

# Using a Complex Systems Perspective to Achieve Sustainable Healthcare Practice Change

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## Abstract

*Background:* There has been a surge of interventions at healthcare settings to achieve practice change, but sustaining these new practices remains a challenge. The purpose of this study was to use the Legacy Sustainability Model, a framework grounded in complexity science, to examine the implementation and sustainability of an interprofessional (IP) collaboration intervention in healthcare. The model considers six factors—communication, connections, coherence, continuous assessment, commitment, and constructs—as essential to build capacity for sustainability.

*Methods:* Three healthcare settings in Alberta implemented IP practice interventions over a six-month period. After three and six months, we interviewed participants at each site to get their views about the progress of the IP intervention and emerging challenges. We examined the interview data for emergence of the six factors of the Legacy Sustainability Model.

*Findings:* Our analysis showed distinct contextual differences between the three sites, as represented by the strengths of the six factors at the outset of the IP interventions and the way the factors evolved throughout the project.

*Conclusions:* Using a complex systems lens allowed us to view the successes and challenges in each site from a different perspective and to highlight areas of strength and weakness that require attention for ongoing IP practice change. Furthermore, the framework has allowed us to compare the implementation of interventions that varied distinctly in nature and context. Interventions that consider Complex Adaptive Systems (CAS) characteristics, such as the dynamic and emergent nature of local interactions and contexts in their design, may hold promise for more effective practice change.

*Keywords:* Interprofessional collaboration; Complex adaptive systems; Sustainability; Practice intervention

## Introduction

In recent years, we have seen a surge in the implementation of collaborative, patient-centred service delivery models as part of ongoing healthcare reform [1]. The objective of these implementations is to achieve interprofessional (IP) collaboration, defined as a process that involves different professional groups working together to improve healthcare [2]. The key for sustaining IP collaboration is to create a continued need for collaboration and ways to embed collaboration through all aspects of the organization [3]. This means that, ideally, efforts to improve service delivery are ongoing and collaboration becomes integrated into the workplace.

Practice change in healthcare has notoriously been difficult to achieve [4,5], considering the pressures of the organizational context to maintain the status quo [6]. Intervention strategies often do not yield the expected success and produce variable and disappointing results [7-9]. Furthermore, when implementing new practices or programs, sustainability is a major concern. In many implementation studies, IP col-

laboration becomes a means to an end for a limited period of time until individual operational improvements have been achieved. More often than not, once practice changes have been made, new problems are not addressed because the strategy did not quite succeed in establishing a pervasive collaborative culture [3] that would foster continuous innovation. Sustainability is rarely built into implementation activities early on. Pluye et al. [10] criticize the “stage model” of developing interventions in which implementation and sustainability follow a chronological and linear process. They suggest that we should address issues of sustainability at the outset by considering events that promote it.

Some have attributed the lack of intervention success to poor implementation fidelity [8]. However, increasingly, authors argue that our view of a Newtonian “clockwork universe,” which underpins most interventions in healthcare, is to blame [11]. In our analysis of IP collaboration implementations and sustainability, we join others who conceptualize healthcare settings as complex adaptive systems (CASs) [4,6,8,9,12-14]. CASs are organic and dynamic systems “where relationships between people are dynamical and not adequately captured in cause-and-effect modelling” [6, p. 342]. Other recognized characteristics of CASs are [8,9,12,14]: organizational members with a capability to learn, interconnectedness between individuals, the ability of individuals to self-organize, and the tendency of these individuals to co-evolve. Order emerges from constant interaction between members in the system [13,14]. The whole is irreducible, and cause and effect are intertwined and embedded within context [15]. CASs typically have fuzzy boundaries, and members can belong to a number of subsystems, which may lead to unexpected actions in response to change [11]. Hence, variability in outcomes is not related to improper implementation but is largely determined by the relationships that are at play in a particular setting [8]. As such, variations in outcomes are to be expected in CASs because of the fundamental nature of these systems [8].

From these characteristics it becomes clear that the local relationships and interdependencies among organizational members are paramount to the functioning of the system [8]. These relationships constitute a means for sensemaking and collective learning and a mechanism for individuals to cope with the uncertainty inherent in a CAS [8,9]. The ability to learn and adapt arises from environmental cues, feedback, or events [16]. The success of an intervention in a CAS will be largely influenced by the relationships in the system in conjunction with local context and how members learn and co-evolve over time [8,9,13,14]. Many authors have argued that in typical linear models, these relationships have consistently been overlooked [17]. Viewing healthcare systems as CASs requires designing interventions that take the dynamic and emergent nature of local interactions and contexts into consideration. Such interventions need to be sensitive to its changing environment, flexible to respond to changes, and robust enough to withstand emergent challenges [8]. This “adaptive” approach incorporates a number of the concerns outlined by Pluye and colleagues [10] into a more dynamical concept of sustainability that we can “build into the initiatives we design” at the beginning [18, p. 4]. Some authors have argued that using CAS perspectives may increase our understanding of complex behaviours in healthcare systems [15-17].

## Study Purpose

The purpose of the study was to use a framework grounded in complexity science to examine the implementation and sustainability of IP collaboration interventions in healthcare. We applied the framework post hoc with the intent to gain insight into factors affecting the success of the intervention at each site as well as the potential of the sites to sustain the practice changes achieved. The research questions explored were: 1) How does the application of the Legacy Sustainability Model, grounded in complexity science, as a framework provide insight into factors affecting the implementation and success of the intervention and the sustainability of IP practice changes? 2) How does the use of the Legacy Sustainability Model as a framework allow comparisons of interventions at various sites?

## Framework Used

We chose the Legacy Sustainability Model [18] as our analysis framework. This model is grounded in CAS concepts and comprises the following six key factors:

- connections to current work, other departments, staff, or customers;
- communication with key stakeholders about the initiative;
- coherence of the initiative with internal direction or policies and external drivers;
- continuous assessment for “fit,” success criteria, and continuous improvement;
- constructs for planning, documentation, or resources; and
- commitment of individuals, resources, and the institution.

The six factors of the Legacy Sustainability Model comprise components that others have also considered important for sustainability, such as leadership support, human resources support infrastructure, the maintenance of financial resources, technologies, ad-hoc training, clear goals, and research-seeking behaviours [10,19,20]. Ongoing assessment and adaptation to ensure continued good fit are further essential components discussed in the literature [21,22]. According to Holladay [18], developing the six factors builds capacity and leads to sustainability by ensuring that the initiative is being embedded into the ongoing operations of the organization. While it is important to consider all of the factors when implementing practice change, it is impossible to determine which factors are most relevant, as they are intertwined [18]. In alignment with CAS thinking [8,9,13,14], the factors in the framework focus heavily on the relational aspects within the system (connections, communication, commitments) but also consider the local context (coherence, continuous assessment).

We used the six factors to guide our analysis and interpretation of the implementation and the potential for sustainability of IP collaboration interventions in healthcare sites.

## Methods

The IP collaboration interventions took place between September 2006 and April 2007 at three healthcare settings in Alberta, Canada. Practice sites were identified

through contacts of research team members. Participation criteria included willingness and time commitment to work with a facilitator to implement IP practice changes and participation in the project evaluation activities. Initial commitment for project participation was secured from the managers at the three sites. Consistent with a CAS perspective, our intervention approach was designed for flexibility and sustainability. This meant that rather than prescribing standardized interventions for the sites, the area of focus and the way the improvements were implemented were at the discretion of the site members. Each site had a project facilitator who worked with members over a six-month period to support the implementation of IP practice interventions. Other than the facilitator, sites did not receive any resources or financial support.

### Data Collection and Analysis

After three and six months, we interviewed 5-6 participants at each site to get their views of how the IP intervention proceeded at their workplace. The semi-structured interviews examined how the project impacted individual learning, professional practice, team functioning, and organizational climate. In addition, the evaluation monitored how IP practice progressed, including the successes and challenges. Project facilitators assisted with recruiting interview participants to ensure a representative sample that included managers and key staff. All participants provided informed consent. The research protocol was approved by the ethics boards of the University of Calgary, the University of Alberta, and the David Thompson Health Region. Interviews lasted approximately 60 minutes and were taped and transcribed. Interview transcripts were coded by three research assistants for themes [23] using QSR N6 software. The research assistants met weekly with the project lead to review the coding and reconcile differences among the coders. Differences were resolved by consensus.

Two of the authors (ES, SD) examined the interview data for emergence of the six factors of the Legacy Sustainability Model (communication, connections, coherence, continuous assessment, commitment, and constructs) at each site. We identified and compared the existence and strengths of the factors and how they changed over time. Particular attention was paid to the factors existing at the outset of the intervention and how contextual factors impacted practice change.

## Results

### Site Descriptions

Table 1 describes staff that participated in the intervention, intervention focus, and outcomes for each site.

#### *Site 1: Geriatric program*

##### *Context*

Site 1 is a geriatric program that extends seniors' independence by helping them manage their health needs. The program has three distinct components: a day program; a care program operating 24 hours a day, seven days a week (24/7); and a

*Table 1*  
**Site descriptions**

Characteristics	Site 1: Geriatric 24/7 program	Site 1: Geriatric day program	Site 2: Children's health network	Site 3: Rural hospital
Number of staff and types of professions	About 25 staff on the two sites; some are shared. Professions include activity convener, social work (SW), physiotherapy (PT), occupational therapy (OT), medicine, psychiatry, nursing (Registered Nurses [RN] and Licensed Practical Nurses [LPN]).		The network has affiliations with over 20 organizations, including Aboriginal, addictions prevention, and community services.	110 staff (40 community care; 70 acute care) from medicine, nursing (RNs, LPNs), pharmacy, PT, OT, nutrition, SW, diagnostic imaging, home health aides.
Core members involved in intervention	9 participants from nursing (RNs and LPNs), recreation therapy, SW, OT, PT, home support; 1 manager.	8 participants from nursing (RNs and LPNs), SW, OT, PT, medicine; 1 manager.	7 managers; 1 evaluator each from SW, nutrition, psychology, nursing; 1 bachelor of health sciences student; 1 SW student.	10-12 participants from nursing (RNs and LPNs), pharmacy, OT, PT; 1 retired physician; 7 students from pharmacy, PT, and nursing.
Intervention objectives	Improve referral process for clients being referred between the two programs.  Enhance communication within and between the two programs.	Redesign admission process for day program to create a more efficient process for staff and clients.  Enhance communication between the two programs.	Improve IP mentorship capabilities of the management team.	Enhance IP practice among staff, thereby building a seamless work environment.  All students at the hospital participate in IP mentoring.
Facilitator support	Initial orientation session.  Monthly meetings with staff.  Literature reviews.  Provided additional information as requested.	Initial orientation session.  Regular email contact with the manager.  Attendance at joint meeting between the two programs.	Initial orientation session.  Monthly meetings with managers to discuss IP issues, write minutes, initiate group activities, disseminate information (relevant literature, upcoming conferences/events).	Assist with staff/student orientation.  Routine site visits.  Participation in departmental discussions on enhancing IP practice.  Feedback and suggestions for sustainability.
Outcomes	Revised process for referrals from day program, including new referral form.  Instituted IP family conferences.  Enhanced Cardex form for basic care plan.  Developed discharge summary.  Held weekly internal IP meetings to discuss issues.	Streamlined process for admissions and removed redundant information from assessment forms.  Designated intake person to do initial assessment; once patient is admitted, other professionals conduct additional in-depth assessments as needed.  Held large team meeting between the two programs.  Improved communication between the two programs.	Improved communication between the two programs. Co-mentored two students by a number of managers.  The students produced two research papers:  1. Literature review of strategies to address child health waitlists  2. Developing an online discussion group on Autism	Reinstated weekly IP rounds.  Introduced the "purple pen" for the patient whiteboard to indicate physiotherapy assessment.  Defined procedure for staff & student orientation to IP practice.  Designated the Nurse Educator as key contact for students and to coordinate IP student activities (embedded in formal job description).

mental health program, each in separate locations and operating independently. The day program and the 24/7 care program participated in the project. Both programs experienced typical pressures due to staff cuts and staff turnover. Internal communication within each program seemed to work well, with IP team meetings occurring on a regular basis. Contact between the two programs occurred only among managers.

### *Intervention focus*

Each program identified an area within their services that suffered from a lack of IP collaboration. One area was the communication between the day program and the 24/7 care program. Although housed in different locations and operating independently from each other, patients are shared between the two programs. For example, patients from the day program are regularly referred to the 24/7 program for overnight care or respite. Staff from the 24/7 program felt that for these patients, information was missing because day care staff did not provide referral forms and discharge summaries. Furthermore, the tracking system lacked relevant treatment information for patients who were placed into long-term care. Besides the stress from feeling ill-prepared to help patients from the day program, it was onerous for 24/7 staff to constantly ask for more detailed information every time a patient was referred.

The second problem related to the high turnover of clients in the day program. The intake assessment process was time consuming and involved a range of providers over several days. Too often, clients left the program after the one-day trial period, rendering the time and energy invested in the client assessment a complete waste. Therefore, staff from the day program decided that a more efficient intake process was needed.

### *Intervention activities and outcomes*

The day program and the 24/7 care program staff worked separately on solving their respective problems. Staff from the day program redesigned the assessment process and designated and trained one team member (a social worker) to collect initial patient information. The 24/7 staff designed new discharge forms and implemented a referral process to be used by the day care staff to improve the exchange of information about shared patients. Once the new processes were designed, implementation of the referral process had some challenges. Some staff in both programs found the process more time consuming and said that the new referral form added very little, if any, value over verbal reporting. This resulted in initially poor compliance as little capacity building was done to help frontline staff carry out the new referral process.

### *Emergence of the six factors of the Legacy Sustainability Model*

*Commitment:* It was then the responsibility of the managers with support from the project facilitator to gain buy-in from staff. At this site, it was difficult for the two program managers to gain commitment for this project from their staff, especially from the frontline members. Neither the project objectives nor how individual team

members could get involved were initially obvious to staff. Thus, staff felt they were “floundering” when trying to focus on an objective that aligned with the project.

*Communication:* Communication became a key objective for this site as lack of communication between the two programs was an ongoing issue: “They would send people [from the day program] but we don’t always get information on the patients to be able to do the care here. It’s been an ongoing issue.” Despite efforts in the past, information exchange between the two programs remained inconsistent. Hence, improving communication between the two programs was identified as one of the objectives, with a number of mechanisms put in place. For the first time in ten years, a joint meeting between the two sites was held. This marked the beginning of enhanced communication between the two programs. The staff came together to discuss each program’s progress and how processes between the two programs could be improved.

*Coherence:* A lack of understanding of the project and perceived lack of coherence with their own work initially hampered staff commitment: “The beginning was kind of nebulous. We weren’t quite sure what the heck this was all about. We were trying to wrap our heads around, but it took us a while to get around what we were doing.” It took several months for this site to settle on a project goal. Once coherence with the project objectives was achieved, staff committed to work on these changes while managers provided guidance and ensured that staff followed through on their decisions.

*Connections:* Connections between the two programs initially occurred primarily at the managerial level. The regular meetings instituted between the two programs offered a new venue for establishing connections in other areas of the organization.

*Constructs:* The new intake form, referral, and communication processes are important constructs that guarantee continuation after project completion. The regular meeting instituted between the two programs is another important mechanism to help staff attain enhanced IP collaboration.

*Continuous assessment for fit:* At the end of the project, staff from the geriatric program were pleased with the improvements but admitted that the process was not easy. Staff said the project has given them permission to explore ways to enhance IP practice. Many of them stated it has created a “can do” attitude and led the way to proactive problem solving: “It’s almost been like a natural evolution. As soon as we start to feel that something is becoming an issue, right away, we throw it on the table and bring it up and say, let’s do what we have done in the past; develop a process to be able to address the issue; work with the other team to fix it. And how can we do that?”

This statement shows that staff may use continuous assessment and ongoing problem solving in future initiatives. However, they were concerned that lack of time would be an obstacle to conducting continuous assessment.

## *Site 2: Children's health network*

### *Context*

Site 2 is an intersectoral network comprising families, regional authorities, First Nations, ministries, provincial agencies, universities, and the not-for-profit sector to improve child health and welfare in Alberta. Its mission is to streamline healthcare delivery by building linkages across regions and sectors in support of accessible and co-ordinated quality services to children, youth, and families as close to home as possible. A core group of eight members from different disciplinary backgrounds occupy the management positions for the network (director, program planning, community education, and outreach). Most of them have been in their positions since the network's inception in 2001 and participated in our project as leaders, spearheading ideas for the whole network.

### *Intervention focus*

The managers were attracted to the project because they saw the potential to move the network closer to becoming a community of practice (CoP)—a self-motivated and voluntary group of people who have an interest in generating knowledge in a specific area [14]. Due to the wide range of locations of potential CoP members, the CoP was designed to be electronic.

Together with the project facilitator, the management team developed goals aligned with the project objectives:

- to maximize the IP expertise of the management team
- to explore the management team's IP mentorship capacity (i.e., the ability of managers to mentor students and staff from other disciplines)
- to explore whether this group would be appropriate for undergraduate student placements

### *Intervention activities and outcomes*

The team aimed to engage graduate students with extensive research capabilities to assist with research to advance the network's services. However, they were unable to recruit graduate students and agreed to recruit two undergraduate students to explore IP mentoring.

They scheduled monthly meetings to discuss the project, their different professional roles and perspectives, student placements, expansion and vision of the network, and research interests. The group arranged resources to support development of the network and the CoP. One resource involved documenting a process for developing a CoP: "We actually went through the process of putting together a charter as our guide for how we will work with different groups around the development of a CoP. And it outlines roles and responsibilities, goals—sort of accountabilities." The group also procured financial support for developing their electronic CoP as a mechanism to develop network efficacy. The managerial team realized that these conversations reinforced "the importance of both managing their relationships [with members of the network] and managing the process [of how to implement IP practice with partners]." After the project, they continued to link with partners in

the network who had become more receptive to the managers' approach of establishing a CoP: "I think we've got a line-up of interested clinical areas because we've said we would help support and facilitate the development of a CoP."

*Emergence of the six factors of the Legacy Sustainability Model*

*Commitment:* A facilitated visioning exercise with all team members revealed the strength and homogeneity of their vision for the network. This reinforced their unified commitment to the project and strengthened their relationships.

*Communication:* The child network had well-established communication processes that could be leveraged for the project. Nevertheless, ensuring clear communication about their progress and struggles throughout the project was crucial for the managers. Their monthly meetings served to inform new members joining the leadership group during the implementation of the project: "And there are some mixed levels in the room, so there are different reporting relationships in that room. We have tried to use those protected hours to really open up the conversation to anybody's ideas, and to any kind of conversation, regardless of the individual's reporting relationship in the room."

The group also tried to realize collaborative goals, including "sharing enough about each other to know us [as individuals] and to know our work," and learning "how to get better at fighting" for their interests.

*Coherence:* The existing IP structure and vision in the child network were consistent with the project objective to further collaboration. Despite their coherence with the project, the team perceived tensions around "doing two things at once." They developed processes to implement an electronic CoP among network affiliates, and, at the same time, they tried to manage an IP student placement. The student placement was not successful, as it did not fully develop the IP mentoring capacity of the group. A later student placement better matched the interests of the group: "I would say that she fit into our process more than us creating a process for her... we've never really supervised a student in quite this way."

*Connections:* The managerial team connected other members to their project goals by inviting other members to management discussions. For instance, the co-chairs of the network's steering committee were invited to share their views on leadership styles, professional socialization, and IP practice with the group. A manager commented on the meeting: "It was fascinating. We thought it was really a worthwhile experience. And it gave both [co-chairs] a stronger understanding of us." As champions of the network, the managers were developing their vision for the network in consultation with network affiliates.

*Constructs:* The management team itself, and the dedicated meeting times, written protocols, and financial resources, were key constructs that aided to reinforce and sustain the IP practice changes.

*Continuous assessment for fit:* The strongest evidence of continuous assessment in the child network was demonstrated by hiring an evaluator to monitor progress of the network's activities and goals. The management team also used their monthly meetings to review student placement issues and make adjustments as needed. For example, when the undergraduate students conducted research for the network, their progress was discussed and plans were reassessed. The managers ended up agreeing that placements for undergraduate students were not suitable due to the complexity of the [network] setting for short-term students, and instead they planned to engage graduate students.

### *Site 3: Rural hospital*

Context: Site 3 is a small rural hospital, a setting which, to some extent, determined its pre-existing culture of collaboration. Relationships among hospital staff and patients extend to social networks beyond hospital boundaries. Staff characterized the hospital as a positive work environment, where they frequently work in small teams and work interprofessionally out of necessity.

### *Intervention focus*

At the initiation of the project, the managers from acute and community care facilitated staff meetings to find a focus for the project. Discussions revealed that while staff from each department may collaborate internally, they had only informal and sporadic contact across departments. Therefore, they agreed to work on improving communication and IP practice between the two departments. In addition, staff had an interest in sharing mentorship of students across disciplines and units to enrich students' clinical placements.

### *Intervention activities and outcomes*

One example of enhanced communication and IP practice is the introduction of the "purple pen." Since physiotherapists were not on rotations during evenings or weekends, they wrote with purple ink on the acute care patient board to inform staff of physiotherapy goals and appointments. This allowed staff to integrate the physiotherapy goals into the care plan. Weekly IP rounds and daily IP case conferences that were open to students were other collaborative strategies.

Prior to the project, individual preceptors set up mentoring opportunities as part of students' learning objectives. As a result of the project, student rotations are more formalized and cross acute and community care units. The nurse educator was put in charge of orienting new staff and students to IP practice and mentoring. The project facilitator presented the IP component at a few staff orientations to familiarize the nurse educator with the materials and to strengthen her commitment to this process. When a new staff member took over the nurse educator position toward the end of the project, co-ordinating IP placements became part of the job description and the project facilitator oriented the new member to IP collaboration and mentoring.

*Emergence of the six factors of the Legacy Sustainability Model*

*Commitment:* The two managers gained commitment through discussing the project with staff members and jointly deciding on the focus areas.

*Communication:* Communication was also a focus for the rural hospital. Enhanced communication occurred through regular staff meetings and through mechanisms such as the “purple pen” and IP rounds.

*Coherence:* The culture of the rural hospital aligned well with the project goals of improving IP collaboration: “Because we are a small team, we do meet daily. It’s a really good opportunity to review clients and come at it from an interprofessional perspective.”

Newcomers, including students, are encouraged to establish collegial relationships quickly: “We get to know them because we’re a small enough group and they have lunch with us and coffee, and they become part of the team in a hurry”.

Prior to the project, the staff at this hospital were engaged in initiatives related to team cohesiveness, patient-centred practice, and other innovative activities. When approached to participate, it was not clear to staff what this project would add. However, the already existing IP culture allowed staff to quickly figure out their focus areas for this project, despite some initial uncertainty about project expectations: “And if anything, you know I think there’s a bit of vagueness around the expectations [of the project] and people weren’t really sure if we should be doing something different than what we had been doing.... And was there something specific that we should be seeing that would be different than we had, perhaps, but made it a bit more complex.”

*Connections:* A retired physician with a strong interest in promoting IP healthcare delivery formed an important connection by assuming the role of “champion.” He was integral in convincing staff that the project would build on their strengths, and he created linkages between this project and other research and healthcare activities at the site. This helped staff identify synergies among activities and removed concerns of duplication.

*Constructs:* This site developed a number of structures and processes that reinforced and helped to sustain IP practice changes: Integrating the co-ordination of IP mentoring for students and staff into the nurse educator job description; developing an IP orientation and re-institution of IP team meetings.

*Continuous assessment for fit:* We were unable to determine if this site developed any capacity for continuous assessment.

**Discussion**

Our analysis of the three healthcare sites shows the contextual differences as represented by the strengths of the six factors at the outset of the IP interventions and

Table 2

**The six sustainability factors in the three sites**

	Site 1 (geriatric program)	Site 2 (children's health network)	Site 3 (rural hospital)
Commitment	Initial commitment from two program managers; buy-in from staff through ongoing discussion	Strong commitment from the whole group	Initial commitment from two program managers; strong internal champion that helped create connections to the project and secure commitment from staff
Communication	Good internal communication existed, but lack of communication across the two sites	Good communication through regular meetings, etc., that facilitated implementation; initiative helped to focus communication	Good internal communication, but lack of communication across the two sites
Connections	Lack of connections between two sites; initial lack of connection to project	Management group able to easily link project work into existing work; considered it a good fit	Initial lack of connection to project, but then realized that project would build on existing strengths
Coherence	Flexible intervention focus and approach allowed to create coherence between project objectives and internal work	Strong coherence of project goals with collaborative philosophy of the management group; see the project as an opportunity to leverage network goals	Focus chosen (interprofessional student placements and enhanced communication across the two areas) was consistent with collaborative environment
Constructs	Development of constructs (joint meetings, discharge forms, assessment process) to embed new processes	Existing network structure and processes function as constructs	Formalized a process for communicating patients' rehab needs to staff; co-ordination of interprofessional mentoring assigned to nurse educator
Continuous assessment	Staff attest to commitment to proactive problem solving	Monthly meetings to discuss progress and make adjustments; hiring of external evaluator for formal assessments	No specific strategies for continuous assessment

Table 3

**Changes achieved in the six sustainability factors throughout the project**

	Site 1 (geriatric program)		Site 2 (children's health network)		Site 3 (rural hospital)	
	Existing	Achieved	Existing	Achieved	Existing	Achieved
Commitment	✓	✓✓	✓✓	✓✓	✓	✓✓✓
Communication	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓
Connections	✓	✓✓	✓✓✓	✓✓✓	✓	✓✓
Coherence	✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
Constructs	✓	✓✓✓	✓✓	✓✓	✓	✓✓
Continuous assessment	✓	✓✓	✓	✓✓✓	✓	✓

Note: Higher number of ✓ denotes stronger existence of factor.

the way the factors evolved throughout the project (Tables 2 and 3). Although we did not develop them intentionally, all six factors of the Legacy Sustainability Model emerged at each site and became integral to the success of the intervention.

Creating coherence with and commitment to the project objectives by staff early on appeared to be important for a successful start-up of the new ideas and practices. These two factors were easily established with the managers of Site 2 (child network) due to the natural fit of the project goals with their ongoing work. Starting with the strong coherence of the site's mandate with the project objectives, the other factors were aligned fairly easily and created capacity among its members to continue building a CoP beyond project completion. The high potential for sustainability became evident when the project was over and the project facilitator had to disengage from this site. This withdrawal initiated a lively discussion in which the group redirected its attention at planning their direction ("I guess we really have to figure out what we want to do").

The success of the project at Site 3 (a rural hospital) is based on the coherence of the existing collaborative environment. Management and champions showed strong commitment to developing the new strategies (constructs). Staff turnover at the site was low, improving the chances for sustainability. By contrast, Site 1 (geriatric) had the lowest level of pre-existing capacity in this respect; this site had difficulties getting started and gaining momentum due to a perceived lack of coherence of the project with their own work.

Despite strong commitment to the project from individual managers or champions, two of the sites somewhat struggled to gain the commitment from their staff. It was not until the staff members at these sites found occasions for regular communication about the project that they were able to connect to the project goals and more fully engage in the project. These discussions consolidated staff commitment as they began to search for ways to improve collaborative issues within the context of their setting.

Communication emerged as critical factor at two sites (geriatric site and rural hospital), with practice changes focusing explicitly on improving communication. After the initial struggles of Site 1 (geriatric), the project left a legacy of constructs (formalized documents and processes) that allow for more meaningful communication and connections among providers between the two programs. The new protocols for patient assessment, referral, and discharge are firmly embedded in the routines of these teams. According to staff, these new communication tools improved information flow and enhanced efficiency and effectiveness of care processes. Staff members argue that patients experience better continuity of care because staff have the right information at the right time. As a result of the communication processes that the two programs developed, staff felt that relations had improved and they felt closer as a group. There was now a sense of "we all belong to one big team," with a shared responsibility for all of the patients. The project also seems to have created some capacity for continuous assessment. At the rural hospital (Site 3), communication was enhanced by conveying patient information on an existing whiteboard with a different colour pen, which was an easy solution to a long-term issue.

These newly developed forms and processes became the new constructs and were embedded into daily operations. Site 3 (rural hospital) also designated the coordination of student mentorship to a position rather than relying on individuals to make it happen, thus creating a strong construct. Site 2 (child network) developed some constructs by dedicating part of their monthly meeting to discussing student mentorship issues, introducing new members to the project, and planning for the CoP development of the network. These constructs support sustainability of the practice innovations because they help to embed them in the site operations.

Although routinization of new processes and structures facilitates sustainability [21], from a complex systems perspective, it is important that ongoing monitoring occurs to ensure that the routinized practices continue to meet the changing demands of the environment. For our project, this means that the sites needed to create an environment that instills a spirit of continuous assessment and improvement of collaborative activities beyond the project duration. In a CAS system, this state is called the “self-organizing landscape,” where “employees work together, teams function, culture emerges, and relationships happen” [18, p. 15]. We were unable to determine if Site 3 (rural hospital) developed any capacity in that respect, even though they were clearly more receptive toward collaboration. Building on well-established collaborations, Site 2 (child network) was the only site that maintained formal structures and processes for continuous assessment (monthly meetings) to keep strategies up to date and relevant long after the project ended.

The staff at Site 1 (geriatric) developed a critical awareness of other issues around collaboration and showed willingness for jointly solving them. This outcome was unexpected because Site 1 had the least favourable conditions for embedding new practices (based on their lack of communication and collaboration), but it achieved the greatest gains toward sustainability. This outcome illustrates that the six factors are “interdependent and massively entangled” [18, p. 13], making it difficult to predict their individual or joint impact. Some scholars assert that careful and systematic planning at the beginning of implementation leads to a higher likelihood of achieving sustainability [19-21]. As Edwards argues, “if sustainability is only a latent concern, it is likely that the project will not be sustained” [19, p. 38]. This reasoning begs the question of whether our intervention would have been more effective (in terms of magnitude of impact and long-term sustainability) and efficient (in terms of speed of implementation) had we addressed the six factors more intentionally throughout the implementation.

There are a number of researchers who have used a CAS framework for post-hoc analysis of healthcare interventions. Two of the studies used the four CAS characteristics—individuals, connections, self-organization, and co-evolution—to examine their findings [9,12]. Leykum et al. [9], in their systematic review, found that interventions with a higher number of CAS characteristics have significantly better outcomes. Brannon et al. [12] demonstrated that agents and processes consistent with the four CAS characteristics were largely responsible for the success of their practice change. In their reflections of 15 years of implementation research in primary care, Crabtree et al. [7] conclude that practice changes cannot be achieved if

the intervention strategies are not consistent with CAS notions of emergence and self-organization.

When designing our implementation, we were conscientious about using approaches that are consistent with a CAS perspective: participatory planning and implementation, flexibility for the design to emerge, use of a mix of standardization across sites for some elements (e.g., common overall goals and guiding principles) while allowing variation of other elements (e.g., focus of activities, desired outcomes) to account for local context and existing culture and leadership [7,25,26]. However, there were times where we felt that the implementation came to a halt, and we struggled with how to create momentum and tangible progress. The success of practice interventions depends on the ability of participants in the system to learn, co-evolve, and adapt [13]. Crabtree and colleagues [7] have stressed the need for frequent reassessing and tailoring of strategies. They argue that small changes alter the conditions for subsequent action by changing the interrelationships between participants. In hindsight, we feel that initial as well as ongoing assessment of the sites using the Legacy Sustainability Model would have served us well by highlighting strengths and weaknesses in each of the six factors and guiding the implementations toward building the capacity in areas of deficit to achieve sustainable practice change.

However, our findings were inferred through post-hoc analysis of data from three specific sites, which constitutes a limitation of our study. There is a risk of selection bias, which might limit the generalizability of our findings. However, there is a clear need for new ways and theories for framing interventions and understanding multi-level, complex behaviours in healthcare systems [15-17, 27], and, in this sense, our study offers some new perspectives and insights. We concur with Crabtree and others that a theoretical framework guided by complexity science can help in the development of quality improvement strategies that will more effectively facilitate practice change [7,11,15,28]. While a CAS framework is increasingly being used to help understand the dynamics of healthcare systems, rigorous guidelines on how to apply CAS to intervention design are missing [13]. Some guiding principles have been offered to focus the interventions without being prescriptive [13].

## Conclusions

Many question why quality improvement efforts in healthcare do not have anticipated or lasting effects on practice change and patient outcomes. Healthcare managers and researchers are challenged to explore strategies that can reduce uptake barriers and facilitate practice change [29]. Doll et al. [30] conclude that “Complexity concepts and principles are well suited to the emergent, messy, nonlinear uncertainty of living systems nested one within the other where relationships among things is more than the things themselves.” This research set out to explore the following questions: 1) How does the application of the Legacy Sustainability Model, grounded in complexity science, as a framework provide insight into factors affecting the implementation and success of the intervention and the sustainability of IP practice changes? 2) How does the use of the Legacy Sustainability Model as a framework allow comparisons of interventions at various sites? The study success-

fully used a CAS framework to examine practice change and behaviour in health-care systems. Using the framework helped us to view the successes and challenges in each site from a different perspective and to highlight areas of strength and weakness that require attention for ongoing IP practice change. Understanding how or why practice change interventions do or do not succeed in the long term is critical to informing recommendations to decision-makers [29]. Furthermore, the framework has allowed us to compare the implementation of interventions that varied distinctly in nature and context. While the overall objective (i.e., enhancing IP practice) was the same for all three sites, the focus area and the way the change was approached varied considerably. It is, therefore, difficult to find common denominators to compare activities across sites. The six dimensions of the Legacy Sustainability Model have relevance across settings and contexts and contribute to sustainability of practice interventions.

Although a number of studies have used a CAS framework for post-hoc analysis, there is a lack of research that intentionally builds CAS characteristics into healthcare intervention design. In conclusion, a CAS framework, and the Legacy Sustainability Model in particular, may offer a valuable tool to design, contrast, and compare diverse interventions across settings and monitor progress toward capacity building. If change agents take steps toward considering these key factors within a CAS, we might be able to create interventions that are more successful and have a greater capacity for sustainable change. Based on current evidence, interventions driven by CAS frameworks hold great promise for creating more effective practice change.

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