Received: 4 May 2023 | Revised: 26 September 2023 | Accepted: 5 October 2023

DOI: 10.1002/lrh2.10399

EXPERIENCE REPORT

Learning Health Systems

Enrichment of core competencies to maximize health system impact: An analysis of an embedded research training program

Bahar Kasaai[1] | Erin Thompson[1] | Richard H Glazier[1,2,3,4] | Meghan McMahon[1,5]

[1]CIHR Institute of Health Services and Policy Research (IHSPR), Toronto, Ontario, Canada

[2]Institute for Clinical Evaluative Sciences (ICES), Toronto, Ontario, Canada

[3]MAP Centre for Urban Health Solutions, St. Michael's Hospital, Toronto, Ontario, Canada

[4]Family and Community Medicine, University of Toronto, Toronto, Ontario, Canada

[5]Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada

Correspondence
Meghan McMahon, CIHR Institute of Health Services and Policy Research, G3 43, 2075 Bayview Avenue, Toronto, Ontario M4N 3M5, Canada.
Email: mmcmahon.ihspr@ices.on.ca

Funding information
Canadian Institutes of Health Research's Institute Health Services and Policy Research

Abstract

Introduction: The Health System Impact (HSI) Fellowship is an embedded research training program that aims to prepare doctoral trainees and postdoctoral fellows for stronger career readiness and greater impact as emerging leaders within and beyond the academy, including in learning health systems (LHS). The program supports fellows to develop 10 leadership and research competencies that comprise the *Enriched Core Competency Framework in Health Services and Policy Research* through a combination of experiential learning, mentorship, and professional development training. This study tracks competency development of HSI fellows over time and examines fellows' perspectives on which program design elements support their competency development.

Methods: A competency assessment tool developed for the program was independently completed by 95 postdoctoral and 36 doctoral fellows (self-assessments) and their respective 203 dyad (academic and health system) supervisors in the 2017 to 2019 program cohorts, who independently rated the strength of fellows' 10 competencies at baseline and several points thereafter. Competency strength ratings were analyzed to understand change over time and differences in ratings across groups (between fellows' sex, supervisor type, and supervisor vs. fellow). Program design element ratings were examined to understand perspectives on their contribution toward fellows' competency development.

Results: Fellows' competency strength significantly improved in all 10 domains over time, based on independent assessments by the fellows and their dyad supervisors. Supervisors tended to rate the fellows' competency strength higher than the fellows did. Differences in competency ratings between male and female fellows (self-assessments) and between academic and health system supervisors were either negligble or not significant. Fellows identified all nine program design elements as enriching their competency development.

Conclusion: The HSI Fellowship provides an opportunity for fellows to develop the full suite of *enriched core competencies* and to prepare a cadre of emerging leaders with the skills and experience to contribute to the advancement of LHS.

KEYWORDS
capacity development, core competency, embedded research, health services research, learning health systems

1 | BACKGROUND

The Health System Impact (HSI) Fellowship is an embedded research training program designed to build capacity for embedded research, support impact-oriented career paths of PhD-trained researchers, and foster the advancement of learning health systems (LHS) across Canada. Led by the Canadian Institutes of Health Research's Institute of Health Services and Policy Research (CIHR-IHSPR), the program aims to prepare the next generation of LHS practitioners with the skills and experience to make meaningful and impactful contributions within and beyond the academy.

Several distinctive program design elements—*italicized* below and described more fully elsewhere[1]—were intentionally integrated into the HSI Fellowship model to realize the program goals. First, fellows (doctoral trainees and postdoctoral fellows) are *embedded* directly within health system organizations (HSO) where they leverage and apply their research skills to lead an *impact-oriented program of embedded research* that addresses pressing organizational priorities. HSI Fellows are *dually mentored and supervised* by a health system and academic leader, who, at the application stage, commit to working together with the fellow on the embedded research program, to providing mentorship for career preparedness and a high-quality embedded learning environment for the duration of the fellowship (all of which are assessed by a national peer review committee of scientists and system leaders).[2] The fellows have *protected time for embedded and academic research*, are *connected with* other fellows and mentors through the program's *National Cohort Training Program*,[3] and equipped with a *professional development training* allowance and an *enriched core competency framework* to guide their skill development. Thus, fellows are supported to focus on *developing their enriched core competencies*, which include research skills (eg, analysis of data and evidence) and professional skills (eg, leadership, change management, dialogue, and negotiation) that are not currently emphasized in most health services and policy research (HSPR) doctoral training programs, but that are viewed as essential skills for health leaders to effect change and make an impact.[4] Competency-based curricula and education have been used and studied elsewhere to ground professional development and assessment in both the health sector and more generally.[5-7] These core program design elements were initially identified through an environmental scan of existing embedded fellowship programs, such as *AcademyHealth's Delivery System Science Fellowship*, and engagements with the leads of those programs.[1,8]

This study reports on fellows' competency development over time in three cohorts (2017-2019) of the HSI Fellowship program. It also examines fellows' perspectives on the contribution that the program design elements make to their competency enrichment.

1.1 | The enriched core competency framework

The HSI Fellowship aligns its training to Canada's *Enriched Core Competency Framework in HSPR*,[9] which was developed in 2015 by the pan-Canadian *Training Modernization Working Group* (TMWG) of the *Canadian Health Services and Policy Research Alliance* (CHSPRA).[9,10] Recognizing that evolving employment trends are landing fewer graduates careers within the academy,[11] the TMWG identified an opportunity to enhance the preparation of HSPR doctoral graduates to navigate and effect change in careers in the broader health system and LHS environments. Through an iterative process,[9] the TMWG identified a suite of 10 core competencies required for success in a range of sectors and roles within the health ecosystem (Table S1), including a maintained emphasis on rigorous research competencies and the introduction of professional core competencies (eg, leadership, change management, collaboration).

The primary objective of this work—to poise PhD-trained scientists for success, impact, and the capabilities to lead LHS practice with a competency framework intervention—is shared by others.[12-17] A comparison of key existing competency frameworks—developed around the same time and focused on health system advancement—highlights certain differences and commonalities in these competency interventions (Table S2). Commonly, all recognize the need to consider how the competencies are operationalized, how they can guide the development of enhanced training curricula, how achievement is assessed, and share the inclusion of a series of research skills and professional skills (eg, leadership, project/team management, collaboration, communication, and knowledge mobilization [sometimes referred to as knowledge translation or implementation science]). In contrast, the frameworks vary in the specific competencies identified—an unsurprising observation, given each framework focuses on a different domain of health systems research (ie, health services research, implementation science, LHS).

1.2 | The enriched core competency—assessment tool

Aligned to the *Enriched Core Competency Framework in HSPR*, the competency assessment tool was co-developed by CIHR-IHSPR and the TMWG as an evidence-informed, fit-for-purpose, customized tool for the HSI Fellowship program. Evidence from a literature review, an environmental scan of existing competency frameworks and tools, feedback from academic and health system leaders, expert review by the TMWG to assess for meaningfulness of the domains and instrument flow, and pilot testing with the inaugural cohort informed the tool's development. Following positive results of a pilot evaluation

with the inaugural cohort of HSI fellows in 2017,[18] the framework and assessment tool were implemented as core elements of the HSI Fellowship program for doctoral and postdoctoral fellows and have been used by all cohorts since.

The competency assessment tool comprises several elements, including: career and fellowship goal setting (professional development planning), competency selection (fellows prioritize three competencies on which to focus throughout the fellowship with mentorship and support from their supervisors), routine self-assessment and reflection throughout the fellowship (fellows meet with their supervisors at fixed time-points to review goals, competency development, professional development activities and actions, areas for continued focus, and career planning), and supervisor assessment and mentorship support (tool available upon request). To support goal setting, tracking of professional development activities and actions in relation to the targeted enriched core competencies, and reflection on key learnings, fellows are asked to develop a *Professional Development Plan* (PDP) (template is provided) and to discuss, review, and adapt it with their supervisors at each competency assessment time-point.

Overall, the tool serves three key purposes: (1) to encourage fellows to be intentional and self-reflective in their professional development; (2) to encourage dyad supervisors to support and mentor their fellows in achieving their professional development goals; and (3) to support program-level learning and improvement (eg, the ability to introduce targeted training offerings in areas where competency development was desired but not observed). Use of the competency framework and tracking tool is a mandatory requirement of the program, and their implementation is further described in the Methods section.

1.3 | Research question and study aim

The present study builds on the initial pilot study of the inaugural cohort of 1-y postdoctoral fellows[18] to contribute a comprehensive analysis of a larger sample of postdoctoral and doctoral fellowship data across three cohorts (2017, 2018, and 2019). The intent is to analyze whether HSI fellows' competencies evolve over the fellowship, if development occurs primarily in the self-identified target areas, the degree of alignment between fellows' and supervisors' competency assessments, and which program elements fellows perceive as being key enablers of their competency development. The study aims to contribute to the literature on competency frameworks and assessments, embedded research training programs, and LHS workforce development.

2 | METHODS

2.1 | Study sample

The study sample includes the participants of the triad fellowship team, including doctoral and postdoctoral fellows and their dyad health system and academic supervisors from the three first HSI Fellowship cohorts since the launch of the program, namely cohorts 2017 (wherein the data was also presented in McMahon et al[8]), 2018, and 2019. Doctoral fellows complete 1-year fellowships and postdoctoral fellows complete 2-year fellowships (exception: the inaugural cohort in 2017 could opt into a 1- or 2-year fellowship). Eligible study participants include all respondents who completed their first competency assessments, including fellows and their dyad health system and academic supervisors.

Exclusion criteria included those who did not respond to the first competency assessment, including postdoctoral fellows (n = 5 excluded, thus 96% total response rate based on 94 respondents), doctoral fellows (n = 4 excluded, 90% response rate), and their dyad supervisors (n = 30 excluded or 84% response rate for postdoctoral supervisors; n = 22 excluded or 69% response rate for doctoral supervisors).

2.2 | Implementation of the competency assessment tool

At the start of the fellowship, incoming fellows and their supervisors were introduced to the competency framework, outlining why, when, and how to use the assessment tool. Doctoral and postdoctoral fellows and their respective dyad supervisors then completed competency assessments using a secure online survey platform at defined time-points throughout the fellowship, including at: baseline (fellows only), 3 mo (all fellows and their dyad supervisors), 12 mo (all fellows and their dyad supervisors), and 24 mo (2-y postdoctoral fellows only and their dyad supervisors). Figure S1 outlines the timeline of the implementation of the tool across cohorts and within the triad fellowship team. Supervisors' first competency assessment occurred at the 3-mo time-point, given many were not well-acquainted with their fellow and lacked the information to assess competence at baseline. Questions and response scales were consistent in all assessments to allow for comparative analysis over time, and between fellow and supervisor ratings. At each time-point, fellows and supervisors independently assessed fellows' competency strength in all 10 core competencies on a Likert-type scale (range: 1-5), relative to their perception of the fellows' peer group's competency strength.

At baseline, fellows were asked to outline their fellowship and career aspirations, identify their top three competencies targeted for development over the course of their fellowship, rate the strength of each competency on a Likert-type scale, and discuss their professional development goals with their dyad supervisors.

At 3, 12, and 24 mo (for postdoctoral), fellows and their dyad supervisors independently complete a competency assessment. Supervisors assess the strength of their fellow's competencies and are invited to reflect on their mentorship approach and identify what they might do differently in the future. Fellows indicate which competencies they had the opportunity to strengthen since the previous assessment, rate the strength of their competence in each of the 10 competency domains, and meet with their dyad supervisors to discuss their professional development progress and areas for focus. At 12 and 24 mo, fellows rate the importance of nine program design elements to supporting their competency development.

2.3 | Descriptive and statistical analysis

All data reported in this study derive from the competency assessment tool, except for the sex variable, which was extracted as a self-reported variable (response options: male, female, no response, prefer not to answer, none of the above) from the *Canadian Common CV* submitted at the time of the fellowship application, to understand sex-based differences in competencies.

Descriptive analyses were conducted on independent, pooled competency assessment data of the respective participant groups to understand fellows' competency development over time, as assessed by the fellows and their respective supervisors. Longitudinal differences in the mean of each competency domain *within a single participant group* (ie, fellow, same fellow sex, academic supervisor, health system supervisor, or dyad supervisors combined) were determined using a paired two-sample *t*-test in the subset where both assessments of the same fellow were available. *Between groups*, statistical differences on the same time-point were assessed using an unpaired two-sample *t*-test for equal or unequal variance, as appropriate in an F-test. The percent change in competency development was calculated based on the difference in the competency rating between the first (baseline) and final assessment, relative to the baseline. All analyses, tables, and figures were conducted and generated using Excel.

3 | RESULTS

3.1 | Study sample characteristics

Doctoral and postdoctoral data have been examined separately to understand competency development in each stream. Table 1 summarizes the characteristics of the study participants at baseline, including the number of fellows (and their self-reported sex and geographic location) and supervisors involved per cohort year, where cohort year represents the start year of the fellowship. Overall, the 94 postdoctoral fellows were embedded in 76 distinct HSOs, affiliated with 42 universities across Canada, and their competencies assessed by 82 academic supervisors and 71 health system supervisors. The 36 doctoral fellows were embedded in 32 HSOs, affiliated with 16 universities and their competencies were assessed by 32 academic supervisors and 31 health system supervisors. Fellows predominantly self-identified as female in both the postdoctoral (mean of 76%) and doctoral groups (mean of 75%).

3.2 | Targeted competencies for development

At baseline, the *top two competencies* targeted by postdoctoral (Figure 1) and doctoral fellows (Figure S2) for focused enrichment during their fellowships were: leadership, mentorship and collaboration (mean of 53% postdoctoral, 50% doctoral fellows), change management and implementation in postdoctoral fellows (mean of 47%) or analysis of data, evidence and critical thinking in doctoral fellows (mean of 44%). The *top third targeted competency* was tied between analysis and evaluation of health and health-related policies and programs (36% of postdoctoral, 28% of doctoral fellows) and understanding health systems and policy-making (35% of postdoctoral, 33% of doctoral fellows). The least frequently targeted competencies were interdisciplinary work (17% of postdoctoral, 11% of doctoral fellows) and networking (15% of postdoctoral, 19% of doctoral fellows). There was heterogeneity thereafter in fellows' targeted competencies for development.

Although fellows identify three target competencies for focused development at baseline, both postdoctoral and doctoral fellows reported they had an opportunity to enhance all 10 competencies by the end of the fellowship (eg, 83%-98% of postdoctoral fellows at 24 mo, depending on the competency, Figure 1). Even the competencies least frequently targeted at baseline witnessed considerable development over time, such as networking and interdisciplinary work, perceived to strengthen by 90% and 94% of postdoctoral fellows (similar to doctoral fellows, Figure S2).

3.3 | Self-assessed strength of competencies

Table 2 shows that at baseline, postdoctoral and doctoral fellows' mean self-assessed competency rating was consistently highest in analysis of data, evidence, and critical thinking (3.59 and 3.42, respectively), followed by interdisciplinary work (3.44 and 3.25, respectively), and analysis and evaluation of health policies and programs (3.16 and 3.22, respectively). The competency with the *lowest* self-assessed rating for both postdoctoral and doctoral fellows was change management and implementation (2.32 and 2.36, respectively).

By 12 mo, the mean self-ratings in all 10 competencies significantly increased for both postdoctoral and doctoral fellows ($P < .001$, Table 2), with increases ranging from 12% to 57% (relative to baseline) depending on the competency and fellow group. By 24 mo (postdoctoral only), development continued in all 10 competencies ($P < .00005$), ranging from a 21% increase (analysis of data, evidence, and critical thinking) to 57% increase (change management and implementation). These increases are equivalent to, on average and at minimum, one full point increase on the five-point Likert-type scale.

Differences in self-assessments between male and female fellows were examined for any sex-specific disparities in competency development and/or self-assessed ratings. Male and female self-ratings did not differ statistically at any time-point, except for a higher baseline rating for networking in female postdoctoral fellows and higher baseline rating for change management and implementation in male doctoral fellows (Tables S3 and S4, respectively, $P < .05$). For both male and female postdoctoral fellows, self-ratings increased significantly in all competency domains from

TABLE 1 Study sample characteristics at baseline.

	2017 cohort[a]	2018 cohort	2019 cohort	Cohorts combined
Funded fellow characteristics (n = 94 postdoctoral, n = 36 doctoral respondents at baseline)				
Postdoctoral fellows	45 (48%)	22 (23%)	27 (29%)	94 (100%)
Doctoral fellows	N/A	19 (53%)	17 (47%)	36 (100%)
Total fellows	45 (48%)	41 (32%)	44 (34%)	130 (100%)
Female, postdoctoral	37 (82%)	14 (64%)	20 (74%)	71 (76%)
Female, doctoral	-	13 (68%)	14 (82%)	27 (75%)
Geographic distribution of postdoctoral fellows[b]	West: 11 (24%) Central: 31 (69%) East: 3 (7%)	West: 12 (55%) Central: 9 (41%) East: 1 (5%)	West: 9 (33%) Central: 18 (67%) East: 0 (0%)	West: 32 (34%) Central: 58 (62%) East: 4 (4%)
Postdoctoral supervisor characteristics (as reported at baseline)				
Health system supervisors	39 (55%)	15 (21%)	17 (24%)	71 (100%)
Academic supervisors	39 (48%)	22 (27%)	21 (26%)	82 (100%)

[a]In the 2017 inaugural cohort, postdoctoral fellows were awarded 1-y (n = 24) or 2-y (n = 21) fellowships; no doctoral fellows were awarded. In other cohorts, fellows were all awarded 1-y doctoral and 2-y postdoctoral fellowships.
[b]Geographic regions were based on location of the HSO, defined as: West (British Columbia, Alberta, Saskatchewan, Manitoba, Northwestern Territories, Yukon Territory); Central (Ontario, Quebec); and East (Nova Scotia, New Brunswick, Newfoundland, Prince Edward Islands).

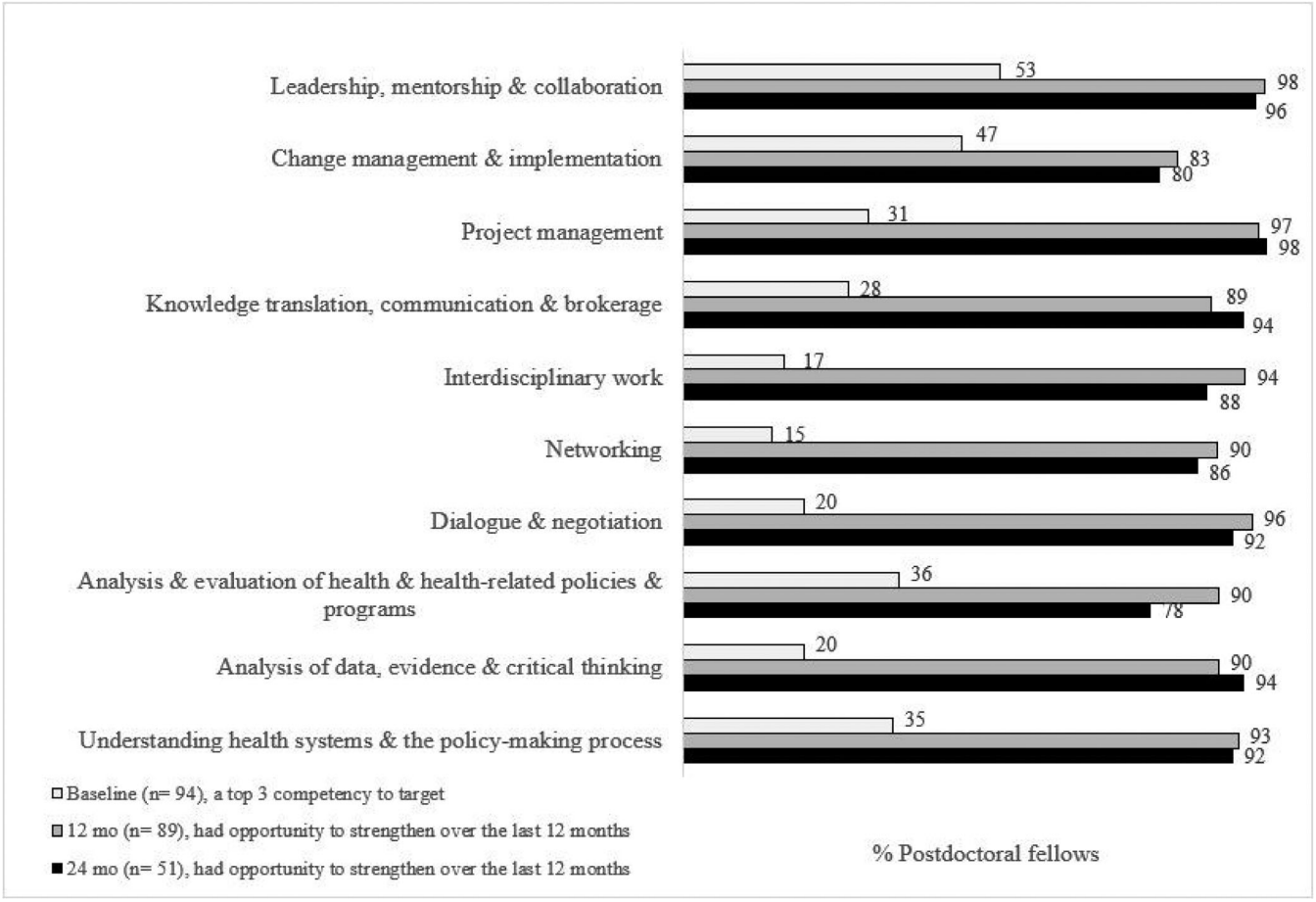

FIGURE 1 Postdoctoral fellows' top three target competencies at baseline, and the opportunity to strengthen over time.

baseline to final assessment ($P < .005$), except for KT, communication, and brokerage in males. In both male and female doctoral fellows, competency strength increased in all 10 domains from baseline to final assessment; and significantly so for females ($P < .005$), but significance was lost for male doctoral fellows in five of 10 competencies (where n = 7).

TABLE 2 Analysis of *postdoctoral* and *doctoral* fellows' self-assessments of competency strength over time.

Competency domain	*Postdoctoral*, mean fellow rating (SD)				*Doctoral*, mean fellow rating (SD)		
	Baseline (n = 94)	12 mo* (n = 89)	24 mo** (n = 51)	% change[a]	Baseline (n = 36)	12 mo.* (n = 35)	% change[a]
Leadership, mentorship, and collaboration	3.04 (0.68)	3.82 (0.67)	4.18 (0.84)	37.3%	3.06 (0.89)	4.20 (0.83)	37.5%
Change management and implementation	2.32 (0.83)	3.38 (0.89)	3.63 (0.94)	56.6%	2.36 (0.76)	3.29 (0.99)	39.2%
Project management	2.88 (0.84)	3.69 (0.85)	3.90 (0.96)	35.3%	3.14 (0.72)	4.03 (0.71)	28.3%
Knowledge translation, communication, and brokerage	2.92 (0.86)	3.79 (0.73)	3.92 (0.77)	34.5%	2.56 (0.91)	4.03 (0.82)	57.6%
Interdisciplinary work	3.44 (0.71)	4.10 (0.77)	4.25 (0.77)	23.6%	3.25 (0.87)	4.26 (0.74)	31.0%
Networking	2.98 (0.82)	3.87 (0.80)	3.88 (1.01)	30.3%	3.00 (0.96)	3.83 (0.92)	27.6%
Dialogue and negotiation	2.84 (0.70)	3.65 (0.81)	4.02 (0.86)	41.4%	2.50 (0.81)	3.94 (0.76)	57.7%
Analysis and evaluation of health and health-related policies and programs	3.16 (0.83)	3.76 (0.80)	3.86 (1.06)	22.3%	3.22 (0.76)	3.89 (0.80)	20.6%
Analysis of data, evidence, and critical thinking	3.59 (0.79)	4.03 (0.71)	4.35 (0.87)	21.3%	3.42 (0.84)	4.11 (0.68)	20.4%
Understanding health systems and the policy-making process	2.65 (0.88)	3.60 (0.93)	3.84 (0.99)	44.9%	2.69 (0.82)	3.91 (1.09)	45.3%

[a]Relative % change from baseline to final assessment (ie, 24 mo in postdoctoral; or 12 mo in doctoral). Significant difference in all 10 competency domains over time ($P < .001$), that is, between baseline and 12 mo* in postdoctoral fellows and doctoral fellows; and between baseline and 24 mo in postdoctoral fellows**, based on a paired two-sample *t*-test on assessment data that were available from both time-points (ie, n = 80, 31, and 44 assessments, respectively).

TABLE 3 Supervisors' assessments of their *postdoctoral and doctoral* fellows' competency strength over time.

Competency domain	Postdoctoral dyad supervisors, Mean rating (SD)				Doctoral dyad supervisors, Mean rating (SD)		
	3mo (n = 153)	12 mo.* (n = 145)	24 mo.** (n = 60)	% change[a]	3 mo. (n = 63)	12 mo.* (n = 50)	% change
Leadership, mentorship, and collaboration	3.57 (0.83)	4.03* (0.74)	4.38** (0.56)	22.8%	3.75 (0.92)	4.22* (0.65)	12.7%
Change management and implementation	3.18 (0.84)	3.53* (0.89)	4.05** (0.79)	27.5%	3.24 (0.91)	4.02* (0.87)	24.1%
Project management	3.62 (0.87)	4.00* (0.91)	4.30** (0.79)	18.8%	3.79 (0.85)	4.32* (0.71)	13.9%
Knowledge translation, communication, and brokerage	3.56 (0.97)	4.08* (0.76)	4.45** (0.59)	25.2%	3.59 (0.84)	4.32* (0.71)	20.4%
Interdisciplinary work	3.85 (0.87)	4.26* (0.75)	4.53** (0.62)	17.8%	3.92 (0.77)	4.50* (0.65)	14.8%
Networking	3.86 (0.85)	4.29* (0.72)	4.58** (0.65)	18.9%	3.90 (0.71)	4.26 (0.78)	9.1%
Dialogue and negotiation	3.39 (0.97)	3.79* (0.88)	4.32** (0.68)	27.3%	3.60 (0.81)	4.20* (0.78)	16.6%
Analysis and evaluation of health policies and programs	3.50 (0.93)	4.03* (0.85)	4.47** (0.68)	27.5%	3.67 (0.74)	4.30* (0.61)	17.3%
Analysis of data, evidence, and critical thinking	3.90 (0.99)	4.36* (0.74)	4.53** (0.62)	16.4%	3.95 (0.71)	4.54* (0.73)	14.9%
Understanding health systems and the policy-making process	3.37 (0.95)	3.97* (0.82)	4.42** (0.59)	31.0%	3.57 (0.73)	4.28* (0.70)	19.8%

Note: Significant increase in the dyad supervisor assessment for all competency domains between 3- and 12-mo* (n = 107 assessments available at both time-points), and between 3- and 24-mo ** (n = 37 assessments available at both time-points) at $P < .005$, based on a paired two-sample *t*-test.
[a]Relative % change from baseline to 24-mo assessment.

3.4 | Supervisors' assessment of strength of competencies (vs. fellows' assessment)

At each time-point, the academic and health system (combined dyad) supervisors independently rated their respective postdoctoral (Table 3) and doctoral fellows' competencies (Table S5). At 3 mo (ie, the supervisors' first assessment), similar to their fellows' baseline self-ratings, the mean dyad supervisor ratings for their postdoctoral and doctoral fellows were the *highest* in analysis of data, evidence, and critical thinking (3.90 and 3.95, respectively), followed by networking (3.86 and 3.90, respectively) *or* interdisciplinary work (3.85 and 3.92, respectively); and *lowest* in change management and implementation (3.18 and 3.24, respectively) and understanding the health system and policy-making process (3.37 and 3.57, respectively).

TABLE 4 Fellows' ratings of the value of program enablers to enhance competency development.

Program element	Postdoctoral 24 mo (n = 51)	Doctoral 12 mo (n = 35)
Being embedded in a health system organization	4.49 (0.92)	4.53 (0.86)
Working on an impact-oriented project of high importance to my host partner organization	4.39 (0.92)	4.39 (0.70)
My professional development training allowance	4.46 (0.86)	4.00 (1.16)
Mentorship from my health system supervisor	4.10 (1.12)	4.15 (1.19)
Mentorship from my academic supervisor	4.02 (1.12)	4.06 (1.00)
Co-mentorship (team-based approach) from my health system and academic supervisors	3.90 (1.25)	3.78 (1.25)
Fellow-to-fellow interactions	3.36 (1.26)	3.52 (1.28)
The protected time for my academic research	4.07 (0.90)	3.89 (1.19)
The National Cohort Retreat and virtual cohort meetings	3.56 (1.11)	3.68 (1.03)

By the end of the fellowship (12-mo for doctoral and 24-mo for postdoctoral fellows), dyad supervisors perceived progressive and significant competency improvement in all 10 domains among their postdoctoral fellows ($P < .005$) and in nine domains among their doctoral fellows ($P < .05$, all except networking). Postdoctoral dyad supervisors' final competency assessment remained the highest in networking (4.58), interdisciplinary work (4.53), and analysis of data, evidence, and critical thinking (4.53). Doctoral dyad supervisors' final assessment remained the *highest* in analysis of data, evidence, and critical thinking (4.54) and interdisciplinary work (4.50). The *lowest* rated competency by dyad supervisors across the fellowship was consistently change management and implementation for both postdoctoral and doctoral fellows, but also witnessed among the largest improvements over time (ie, a 28% and 24% strength increase from baseline to final, respectively).

To understand whether health system and academic supervisors assessed their fellows' competency strength differently, ratings were stratified *between* supervisor types (Table S6 for doctoral and Table S7 for postdoctoral fellows). Differences in competency strength *between* supervisor types were not significant except for three domains: leadership, mentorship, and collaboration (at 3 mo for postdoctoral), interdisciplinary work (at 12 mo for doctoral and postdoctoral), and networking (at 12 mo for doctoral only)—all rated higher by academic supervisors ($P < .05$). Similar to the combined dyad supervisor ratings, each supervisor type perceived progressive improvements in all 10 domains of their postdoctoral or doctoral fellows' competencies over time, but significance was lost over time when stratified by supervisor type (except in the postdoctoral fellows' academic supervisor group, $P < .05$), possibly due to a reduced sample size.

A comparison of the fellows' versus their dyad supervisors' mean ratings of competency strength reveals that the supervisors assess their fellows' competencies as stronger than the fellows themselves in all 10 domains, with significantly higher ratings by supervisors in seven domains for postdoctoral (Table S7) and in four domains for doctoral fellows (Table S8).

3.5 | Program design element contributors to competency development

Table 4 presents fellows' end-of-fellowship ratings of the importance of nine defined program design elements to enabling their competency development (using a 5-point Likert-type scale). By the end of the fellowship, fellows identified the *top four enablers* as: being embedded in an HSO (consistent top enabler), working on an impact-oriented project of high importance to the HSO, the professional development training allowance, and mentorship from the health system and academic supervisors. All nine enablers were rated at least moderately important by doctoral and postdoctoral fellows (mean ratings ranging from 3.36 to 4.53).

4 | DISCUSSION

Human capital is a foundational building block for enabling rapid learning and improvement within HSOs and advancing LHS capacity. Doctorate holders in HSPR and related fields have specialized skills in research, analysis, and critical thinking that are vitally important. However, research skills are insufficient on their own to drive change. Individuals must also have capabilities in other domains that enable them to understand pressing health system priorities and translate those into researchable questions, to partner with policy-makers, patients, and providers to co-design contextualized evidence-informed solutions, and ideally, to support implementation of those solutions in complex environments and systems to improve performance and outcomes. The *Enriched Core Competency Framework in HSPR* was designed with this vision, to enhance doctoral and postdoctoral training and equip the next cadre of LHS practitioners with the skills, competencies, expertise, and lived experience needed to tackle real-world health system priorities. By intentionally aligning to this competency framework and leveraging nine program design elements, the HSI Fellowship aims to contribute to the development of this human capital in Canada.

The present study examined the competency development of 2-y postdoctoral and 1-y doctoral fellows of the HSI Fellowship program across three program cohorts. This study assessed whether HSI fellows' competencies evolved over the duration of their embedded research fellowship, whether competency development occurred primarily in the self-identified target competency areas, the degree of alignment between fellows' and supervisors' competency assessments, and identify which program elements were perceived to be key enablers of competency development. The study contributes to the evidence base on LHS-oriented competency frameworks and embedded research training

programs, and their potential to contribute to building the human capital for LHS. Overall, the study findings build on, and are consistent with, a pilot study of a 1-y postdoctoral fellows of the inaugural 2017 cohort.[18] Four key findings and their implications, future directions, and study limitations are discussed below.

First, fellows and their dyad supervisors independently perceived progressive and significant development of the 10 core competencies over the course of the fellowship. Postdoctoral and doctoral fellows also rated nine defined program elements of the HSI fellowship as moderately to highly contributing to their competency development. These two findings suggest that the HSI Fellowship offers a vehicle for fellows to strengthen their enriched core competencies.

Second, the competency development reported was generally consistent and meaningful across all fellowship program participants, including postdoctoral and doctoral fellows and their dyad supervisors. Although broader standard deviations were sometimes observed (which can at least in part be explained by the subjectivity of competency-based assessments[19]), the perceived competency enrichment between baseline and final assessment was consequential in *absolute* value (eg, mean increase of at least one point in Likert scale ratings in fellow assessments) and *relative value* (eg, ranging from 20% to 56%), with significant statistical power (P-values ranging between 0.001 and 0.005). Further, baseline assessments by all participants were generally higher in the research competency domains (eg, analysis of data, evidence and critical thinking, and analysis and evaluation of health-related policies and programs) and lower in the professional competency domains (eg, change management, and dialogue and negotiation). These same professional competency domains also witnessed the greatest development gains over the course of the fellowship. Change management was consistently the lowest rated across all participants and throughout the fellowship. These findings may reflect the emphasis on rigorous scholarly training in university doctoral curricula, suggesting that embedded training opportunities like the HSI Fellowship that align to a competency framework with professional skills can help enhance the preparation of doctorally trained individuals for LHS careers.

Third, there were negligible differences in competency ratings between male versus female fellows and between supervisor type (health system and academic), in both doctoral and postdoctoral fellow groups. However, differences in competency ratings were observed between fellows and their supervisors. Fellows tended to be more self-critical of their own competence than their supervisors in all 10 domains, and significantly so in seven competencies (postdoctoral fellows) and four competencies (doctoral fellows). Further, while rating trends were similar in both supervisor types, health system supervisors scored fellows lower than their academic counterparts in a few professional domains (ie, leadership, mentorship, and collaboration for postdoctoral fellows; networking for doctoral fellows; and interdisciplinary work for both fellow groups, $P < .05$), suggesting that health system supervisors may assess professional competencies differently, possibly due to the complex environment of the embedded HSO setting.

Fourth, among nine defined design elements of the HSI Fellowship, the top four contributors to competency development were perceived to be: being embedded in an HSO, working on an impact-oriented project of high importance to their HSO, the professional development training allowance, and the mentorship received from their health system supervisor. Fellows' moderate ratings of certain design elements (ie, the National Cohort Retreat and virtual learning sessions, fellow-to-fellow interactions, and the team-based co-mentorship model) prompted the introduction of program interventions in 2020-2021 to strengthen these design elements. To enhance the value of the National Cohort, the enriched core competency training offerings, and fellow-to-fellow interactions, CIHR-IHSPR funded a multi-year National Cohort Training Platform[3] that is led by alumni fellows and health system and academic leaders in the fellowship program. This pan-Canadian consortium has developed curriculum and training opportunities aligned to the enriched core competency framework, hosts monthly sessions with the fellows, and organizes an annual retreat that brings fellows, supervisors, alumni, and program partners together for in-person networking, collaboration, and learning. To emphasize and support the co-mentorship dyad model, CIHR-IHSPR introduced an orientation session for mentors that is held at the start of the fellowship and developed a *mentorship toolkit* to support mentors in their support of their fellows' competency development (available upon request).

Overall, the study findings suggest the HSI Fellowship offers a vehicle for fellows to strengthen existing research competencies and develop capabilities in professional competencies that are critical to advancing LHS. The findings are consistent with a pilot evaluation of 1-y postdoctoral fellows from the 2017 cohort.[18]

4.1 | Study strengths and limitations

The strengths of the study are (1) the comprehensiveness and richness of data from multiple sources (1-y doctoral, 2-y postdoctoral fellows, and both fellow (self-reported) and dyad supervisor (independent) competency assessments) and across three cohorts; (2) the use of a an evidence-informed, customized competency tool and framework developed specifically for the participant group (doctoral trainees in Canadian HSPR training programs); (3) the complementary data on fellows' perceptions of the fellowship in enabling competencies; and (4) the potential reproducibility of the competency framework, tool, and other HSI Fellowship program elements for implementation or adaptation in other programs, settings, and contexts. The HSI Fellowship model was inspired by and adapted from other innovative programs like *AcademyHealth's Delivery System Science Fellowship*, which share similar program elements,[1,8] and the competency framework was informed by the literature and with insight and advice from health system and academic experts.[9] Further, the HSI Fellowship model has already inspired the creation of other embedded research programs in several Canadian provinces, including the *Ontario Health Teams Impact Fellowship* (which also adopted the enriched core competency framework and assessment tool)[20] and the Nova Scotia *Network of Scholars Program*.[21] Additionally, the heterogeneity of the learning environments funded within the HSI Fellowship

program is considerable, including the fellows' HSOs and academic institutions (which vary across geographic location, size, organizational structure, profit status, and other factors) and supervisors (who are diverse in their expertise, experience, and other factors); yet, amidst this heterogeneity, this study found that a standardized competency framework and tool are feasible to implement and that competency development is positively enriched across all cohorts.

Among the study limitations are (1) the fellow competencies are self-assessed, which although a standard means to assess competencies[12,16,22] may be subject to bias; (2) the absence of a control group (ie, of doctoral trainees and postdoctoral fellows not involved in the program and not using the competency framework), means that a causal relationship cannot be established; and (3) the lack of qualitative data regarding the fellows' and supervisors' experience with the fellowship and competency development and the resulting impacts, which is the focus of future research.

Altogether, the study findings are a promising signal of the contributions of the fellowship and its design elements in fellows' competency development.

4.2 | Future research and policy directions

Overall, the *Enriched competency framework in HPSR* is a rigorously developed accessible framework[9] that holds promise as a mechanism to support core competency enrichment in the context of the HSI Fellowship program and potentially other embedded research and LHS training programs. Evidence so far suggests that the HSI Fellowship is innovative and impact-oriented,[23-26] and its constituent building blocks (nine design elements) hold promise for replicability in other training programs across Canada and abroad.

Still, continuous program improvement is critical and several areas for improvement have been identified. For instance, the *Enriched competency framework in HPSR* was introduced in 2017, prior to recent milestones that redefined our values within the health system and society at large, such as the COVID-19 pandemic, the death of George Floyd and the Black Lives Matter movement, the discovery of the bodies of Indigenous children buried on the grounds of residential schools, and the popularization and spread of the LHS model in Canada. To ensure the competency framework reflects the current context and the future skills required to advance health system improvement, a pan-Canadian Task Force was established in 2022 to commence review of the framework. Preliminary data has already identified the importance of including equity as a competency domain, in line with recently published frameworks.[13,27] Additionally, there is an opportunity to provide greater support and training for the supervisors/mentors in the program (who play a critical role in supporting fellows' learning and research impacts) and to understand the attributes of high-quality embedded learning environments in HSOs (which provide the embedded training environment). Currently, the program's professional development training and competency framework and tools are primarily geared to the fellow. Increasing the dyad mentors' capabilities to support the fellow together and to engage in and use embedded research, while supporting HSOs to strengthen their cultures/systems/processes for learning and improvement, may translate into higher-quality embedded learning environments and stronger embedded research impacts. Thus, understanding the competencies needed to drive LHS improvement at the individual-level (eg, fellows/LHS practitioners), mentor-level, and HSO-level provides important insight to inform these efforts.[28] Future research, which is beyond the scope of this paper but currently underway, includes exploring the broader impacts that the HSI Fellows are making, as a result of their participation in the HSI Fellowship.

5 | CONCLUSION

To realize the full potential of LHS and its workforce at the individual-level (fellow's career and professional development), organizational-level (advancing HSO priorities and their impact goals), and system-level (advancing the model of LHS across Canada), the forthcoming cadre of LHS practitioners must be equipped with the skill sets, competencies, and experiential training to navigate the complexity of LHS and straddle the academic-HSO ecosystems. The HSI Fellowship was conceived in Canada with this vision, and this study validates that the triad fellowship team independently perceive the full suite of competencies that enrich fellows who participate in the program. Further, fellows positively perceive nine program design elements (including embeddedness in an HSO, working on an impact-oriented project in the HSO, dual mentorship model, and professional development allowance) as enablers of their competency development. This study adds to the literature that embedded research programs like the HSI Fellowship are a promising strategy to develop LHS human capital and to prepare PhD-trained individuals for impactful careers in a wide range of sectors.[23-26]

AUTHOR CONTRIBUTIONS

Meghan McMahon conceptualized the design and methods. Bahar Kasaai completed acquisition of data and analysis. Bahar Kasaai and Meghan McMahon drafted. Erin Thompson and Richard Glazier contributed to drafting and critical review of the manuscript. Meghan McMahon and Richard Glazier provided supervision.

ACKNOWLEDGMENTS

The authors wish to acknowledge the leadership and contribution of Dr. Adalsteinn (Steini) Brown, Dean, Dalla Lana School of Public Health, University of Toronto; and Dr. Stephen Bornstein, Professor Emeritus, Memorial University of Newfoundland, who co-chaired the Pan-Canadian Training Modernization Working Group during the study period and who led the development of the Pan-Canadian Training Modernization Strategy. The authors also wish to thank the health system, academic and funding partners who share a commitment to embedded research and support the Health System Impact Fellowship program, and the National Cohort Training Program's leadership and all fellows for their commitment to evidence-informed health system improvement.

CONFLICT OF INTEREST STATEMENT

This work was supported by the Canadian Institutes of Health Research's Institute of Health Services and Policy Research (CIHR-IHSPR). The authors have no further conflicts nor ethics reviews to disclose.

ETHICS STATEMENT

The study data were obtained from CIHR program reporting (competency assessments) to inform program-level quality improvements. The sex data were obtained as per CIHR's *Applicant Consent Requirements* (section 6.1). Additionally, while sex as a demographic factor was available from self-reporting data and allowed for sex-based analyses in competency ratings (generally not significant), other demographic variables such as race or ethnicity were not available in program reporting.

ORCID

Bahar Kasaai https://orcid.org/0000-0001-7264-7151
Richard H Glazier https://orcid.org/0000-0002-7952-8320
Meghan McMahon https://orcid.org/0000-0001-9977-6412

REFERENCES

1. McMahon M, Tamblyn R. The health system impact fellowship: perspectives from the program leads comment on "CIHR health system impact fellows: reflections on 'Driving Change' within the health system". *Int J Health Policy Manag*. 2019;8:623-626.
2. CIHR. CIHR Funding Opportunity: Health System Impact Fellowship (review criteria). 2022 [Online]. ResearchNet. Available: https://www.researchnet-recherchenet.ca/rnr16/vwOpprtntyDtls.do?prog=3804&view=currentOpps&org=CIHR&type=EXACT&resultCount=25&sort=program&all=1&masterList=true&language=E#evaluation
3. CIHR-IHSPR. National Cohort Training Program Announcement. 2021. https://cihr-irsc.gc.ca/e/52583.html
4. Parker G, Smith T, Shea C, Perreira TA, Sriharan A. Key healthcare leadership competencies: perspectives from current healthcare leaders. *Healthc Q*. 2022;25:49-56.
5. Freshman B, Rubino L. Emotional intelligence: a core competency for health care administrators. *Health Care Manag*. 2002;20:1-9.
6. Gowie M, Wilson D, Gregory S, Clark LL. Development of a core competency framework for clinical research staff. *J Interprofessional Educ Pract*. 2020;18:100301.
7. Ruiz Y, Matos S, Kapadia S, et al. Lessons learned from a community-academic initiative: the development of a core competency-based training for community-academic initiative community health workers. *Am J Public Health*. 2012;102:2372-2379.
8. Mcmahon M, Bornstein S, Brown A, Simpson LA, Savitz L, Tamblyn R. Training for health system improvement: emerging lessons from Canadian and US approaches to embedded fellowships. *Health Policy*. 2019a;15:34-48.
9. Bornstein S, Heritage M, Chudak A, Tamblyn R, Mcmahon M, Brown AD. Development of enriched Core competencies for health services and policy research. *Health Serv Res*. 2018;53(Suppl 2):4004-4023.
10. (CHSPRA), C. H. S. A. P. R. A. Modernizing health services and policy research training: a pan-Canadian strategy. Report from the Working Group on Training. 2015.
11. Mcmahon M, Habib B, Tamblyn R. The career outcomes of health services and policy research doctoral graduates. *Health Policy*. 2019c;15:16-33.
12. Burgess JF, Menachemi N, Maciejewski ML. Update on the health services research doctoral Core competencies. *Health Serv Res*. 2018;53(Suppl 2):3985-4003.
13. Coley RY, Duan KI, Hoopes AJ, et al. A call to integrate health equity into learning health system research training. *Learn Health Syst*. 2022;6:e10330.
14. Feldman SS, Allgood A, Hall AG, Lemak CH, Berner ES. Competency analysis and educational strategies to meet the demand for a learning health system workforce. *Learn Health Syst*. 2022;6:e10324.
15. Forrest CB, Chesley FD Jr, Tregear ML, Mistry KB. Development of the learning health system researcher core competencies. *Health Serv Res*. 2018;53:2615-2632.
16. Franklin PD, Drane D, Wakschlag L, Ackerman R, Kho A, Cella D. Development of a learning health system science competency assessment to guide training and proficiency assessment. *Learn Health Syst*. 2022;6:e10343.
17. Schleiff MJ, Rangnekar A, Oviedo Gomez F, Teddy G, Peters DH, Balabanova D. Towards core competencies for health policy and systems research (HPSR) training: results from a global mapping and consensus-building process. *Int J Health Policy Manag*. 2020;11:1058-1068.
18. Mcmahon M, Brown A, Bornstein S, Tamblyn R. Developing competencies for health system impact: early lessons learned from the health system impact fellows. *Health Policy*. 2019b;15:61-72.
19. Virk A, Joshi A, Mahajan R, Singh T. The power of subjectivity in competency-based assessment. *J Postgrad Med*. 2020;66:200-205.
20. OHT. Ontario Health Teams (OHT) impact fellowship. 2023 [Online]. Available: https://ohtfellows.ca/
21. Murphy GT, Sampalli T, Embrett M, et al. The network of scholars strategy: a case study of embedded research activities in Nova Scotia to advance health system impact and outcomes. *Healthc Pap*. 2022;20:33-43.
22. Karnoe A, Furstrand D, Christensen KB, Norgaard O, Kayser L. Assessing competencies needed to engage with digital health services: development of the eHealth literacy assessment toolkit. *J Med Internet Res*. 2018;20:e178.
23. Blanchette MA, Saari M, Aubrecht K, et al. Making contributions and defining success: an eDelphi study of the inaugural cohort of CIHR health system impact fellows, host supervisors and academic supervisors. *Health Policy*. 2019;15:49-60.
24. Bornstein S, Mcmahon M, Yiu V, et al. Exploring mentorship as a strategy to build capacity and optimize the embedded scientist workforce. *Health Policy*. 2019;15:73-84.
25. Kasaai B, Thompson E, Glazier R, Mcmahon M. Early career outcomes of embedded research fellows: an analysis of the health system impact fellowship program. *Int J Health Policy Manag*. 2023;12:1-10.
26. Sim SM, Lai J, Aubrecht K, et al. CIHR health system impact fellows: reflections on "driving change" within the health system. *Int J Health Policy Manag*. 2019;8:325-328.
27. ACADEMYHEALTH. AHRQ updates learning health system competencies to include health equity. 2022 [Online]. https://academyhealth.org/blog/2022-08/ahrq-updates-learning-health-system-competencies-include-health-equity
28. 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:e061124.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Kasaai B, Thompson E, Glazier RH, McMahon M. Enrichment of core competencies to maximize health system impact: An analysis of an embedded research training program. *Learn Health Sys*. 2024;8(2):e10399. doi:10.1002/lrh2.10399