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# Actioning the Learning Health System: An applied framework for integrating research into health systems

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A R T I C L E I N F O

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A B S T R A C T

Health systems across the world experience pervasive gaps in the speed with which high quality evidence is generated, implemented and refined. A Learning Health System (LHS) approach that blends research with health care operations is to eliminate or reduce delays. This paper builds on existing LHS frameworks to deepen our practical understanding of the research-health systems operations interface and to provide actionable insights on how to realize a LHS in practice. We present a LHS action framework that describes how research and health care operations are linked and enacted in a comprehensive LHS approach to advance population health and health equity. Health systems seeking to implement a LHS approach can use this framework to identify capabilities necessary to enact the learning elements, including key questions and methods, to ensure a systematic approach to learning and achieving equity-centered quadruple aim metrics.

## 1. Introduction

Improving the ability of health systems to rapidly learn and apply evidence has shifted from an opportunity to an imperative. Health systems across the world are stressed – high quality primary care is increasingly inaccessible (Jabbarpour et al., 2023; Lawson, 2023), hospitals and emergency rooms are over capacity (Kelen et al., 2021; van Ginneken et al., 2022), healthcare workforce shortages and burnout are pervasive (Dobson, 2023; Murthy, 2022), and citizens face many barriers and inequities in receiving care.(Schneider et al., 2021) While high-quality evidence is available, or could be rapidly generated, to help solve these problems, the mechanisms and approaches to generate and implement evidence at scale are often absent or inadequate. A recent global evidence report (Global Commission on Evidence to Address Societal Challenges, 2022) underscores the omnipresent gaps in how evidence is generated and used at all levels – from government policy makers to patients and community members. The consequence is born by individuals and populations who do not dependably benefit from the large societal investments made in clinical, health services, and population health research – consequences that are exacerbated for structurally disadvantaged groups resulting in widening inequities. (Lavizzo-Mourey et al., 2021)

Conceptualized 15 years ago (Etheredge, 2007; Institute for Medicine, 2007), the learning health system (LHS) is a potential antidote. The LHS is an evolution of the earlier evidence brokering notion of 'knowledge translation and exchange' (Straus et al., 2009) to one that fuses research and health care delivery enterprises by embedding advanced research methods within the context of everyday care. (Lavis et al., 2018; Reid & Greene, 2023) (Fig. 1) By capitalizing on health care system's big data resources and garnering insights directly from patients, caregivers and care providers (Kuluski & Guilcher, 2019), LHSs aspire to a future state where many forms of high-quality evidence are rapidly generated, synthesized, blended, and applied. Nuanced insights stemming from the most recent information are swiftly made available to decision makers in all settings including the hospital room, family room, management office, and boardroom.(Reid, 2016) A comprehensive LHS approach is particularly relevant in the complex multicomponent changes to how health care is organized, financed, and delivered.

While LHS aspirations are broadly supported, guidance on the best practices for operationalizing the concept in practice remains

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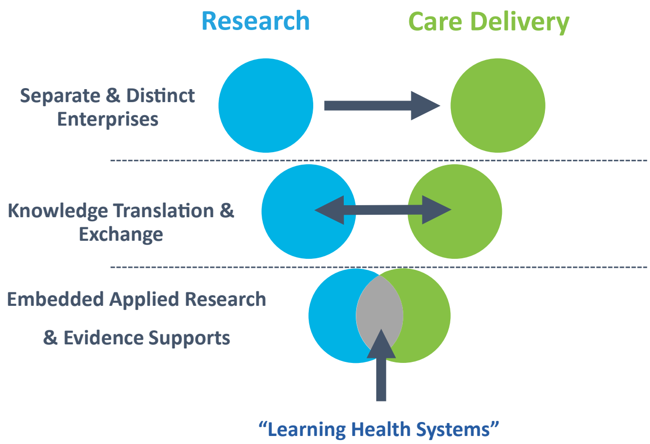


**Fig. 1.** Evolution of Health Systems & Research Relationship.

underdeveloped. Many frameworks have been developed for a variety of purposes, such as to gain conceptual clarity, anchor on core values, guide strategic planning, boost stakeholder support, build technical infrastructures, integrate health equity, and evaluate LHS implementation efforts. This paper builds on existing LHS frameworks with a focus on the application of LHS concepts in practice to deepen a practical understanding of: a) how various types of research evidence provide actionable insights for health system decision makers; b) where LHS researchers intersect with health system operators; and c) what contextual features fuel and moderate the LHS in practice. With a focus on building "whole systems" that are accountable for equitably and proactively serving defined populations, we present an action-oriented framework that demonstrates where and how high-quality research evidence and complementary inputs, derived across scientific disciplines, can be practically embedded within the operations of health systems.

## 2. Methods

### 2.1. Literature review

A narrative review (Paré & Kitsiou, 2017) was used to conduct a comprehensive overview of existing LHS frameworks and synthesize information on the LHS – specifically LHS models and their key constructs and implementation considerations. We first included review articles if they were: published in the last 10 years in the peer-reviewed or grey literatures; included LHS frameworks or models focused on whole-system learning; and included a description of its key constructs, evidence types and implementation considerations. Articles not matching these inclusion criteria or those focused solely on a particular health service sector (e.g., cancer care) or disease states (e.g., wound care) were excluded. The key terms "learning health system/(s)", "learning health system framework/(s)/models/programs" and their closely related synonyms were inputted into PubMed, Web of Science, Google Scholar and CINAHL. All types of review articles including systematic reviews, narrative reviews, environmental scans, and scoping reviews were included. Given that the LHS literature is rapidly involving, we also searched these databases for original manuscripts not cited by the review articles. A Google search using the key terms and a search of public health agencies' and organizations' websites were also used to locate relevant grey literature. Additionally, references for included grey and peer-reviewed literature were reviewed for articles with frequently cited lead authors. Articles were then reviewed by one team member using a structured approach (RJR). Extracts included the LHS model's purposes and intended uses, the core constructs, elements and outcomes, the scientific methods and evidence types considered, any technical requirements and engagement requirements, and any implementation considerations including barriers and enablers of success. Where necessary, review of the original manuscripts was undertaken to clarify these details.

### 2.2. Framework development

We identified several sentinel LHS models and frameworks based on their centrality to the LHS concept, the comprehensiveness of the constructs, having a population-based focus, and applicability to action-oriented LHS learning cycles. (Allen et al., 2021; Brooks et al., 2017; Foley & Vale, 2023; Friedman et al., 2017; Greene et al., 2012; Menear et al., 2019; Montori et al., 2019; Parsons et al., 2021; Psek et al., 2015; Rice et al., 2023) Because of their emphasis on operationalizing action within health systems, the three frameworks proposed by Greene et al. (Greene et al., 2012), Psek et al. (Psek et al., 2015), and Allen et al. (Allen et al., 2021) served as the core basis for further development of an action-oriented framework. To clarify the "learning" foci, we examined the components of these models based on our experience of applying research within health systems to enact change. In addition to bringing clinical expertise, the author team has applied scientific expertise in relevant fields (i.e., health services and systems research, population health analytics, patient-centered engagement and codesign, evidence syntheses, implementation and behavioural science, equity, realist evaluation, health economics, community engagement and community participatory action research) with international experience applying these methods in partnership with local health system leaders and operators. The author team also brings experience in health system operational leadership. To reduce the complexity of our action framework for practical use, we had a series of iterative discussions amongst authors to achieve consensus on a parsimonious set of learning needs, evidence sources and scientific foci, as well as a set of core model enablers and modifiers.

We then presented the preliminary "action framework" to a LHS working group (comprised of applied researchers, system leaders, patients and community leaders), convened by a network of 14 research centres that support patient-oriented research and capacity building in Ontario, Canada (Ontario Strategy for Patient-Oriented Research Support Unit). (OSSU) After incorporating feedback from the 20-person OSSU LHS working group, the action framework was revised and subsequently presented to a larger group of 33 healthcare policy makers, patients, caregivers and researchers from Ontario interested in applying a LHS approach across service sectors. Detailed notes on the model were captured through a structured virtual discussion forum. The authors incorporated these perspectives into the resultant framework, which was reviewed with and endorsed by the LHS working group.

## 3. Results

### 3.1. Existing LHS models and frameworks

Twelve review articles focused on LHS models and frameworks were included in this review (Table 1), largely based on Friedman et al.'s three knowledge-to-action steps (Friedman et al., 2017): deriving knowledge from everyday health system practice data; using derived knowledge to change practice in new ways; and generating new data from these changes to refine the knowledge base. Others expanded the framework to include additional knowledge sources, including syntheses of existing high-quality evidence (Easterling et al., 2021; Guise et al., 2018) and qualitative insights from patient, families and providers. (Kuluski & Guilcher, 2019) Menear and colleagues (Menear et al., 2019) added to these frameworks by conceptualizing that LHSs operate at three nested levels: (a) the micro-clinical level, where learning activities center on using best evidence for clinical decision-making by providers and patients; (b) the meso-organizational level that focuses on generating and using evidence on health service delivery arrangements and population health; and (c) at the macro-system level where the focus is

**Table 1**
Citation List of Review Articles on LHS Frameworks and Models.

| | Article | Year |
|---|---|---|
| 1. | Foley, T., Vale, L. (2023) A framework for understanding, designing, developing and evaluating learning health systems, Learn Health Syst, 7(1), e10315. | 2023 |
| 2. | Rice, E., Mashford-Pringle, A., Qiang, J., et al. (2023) Frameworks, guidelines, and tools to develop a learning health system for Indigenous health: An environmental scan for Canada, Learn Health Syst, e10376. | 2023 |
| 3. | Allen, C., Coleman, K., Mettert, K. et al. (2021) A roadmap to operationalize and evaluate impact in a learning health system, Learn Health Syst, 5(4), e10258. | 2021 |
| 4. | Enticott, J., Johnson, A., Teede, H. (2021) Learning health systems using data to drive healthcare improvement and impact: a systematic review, BMC Health Serv Res, 21(1), 200. | 2021 |
| 5. | Easterling, D., Perry, A.C., Woodside, R. et al. (2021) Clarifying the concept of a learning health system for healthcare delivery organizations: Implications from a qualitative analysis of the scientific literature, Learn Health Syst, e10287. | 2021 |
| 6. | Foley, T., Horwtiz, L., Zahran, R. (2021) Realising the potential of learning health systems, Newcastle, UK: Newcastle University. | 2021 |
| 7. | Platt, J.E., Raj, M., Wienroth, M. (2020) An Analysis of the Learning Health System in Its First Decade in Practice: Scoping Review, J Med Internet Res, 22(3), e17026. | 2020 |
| 8. | Zurynski, Y., Smith, C.L., Vedovi, A. et al. (2020) Mapping the Learning Health System: A scoping review of current evidence, Sydney, Australia: Macquarie University. | 2020 |
| 9. | Menear, M., Blanchette, M.-A., Demers-Payette, O. et al. (2019) A framework for value-creating learning health systems, Health Res Policy Sy, 17(1), 79. | 2019 |
| 10. | Lavis, J.N., Gauvin, F.P., Mattison, C.A. et al. (2018) Rapid synthesis: Creating rapid-learning health systems in Canada, Hamilton, Canada: McMaster Health Forum | 2018 |
| 11. | Lavis, J.N., Gauvin, F.-P., Reid, R.J. at al. (2018) Rapid synthesis: Creating a rapid-learning health system in Ontario, Hamilton, Canada: McMaster Health Forum | 2018 |
| 12. | Budrionis, A.,Bellika, J.G. (2016) The learning healthcare system: where are we now? A systematic review, Journal of biomedical informatics, 64, 87–92. | 2016 |

on policy making including resource allocation and regulatory requirements. Montori et al. focused on the micro-clinical level by linking caring and learning activities.(Montori et al., 2019) To advance the practical integration of research into health systems for rapid-cycle change, Greene et al. (Greene et al., 2012) provided specificity to the knowledge-to-action cycles by outlining five sequential learning steps, modeled after the Institute for Quality Improvement's plan-do-study-act quality improvement (QI) framework.(Langley et al., 2009) The utility of Greene et al.'s LHS model is enhanced by the inclusion of advanced research methods, relevance to health service improvement mechanisms, and applicability for LHS initiatives ranging from the micro to macro level. Brooks, Parsons and colleagues (Brooks et al., 2017; Parsons et al., 2021) offered complementary frameworks to incorporate equity perspectives suggesting that equity is only incorporated when sociodemographic data are integrated, individuals from equity deserving groups are empowered and design is informed by lived experiences extending beyond the health care system. Equity-deserving groups refer to groups of individuals who, due to systemic discrimination, experience barriers to resources and opportunities that are readily available to other individuals in society that are vital to obtaining just outcomes. These groups include, but are not limited to, women, and LGBTQ2+, Indigenous and racialized peoples, and those living with a disability/(es). Using the term equity-deserving groups does not negate the fact that everyone deserves equity; it recognizes the structural barriers impacting those experiencing marginalization.(Government of Canada, 2022; Milaney et al., 2022; Nascimento et al., 2023) Brooks, Parsons and colleagues note that equity-deserving communities should be continuously engaged in, and made aware of, all aspects of LHS operations to deepen their trust in the system and promote accountability of the LHS.(Brooks et al., 2017; Parsons et al., 2021) Further, Rice et al. developed a LHS "accountability checklist" to ensure that evidence is built with equity-deserving communities, particularly Indigenous communities, rather than extracting knowledge from communities with little benefit.(Rice et al., 2023)

Other LHS-related frameworks emphasize the key enablers and barriers that speed or limit LHS adoption, including infrastructures, processes, and resource requirements.(Allen et al., 2021; Foley & Vale, 2023; Menear et al., 2019; Psek et al., 2015) Notably, Allen et al. (Allen et al., 2021) advanced a logic model that specifies core inputs, including financial commitments, scientific and human resources requirements, governance arrangements (including mechanisms to set learning priorities), partnerships and learning networks, technological requirements (related to health data, advanced analytics, and digital assets) and oversight (including regulatory, legal, privacy and ethical compliance).

The existing frameworks lay out a notional range of learning values, activities, supports, and requirements for systems that aspire to a more organized set of activities for improving care rapidly through an LHS approach. However, existing LHS models and frameworks lack practical detail as how different streams of evidence and research methods intersect in the learning activities, and where (and with whom) relationships between researchers and health system operators are formed and sustained.

### *3.2. Developing an LHS action framework for integrating research into health care operations*

Through iterative development, we conceptualized an action framework as a LHS production "engine" as this analogy was readily understood by patient partners, researchers, and system leaders.(Fig. 2) The engine has five "learning gears" that are meshed and sequenced, encompassing a range of research evidence types that, when they intersect, create motion that produces one or more equity-centered quadruple aim outcomes. The larger external system gear also intersects three smaller system gears representing medical care (hospital, surgical, and outpatient care), community health services (home care, long term care, community providers, and public health) and non-health service delivery sectors (social services, educational institutions, and municipalities). These smaller gears have distinct roles but must collaborate together within the system to deliver integrated care solutions. Taken together, these gears function to drive learning for an integrated "whole system" approach to health.

The engine's five learning gears are animated by formed affinities between researchers and health system operators, the loci where partnerships are built and sustained, and where patients' and citizens' insights and perspectives, equitably garnered, are integrated. Learning gears are situated within a larger engine, that specifies the "fuel" and "accelerants" needed for the gears to rotate, produce motion, and achieve equity-centered outcomes, as well as "moderators" and "brakes" that change and restrict the engine's direction and velocity. Table 2 lists the most common types of existing evidence and flows of new evidence realized within each gear.

### *3.3. The centrality of equity to the LHS action framework*

A central challenge for all LHS activities is ensuring that learning is informed by, inclusive of, and creates value for persons and communities from equity-deserving groups. The deep and pervasive inequities persist in healthcare delivery, resource distribution, and outcomes will not be resolved by learning in the same ways within the systems that created and perpetuate inequities. Disparities are most obvious in the form of racism, particularly toward Indigenous and Black populations, but also include the structural marginalization that leads to individuals who experience poverty, unstable housing, food insecurity, and precarious employment, among others.(Public Health Agency of Canada, 2023) Equity for the LHS is defined as the elimination of systematic disparities across quadruple aim metrics amongst groups that experience

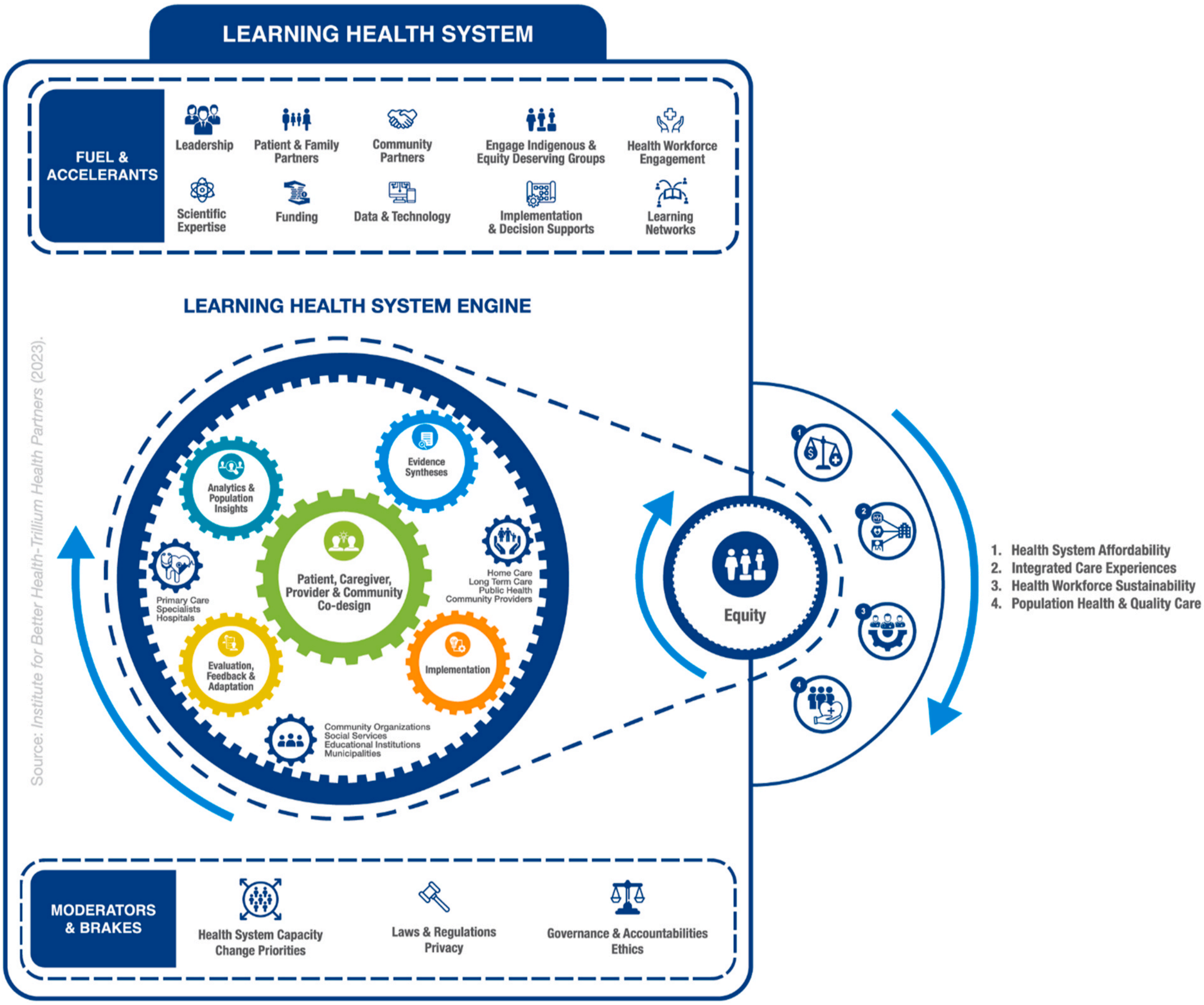


**Fig. 2.** Learning Health System Action Framework.

varying levels of social advantage or disadvantage. These disparities frequently result in those who experience disadvantages (e.g., race, low-socioeconomic status, gender identity) having worse health outcomes compared to their socially advantaged counterparts.(Braveman & Gruskin, 2003) Overcoming groups who have experienced inequities well-founded mistrust of healthcare institutions is a core factor to achieving active participation and meaningful partnership with these groups. LHSs have the potential to relieve these injustices, but only through intentionally addressing them in a coordinated and multifaceted way throughout the learning process.(Brooks et al., 2017; Parsons et al., 2021; Rice et al., 2023) Since many equity gaps relate to factors outside the healthcare system, the LHS requires expanded system thinking and new relationships to influence external structural factors such as labor, housing, income assistance, criminal justice, and education.(Reid & Greene, 2023)

Embedding and acting on equity as a central priority requires additional time and skill. When utilizing existing research to create evidence synthesis products, researchers must question how equity-deserving groups were involved in the creation of evidence and how their perspectives are considered (or more often, how they were excluded), and whose voices are absent. Gathering qualitative narratives of the lived experience of persons experiencing inequities is a critical first step to understanding the manifestations of racism and other forms of discrimination, systemic bias, and oppression. When working with structurally-disadvantaged groups and the data generated, it is important to consider issues of data sovereignty, governance, and controls on how data are collected and used. For instance, in Canada, researchers working with Indigenous populations must adhere to OCAP (ownership, control, access, possession) principles.(First Nations Information Governance Centre, 2023) These principles assert that Indigenous populations have control over data collection processes, and that they own and control how this information can be used, in line with the respective community's worldview, traditional knowledge, and practices. Similarly, the Global Indigenous Data Alliance has established international data principles to protect Indigenous People's rights and interests (Carroll et al., 2020), but sparse literature exists that examines how these principles are practically applied to inform routine data collection and use in healthcare. Similar to OCAP, Black community leaders collaborated with health equity experts to propose a data governance framework for data collected from Black communities in Canada.(Black Health Equity Working Group, 2021) The EGAP (engagement, governance, access, protection) framework envisions Black communities maintaining control over collection and use of data for research and learning purposes to ensure it advances health equity and dismantles anti-Black racism.

Co-design methods must also engage with the communities and prioritize bringing voices from equity-deserving groups to the table and elevating the power of these individuals in decision-making.(Moll et al., 2020) This ensures that, in pursuit of fostering a greater understanding of larger population health needs (Moll et al., 2020), the voices of equity-deserving groups are centered. When health system innovations or changes are introduced as a result of partnership and co-design,

**Table 2**
Learning Health System Research Evidence & Complementary Inputs.

| Learning Health System (LHS) Learning Gear | Key Questions | Types of Research Evidence | Complementary Inputs & Methods |
|---|---|---|---|
| 1. Advanced Analytics & Population Insights | • Where are the system gaps?<br>• What is driving them?<br>• Where are the inequities? | • Descriptive quantitative analyses (using administrative or EMR data)<br>• Survey research (e.g., mailed, phone, digital, mixed methods surveys)<br>• Equity analyses (e.g., marginalization/deprivation indices, relative inequality analyses)<br>• Modelling studies (e.g., predictive, causal, prescriptive & multi-level, including machine learning &artificial intelligence &)<br>• Focus groups<br>• Qualitative interviews (e.g., one-on-one interviews, semi-structured interviews)<br>• Rapid thematic analyses | • Nominal group techniques<br>• World cafés<br>• Community asset maps<br>• Patient journey maps |
| 2. Evidence Synthesis & Curation | • What do we know about this problem and its drivers more generally?<br>• What do we know about the effectiveness of interventions tested elsewhere?<br>• What do we know about the implementation of this strategy and who it reaches?<br>• What are optimal ways we can approach evaluation, feedback, and adaptation? | • Quantitative evidence synthesis (e.g., meta-analysis, systematic evidence review)<br>• Qualitative evidence synthesis (e.g., critical interpretive synthesis, meta-ethnography)<br>• Mixed evidence synthesis (e.g., realist synthesis<br>• Evidence mapping without synthesis (e.g., scoping reviews, narrative reviews)<br>• Reliably updated evidence synthesis (e.g., living evidence syntheses) | • Environmental scans<br>• Concept maps |
| 3. Patient, Caregiver & Provider Co-design | • What design considerations are most important by differing stakeholders?<br>• How do requirements differ for equity deserving groups? | • Community-based participatory research<br>• Qualitative interviews (e.g., one-on-one semi-structured interviews) & survey output<br>• Focus groups<br>• Digital storytelling, photovoice | • Deliberative methods (e.g., Delphi panels, future state mapping, stakeholder dialogues) |
| 4. Implementation & Reach | • Who needs to do what differently?<br>• What is happening now and why?<br>• How do we best train people for new work? | • Behavioral science methods (e.g., assessing behavioural drivers, specifying program theory)<br>• Formative & developmental evaluations<br>• Implementation modeling (e.g., agent-based and participatory systems dynamics modeling)<br>• Feasibility and readiness assessments | • QI/Implementation methods (e.g., learning collaboratives, coaching, practice facilitation)<br>• Technology diffusion & adoption (e.g., user-centered design methods) |
| 5. Rapid Cycle Evaluation, Feedback & Adaptation | • Who is this program working best for and how?<br>• What degree does the implementation reach across equity-deserving groups?<br>• Are there unintended consequences?<br>• What adaptations are needed to scale and sustain? | • Experimental quantitative evaluations (e.g., practical controlled trials)<br>• Quasi-experimental quantitative evaluations (e.g., interrupted time-series; propensity score matching; synthetic control; and regression-discontinuity and stepped wedge designs)<br>• Observational evaluations (e.g., quantitative, quantitative & mixed methods)<br>• Realist evaluations (e.g., hybrid designs)<br>• Process evaluations<br>• Configurational comparative methods | |

subsequent developmental, formative, or summative evaluation phases should consistently and proactively monitor disparities among groups across all measures, including the ongoing collection of qualitative insights. This standard practice recognizes the impact of systemic racism and marginalization and anticipates unintended consequences, positioning actors within the LHS to identify inequities and adapt, mitigating unintended consequences as early as possible. Health service organizations can and should be guided by the accountability checklist developed by Rice et al. (Rice et al., 2023) as a tool to support embedding of health equity across the LHS continuum. As Rice et al. (Rice et al., 2023) note, it is important to recognize that “the partnership and patient-centred principles within LHS frameworks should not be seen as a substitute for Indigenous-developed ethical frameworks like OCAP, Inuit Qaujimajatuqangit (I.Q. or Inuit societal values), and Métis research principles, which contain guiding principles and practices not accounted for in these frameworks.”

### *3.4. The applied Learning Health System action framework*

#### *3.4.1. Learning gear #1: advanced analytics and population insights*

The ‘big data’ resources from administrative health records and electronic health records (EHRs) linked to other sources of health data serve as the starting point for an LHS approach.(Foley & Vale, 2023; Menear et al., 2019; Platt et al., 2020). Contemporary EHR data capture rich data on patient health needs, diagnostics, behaviors, patient-provider communications, interventions, care processes, costs, and clinical outcomes; these data can then feed into advanced descriptive, predictive, or causal analytics to generate actionable and timely insights.(Hernan & Robins, 2006) (Table 2) Descriptive analyses of healthcare use through administrative data and EHRs are critical to quantify and characterize health needs, including social determinants of health, and are used by systems to define priority populations and address needs across the social and clinical spectrum. Predictive methods, including machine learning and artificial intelligence (Rosella, 2022; Rosella & Harish, 2022), are increasingly being applied to risk-stratify groups to elucidate who will benefit from specific interventions. Powerful causal questions enable near real-time answers to pressing questions to identify what is driving observed phenomena (Miles et al., 2020) – an approach we saw many examples of during COVID-19.(Dickerman et al., 2021)

In this learning gear, LHS evidence from big data analytics is complemented with key insights from other methods to gather input and understand people's and populations' experiences and contexts, insights which cannot be obtained using quantitative datasets alone. Health services administrative and EHR data alone do not reveal socio-historical contexts and issues that systemically and systematically disadvantage some populations. Ethnographic studies, focus groups, nominal group techniques, and rapid qualitative thematic analyses present relevant methods to generate evidence that helps understand context.(Gale et al., 2019; Singh et al., 2022; B. Taylor et al., 2018; Vindrola-Padros, 2021) Complementary processes to gather input and derive actionable insights are also important such as community asset mapping and World Café's. In this learning gear, researchers and health system operators can also come together with Indigenous knowledge keepers and Indigenous leaders to learn from them where the key imbalances are located based on Indigenous ways of knowing (Simonds & Christopher, 2013), such as Indigenous sharing circles (Hunt & Young, 2021) and Two Eyed Seeing.(Bartlett et al., 2012) In this learning gear, researchers and health system operators come together to answer questions such as "Where are the system gaps and what is driving them?" and "Where are the inequities?" Key operational partners within health systems include enabling services such as the systems' business intelligence, decision support, health technology, program planning, care experience, and performance measurement teams.

#### *3.4.2. Learning gear #2: evidence synthesis and curation*

Syntheses of the existing evidence base complements population analytics by identifying the nature, and understanding the success (or lack thereof), of solutions to similar problems tested elsewhere, whether at the micro, meso or macro level. Evidence synthesis products are varied and include quantitative evidence synthesis (e.g., a meta-analysis that estimates an effect size for a solution that has been tested in many different contexts), qualitative evidence synthesis (e.g., a critical interpretive synthesis that develops a framework to describe the pathways through which a solution may generate or fail to generate an impact), mixed evidence synthesis (e.g., a realist synthesis that examines what works for whom under what circumstances), and evidence mapping without synthesis (e.g., a scoping review or evidence map that identifies the groups and contexts where evidence is and is not available).(Kastner et al., 2012) These products also vary in their time-bound nature, including rapid contextualized evidence syntheses (undertaken to isolate what was been learned that is likely to be relevant to a particular issue and context), a global public good that can be used by anyone, and a living evidence synthesis that is updated as the context, issue or evidence evolve. Within the LHS, living evidence products are most powerful as they constantly incorporate the latest evidence to inform rapid-cycle changes in design and implementation.(Bendersky et al., 2022; Turner et al., 2023) Evidence syntheses provide a mechanism to not only objectively rate the strength of the existing evidence and understand socio-historical context, but to unpack multi-component interventions to determine which components are core to achieve intervention fidelity (i.e., necessary ingredients) and which are adaptable to local context.(Damschroder et al., 2009)

Evidence synthesis-based recommendations in the form of guidelines and technology assessments can also be drawn upon in learning cycles. While they can be developed locally, they are more commonly developed by global bodies like the World Health Organization and by national and sub-national entities like professional associations. Local groups will need to decide whether to adopt or adapt such recommendations, a process that can be formalized using approaches like Adolopment (Schünemann et al., 2017), among others. While we focus here on learning from existing evidence about solutions that can then serve as an input to the gears that follow, evidence synthesis is also a powerful tool for learning from a range of contexts in ways that inform the other gears as well. Questions to drive learning in this context include 'What do we know about this problem and its drivers more generally?', 'What do we know about the implementation of this strategy and who it reaches?', or 'What are the ways we can approach evaluation, feedback and adaptation?'

As existing evidence often does not include the most vulnerable populations, examining what we have learned from existing evidence alongside patients, families, caregivers and healthcare providers helps to contextualize meaningfulness and applicability of existing evidence for equity-deserving populations. Where these relationships have yet to be established, LHS actors can partner with community led organizations, such as Equity-Mobilizing Partnerships in the Community (EMPaCT), (Sayani et al., 2022) to centre the voices of equity-deserving groups in contextualizing evidence and highlighting knowledge gaps.

#### *3.4.3. Learning gear #3: patient, caregiver and provider co-design*

Central to the LHS and at the nexus of all the learning gears is the co-design of care approaches that are informed by local data and high-quality evidence syntheses, tailored to local context, and aligned to address foreseeable barriers to adoption and maintenance. This requires direct engagement with people who are impacted by the problem at hand – patients, caregivers, care providers, community members – along with those who have the ability to influence or are directly involved in the co-designed service – healthcare professionals, managers, and health system operators.(Bammer, 2013) It is also important that co-design activities consider cross-sectoral approaches (potentially refining approaches to housing, income assistance, education etc.) in collaborations with operators and leaders in those sectors.

When engaging in co-design, taking the time to deliberately build trusting relationships is essential. Paying attention to power differences among participants, particularly those from equity deserving groups, is vital to help people feel safe to speak and have their perspectives considered in the co-design activity.(Harrison et al., 2022) This can be achieved by early engagement and expectation management and, assessing learning needs among all stakeholders, removing barriers to engagement (due to language, disability, logistics, costs, and technology) and exploring organisational capability and readiness for engagement.(Moll et al., 2020) Tools are available to develop readiness for co-design such as Healthcare Excellence Canada's toolkit for building Engagement Capable Environments. People undertaking co-design work can use the items in this toolkit to assess organisational capability, readiness for engagement as well as barriers that need to be addressed before proceeding with co-design activities.(Healthcare Excellence Canada, 2023) Co-design methods (Palumbo, 2016) align and intersect with participatory action research, consumer engagement, design science, and user centered design methods (Green et al., 2020; Robert, 2013) and increasingly incorporate newer methods such as photovoice and digital storytelling.

Co-design activity typically happens in the form of group discussions (e.g., focus or working groups) and structured deliberations (e.g., stakeholder dialogues, Delphi panels, future state mapping events), although other forms exist (e.g., design sprints).(Banfield et al., 2015) In this gear, researchers and health system operators come together with patients, families and providers to answer questions such as "What design considerations are most important?" and "How do requirements differ for equity deserving groups?" Researchers in this domain often have natural operational partners responsible for patient and community relations and who work with patient and family advisory councils on improvement efforts, in addition to partnerships with patients, families, and communities themselves.

#### *3.4.4. Learning gear #4: implementation and reach*

The failure of many promising multicomponent interventions results from either poor alignment with the nature of the problem or weak and inconsistent execution, rather than failures of underlying evidence or concept. Poorly articulated or loosely designed implementation strategies (e.g., too complex, do not adequately address barriers) often leads to suboptimal uptake, poor outcomes, and failure to integrate new behaviours as normalized parts of a system.(Damschroder et al., 2009; Dopp et al., 2019a, b; Lyon & Koerner, 2016) Core to avoiding these common pitfalls is utilizing implementation science methods to promote the systematic and routine design of interventions and uptake of methods to improve health service effectiveness.(Eccles & Mittman, 2006) Specifically, pursuing the systematic understanding of what drives current behaviours of key stakeholders, identifying the most appropriate strategies to support the desired behaviour change, and specifying how they should be implemented.(Proctor et al., 2011) Specificity in the target stakeholder, behavior, timing, dose, implementation outcomes, and justification are all required to ensure the resulting insights are fully actioned across the necessary players.(Proctor et al., 2013)

The UK Medical Research Council (MRC)'s guidance on developing and evaluating complex interventions is the recognized gold standard for robust implementation.(Skivington et al., 2021) The most commonly-used evidence-based implementation frameworks operationalize MRC guidance and include the Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009; Damschroder et al., 2022), the RE-AIM framework (Glasgow et al., 2019), the Theoretical Domains Framework (Atkins et al., 2017), and the Non-adoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework.(Greenhalgh & Abimbola, 2019) When applying these frameworks within the implementation learning gear, it is important that explicit attention is paid to reducing likely implementation disparities across equity deserving groups.(Woodward et al., 2021) As healthcare is a fundamentally human interface, behavioural science frameworks are also key supplements within this learning gear as they assist with managing behaviour change at both individual and collective levels. The Capability, Opportunity, Motivation, Behaviour (COM-B) model (Michie et al., 2011), a framework for understanding specific behaviours and the conditions that drive them, is well positioned to support health system learning efforts. By asking the question "What conditions internal to individuals and their broader context need to be in place for a specified behavioural target to be achieved?", it links behavioural analysis with the adoption of evidence-based practices. Implementation and behavioural science frameworks are topic agnostic and are therefore easily adapted to the particular LHS learning need and knowledge level. In this gear, researchers and health system operators come together to answer questions such as "Who needs to do what differently?", "What is happening now and why?" and "How do we best train people for new work?" Key operational partners within health systems to support this work include quality improvement teams, project management, strategy, health informatics, and clinical program leaders.

Practically, deploying evidence-based strategies for successful implementation is key such as the use of clinical and operational champions, coaching, practice facilitation, and learning collaboratives. (Britto et al., 2018; Chase et al., 2014; Santos et al., 2022; Taylor et al., 2013) Where possible, champions should be identified based on influence, ownership, persuasiveness, perseverance, and a participatory engagement style.(Bonawitz et al., 2020) These attributes help overcome system siloing, build and leverage networks, create tension for change, cultivate a learning climate, and optimize compatibility with existing workflows. Strategies to support change include building coalitions to cultivate partnerships; conducting local needs assessments to clearly articulate the case for change; developing a formal implementation plans that specify goals and strategies; organizing educational events on proposed changes; using facilitation strategies to encourage interactive problem solving; and developing reminder systems.(Parchman et al., 2022) Co-design as a core practice also ensures that interventions have a good fit with stakeholders' values and goals. Scale should also be considered from the outset of implementation to ensure that new activities are sustainable. While evidence-based strategies for spread and scale remain scarce, organizations and teams can look to the NAASS framework (Greenhalgh et al., 2017) as a guide to proactively and systematically consider and plan for known influences. In these efforts, relevant partners extend to the system level and may include political, regulatory, legal, governmental, professional, and community partners. Learning networks also provide an opportunity for shared learning across individual systems. Such networks use repositories and opportunities to share resources and learnings from others' experiences. (Britto et al., 2018)

### 3.4.5. *Learning gear #5: rapid cycle evaluation, feedback and adaptation*

LHS approaches rely heavily on realist evaluation methods (Pawson & Tilley, 1997) using a combination of qualitative, quantitative, and hybrid approaches staged at the developmental, formative, and summative implementation stages.(Patton, 2010; Wodchis et al., 2021) A central focus in this gear is to measure how well the multicomponent invention is working, for which patient population(s), and under what conditions. Evaluation is also key to pointing to the use of ineffective and inefficient care processes for elimination and creation of new capacity. Logic models or similar approaches are helpful to focus evaluation measurement on the key inputs, intervention design components, and resultant processes and outcomes (intended and unintended) in the short, medium and long term.(Julian, 1997) Evaluators must also capture important contextual factors such as competing demands, staffing pressures, or exogenous events. Pragmatic randomized trial designs are considered ideal evaluation designs (Richesson et al., 2017; Simon et al., 2020), particularly those encouraging early feedback and intervention adaptation.(Coury et al., 2017) Because of feasibility constraints, robust quasi-experimental studies are more commonly used, including those with stepped-wedge or time-series designs, among others.(Miller et al., 2020) Quantitative insights are combined with findings from integrated qualitative evaluation methods such as rapid thematic analyses and ethnographic inquiries (Gale et al., 2019; Singh et al., 2022; Taylor et al., 2018; Vindrola-Padros, 2021) that can point to key mechanisms and needed changes to program activities.

Evaluation is most useful when it is active with frequent (rapid-cycle) feedback leading to program adaptation. The gear is tightly enmeshed with the implementation and co-design learning gears so that modifications can be made to the implementation strategy or co-design components when suboptimal outputs or early outcomes are detected. Connections of researchers with health system business intelligence and quality improvement teams are natural health system affinities. A core function of LHS evaluators is to partner with these teams and empower them to develop internal expertise with robust rapid-cycle evaluation capacity. Local health system teams often have the most rapid data to monitor implementation while external comparator data can be periodically leveraged to provide counter-factual and more substantive evidence of effectiveness alongside contextual qualitative interpretive data. In this gear, researchers and health system operators come together to answer questions such as "Who is this program working best for and how?", "What degree of reach do we have across equity-deserving groups?", "Are there unintended consequences?" and "What adaptations are needed to scale and sustain impact?" Operational partnership is key to sparking learning within this gear and is similar to the prior gear, including quality improvement teams, project management, strategy, health informatics, and clinical program leaders.

## 3.5. *Fueling and regulating the LHS engine for impact*

Whether measured in the short, medium, or long-term at the micro-meso- or macro level, the impact of the LHS relates to how the health system meets its quadruple aims – health (individual or population), patient and caregiver experience, care team work-life, and affordability

– with equity as a unifying objective across aims. LHS activities also have to prove the value of this approach by both substantially reducing the knowledge-to-action latency periods in achieving equitable improvements in health, experiences, and affordability.(Allen et al., 2021) The learning gears are enacted and supported by contextual factors that may either accelerate or impede progress and rapid learning success. By studying early LHS examples, researchers have articulated the various inputs and requirements needed for the LHS to thrive (fuels and accelerants), and the many barriers, tensions, and rules that determine direction, moderate speed, and slow or stall function (moderators and brakes).(Reid & Greene, 2023; Zurynski et al., 2020) Modeled after Allen et al. (Allen et al., 2021), Table 3 provides description of these key factors and highlights the necessary inputs to enable the LHS engine. Inputs extend beyond the necessary resources and capacities (i.e., funding, scientific expertise, data and technology, implementation and decision supports) to include engagement with a range of necessary stakeholders (i.e., patients and caregivers, persons from Indigenous and other groups experiencing inequities, and community partners), and learning networks that increase connectivity across organizations and structural siloes. To create conditions for learning to flourish, capable leadership that is collaboratively offered by health system research and community leaders is needed. While the fuels are generally applicable to all learning gears, several of the fuels are central to specific learning gears. Data and technology are critical to enable advanced analytics and rapid cycle evaluation. Similarly, the engagement fuels (i.e., patient, family, community, and health workforce) are essential for robust co-design activities. Learning health system efforts also require evolved but robust governance and accountability mechanisms to establish learning priorities. Mechanisms to ensure adherence to ethical principles, privacy standards, and local laws and regulations are key, but must function in ways that balances the integrity of the underlying principles with the rapid pace envisioned by the LHS.

## 4. Discussion

This paper describes the specific elements of a LHS action framework and how each component is enacted in a “whole system” approach to rapidly advance population health and health equity. We expand upon Freidman et al.’s (Friedman et al., 2017) original three activities of a LHS (knowledge from data, practice change from knowledge; new data from practice change) and provide specific actions, methods, and guiding questions for each of five learning gears. In addition to its intuitive appeal to patient partners and health system operators, we use an engine and gears analogy to highlight the importance and interconnectedness of each evidence type in driving subsequent activity. We also highlight the inclusion of specific health system operational partners central to the effective operationalization of the LHS. The framework proposed here is particularly applicable to large multicomponent interventions that affect how patients and providers interact, how teams operate, how socioeconomic determinants of health are addressed, and how care is tailored for equity-deserving groups. In practice, some problems may require single component changes or slight modifications to yield better outcomes (including redesign of existing strategies and programs or their component parts). A comprehensive approach, as outlined here, may not be necessary and stakeholders should only select those learning gears and evidence types that are relevant and needed. It is important to note that LHSs involve continually responding to system needs through a range of responses, that can be simple and well established or multicomponent nuanced approaches that require new evaluations. Our framework will inform approaches across this spectrum.

Health systems seeking to implement an LHS approach can use this framework to guide their actions, including to identify individuals and groups necessary to enact each of the gears, inform key questions and methods, and ensure a systematic approach to learning and advancement of the equity-centered quadruple aims. By fueling the system with linked data, analysis, and implementation research capabilities, health

**Table 3**
Learning Health System Fuels, Accelerants, Brakes & Moderators.

| Item | Description |
|---|---|
| **Fuel & Accelerants** | |
| Leadership | Leaders who understand the health system and foster experiential learning, with strong competencies in communication, emotional intelligence, and working with data and evidence (Parker et al., 2022) |
| Patient & Family Partners | Patient and family partners involved establishing and maintaining learning activities (Lee-Foon et al., 2023) |
| Community Partners | Partnerships with organizations and groups external to the health care system, including care, civic and voluntary community organizations (Psek et al., 2015) |
| Engagement with Indigenous & Equity Deserving Groups | Engagement and partnership with community groups representing Indigenous, racialized and other equity deserving groups (Parsons et al., 2021; Rice et al., 2023) |
| Health Workforce Engagement | Engagement of health care professionals and teams across health care sectors |
| Scientific Expertise | Methodological expertise in creation and use of evidence types (Allen et al., 2021) |
| Funding | Mechanisms to support short-term learning projects and sustainable infrastructures (Reid & Greene, 2023) |
| Data & Technology | Population-based, integrated and interoperable data systems for care, improvement, management and research purposes. Data used to measure equity-based quadruple aim metrics. Allows for real-time access to facilitate rapid learning cycles (Allen et al., 2021) |
| Implementation & Decision Supports | Decision support technologies at multiple layers to make available best-quality evidence for decision making (Allen et al., 2021) |
| Learning Networks | Learning networks can be comprised of local, regional and national health systems, interdisciplinary teams, patients, communities and healthcare managers. Networks may also be data focused using information technology tools used to collect, store, share and systematically analyze health data (Zurynski et al., 2020) |
| **Brakes & Moderators** | |
| Governance | Set of structures & processes for steering institutional activity, influencing most major aspects of organizational behavior and recognizing the complex relationships between multiple stakeholders. It also incorporates political, financial, managerial as well as daily operational issues (Chanturidze & Obermann, 2016) |
| Priority Setting Opportunities | Mechanisms to establish joint learning priorities for systems, patient and family partners, and community partner organizations (Reid & Greene, 2023) |
| Health System Learning Capacity | Time and resource investments required for health systems to maximize their ability to learn Includes building healthcare providers’ and health system leaders’ skills and capacities to learn via ongoing education and selecting appropriate roles for them within health systems (Sheikh & Abimbola, 2021) |
| Laws & Regulations | Mechanisms to ensure adherence to appropriate laws, regulations, agreements & standards (e.g., labor standards) |
| Privacy | Mechanisms to adhere to privacy regulations vs a vis clinical care and data use |
| Ethical Oversight | Mechanisms to insure ethical oversight and navigate overlap between quality improvement, clinical care, and research (Reid & Greene, 2023) |

systems can improve the efficiency and equity of health outcomes at a population level. We note the influence of both accelerants and brakes that need to be managed to enable success, recognizing that the nuance of each requires further specification to support the optimization of the LHS in practice.

The action-oriented framework is intended to provide specific guidance to health systems aiming to implement a LHS approach for rapid-cycle evidence-based change. To advance the science of LHS, future work can further develop this framework using an iterative approach such as critical interpretive synthesis. To further both the science and application of the LHS in practice, we encourage those on an LHS journey to detail their actions, experiences, and learnings. Finally, further elucidation of the fuels and accelerants, as well as the moderators and brakes, are needed to provide more concrete and actionable guidance to individuals, teams, and systems who are adopting a LHS approach.

Our action framework is intended to be succinct and practical at the expense of being exhaustive. The intent of our manuscript was to create a LHS framework applicable to whole system change by reviewing evidence and generating discussions for this context. Because we purposively excluded consideration of frameworks and operational examples that focused on particular healthcare sectors or disease states, our framework may be limited by missing general LHS perspectives that derive from selective LHS applications. Since we did not review all existing frameworks, we may have missed some important nuances. However, we believe that we captured the essence of core LHS components to inform the action framework.

Research on LHSs is developing rapidly and is still relatively nascent. Even so, most papers included in past reviews have been conceptual in nature and focus on defining concepts and mechanisms of LHS. Few have considered the real-world application of LHS or provided explicit guidance on how to implement and activate a whole-system LHS, including scoping the relevant evidentiary types, and describing the researcher-operator affinities. This paper has proposed specific practices and activities to implement a LHS. It thereby also serves to enable researchers and practitioners to test the proposed mechanisms.

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## CRediT authorship contribution statement

**Robert J. Reid:** Conceptualization, Writing – original draft. **Walter P. Wodchis:** Conceptualization, Validation, Writing – review & editing. **Kerry Kuluski:** Conceptualization, Validation, Writing – review & editing. **Nakia K. Lee-Foon:** Methodology, Validation, Writing – review & editing. **John N. Lavis:** Conceptualization, Validation, Writing – review & editing. **Laura C. Rosella:** Conceptualization, Validation, Writing – review & editing. **Laura Desveaux:** Conceptualization, Funding acquisition, Resources, Writing – review & editing.

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The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Robert Reid, Laura Desveaux, Walter Wodchis, Laura Rosella and Nakia Lee-Foon receive salary support from Trillium Health Partners, a large publically funded hospital system located in Mississauaga, Ontario, Canada. This may be considered a competing interest since the hospital system has an interest in improving its operations using a learning approach.

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