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COMMENTARY

Learning Health Systems

Four distinct models of learning health systems: Strength through diversity

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Abstract

The concept of a learning health system (LHS) was established nearly 20 years ago as a unifying commitment to speed the generation and use of evidence primarily by leveraging rapid advances in data and technologies, resulting in optimized care for each patient. In the ensuing decades, vanguard adopters of the LHS who have sought to move the LHS from conceptual to operational have done so in ways that fit with and reflect their organizational structure, mission, and culture—as well as their personal values and experiences. They have also extended the focus from health care to include individual and population health more broadly. This commentary describes four distinctive models that have evolved as learning health system activities have matured. Viewing this diversity as a strength, the features, commonalities, and unique differences of these models are described.

KEYWORDS
learning health systems, learning health system models, model characteristics

The concept of a learning health system was established nearly 20 years ago by the Institute of Medicine, now the National Academy of Medicine (NAM), as part of the charter for the Roundtable on Science and Value and Science-Driven Health Care.[1] It was envisioned as a unifying commitment to speed the generation and use of evidence by leveraging rapid advances in data and technologies, resulting in optimized care for each patient. The NAM's definition is intentionally broad, encompassing the foundational importance of science, informatics, incentives, and culture as necessary elements for learning; the central role of patients and families as active participants in their care; and a cycle of continuous improvement as the unwavering imperative. This broad conceptualization has provided useful grounding for those who aspire to build learning health systems, and it is not prescriptive as to how a system actualizes this definition in real-world settings. Thus, in the ensuing decades, vanguard adopters of the LHS who have sought to move the LHS from conceptual to concrete have done so in ways that fit with and reflect their organizational structure, mission, and culture—as well as their personal values and experiences.

Given the well-established challenges of ensuring better health outcomes and lower health care costs, interest in alternatives to the status quo remains high.[2] The LHS—with its emphasis on leveraging evidence and data in a rigorous and rapid fashion—has been held out as a promising antidote to the current state. Proponents have shown that integrating evidence at the point of care—a key pillar of the LHS—is possible.[3,4] Many systems that have adopted the LHS as a cornerstone to their improvement efforts have published organizing frameworks[5–8] and common principles,[9,10] and the growth of the field has also yielded beneficial scoping reviews about various facets of the LHS.[11–14]

The proliferative literature—and, indeed, the existence of this journal as a venue for publications on the growth and maturation of the LHS—is encouraging. To support continued growth of the LHS and respond to the need for more tactical descriptions to complement conceptual frameworks and experience reports, this commentary describes four distinctive models that have emerged as learning health system activities have matured. Features, commonalities, and unique

differences are described to help others who wish to examine their own capabilities, and perhaps even align their own approach to one of the models described herein. Our aim is to codify the increasingly common approaches to building an LHS so that those seeking to better understand and progressively implement an LHS can examine their own capabilities and goals, and then identify and apply the model that is most aligned with their local context.

1 | EMERGENCE OF FOUR DISTINCTIVE LHS MODELS

Our collective experience with Learning Health Systems, as a concept and a set of methods, dates back to 2009. Looking back to that date, one might have expected a singular vision of a Learning Health System to have evolved; but from our perspective, something much more divergent happened. To appreciate this, one need only compare the notion of a learning network[15,16] that originated from the work of ImproveCareNow[3] to the notion of a pragmatic trial pipeline[17,18]—both of which are portrayed in the literature as examples of Learning Health Systems—to see the extent of the divergence. Reports emerging from the federal government[19] and from the National Academy of Medicine[20] portrayed yet another model of LHS stimulated by publicly funded initiatives; and another emergent model emphasizes the role of the so-called embedded LHS researchers.[21,22]

The four models that have emerged are described below at a high level of abstraction, with Table 1 (introduced below) providing further detail. All models seek to improve health and health care through systematic self-study and application of what is learned.

1. The *participative model* is inspired by the concepts of learning organizations[23] and learning networks.[3,15,16] Participative LHSs carry out improvement cycles targeting specific health problems, supported by a social-technical infrastructure and emphasizing co-creation across all stakeholders. In a fully mature participative LHS, these activities pervade the entire organization or network and create a distinctive culture within it. Notable examples include networks such as ImproveCareNow,[3,16] PEDSNet,[24] and institutionally based efforts such as those at the Geisinger Health System,[25] the Universities of Michigan[26] and Minnesota,[27] and Wake Forest University.[5]
2. The *embedded researcher* model emphasizes the role of individuals or small teams that are attached to programs for the purpose of generating real-world evidence that will generate insights that promote the achievement of the program's health improvement goals.[5,20,28] An embedded researcher-focused LHS grows as the number of embedded researchers within a host organization grows. Notable examples include the activities funded under the e-STaR program,[29] Kaiser Permanente's Care Improvement Research Team,[30] the Texas Health Scholars Clinical Research Program,[31] and the embedded research partnership at Stanford Medicine.[32]
3. The *pragmatic trial* model is based on a primarily technical infrastructure that enables rapid and efficient collection and analysis of

TABLE 1 Characteristics of four learning health system (LHS) models.

LHS model (examples)	Home discipline(s)	Change strategy	Morphology	Scale and visibility	Valuing of time urgency	What determines the intervention?	Patients' role	Required infrastructure	Organizational penetration potential	Determination of what gets addressed
Participative	Behavioral and system science	Iterative cycles by collaborative communities	Co-occurring cycles with shared infrastructure	Meso	Low	What the community collectively decides	Co-creators	Socio-technical services supporting all learning cycle facets	High: End-goal is to pervade the organization and its culture	Learning communities emerge organically or may be incentivized
Embedded Researcher	Health services research, health economics	Real-world evidence generated by LHS scientist	Embedded in projects	Micro-meso	Moderate	What the data show + what the project leadership decide	Recipients of care	Community of LHS scientists + shared tools	Limited: May not extend beyond the projects directly supported	Strategic needs of the organization and/or external funding
Pragmatic trial	Informatics, clinical research	Statistical comparison of alternatives	Self-contained studies	Micro-meso	High	Adoption of statistically superior alternative	Sources of data	Technology-intensive pipeline	Limited: May not extend beyond the trials carried out	Pipeline governance oversees trial selection process
Programmatic	Public policy and organizational science	Embedded in the aims of funded programs	Funded programs	Macro	Moderate	What agency leadership and/or advisory boards decide	Beneficiaries of programs	Some programs build infrastructure; others require it as prerequisite	Moderate: May not spread beyond what is directly funded	Agency leadership and advisory board perceptions of population needs

real-world data comparing the success of intervention options.[33] Improvement is achieved by widely implementing the option that demonstrates greater success, and a pragmatic trial-focused LHS grows as the number and diversity of pragmatic trials increase. Notable examples include mature efforts at Vanderbilt University[17] and NYU Langone Health System.[18]

4. The *programmatic* model seeks to promote LHS through the initiation of publicly funded programs, each of which supports data-driven health improvement and/or the development of widely shared infrastructure. Governmental payers, such as the Center for Medicare and Medicaid Services, have taken interest in promoting LHS methods to improve care and care outcomes.[34] Large-scale employment of LHS discovery and implementation activities emerges through the aggregation of these funded programs on a national or provincial scale.[35–37] Other notable examples include PCORnet®,[38] programs of the VA Health System,[39] as well as NIH-funded LHS programs such as the Genomics-Enabled-LHS[40] and EPInet.[41]

2 | DIFFERENTIATING THE FOUR MODELS

To promote a clearer comparison and contrast of the four models, Table 1 offers characteristics that differentiate them. We define each of these characteristics, comprising the column headers in Table 1, as follows:

Home discipline(s): The methods employed in each model rest on the theories, literature, and methods associated with specific and differing scientific disciplines. The disciplines called out in each cell can be thought of as identifying the literature one would consult to appreciate the origin of the model and learn in detail about the methods employed in it.

Change strategy: All LHS models seek to improve individual and population health with data-driven interventions. Fundamental and unique to each model is a distinctive strategy for effecting changes targeted at health improvement.

Morphology: LHSs can take on different shapes and forms. This characteristic relates to what one would look for if one were trying to verify the existence of an LHS that is based on a particular model.

Scale and visibility: Tied closely to a model's morphology is a scale at which it typically operates and its consequent visibility. At micro-scale, LHS activity exists within projects and is not readily visible. At meso-scale, LHS activities, either within a single organization or through a network of organizations, have a scope and identity that makes them visible. At macro-scale, LHS activities are highly visible through the descriptions of funded projects and initiatives.

Time urgency: Built into the culture of each model is a sense of the importance of producing rapid changes. Some models give high priority to rapidity, whereas others are willing to sacrifice speed for the potential to effect more systemic changes.

What determines the intervention: As noted above, all models employ data-driven interventions to improve health. The models differ in the strategies and criteria used to decide the shape and focus of the intervention(s).

Patients' role: The models vary in how patients are perceived, and the role patients play in the improvement process.

Required Infrastructure: All systems, in varying ways and to varying extents, require technical and social infrastructure in order to function efficiently. Infrastructures provide centralized services that all facets of the system may use. The four LHS models vary in the infrastructural services that they require.

Organizational penetration potential: The LHS models vary, by virtue of their values and structure, in the extent to which they can pervade the environment in which they are based. The ability to influence and penetrate the organization is also tied to scale and visibility.

Determination of what gets addressed: Since virtually any health problem can be addressed by an LHS, the problems that make it "to the table" determine what is going to be achieved. The four models vary with respect to how these determinations are made.

3 | DISCUSSION

It is beyond the scope and intent of this Commentary to take a deep excursion into each cell of Table 1. We recognize that the content of each cell is open to debate, and we would welcome these discussions. Nonetheless, we believe that the variability in the cells within each column of the table confirms our thesis that the four models of LHS propounded here differ significantly along multiple axes. We hope that our analysis will promote useful discussion among and across proponents of each model. Ideally, in our view, when the future developers and supporters of LHS describe their efforts, they will identify which model or models they are following. This will support ongoing efforts to build the field and the collective ability to solve complex challenges in health and health care.

While Table 1 illuminates differences across the models, it is important to be mindful of their similarities. Principally, all models share the end goal of improved individual and population health, and all undertake improvement through rigorous methods of discovery leading directly to the implementation of what is discovered. All seek to shorten the "17-year" latency between discovery and implementation[42] and all seek to abide by the LHS Core Values[9] and Shared Commitments[10] that have been advanced in the literature. While the models differ in how teams are constituted and how decisions are made about priority interventions, interdisciplinary teamwork is fundamental to all four.

At this point in the evolution of Learning Health Systems, we believe the existence of distinctive models is a strength. Proponents and practitioners of different models can—and should, in our view—learn from each other and build bridges between them rather than silos or walls around them. While programs[43–45] that train future "LHS scientists" might emphasize a particular model and/or area of specialization, such programs should prepare their graduates to apply their training across the range of models, such that they may adapt

and contribute—with fluency and fluidity—to participatory research initiatives, embedded research institutes, academic health systems, or policy roles.

CONFLICT OF INTEREST STATEMENT

Sarah M. Greene reports consulting for the National Academy of Medicine.

REFERENCES

1. Institute of Medicine. *The Learning Healthcare System: Workshop Summary*. The National Academies Press; 2007. doi:10.17226/11903
2. Mate KS, Clark J, Salvon-Harman J. To improve health care, focus on fixing systems—not people. *Harv Bus Rev*. 2024.
3. Crandall W, Kappelman MD, Colletti RB, et al. ImproveCareNow: the development of a pediatric inflammatory bowel disease improvement network. *Inflamm Bowel Dis*. 2011;17(1):450-457. doi:10.1002/ibd.21394
4. Corley DA, Schmittdiel JA, Rouillard S, Chen YF, Lieu TA. Creating pragmatic, rapid-cycle, evidence-based innovation: the Kaiser Permanente Northern California Delivery Science and Applied Research (DARE) program. *Learn Health Syst*. 2025;9(1):e10424. doi:10.1002/lrh2.10424
5. Easterling D, Perry A, Miller D. Implementing the learning health system paradigm within academic health centers. *Learn Health Syst*. 2024;8(1):e10367. doi:10.1002/lrh2.10367
6. Allen C, Coleman K, Mettert K, Lewis C, Westbrook E, Lozano P. A roadmap to operationalize and evaluate impact in a learning health system. *Learn Health Syst*. 2021;5(4):e10258. doi:10.1002/lrh2.10258
7. Foley T, Vale L. A framework for understanding, designing, developing and evaluating learning health systems. *Learn Health Syst*. 2022;7(1):e10315. doi:10.1002/lrh2.10315
8. Reid RJ, Wodchis WP, Kuluski K, et al. Actioning the Learning Health System: an applied framework for integrating research into health systems. *SSM Health Syst*. 2024;2:1-11. doi:10.1016/j.ssmhs.2024.100010
9. Rubin JC, Silverstein JC, Friedman CP, et al. Transforming the future of health together: the learning health systems consensus action plan. *Learn Health Syst*. 2018;2(3):e10055. doi:10.1002/lrh2.10055
10. McGinnis JM, Fineberg HV, Dzau VJ. Shared commitments for health and health care: A trust framework from the learning health system. *NAM Perspectives*. Commentary, National Academy of Medicine, Washington, DC. 10.31478/202412c
11. Platt JE, Raj M, Wienroth M. An analysis of the learning health system in its first decade in practice: scoping review. *J Med Internet Res*. 2020;22(3):e17026. doi:10.2196/17026
12. McDonald PL, Phillips J, Harwood K, Maring J, van der Wees PJ. Identifying requisite learning health system competencies: a scoping review. *BMJ Open*. 2022;12(8):e061124. doi:10.1136/bmjopen-2022-061124
13. Ellis LA, Sarkies M, Churruca K, et al. The science of learning health systems: scoping review of empirical research. *JMIR Med Inform*. 2022;10(2):e34907. doi:10.2196/34907
14. Anderson JL, Mugavero MJ, Ivankova NV, et al. Adapting an interdisciplinary learning health system framework for academic health centers: a scoping review. *Acad Med*. 2022;97(10):1564-1572. doi:10.1097/ACM.0000000000004712
15. Lannon C, Schuler CL, Seid M, et al. A maturity grid assessment tool for learning networks. *Learn Health Syst*. 2021;5(2):e10232. doi:10.1002/lrh2.10232
16. Seid M, Hartley DM, Margolis PA. A science of collaborative learning health systems. *Learn Health Syst*. 2021;5(3):e10278. doi:10.1002/lrh2.10278
17. Lindsell CJ, Gatto CL, Dear ML, et al. Learning from what we do, and doing what we learn: a learning health care system in action. *Acad Med*. 2021;96(9):1291-1299. doi:10.1097/ACM.0000000000004021
18. Horwitz LI, Kuznetsova M, Jones SA. Creating a learning health system through rapid-cycle, randomized testing. *N Engl J Med*. 2019;381(12):1175-1179. doi:10.1056/NEJMsb1900856
19. Friedman CP, Wong AK, Blumenthal D. Achieving a nationwide learning health system. *Sci Transl Med*. 2010;2(57):57cm29. doi:10.1126/scitranslmed.3001456
20. McGinnis JM, Fineberg HV, Dzau VJ. Advancing the learning health system. *N Engl J Med*. 2021;385(1):1-5. doi:10.1056/NEJMp2103872
21. Greene SM, Reid RJ, Larson EB. Implementing the learning health system: from concept to action. *Ann Intern Med*. 2012;157(3):207-210. doi:10.7326/0003-4819-157-3-201208070-00012
22. Damschroder LJ, Knighton AJ, Griese E, et al. Recommendations for strengthening the role of embedded researchers to accelerate implementation in health systems: findings from a state-of-the-art (SOTA) conference workgroup. *Healthc (Amst)*. 2021;8 suppl 1(suppl 1):100455. doi:10.1016/j.hjdsi.2020.100455
23. Senge PM. *The Fifth Discipline: the Art and Practice of the Learning Organization*. Broadway Business; 2006.
24. Forrest CB, Margolis P, Seid M, Colletti RB. PEDSnet: how a prototype pediatric learning health system is being expanded into a national network. *Health Aff*. 2014;33(7):1171-1177. doi:10.1377/hlthaff.2014.0127
25. Williams MS, Buchanan AH, Davis FD, et al. Patient-centered precision health in a learning health care system: Geisinger's genomic medicine experience. *Health Aff*. 2018;37(5):757-764. doi:10.1377/hlthaff.2017.1557
26. University of Michigan. Our approach to learning health sciences. Accessed March 12, 2025. https://medicine.umich.edu/dept/lhs/explore-learning-health-sciences/ourapproach
27. University of Minnesota Center for Learning Health System Sciences. Accessed March 12, 2025. https://med.umn.edu/clhss
28. Pronk NP, Augustson JL, Kottke TE, Dehmer SP, Margolis KL, Frisch K. A learning health system to generate and accelerate innovation: the HealthPartners institute. *NEJM Catal Innov Care Deliv*. 2024;5(6). doi:10.1056/CAT.23.0312
29. Learning Health System (LHS) Embedded Scientist Training and Research (E-STaR) centers. Accessed March 12, 2025. https://www.ahrq.gov/pcor/ahrq-pcor-trust-fund-training-projects/pcor-lhs.html
30. Gould MK, Sharp AL, Nguyen HQ, et al. Embedded research in the learning healthcare system: ongoing challenges and recommendations for researchers, clinicians, and health system leaders. *J Gen Intern Med*. 2020;35(12):3675-3680. doi:10.1007/s11606-020-05865-4
31. Masica AL, Velasco F, Nelson TL, et al. The Texas Health Resources Clinical Scholars Program: learning healthcare system workforce development through embedded translational research. *Learn Health Syst*. 2022;6(4):e10332. doi:10.1002/lrh2.10332
32. Vilendrer S, Saliba-Gustafsson EA, Asch SM, et al. Evaluating clinician-led quality improvement initiatives: a system-wide embedded research partnership at Stanford Medicine. *Learn Health Syst*. 2022;6(4):e10335. doi:10.1002/lrh2.10335
33. Weinfurt KP, Hernandez AF, Coronado GD, et al. Pragmatic clinical trials embedded in healthcare systems: generalizable lessons from the NIH Collaboratory. *BMC Med Res Methodol*. 2017;17(1):144. doi:10.1186/s12874-017-0420-7
34. Digital quality measurement in a learning health system. Accessed March 13, 2025. https://ecqi.healthit.gov/dqm?qt-tabs_dqm=about-dqms
35. Boes S, Mantwill S, Kaufmann C, et al. Swiss Learning Health System: a national initiative to establish learning cycles for continuous health system improvement. *Learn Health Syst*. 2018;2(3):e10059. doi:10.1002/lrh2.10059
36. Auer AM, Hanson P, Brady-Fryer B, Alati-It J, Johnson AL. Communities of practice in Alberta Health Services: advancing a learning

organisation. *Health Res Policy Syst*. 2020;18(1):86. doi:10.1186/s12961-020-00603-y
37. Scobie S, Castle-Clarke S. Implementing learning health systems in the UK NHS: policy actions to improve collaboration and transparency and support innovation and better use of analytics. *Learn Health Syst*. 2020;4(1):e10209. doi:10.1002/lrh2.10209
38. Fleurence RL, Curtis LH, Califf RM, Platt R, Selby JV, Brown JS. Launching PCORnet, a national patient-centered clinical research network. *J Am Med Inform Assoc*. 2014;21(4):578-582. doi:10.1136/amiajnl-2014-002747
39. Elnahal SM, Clancy CM, Shulkin DJ. A framework for disseminating clinical best practices in the VA health system. *JAMA*. 2017;317(3):255-256. doi:10.1001/jama.2016.18764
40. The Genomics-Enabled Learning Health System (gLHS). Accessed March 12, 2025. https://www.genome.gov/Funded-Programs-Projects/Genomics-enabled-Learning-Health-Systems
41. Vohs JL, Srihari V, Vinson AH, et al. The academic community early psychosis intervention network: toward building a novel learning health system across six US states. *Learn Health Syst*. 2025;9(2):e10471. doi:10.1002/lrh2.10471
42. Balas EA, Boren SA. Managing clinical knowledge for health care improvement. *Yearb Med Inform*. 2000;1:65-70.
43. Learning Health System Embedded Scientist Training and Research (LHS E-StaR) centers. Accessed March 1, 2025. https://www.ahrq.gov/pcor/ahrq-pcor-trust-fund-training-projects/pcor-lhs.html
44. McMahon M, Brown A, Bornstein S, Tamblyn R. Developing competencies for health system impact: early lessons learned from the health system impact fellows. *Healthc Policy*. 2019;15(SP):61-72. doi:10.12927/hcpol.2019.25979
45. Greene SM, Holmes KL. Learn to fly: training and competencies to support the multidisciplinary workforce needs of learning health systems. *Learn Health Syst*. 2022;6(4):e10347. doi:10.1002/lrh2.10347

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