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Critical Care Recovery Center: a model of agile implementation in intensive care unit (ICU) survivors

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Abstract

Background: As many as 70% of intensive care unit (ICU) survivors suffer from long-term physical, cognitive, and psychological impairments known as post-intensive care syndrome (PICS). We describe how the first ICU survivor clinic in the United States, the Critical Care

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Description of authors' roles

SW designed both the quantitative and focus group study design, collected the focus group data, analyzed the focus group data, interpreted the quantitative and focus group data, and drafted the manuscript. PH interpreted the quantitative and focus group data and drafted the manuscript. CX and SG were responsible for the statistical design of the quantitative results, carrying out the statistical analysis, contributed to the data interpretation, and provided content review. DA, DG, and YN contributed to the study design of the focus group, collected the focus group analysis data, and analyzed focus group data. NF, MA, SK, and MB contributed to the study design of the focus group, contributed to the data interpretation, and provided content review. BK oversaw quantitative and focus group study design, provided content review, and drafted the manuscript.

Conflict of interest declaration

We certify that the authors have no conflicts of interest relevant to this submitted manuscript.

Supplementary material

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Recovery Center (CCRC), was designed to address PICS using the principles of Agile Implementation (AI).

Methods: The CCRC was designed using an eight-step process known as the AI Science Playbook. Patients who required mechanical ventilation or were delirious 48 hours during their ICU stay were enrolled in the CCRC. One hundred twenty subjects who completed baseline HABC-M CG assessments and had demographics collected were included in the analysis to identify baseline characteristics that correlated with higher HABC-M CG scores. A subset of patients and caregivers also participated in focus group interviews to describe their perceptions of PICS.

Results: Quantitative analyses showed that the cognitive impairment was a major concern of caregivers. Focus group data also confirmed that caregivers of ICU survivors ($n = 8$) were more likely to perceive cognitive and mental health symptoms than ICU survivors ($n = 10$). Caregivers also described a need for ongoing psychoeducation about PICS, particularly cognitive and mental health symptoms, and for ongoing support from other caregivers with similar experiences.

Conclusions: Our study demonstrated how the AI Science Playbook was used to build the first ICU survivor clinic in the United States. Caregivers of ICU survivors continue to struggle with PICS, particularly cognitive impairment, months to years after discharge. Future studies will need to examine whether the CCRC model of care can be adapted to other complex patient populations seen by health-care professionals.

Keywords

critical care; PICS; cognition; delirium; depression; frailty; aging; caregiver stress

Introduction

More than 5.5 million patients are admitted each year to intensive care units (ICU) in the United States. About 50–70% of ICU survivors suffer from long-term cognitive, psychological, and functional impairments from their ICU hospitalization, known as post-intensive care syndrome (PICS) (Desai *et al.*, 2011). PICS is a major concern for older adults and their health-care providers for several reasons. First, more than 50% of ICU admissions are patients 65 years and older; this proportion is likely to grow as the population ages (Angus *et al.*, 2000; Baldwin, 2015). Second, due to the dramatic improvements in the quality of ICU care over the past few decades, the number of ICU survivors, including older survivors with PICS, is expected to increase (Needham *et al.*, 2012). Third, older ICU patients are especially vulnerable to developing neuropsychiatric disorders during their ICU and post-ICU course. About 60% to 80% of older ICU patients become delirious, and nearly 70% of older ICU delirium survivors acquire post-ICU, mild cognitive impairment (MCI), and Alzheimer's and other related dementias (ADRD) (Brummel *et al.*, 2014; Gibson, 2010; Pandharipande *et al.*, 2007; Pisani *et al.*, 2009; Schweickert *et al.*, 2009). Finally, preadmission frailty, a common condition in older adults, is associated with poorer post-ICU outcomes and increased health-care utilization (Muscedere *et al.*, 2017).

In 2011, Eskenazi Hospital, an affiliate of the Indiana University School of Medicine, recognized the need to provide high-quality post-hospital services for these vulnerable ICU

survivors. Despite recognition of the impact of PICS on a growing number of older ICU survivors on health-care utilization and caregiver burden, there are limited evidence-based practices (EBPs) for this population (Schofield-Robinson *et al.*, 2018). Closing this gap between the complex needs of “real world” patients and the best available EBPs presented a unique challenge, as our team used the tools of implementation science to guide the creation of the first ICU survivor clinic in the United States, the Critical Care Recovery Center (CCRC). Implementation science generally describes the rapid adoption and quality of use of evidence-based practices to improve patient outcomes (Boustani *et al.*, 2018; Callahan *et al.*, 2018). However, adoption of EBPs in local health-care systems can be imperfect for various reasons (Satterfield *et al.*, 2009). First, the subjects who participate in research studies may differ greatly from the patients who are receiving treatment in a local health-care system. Second, the clinical trials are conducted under scientifically rigorous circumstances to ensure the validity of the scientific findings. Finally, local health-care systems may have unique constraints in terms of provider or financial resources, which, in turn, may affect the achievement of perfect fidelity for the core components of an EBP.

As part of our experience of creating the CCRC, our group developed the concept of agile implementation. Agile implementation describes “a reproducible and scalable process to rapidly localize, implement, and sustain evidence-based health care services.” (Boustani *et al.*, 2018) In this paper, we will describe the major principles of agile implementation science and how these principles guided our design of the CCRC. We will then summarize earlier published findings about the CCRC, present new quantitative and qualitative findings about ICU survivors’ informal caregivers’ perceptions of PICS, and discuss the implications for how the AI Science Playbook may be useful for developing novel models of care in highly complex patients seen by geriatric psychiatrists.

Methods

Complex adaptive system (CAS)

EBPs are usually developed through rigorously performed clinical trials with sources of “real-life” change and variation controlled for as much as possible. However, these various controls can result in difficulty adapting EBPs to the “real world” of health care. The concept of the complex adaptive system (CAS) reflects these real-world challenges, and the underlying concept of agile implementation is to create a process that accounts for and responds to these real-world challenges (Boustani *et al.*, 2019).

Complexity theory defines a CAS as a network of interdependent, semiautonomous agents, which are constantly adapting to a dynamic environment. Due to the interdependent nature of a CAS, its outcome cannot be predicted by looking at individual interactions, which makes the system “complex.” Figure 1a conceptualizes the health-care system as a CAS. The center of the CAS is the Healthcare System Performance (HCSP) (depicted by the gray circle). The HCSP is the outcome of the CAS, but it also responds to the perturbations in the internal environment of the health-care system (depicted by the white circle). These perturbations arise from the agents (the vertices) undergoing change themselves or interacting with other agents (the black lines). Agents can also respond to perturbations from

the HCSP. Finally, the constant exchange (the gray arrows) between the internal environment and external environment (the black circle) can be a source of change for internal agents.

Figure 1b depicts how the interactions of the CAS contributed to the development of the CCRC. For example, when the Centers of Medicare and Medicaid (CMS) started to publicly post hospital readmission rates, this led ICU physicians to change their focus to the high readmission rates of ICU survivors. This is an example of how external change causes an adaptive response in an internal agent, as depicted by the gray boxes and gray arrow. The physicians then approached the administration and management (A and M) about creating the CCRC. This is an example of internal change due to an interaction between two agents, as depicted by the dashed boxes and dashed black line. The planned creation of the CCRC led to a “perturbation” of the HCSP, which led to changes in other agents (personnel and facilities), as the necessary resources were being brought together for the CCRC. This is an example of how agents respond to changes in the HCSP, which is depicted by the black boxes and hashed black lines.

Agile Implementation Science Playbook

The Agile Implementation (AI) Science Playbook outlines a reproducible, eight-step process that describes how to rapidly implement and sustain evidence-based health-care practices in a CAS (Boustani *et al.*, 2019). Figure 2 depicts how the vision of the CCRC was executed using the AI Science Playbook. First, physician-researchers performed an analysis of local hospital data to demonstrate high mortality and post-hospital acute care utilization in ICU survivors. After presenting this data to the A and M, this led to the stakeholders’ demand for post-ICU recovery services (Step 1). The clinical leadership then decided to implement a modified version of the Healthy Aging Brain Center model, an interdisciplinary collaborative care model, which had been shown to improve outcomes in older patients with dementia and late-life depression (Step 2). Indicators of success were identified; these included improved cognitive, psychological, and functional outcomes and reduced acute health-care utilization and costs (Step 3). Minimum-care components involved early functional assessment, monitoring of longitudinal outcomes, and patient/caregiver education (Step 4). Implementation sprints, which are focused work aimed at adapting a service to a local setting, were then performed to address unforeseen circumstances (Step 5). For example, high no-show rates in the clinic prompted addition of a direct referral from the ICU and a pre-clinic phone call to the patient/caregiver to promote the clinic. We also performed monitoring with quarterly dashboards (Step 6) for such metrics as percent receiving inappropriate/potentially inappropriate medications, number of primary care visits, etc. Care utilization was tracked via readmissions, emergency department (ED) visits, and health-care costs (Step 7). Lastly, by developing a minimally standardized operating procedure, services have been extended to home-based ICU and trauma survivors. Further details describing the creation of CCRC using the AI Science Playbook are described elsewhere (Boustani *et al.*, 2019).

Structure of the CCRC

The CCRC was initially based at Wishard Memorial Hospital (WMH) and later transitioned to the Sidney and Lois Eskenazi Hospital in 2013. The interdisciplinary team includes a

critical care physician, pharmacist, medical assistant, a psychometrician, and most importantly a care coordinator (usually the social worker and/or a nurse). The care coordinator plays a central role in facilitating collaboration and communication with other services, provides psychoeducation of patient and caregivers about PICS and caregiver stress, and delivers treatments for caregiver stress, such as depression-focused psychotherapies (interpersonal psychotherapy and cognitive behavioral therapy). Additional support services are also available from physical therapy, neuropsychology, and psychiatry (Khan *et al.*, 2015). The goals for the CCRC are to (1) maximize cognitive, physical, and psychological recovery; (2) increase patient and caregiver satisfaction; (3) improve transitions of care; and (4) decrease resource utilization in the form of rehospitalizations and emergency department visits.

The CCRC enrolled adults who were 18 years and older, had an ICU admission, and either were on mechanical ventilation or had delirium for 48 hours. Patients receiving hospice or palliative care services at time of discharge were excluded from clinic enrollment. The initial assessment included a clinical interview and physical exam, neuropsychological testing, physical function battery, medication reconciliation, blood tests, and/or imaging. For neuropsychological testing, patients were administered the Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological battery or the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph, 1998). They also completed the Trail Making Test (TMT), which consists of two parts to measure processing speed (TMT-A) and executive functioning (TMT-B) (Reitan and Wolfson, 1985). They also completed screens for depression (Patient Health Questionnaire 9 [PHQ-9]) (Kroenke *et al.*, 2001) or the Geriatric Depression Scale 30 (GDS-30) (Yesavage *et al.*, 1983), anxiety (Generalized Anxiety Disorder-7 [GAD-7]) (Kroenke *et al.*, 2007), and trauma-related symptoms (Post-traumatic Symptom Scale [PTSS-10]) (Stoll *et al.*, 1999). Patients and/or caregivers also reported functional deficits using the Physical Self-Maintenance Scale (PSMS) as a measurement of activities of daily living (ADLs) and instrumental activities of daily living (IADL).

The HABC-M self-report (HABC-M SR) version was also completed by patients with normal cognition, MCI, or early ADRD at the initial visit (Monahan *et al.*, 2014). The HABC-M SR has been validated against standardized assessments of PICS (Wang *et al.*, 2019). In patients who had a caregiver accompany them, the caregiver version of HABC-M (HABC-M CG) was also completed at the initial visit (Monahan *et al.*, 2012). Both versions of the HABC-M have functional, psychological, and cognitive subscores. The CG version also has an additional caregiver stress scale. Each question is rated on the basis of the patient's perceived frequency of the symptom during the 2 preceding weeks: 0 = not at all (0–1 day), 1 = several days (2–6 days), 2 = more than half the days (7–11 days), 3 = almost daily (12–14 days). The maximum scores for cognitive, functional, psychological, and caregiver stress subscales are 18, 33, 30, and 12, respectively. The maximum total score for the HABC-M CG is 93. Higher numbers for the four subscales and the total score correlate with higher severity of symptoms.

Two weeks after the initial assessment, the CCRC team held a family conference with the patient and designated caregiver. If clinically indicated, patients and caregivers were seen for

additional visits in the CCRC for ongoing follow-up. At the follow-up visits similar to initial visits, the cognitive, physical, and functional symptoms over the past 2 weeks were assessed using the HABC-M SR and/or CG (Khan *et al.*, 2015).

Statistical Analyses

One hundred twenty subjects who completed baseline HABC-M CG assessments and had baseline demographics collected were included in the analysis to identify baseline characteristics that correlated with higher HABC-M CG scores. Age, sex, race, education, level of independence, and a list of medical conditions were analyzed as candidate independent variables. Candidate medical conditions considered were: Alcohol abuse, smoking, head injury with loss of consciousness, drug dependence, cardiac respiratory arrest, cardiac disease, CNS (including stroke, seizure, and Parkinson's disease), mini-stroke, hypertension, diabetes, hypoglycemia, COPD, urinary incontinence, vision impairment, hearing impairment, falls, schizophrenia and other psychiatric disorders, depression, cancer, and delirium. Logarithm of baseline HABC-M CG total score and subscales were used as outcome variables in multivariate linear regression models. Models were selected with stepwise selection, with the significance level for entry into the model at 0.15 and the significance level for staying in the model at 0.10. All quantitative analyses were performed using SAS v9.4.

Thirty-five subjects were included in pairwise comparison of HABC-M CG total scores and subscales from a baseline visit to a subsequent follow-up visit using paired t tests. To adjust for the individual difference in time range between two visits, the mean monthly change of scores were calculated and tested against 0 with one sample t test.

Focus Groups

A subgroup of patients and their caregivers/family members participated in focus groups to characterize their perceptions of PICS. CCRC patients who were fluent in English had normal cognition, mild cognitive impairment, or early dementia; no behavioral disturbances that would interfere with group participation; had at least 3 months but no more than 5 years past their discharge date of the sentinel hospitalization; and were willing to participate in a recorded interview were invited to participate. Caregivers or family member who were 18 years and over, fluent in English, agreed to participate in a recorded interview and cared for a CCRC patient between 3 months to 5 years from their discharge date of the sentinel hospitalization were invited to participate. The interviews for focus groups consisted of open-ended questions prompting discussion of their experiences in the ICU and their post-ICU course. Focus groups were audiotaped and professionally transcribed. Emergent themes were identified using free coding techniques and inductive content analysis. Codes were based on the Patient Reported Outcome Measurement Information System (PROMIS) framework (PROMIS, 2019). Coding consensus was reached with two independent reviewers until a kappa of at least 0.85 was obtained.

Results

Table 1 summarizes the baseline demographics and clinical characteristics of the 120 CCRC participants whose caregivers completed a HABC-M CG and had baseline demographics collected. The average age of the CCRC participants was 52.1 (13.2), and almost half were female and African American. Nearly half had a documented history of depression prior to their CCRC visit. Nearly half had delirium during their ICU hospitalization, and over 80% had respiratory failure. The average MMSE score was 24.8, which was consistent with the MCI-early stage ADRD range. Nearly one-third had moderate to severe depressive symptoms at their baseline visit prior to receiving any treatment in the CCRC. Average HABC-M CG subscale scores ranged from 2.8–7, with an average total score of 21.2. This corresponded with an average number of points per item of 0.59 for the functional subscale, 0.70 for the psychological and caregiver stress subscales, 0.80 for cognitive subscale, and 0.68 for the total scale.

Table 2 describes which demographic and clinical characteristics corresponded to baseline HABC-M CG subscores and total score. Those without a history of cardiac disease, who were not African American, and had more difficulty performing IADLs independently, were more likely to have higher total scores. Those who had a history of falls and more difficulty performing IADLs and ADLs independently were more likely to have higher functional subscores. Those who were younger, male, had a history of falls, a history of CNS disorders, not African American, and more difficulty performing IADLs independently were more likely to have higher psychological subscores. Those who had more difficulty performing IADLs independently, a history of CNS disorders, a history of falls, and loss of consciousness were more likely to have higher cognitive subscores. Caregivers of ICU survivors who were not African American and had more difficulty performing IADLs independently were more likely to have higher caregiver stress scores.

A subset of patients had longitudinal follow-up ($N = 35$), and their caregivers completed two HABC-M CG. Caregivers did not report any improvement in cognitive, psychological, functional, caregiver stress, and total scores over the course of two visits, which were separated by an average of 179 days (Supplementary Figure 1, $P > 0.05$ for all subscales and total score).

Ten patients and 8 caregivers also participated in the focus group assessments. The mean age of CCRC patients who reported demographic data ($N = 8$) was 63 years. Patients were more likely to describe physical symptoms (25.3% vs. 12%) compared with caregivers. Caregivers were more likely to describe cognitive symptoms (36.0% vs. 26.3%) and mental health symptoms (32.0% vs. 22.1%) than what the ICU survivors themselves perceived. One caregiver explained, “He does not remember when I give the medications to him. That drives me nuts, but I understand he can’t help it.”

With regard to caregivers’ expressed needs and experiences, the majority (55.7%) of caregivers cited “dealing with complications” as an area of importance. One caregiver expressed, “I don’t know where to start. Life changed. I kind of wished I knew the changes.” Caregivers (27.3%) reported a “need for good advice and peer support.” Another caregiver

explained at the end of the focus group, “It helped to hear from other people, especially someone who has had a stroke and to hear some of the challenges. I could identify with you. I don’t have that in my life where I have someone to identify with the challenges that I have with [Patient] X.”

Discussion

Compared to the rest of the population, ICU patients have three to five times higher health-care costs the year before and after ICU hospitalization (van Beusekom *et al.*, 2018). As ICU survivors continue to age and suffer from the sequelae of neuropsychiatric disorders, there is a growing need to rapidly implement models of care, which can improve the health of populations and reduce health-care costs (Berwick *et al.*, 2008). To date, however, there is insufficient research to recommend EBPs for follow-up services for ICU survivors (Schofield-Robinson *et al.*, 2018). Despite this gap in our current research knowledge, we were able to use the AI Science Playbook, a novel implementation science strategy, to address this gap in our current research knowledge to meet the health-care needs of this vulnerable aging population. By following the eight interconnected steps of the AI Science Playbook, we successfully adapted an evidence-based model of care designed for older adults with dementia and late-life depression to the ICU survivor population and built the CCRC, the first ICU survivorship clinic in the United States.

Our previous studies of a smaller group of CCRC participants ($n = 51$) showed that almost 90% had MCI or ADRD on detailed neuropsychological testing, and 59% had depression (Wang *et al.*, 2017b). Cognitive, functional, and total scores, but not psychological scores, on the HABC-M SR ($n = 53$) improved over two visits (Khan *et al.*, 2015). A subsequent study then showed that nearly one-third of patients had untreated or inadequately treated depressive symptoms at the initial assessment in the CCRC (Wang *et al.*, 2017a). This suggests limited access to mental health treatment prior to their CCRC evaluation, as well as partial or non-response to antidepressants may explain why treatment of post-ICU depression could be more difficult.

In this paper, we expanded our earlier findings about the CCRC to include caregiver data. Most of the relationships between clinical and demographic characteristics and HABC-M CG scores were consistent with previous literature. Younger patients are more likely to have PICS-associated psychological symptoms (Huang *et al.*, 2016; Jackson *et al.*, 2014). Difficulties with physical functioning are associated with caregiver stress (Choi *et al.*, 2014; Comini *et al.*, 2016). Falls are associated with cognitive disorders (Montero-Odasso *et al.*, 2018). CNS disorders are often associated with psychological and cognitive difficulties.

Interestingly, though, functional difficulties were associated with cognitive and psychological scores. This suggests that caregivers may be perceiving cognitive and psychological difficulties as leading to functional impairment. Also, given the high prevalence of African Americans, we are the first to observe that caregivers of African Americans report less caregiver distress and lower severity of PICS symptoms. This finding needs to be confirmed in other populations, but it does suggest that the AI Science Playbook may need to be expanded to include cultural backgrounds of patients and caregivers. One

finding that was inconsistent with what we would have expected was the relationship between cardiac disease and lower severity of total PICS symptoms. This may be due to selection bias since patients who were quite frail may have been placed in a skilled nursing facility, and hence were less likely to attend the ICU survivor clinic. Also, earlier studies suggested that female patients were at higher risk for psychological symptoms after critical illness (Hopkins *et al.*, 2010; Wade *et al.*, 2012). Our inconsistent finding may be due to differences in population characteristics. Both our quantitative findings from the HABC-M CG scales and the qualitative findings from the focus groups suggest that caregivers were more likely to describe cognitive symptoms than the patients did. The subset of caregivers who completed multiple visits also did not report significant improvement in any of the patients' symptoms, unlike our earlier findings with those who completed the self-report. This discrepancy between our earlier findings about patients reporting improvement with CCRC may be due to the fact that those survivors who were accompanied by caregivers to the CCRC were likely to be frailer than those who came independently. Finally, a future study will need to validate the HABC-M CG against standardized assessments to determine how much of the HABC-M CG may be affected by caregiver perception.

Traditionally, implementation science has focused on closing the research-to-practice gap (Figure 3a). However, even when health-care professionals are educated and aware of EBPs, they often still fail to adhere to EBPs. This “research to real world” gap arises because health-care professionals may not feel that EBPs are applicable to their more complex, real-world patients, or that practicing EBPs is not feasible or too time-consuming because of real-world constraints in their local health-care system. The AI Science Playbook addresses this research-to-real-world gap by providing a systematic process to identify challenges that may be unique to the local population and health-care system, and where an EBP does not fit or fail to result in the desired outcomes (Figure 3b).

The key step in the AI Science Playbook to closing this research-to-real-world gap is having the team conduct sprints as often as necessary until the evidence-based protocols are successfully translated into the real-world setting. This step is crucial to identifying failures when an EBP is adapted, and for modifying the protocols until the desired results are achieved. For example, we were able to identify that the collaborative care model originally designed for dementia and late-life depression did not adequately address post-ICU depression, possibly because there was a high prevalence of patients who entered the CCRC who had a partial or no response to antidepressants. In our ongoing clinical trial funded by the National Heart Lung Blood Institute (NHLBI) and the mobile Critical Care Recovery Program (mCCRP), we addressed this concern by modifying the CCRC model of care to include a geriatric psychiatrist in the mCCRP model to provide consultation, given the anticipated complex psychiatric needs of this population (Khan *et al.*, 2018). We also expanded the caregiver education portion about PICS to provide more detailed behavioral coaching so caregivers would be better equipped to manage the combination of cognitive symptoms and behavioral and functional impairments seen in ICU survivors. We have also implemented similar changes in the CCRC and will be repeating our longitudinal analyses of the HABC-M CG and the patient-caregiver focus groups to see if these changes better address the caregivers' needs.

In summary, our paper describes how AI is used to design and execute the CCRC, the first ICU survivor clinic in the U.S. delivering care for a frail, aging population with comorbid cognitive, psychological, and functional impairments and its caregivers. Our work is unique because the CCRC is the first model of care that is designed and executed using the AI Science Playbook. We have also now characterized both patient and caregiver data from the first ICU survivor clinic. Most importantly, our work lays the foundation for how to adapt our collaborative care model for other complex older adult populations who are also seen by geriatric health-care workers but for whom we have limited evidence on how to provide patient-centered, cost-effective care. For example, one major area of concern is acute care utilization in patients who have dementia with behavioral disturbances. Maust *et al.* (2017) showed that caregiver stress was a major driver behind acute care utilization in these patients. Similarly, patients with delirium in non-ICU populations also often suffer from post-hospital MCI and ADRD, depression, and frailty. Using the AI Science Playbook to adapt our collaborative care model for these populations may allow clinicians to translate relevant EBPs in other populations who are less complex to determine their effectiveness and feasibility in these more complex populations. In terms of limitations, the localized models of care created using the AI science are not a proxy for rigorous clinical trials for the creation for EBPs. Nevertheless, in populations in which EBPs are not available or have significant limitations, AI can close the gap. Moreover, these localized models of care can provide valuable preliminary data for the future conduct of rigorous clinical trials in these complex older patients seen by geriatric clinicians, who are frequently excluded from traditional clinical trials.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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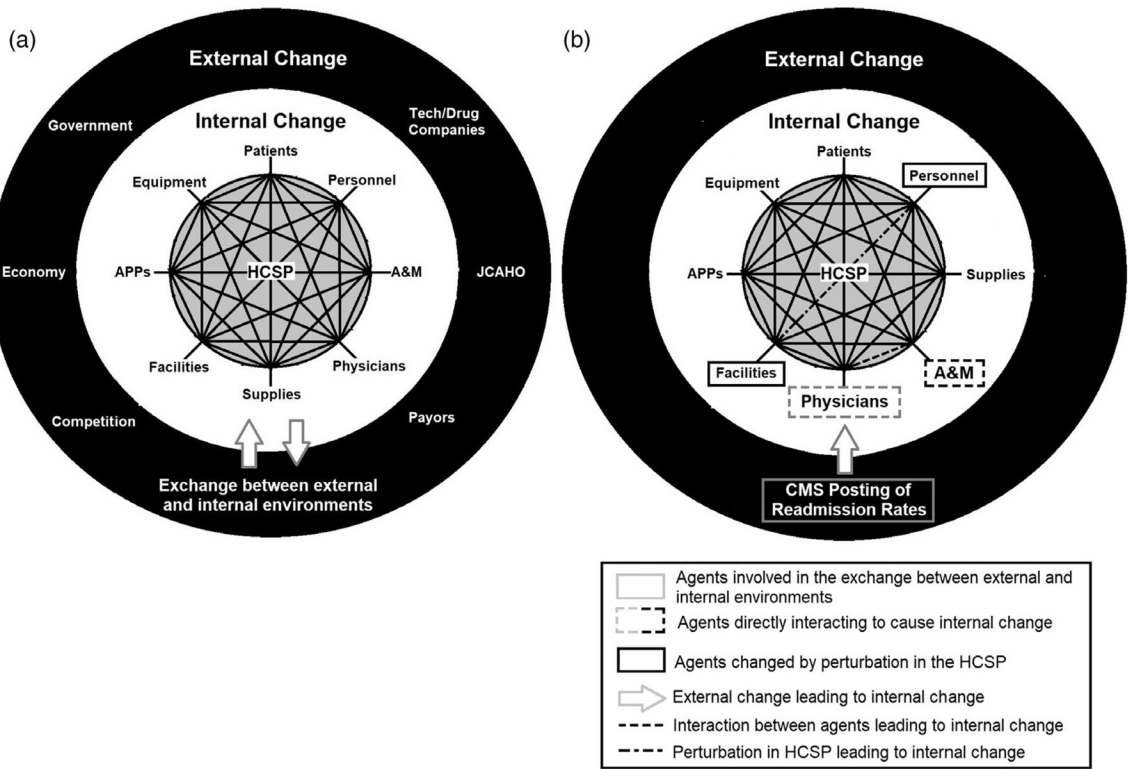


Figure 1.
 (a) Representation of the Health Care System and Its Interactions with the External Environment as a Complex Adaptive System. HCSP, Health Care System Performance; A&M, Administration and Management; APP, Advanced Practice Practitioners; JCAHO, Joint Commission and Hospital Organization. (b) Interactions in the Complex Adaptive System that have contributed to the CCRC.

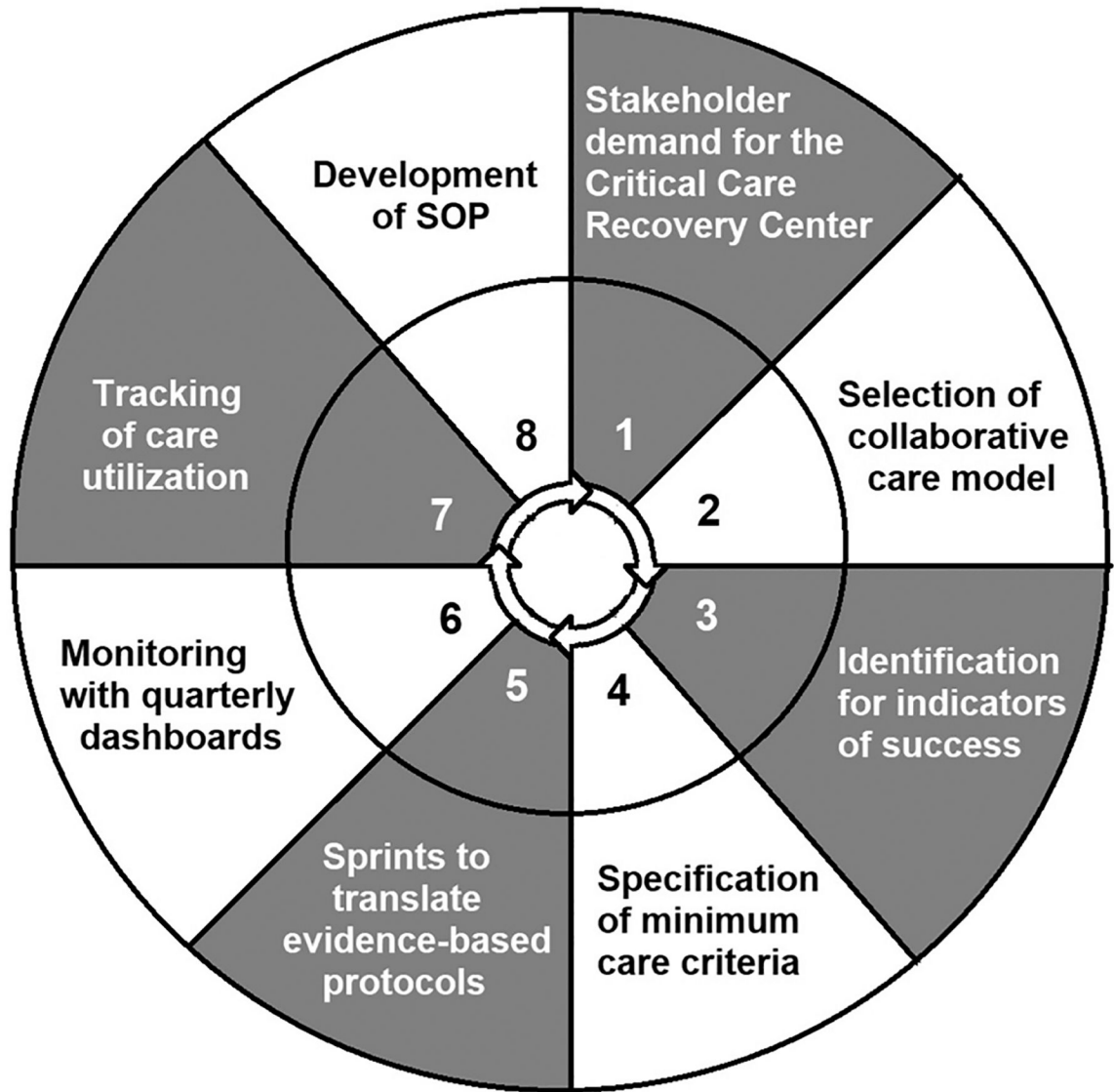


Figure 2.
Agile Implementation Science Playbook to Create the CCRC.

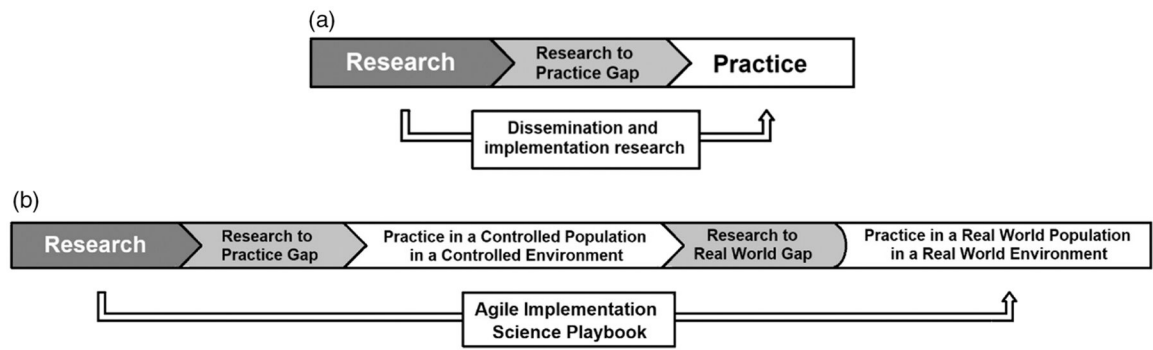


Figure 3. (a) Implementation Science Closes the Research to Practice Gap. (b) Agile Implementation Science Playbook Closes the Research to Real World Gap.

Table 1.

Baseline demographics and clinical characteristics of CCRC participants with completed HABC-M CG

CHARACTERISTICS	CCRC PARTICIPANTS (N = 120)
Demographics	
Age	52.1 (13.2)
Female	53 (44.2)
African American	52 (44.8)
Education (years)	11.4 (3)
Comorbidities	
Alcohol use disorder (current or previous)	37 (34.9)
Tobacco use disorder (current or previous)	78 (69.0)
History of depression	51 (44.3)
CNS disorders	43 (37.7)
Cardiac disease	35 (30.4)
Diabetes mellitus	27 (23.7)
Hypertension	75 (65.2)
COPD	48 (42.1)
Cancer	16 (14)
Hospital characteristics	
Hospital days [★]	14 (8–22)
ICU days [★]	9 (4–16)
Delirium	54 (48.2)
Respiratory failure	95 (84.8)
Initial CCRC visit information	
Time between initial visit in CCRC and hospital discharge	88.7 (56.5)
MMSE	24.8 (5.7)
Moderate to severe depression [†]	33 (33.3)
PSMS total score (0–6)	4.3 (1.7)
IADL total score (0–7)	3.2 (2.3)
HABC-M CG scores	
Functional subscale (0–33)	6.5 (7.7)
Psychological subscale (0–30)	7 (6.9)
Cognitive subscale (0–18)	4.8 (5.3)
Caregiver stress subscale (0–12)	2.8 (3.8)
Total score (0–93)	21.2 (19.7)

N = 108–120 for all variables except for history of depression (N = 99), PSMS total score (N = 94), and IADL total score (N = 93).

Unless specified otherwise, values are calculated as mean (standard deviation) for continuous variables, and as N (%) for dichotomous variables.

[★] Values are calculated as median (interquartile range).

[†] Moderate to severe depression is defined as Geriatric Depression Scale-30 ≥ 20 or Patient Health Questionnaire-9 ≥ 10 prior to treatment in CCRC.

Higher scores for HABC-M CG subscales and total score indicate greater severity of symptoms.

CCRC = Critical Care Recovery Center. HABC-M CG = Healthy Aging Brain Center Monitor Caregiver Version. CNS = central nervous system. COPD = chronic obstructive pulmonary disease. MMSE = Mini-Mental State Examination. PSMS = Physical Self-Maintenance Scale. IADL = Instrumental Activities of Daily Living.

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Table 2.

Relationship between patient characteristics with baseline HABC-M CG scores

HABC-M CG SCORE [★]	DEMOGRAPHIC AND CLINICAL CHARACTERISTICS	PARAMETER ESTIMATE	STANDARD ERROR	P-VALUE
Total score	Cardiac disease	-0.66	0.25	0.011
	African American	-0.62	0.24	0.011
	Falls	0.64	0.29	0.030
Functional subscale	IADL total score	-0.27	0.05	<.0001
	Falls	0.72	0.26	0.007
	ADL total score	-0.16	0.07	0.035
Psychological	IADL total score	-0.16	0.06	0.006
	Age	-0.02	0.01	0.0005
	Female	-0.39	0.18	0.031
Cognitive subscale	Falls	0.62	0.22	0.005
	CNS	0.47	0.18	0.012
	African American	-0.36	0.18	0.047
Caregiver stress subscale	IADL total score	-0.15	0.04	0.0003
	IADL total score	-0.25	0.04	<.0001
	CNS	0.40	0.19	0.041
Caregiver stress subscale	Falls	0.49	0.23	0.032
	Loss of consciousness	0.44	0.19	0.025
	African American	-0.47	0.19	0.014
	IADL total score	-0.10	0.04	0.021

[★]Dependent variables were transformed to be the logarithm of (HABC-M CG score + 1).

HABC-M CG = Healthy Aging Brain Center-Monitor Caregiver Version. ADL = Activities of Daily Living. IADL = Instrumental Activities of Daily Living. TIA = transient ischemic attack. CNS = central nervous system.

Higher scores on HABC-M CG indicate higher severity of symptoms.

Higher ADL and IADL total scores indicate higher functional performance.