Author Agreement Statement

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs

Declaration of Interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: