Wagi *et al.*
Implementation Science Communications (2025) 6:56
https://doi.org/10.1186/s43058-025-00743-8

Implementation Science Communications

RESEARCH

Open Access

Leveraging inter-organizational networks to scale up a sepsis recovery program: results from an application of the Making Optimal Decisions for Intervention Flexibility during Implementation (MODIFI) method

Cheyenne R. Wagi[1*], Marc A. Kowalkowski[2], Stephanie P. Taylor[3], Aliza Randazzo[1], Asha Ganesan[4], Amit Khanal[5] and Sarah A. Birken[1]

Abstract

Background Nearly two million adults in the United States are hospitalized with sepsis yearly, with survivors facing complications that result in high rates of hospital readmission and mortality after discharge. We demonstrated improved outcomes following discharge among sepsis survivors who participated in the Sepsis Transition And Recovery (STAR) program; however, important differences among hospitals require STAR's adaptation to facilitate its implementation and ensure its effectiveness in new settings.

Purpose The purpose of this study was to adapt STAR to hospitals with diverse characteristics.

Methods We used the Making Optimal Decisions for Intervention Flexibility during Implementation (MODIFI) approach. We identified STAR core functions (i.e., effectiveness-driving features) using semi-structured key informant interviews ($n=7$). We identified adaptations using semi-structured interviews with clinicians and leaders with expertise and oversight of resources related to transitions of care after sepsis hospitalization ($n=7$) from four hospitals that systematically differed from the hospitals in which we originally found STAR to be effective.

Results Network theory, which proposes that performance improves with more efficient flow of information within and across hospitals, underlays STAR's eleven core functions. Adaptation included specific points-of-contact, communication preferences, and methods for achieving buy-in. We used proposed adaptations to tailor STAR protocols to each hospital.

Conclusions We used MODIFI, a state-of-the-science method, to adapt a program that was effective in promoting transition and recovery in sepsis survivors to facilitate its scale-up to diverse hospitals. Future studies will assess STAR's implementation and effectiveness in diverse hospitals.

Keywords Sepsis, Evidence-Based Intervention, MODIFI for Implementation Science, Network Theory, Core Functions, Adaptations

*Correspondence:
Cheyenne R. Wagi
cwagi@wakehealth.edu
Full list of author information is available at the end of the article

Contributions to the literature

- We expanded upon MODIFI by integrating Kirk's core functions methodology, which our team has extensively implemented and improved through multiple studies, into MODIFI's step 1 substep "Identify key information about the intervention," representing a methodological contribution that improves upon the newly published MODIFI method.
- We identified the core functions of STAR, a first-of-its-kind sepsis recovery intervention, and the adaptations required to scale STAR beyond the hospitals in which it was originally tested.
- We identified that intervention centralization may lead to fewer needed adaptations when implementing in new locations.

Background

Sepsis is a life-threatening organ dysfunction caused by a dysregulated host response to infection [1]. Almost two million adults in the United States are admitted to the hospital with sepsis each year [2]. Although in-hospital mortality has improved, sepsis survivors often face ongoing complications such as functional limitations, future infections, and worsening comorbidities resulting in high rates of hospital readmission and mortality after discharge [3, 4].

To improve outcomes following discharge among sepsis survivors, we developed the Sepsis Transition And Recovery (STAR) program, that delivers a wide scope of care activities, tailored to the individual needs of the heterogenous population of sepsis survivors [5, 6]. The STAR program uses telehealth nurse navigation to deliver a bundle of best-practice care elements for longitudinal post-sepsis care up to 90 days. These care elements are directed towards the specific challenges and sequelae following a sepsis hospitalization: 1) identification and treatment of new physical, mental, and cognitive deficits; 2) review and adjustment of medications; 3) surveillance of treatable conditions that commonly lead to poor outcomes including chronic conditions that may de-stabilize during sepsis and recovery; and 4) focus on palliative care when appropriate. The STAR program elements comprise an evidence-based intervention (EBI), supported by expert opinion [7], observational data [8], and randomized controlled trial (RCT) outcomes [9, 10]. In an RCT of STAR in three hospitals, we found that the STAR program reduced 30-day mortality and rehospitalizations by 5% compared to usual care alone [10]. A secondary follow-up evaluation showed that benefits of STAR participation continued up to at least 12 months after hospital discharge [9]. Currently, the STAR program has been implemented in 8 hospitals across the same health system [11].

Extending the benefits of the STAR program to hospitals beyond the ones previously studied has the potential to mitigate the immense burden of post-sepsis adverse outcomes, particularly for underserved populations; however, there are important differences among hospitals that require STAR's adaptation to facilitate its implementation and ensure its effectiveness in new settings. STAR's implementation and effectiveness may have been influenced by the unique characteristics of the hospitals where it is currently implemented. For example, differences in hospital resourcing, communication, technology infrastructure, leadership style, co-existing programs, and prioritization of sepsis may influence the effectiveness of a sepsis transition intervention. Context differences such as these significantly influence implementation, but these differences are not necessarily easily identified or anticipated, therefore, identifying how context may influence required adaptations is an essential early step for successful implementation. Ensuring STAR's effectiveness in new contexts requires its adaptation to accommodate new settings' unique features. Thus, the purpose of this study was to adapt STAR for implementation in four hospitals in a separate health system with distinct geographic, resource, and case-mix differences from the hospitals in which it had already been implemented [12].

Methods

We combined Kirk et al.'s methods for identifying intervention core functions [13] and the MODIFI method [14] to identify adaptations. MODIFI Step 1 includes learning about the users, local context, and intervention. We used Kirk's methods to learn about the STAR intervention (MODIFI Step 1 substep) to identify of STAR's core functions (i.e., effectiveness-driving features), which cannot be modified without compromising its effectiveness [13]. MODIFI Step 2 involves adapting the intervention and identifying adaptations required for the new setting, including setting-appropriate forms of the intervention's core functions (i.e., activities used to carry out core functions). MODIFI Step 3 evaluates adaptations [13, 14].

MODIFI step 1: learn about the users

MODIFI Step 1, sub-step: learn about the intervention/ identify STAR's core functions

Methods of identifying core functions are described in detail elsewhere [13]. Briefly, identifying intervention core functions involves culling existing information regarding the intervention to develop a draft intervention description (e.g., based on protocols, publications); interviewing individuals with perspective on the intervention

(e.g., developer, project manager); and developing a theory of change (i.e., the hypothesized mechanisms through which the intervention influences outcomes).

STAR draft description

CW (Research Associate) worked with STAR principal investigators (PIs: ST and MK) to identify existing STAR documents (i.e., publications, standard operating procedure, protocol, and internal planning documents). CW drafted the description using STAR documents to define a comprehensive list of STAR's activities, and who, where, when, and how STAR was administered. This document gathered and described the forms of STAR. SB (Co-I, Implementation Expert), who has expertise in core functions identification methods [13, 15, 16], and the STAR program manager reviewed the draft description for comprehensiveness and accuracy.

Sampling and recruitment

We used a purposive sampling technique to recruit individuals who were integral to STAR's development and evaluation (ST, MK) and key partners in the implementation process (medical and administrative leaders and STAR navigators). We targeted these individuals based on their level of understanding of STAR processes, program role and experiences, and knowledge of original study hospitals. We also used a snowball sampling approach, asking participants to identify additional individuals with relevant perspective on STAR core functions. Recruitment took place via email, and participants were offered a $50 prepaid debit card as reimbursement for their time.

Data collection

Semi-structured interviews were conducted by CW and SB via Webex, a multifunctional web conferencing platform. The interview questions sought to verify, edit, and build upon the information in the STAR draft description to identify the effectiveness-driving features of the intervention and its implementation. All participants were provided with a copy of the STAR draft description in advance of the interviews. CW revised the draft description after interviews with the STAR developers and before interviews with other participants. Interviews were recorded and transcribed verbatim. The study was approved by the Wake Forest University School of Medicine Institutional Review Board (IRB # IRB00087673, approval date 10/14/2022).

Analysis

We developed the codebook by combining Kirk's Model for Adaptation Design and Impact (MADI) [17], a priori codes based on interview questions, and additional emergent codes. MADI characterizes types of adaptations, proposes how these adaptations may impact outcomes, and offers guidance for how to design adaptations with these outcomes in mind.[17] We considered the types of adaptations required by individual sites and the ways these adaptations may impact STAR's implementation and effectiveness. The interviews were coded in ATLAS.ti version 23. AR (Project Manager) and CW used template analysis and co-coded two interview transcripts to ensure consistency. After resolving initial coding discrepancies, AR and CW independently coded the remaining interview transcripts. CW and AR then used grounded theory to identify themes for each code. CW, AR, and SB reviewed the emerging themes and met to build consensus and revise the preliminary STAR description to reflect the emerging STAR core functions.

We then met with interview participants, including STAR PIs (ST and MK), methodology experts (SB, CW, and AR), and STAR navigators to solicit feedback on the revised STAR description. CW and SB incorporated participants' feedback into the STAR description and discussed results in a total of five subsequent internal team meetings with STAR PIs (ST and MK) until consensus was reached regarding STAR's core functions. The team then discussed forms (e.g., on-the-job training for sepsis care/needs). The team then discussed potential moderators of core functions' influence (e.g., paramedicine van had limited travel radius).

SB and CW organized core functions into as relating to the intervention or its implementation. Intervention core functions are the features of the intervention that drive its effectiveness and thus cannot be compromised. Implementation core functions are the components necessary to achieve intended implementation outcomes (e.g., acceptability; feasibility). We distinguished between intervention and implementation core functions in a previous study, where only with the presence of all intervention and implementation core functions would the program include all elements necessary and sufficient to achieve the intended outcomes of the intervention [16].

Finally, to explain the change underlying STAR's implementation and effectiveness—i.e., the mechanism(s) thought to drive STAR's integration into practice and influence on patient outcomes—SB identified relevant organization theories. Based on concepts related to power, autonomy, and control, organization theories explain how and why interventions such as STAR are adopted, implemented, and sustained in new contexts. Using established methods for selecting and applying implementation science theories, models, and frameworks [18, 19], SB reviewed the organization theories described by the Organization Theory for Implementation Science (OTIS) framework in a series of abstraction forms [20]. These forms included information such as an

overview, example application, and constructs of each of the nine theories described. SB discussed the organization theories with CW and arrived at the theory that best fit with the emerging themes from the interviews. We applied the selected theory, again using established methods for selecting and applying implementation science theories, models, and frameworks [18, 19], by mapping themes from interviews onto the theory's constructs [19].

MODIFI Step 1, sub-steps: learn about users and context

STAR study PIs (ST and MK) identified representatives at each of the hospitals ($n=4$) for which the STAR program would be adapted, as well as health system representatives. Based on institutional knowledge, we identified clinicians and leaders with expertise and oversight of resources related to transitions of care after sepsis hospitalization. The project manager invited potential semi-structured interview participants via email with up to three additional contacts. We also used a snowball sampling approach, asking participants to identify additional individuals with relevant perspectives on adaptations required to carry out STAR core functions at their hospital.

CW and SB conducted the interviews via Webex. The purpose of the interviews was to learn about the users, local context, and identify key information about STAR (core functions). To accomplish this, we presented STAR core functions to participants and asked them to consider adaptations required to carry out the core function at their hospital. Interviews were recorded and transcribed verbatim.

MODIFI Step 2

To adapt the intervention, CW used grounded theory [21] in a rapid analysis of the interview data to inductively identify codes representing adaptations that would be required to carry out STAR core functions at each hospital. Adaptations were new forms of STAR core functions that were responsive to user needs and assets and characteristics of the local context (e.g., a different mode of communication than the one used in the original STAR program).

MODIFI Step 3

Analysts CW and SB presented site-specific adaptations during a virtual meeting with the STAR team, including PIs (including a sepsis care provider who was familiar with the original and new hospitals), project managers, and local medical director. The meeting provided time for the analysts and STAR team to discuss the adaptations, ask questions, and develop specific ways in which the adaptations could be addressed or implemented. The study Project Manager (AG) and PI (MK) took notes during this call and STAR study PI (MK) then used these notes to develop site-specific protocols that included the adaptations. Planned program content changes were confirmed by group discussion during a STAR team meeting. This meeting included STAR PIs, the Implementation Expert, the Clinical Expert, the Research Associate, and Program Managers. We assessed for consensus on adaptations, providing evidence for the adaptation, using quotes from the interviews as needed.

Results

MODIFI Step 1 and identifying STAR's core functions

We completed seven interviews with members of the STAR development and implementation team, including STAR PIs ($n=2$), a medical director ($n=1$), nurse navigators ($n=3$), and administrator ($n=1$). Resulting changes to the draft STAR description included details regarding implementation and resources used to deploy the intervention. The preliminary list included 17 core functions. The five team meetings resulted in combining several of the 17 core functions, yielding a final list of 11 core functions (Table 1).

The change underlying STAR's implementation and effectiveness can be explained using network theory. Network theory emphasizes social relations among actors (e.g., patients; providers; hospitals) and how characteristics of those relations contribute to actors' performance and behavior [22–25]. In the context of STAR, actors include patients, STAR navigators, healthcare professionals, participating hospitals, and the community-based organizations that provide sepsis-related care (Fig. 1). Characteristics of actors' relations include the directness of ties (e.g., the number of actors with which a STAR navigator must interact to understand the patient's condition), how frequently actors interact, and the cohesion of the network. Core functions are collectively necessary and minimally sufficient conditions for successful implementation. Thus, a single theory of change underlies the core functions.

1. *STAR facilitates deployment of existing hospital network to assist with sepsis management.* (Implementation Core Function) Readiness is a precursor to healthcare professionals' acceptance and engagement in STAR [26]. A medical director explained,"That's the first thing you need to assess, do they [the health care system/clinic] have the desire to change? Do they see a problem that they want to fix?" (Medical Director, D3). A clinic may demonstrate readiness by having staff already trained in common complications experienced by patients surviving sepsis hospitalization. They may

Table 1 STAR core functions

	Core Function
1	STAR facilitates deployment of existing hospital network to assist with sepsis management
2	Hospital leadership buy-in promoted network cohesion
3	Communication with healthcare professionals in the hospital strengthened STAR navigators' ties to patients
4	STAR navigators had access to the information and support required to connect patients with services
5	A clinical leader with influence over transitions of care served as a central node for the STAR network
6	STAR automated accurate, timely identification of patients with sepsis
7	STAR required minimal engagement on the part of hospital leaders, providers, or staff
8	STAR navigators had comprehensive knowledge of sepsis care and assessment
9	STAR navigators had reasonable caseloads
10	STAR engaged patients in the network of actors in sepsis recovery
11	STAR navigators increased the directness of patients' ties to relevant support and referrals

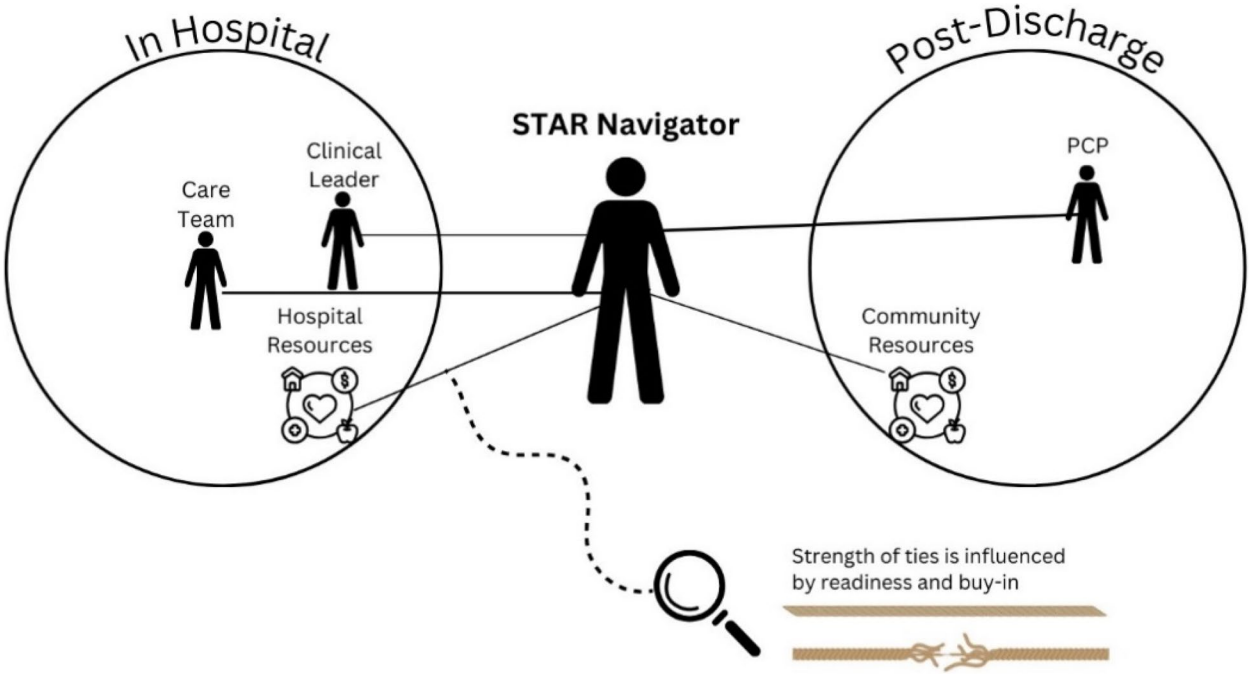

Fig. 1 STAR Network. Figure 1 The STAR Navigator is the central node tying together in-hospital and post-discharge team members and resources. In the in-hospital circle are the patient's care team, clinical leader, and hospital resources. The post-discharge circle contains the patient's primary care provider and community resources. The STAR Navigator has ties between themself and the other entities. The strength of the ties is dependent on readiness and buy-in for the organization. Closeness of ties is related to the frequency with which the Navigator is in contact with or engages with the entity (person or resource)

also demonstrate readiness by declaring a need to improve outcomes after sepsis but not having taken further steps to achieve their goal. Additional efforts on the part of the central node may be required to demonstrate improving outcomes after sepsis as a priority for the institution.

2. *Hospital leadership buy-in promoted network cohesion*. (Implementation Core Function) For STAR to be effective, hospital leadership must ensure access to resources**,** including the providers in the hospital with whom the navigators need to communicate, medical resources/supplies, and access to the resources the hospital had access to through community partnerships (i.e., paramedicine). Leaders must appreciate the impact of sepsis on their health system, as this ensured that they saw the value-add

of STAR. A co-principal investigator explained, "People are aware that sepsis is a main, a big driver of hospital readmission with our system, but also nationally" (Co-Principal Investigator, D4). The factors that influenced buy-in were hospital-specific; thus, this core function required tailoring to drivers of local leadership's buy-in. Leadership buy-in influenced availability of and access to resources: "I was here when we introduced to two new hospitals, and that key meeting with your stakeholders and, you know, people who are truly involved…in the process**…**at the different sites, to me, that's invaluable. Like you have to have people that are bought into the process and not someone who this is just, like, adding on to them… [T]o me, that's a key to-to success is when I—as a new kid on the block talking to people, you know, when they're bought into it, it's like you-you can make things happen a little bit further. You know, they can give you resources" (STAR Nurse Navigator, D7).

3. Communication with healthcare professionals in the hospital strengthened STAR navigators' ties to patients. (Implementation Core Function) STAR navigators are stationed remotely; thus, it is essential to have providers in the hospital to support the program by completing patient follow-up and clarifying patient information, thereby supporting early and consistent engagement of healthcare professionals in the hospital with STAR navigators. A medical director explained,"I think part of the secret sauce of STAR is [navigators'] integration with the care delivery team"(Medical Director, D3). A nurse navigator said, "We have the sepsis nurse navigator there that can actually go in and review" (STAR Nurse Navigator, D1). This communication allows navigators to have someone who can follow up with patients as needed. In the original intervention, navigators were introduced to these professionals through monthly virtual meetings to help them build their network of contacts. The methods through which navigators are introduced to healthcare professionals, the number of healthcare professionals, and the roles of these professionals are hospital-specific.
4. *STAR navigators had access to the information and support required to connect patients with services*. (Intervention Core Function) STAR reduces readmission by connecting patients with services they need to remain healthy, ensuring that navigators can connect patients to resources that can help them both in the hospital and post-discharge. A co-principal investigator (D2) said, "If they [the patients] screen positive for depression, they get referred to behavioral health… [I]f they need physical therapy or DME or something for functional needs, then navigators can often put those referrals in, or they'll communicate with the patient's primary care provider to get those done" (Thus, STAR requires navigators to have access to information and resources. One nurse navigator (D7) explained, "A really big, important part of my orientation was just really understanding insurance and what it can and can't do, and all of … [the hospital and community] resources. You know, if you have resources, that's like 50% of the battle." Navigators may be positioned in a central clinic, requiring adaptation to ensure navigators' connection to resources needed to assist patients.
5. *A clinical leader with influence over transitions of care served as a central node for the STAR network*. (Intervention Core Function) A clinical leader is needed when a complex issue arises such as addressing medication discrepancies, which are common after sepsis. Identifying these individuals and engaging them early on provided an opportunity for navigators to continue this relationship and reach out to the clinical leaders when the need arose. A medical director explained, "Engaging many different leaders, not just the CMO and the quality person but talking to the leader of the hospitalist group and the leader of the surgical group and trying to get in front of those providers and letting them know what's going on." (Medical Director, D3). Ensuring STAR's effectiveness requires identifying hospital-specific clinical leaders.
6. *STAR automated accurate, timely identification of patients with sepsis*. (Intervention Core Function) STAR identified patients each day using an EHR-based algorithm developed from existing, standard clinical definitions of sepsis and a locally derived readmission risk prediction model. Identifying eligible patients who are most likely to benefit is important to ensure efficient use of a limited resource like STAR. Automating this process reduced the burden to clinicians and promoted uniform application of eligibility criteria. Other institutions may choose to modify algorithm components for implementation, while maintaining automation of the patient identification process to minimize added requirements of the clinical teams.
7. *STAR required minimal engagement on the part of hospital leaders, providers, or staff*. (Implementation Core Function) Hospital leadership must determine which programs are cost, time, and outcome effective to implement. As STAR comes largely pre-packaged, it required little effort on

the part of hospital leaders and administrators, decreasing the financial and time costs of implementing a new program. STAR implementation requires limited effort from hospital providers and staff, who have low capacity to for additional work and training. Aside from hospital leadership buy-in for STAR (core function 4), STAR required little else from the hospital to operate effectively.

8. *STAR navigators had comprehensive knowledge of sepsis care and assessment*. (Intervention Core Function) To navigate patients through their sepsis care, navigators must be experts in clinical and social determinants of health that impact patients diagnosed with sepsis. STAR centralized hiring and training navigators, ensuring all navigators had the skills and information needed to successfully implement the intervention and support patients. A co-principal investigator explained, "We do a little bit of sepsis-specific training. …[W]e give [them] some articles to read and videos to, you know, watch to catch them up on post-sepsis care so that they're kind of experts" (Co-Principal Investigator, D2). Training was the form used by the STAR program to achieve this core.
9. *STAR navigators had reasonable caseloads*. (Implementation Core Function) The number of patients assigned to each navigator was planned to allow for the deep involvement with patients required to minimize the need for readmission. It was recommended that caseloads were not to exceed 50 patients per navigator at any time, with lower volumes advised for higher patient acuity.
10. *STAR engaged patients in the network of actors in sepsis recovery*. (Intervention Core Function). STAR navigators continued to contact patients post-discharge to monitor their health (symptoms, vitals, functional status), prompting the patients to continue to monitor their own health and health needs. New sites have access to resources similar to original sites. The tools for increasing patient participation can be transferred without adaptation. These tools include ongoing support for patients that includes continued patient check-ins to ensure adherence to care guidelines and follow-up appointments.
11. *STAR navigators increased the directness of patients' ties to relevant support and referrals*. (Intervention Core Function). STAR navigators identified patient-specific needs, in part by using health behavior counseling and emotional listening. A centralized team hires and trains all navigators to ensure consistency and competency in sepsis knowledge and counseling skills.

MODIFI Step 2

We conducted interviews ($n=7$) with site and health system representatives from the four hospitals targeted for STAR implementation. Interview participants included clinical and administrative leaders ($n=5$) and nurse and physician roles ($n=2$). The results of these interviews were pragmatic point-by-point adaptation needs for the STAR program to be implemented in participants' hospitals. Adaptation recommendations are displayed in Table 2. Adaptation recommendations included specific points-of-contact for clinical leaders in the hospital and for people in the hospital that could help the navigators to learn about available resources. Recommendations for communication methods were also common discussion points. Interviewees shared communication best practices (i.e., EPIC secure chat or CarePort for referrals) and meetings at which navigators can build relationships with care team members.

Around buy-in, most interviewees mentioned needing data to demonstrate programmatic effectiveness in both improving patient outcomes and reducing readmissions. For hospital exhibits readiness, points of consideration for adaptation included current rates of sepsis readmissions, current sepsis-related programs, and barriers such as staffing shortages.

These findings were presented during STAR staff meetings. During these meetings, we clarified information on the hospital sites in which the new implementation would take place that was brought up by the interviewees. We also discussed with the STAR PI how to operationalize the adaptations. We used the meetings to describe plans engaging clinical leaders and connecting navigators with key stakeholders.

MODIFI Step 3 – evaluate the adaptation

The results of the interviews were used to create updated hospital-specific protocols for STAR. Specifically, adaptation recommendations were categorized by protocol domain (e.g., Planning/Roll Out, Patient Identification, Initial Assessment, Early Transition). Some of the points included in the new protocol included engaging clinical leaders during the planning and roll out phase. These leaders were invited to participate in STAR team meetings with the navigators and STAR PI. The protocol also included ensuring navigators access to key communication tools for the new sites, including EPIC and Rover.

Discussion

We identified the core functions of STAR, a first-of-its-kind sepsis recovery intervention, and the adaptations required to scale STAR beyond the hospitals in which it was originally tested. These core functions represented a

Table 2 Hospital-specific Adaptations for Adaptable STAR Core Functions

Core Functions (as they were presented as the time of the interviews with navigators)	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Overview
STAR navigators have access to the information and support required to connect patients with services	- Base the navigator out of the transition's clinic - Leverage existing support and information networks between the navigators and the transitions clinic (e.g., weekly meetings)	- Establish route for information (staffing shortages make phone calls difficult, regularly scheduled calls/meeting may not be feasible)	- Connect STAR navigator with other existing navigators - There are existing groups to connect the navigator with: sepsis quality group, internal medicine quality group - Encourage the navigator to attend the hospitalist Group weekly meeting - Be aware the hospital is in process of developing a Medicine Quality Group	- The navigator can use the care management notes to see what the plans are for that patient - This hospital uses CarePort for referrals, which is where navigators will see where patients have been referred and can communicate via CarePort	- The system uses a combination of Google and Find Help, which are the systems resource pool - The Ambulatory side uses EPIC messaging, which will be the best way for navigators to get into contact with the ambulatory team - Other modes of communication include telephone messaging and teams - When PHI information needs to be shared,navigators should use telephone or EPIC
A clinical leader serves as a central node for the STAR network	- Engage the director of the transition's clinic	- Engage the drector of nursing	- Engage the director of the transition's clinic	- Engage the hospitalist group lead attending physician	N/A
Healthcare professionals increase the directness of STAR navigators' ties to patients	- Engage existing navigators and case management - Engage the head of respiratory therapy	- Engage physician leaders - Engage medical directors for SNFs - Engage APPs	- Engage existing navigator - Engage the director of the hospitalist group - There are two hospitalists and two APPs with daily rounds that could be useful for the navigator to contact	- The navigator should join a staff meeting to meet staff - STAR navigator would need to check to see if the patient is already covered by a pre-existing navigation program	- The internal care management team has been made aware of STAR - Internal education was conducted with hospitalist group so they knew what to expect from STAR - There is a sepsis navigator internal to the facility (need to clarify which patients go to that navigator vs the STAR navigator)
Hospital leadership buy-in promotes network cohesion	- Advocate for paid-for navigator position - In talks with hospital leadership, focus on how STAR reduces readmissions and avoiding penalties -Reducing readmissions will get everyone to buy in	- Physician leaders need to be on board - To get everyone on board, you would need to start at the corporate level, then go to the director of operations, then the medical director, and finally the director of nursing - Important to have leadership at meetings in the beginning so it's not just the navigator	- If you show a decrease in readmissions from sepsis, buy-in will increase - Improvement in community health outcomes will increase buy-in - Healthcare dollars saved is another way to convince leadership of STARs value - Include their existing intervention of the sepsis kits: put navigator info w/kits and reach out to patients and remind them to use kits	- A navigator can fill the gap that they do not know what happens to patients once they leave the hospital, it would be helpful to follow a patient to prevent readmission - Post intervention, future buy-in would be up to the Senior VP for the market	- There is an increased interest in sepsis programs because of high readmissions of sepsis patients; use this info to increase buy-in potential - Data showing program success (morbidity/mortality) will make the case for buy-in - In the absence of a grant, the hospital will need to shift/redistribute funding, which is important to keep in mind for sustainability

Table 2 (continued)

Core Functions (as they were presented as the time of the interviews with navigators)	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Overview
STAR navigators communicate with healthcare professionals in the hospital with direct access to patients	- The director of the transition's clinic will oversee STAR implementation; get the navigator into contact with the director early on	- Engage the director of nursing - Enagage the medical director	- Engage the existing navigator, director of the hospitalist group, APPs, and hospitalists - There is a regular meeting with the above people the STAR navigator could attend	- Meet staff in a staff meeting - Use Rover and Epic to contact the attending	- Engage the internal care management team and hospitalist group - STAR navigators were affiliated with the team so they were already part of the broader care management team, reducing the need for introductions - Community health workers and social workers support additional needs for SDoH, therefore it is important to engage these individuals for navigator to have knowledge of and access to resources
Site exhibits readiness for the assistance with sepsis management that STAR offers	- Population is older, sicker, and has a greater percentage of patients on Medicare, which makes the site a good place to try STAR and increases the need for STAR - Have high readmissions rates and want to focus on readmissions, which increases the need for STAR.-Has existing community paramedicine to support STAR, which the navigator can utilize for patients post-discharge	- Significant staffing shortages to be aware of when submitting referrals	- Clinic inundated with sepsis cases, which increases the need for STAR - The surrounding population is low SES, low medical literacy, poor SDoH indicators, and has many barriers to primary care and follow-up; the navigator should be aware of this to provide the best support to patients - Has existing sepsis kit program the navigator can use to help patients	- Sepsis is the longest length of stay at their hospital. It's also the highest for readmissions, increasing the need for STAR - Sepsis readmissions contribute to the bottom line, increasing the need for STAR	- Clinics need more understanding of "research," to be ready for research-based intervention implementation
STAR automates accurate, timely identification of patients with sepsis	Core function will not require adaptation				
STAR requires minimal engagement on the part of hospital leaders, providers, or staff	Core function will not require adaptation				
STAR navigators have comprehensive knowledge of sepsis care and assessment	Core function will not require adaptation				
STAR navigators have reasonable caseloads	Core function will not require adaptation				

Table 2 (continued)

Core Functions (as they were presented as the time of the interviews with navigators)	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Overview
STAR engages patients in the network of actors in sepsis recovery	Core function will not require adaptation				
STAR navigators increase the directness of patients' ties to relevant support and referrals	Core function will not require adaptation				

diverse range of multilevel components, including leadership buy-in and engagement, networks and communication, and tools and processes. Stakeholders from new implementation hospitals also highlighted opportunities for local organization and practice changes to accommodate STAR and drive sustained program benefit. Our findings support a systematic approach to help hospitals implement STAR to address post-hospital care gaps that contribute to poor recovery outcomes after sepsis for millions of sepsis survivors.

Growing awareness of the need for proactive health system approaches to support survivors of sepsis and other critical illnesses to prevent further decline, rehospitalization, and late mortality has prompted implementation of several different models of care [27]. However, understanding of the effectiveness and scalability of these strategies is limited. Future research in developing interventions for serious illness survivors should consider explicit specification of core functions following the approach we used here. This process promotes understanding of the factors driving the success of the intervention and the core functions serve as a blueprint for those wishing to implement successful programs. Additionally, fidelity of ongoing programs can be evaluated by whether the core functions are in place and sustained and identification of core functions and forms enables a systematic approach to adaptation for dissemination and scale-up. When new programs enact necessary adaptations to different contexts, implementers can assess whether the adapted forms still fulfill their related core function.

Notably, only half of STAR's core functions were identified as requiring site-specific adaptation, and half were identified as being centralized and therefore requiring no site-specific adaptation. The centralization of many of STAR's core functions is consistent with the intervention's theory of change; network theory's tenets suggest that centralization of critical resources is ideal for an intervention that seeks to leverage networks to get patients needed resources. Centralization increased the density and, therefore, the efficiency of the vast array of resources and services required to facilitate recovery among patients with sepsis. These findings are consistent with other studies that have identified strategies designed to improve collaboration across health systems [28]. Our findings underscore the potential benefits of interventions designed to bridge organizations that must collaborate to deliver any type of care, such as navigators and tools for information-sharing (e.g., shared electronic health records).

Limitations. This study has some important limitations. Our methods of identifying core functions were not experimental, so we do not have evidence of a causal relationship between the core functions that we identified, and outcomes observed in our RCT. Instead, our approach is theory-based and thus posits specific mechanisms that should be studied in future work. Further, although it was our intention to engage all relevant parties in interviews, it is possible that we omitted the perspective of some individuals with important perspectives on STAR's core functions and potential adaptation to new settings. Nevertheless, consistency in findings from our interviews suggest that our characterization of STAR and needed adaptations suggest sound representation. We also confirmed validity of results in multiple ways (e.g., assessing face validity of core functions in meetings with STAR developers; soliciting feedback on proposed interventions from STAR navigators in new settings).

While MODIFI provides a framework through which to identify context-appropriate adaptions [14], its focus on core functions and articulation of methods for identifying core functions is limited. We expanded upon MODIFI by integrating Kirk's core functions methodology, which our team has extensively implemented and improved through multiple studies, into MODIFI's step 1 substep "Identify key information about the intervention," representing a methodological contribution that improves upon the newly published MODIFI method [13, 15, 16, 29].

Conclusion

We used a systematic approach to identify 11 core functions of a successful program to promote transition and recovery in sepsis survivors and specified allowable adaptations necessary for dissemination to new contexts while maintaining effectiveness. We continue to identify adaptations at new implementation sites and STAR as STAR implementation expands.

Abbreviations

EBI	Evidence-based intervention
MADI	Model for Adaptation Design and Impact
MODIFI	Making Optimal Decisions for Intervention Flexibility during Implementation
RCT	Randomized controlled trial
STAR	Sepsis Transition And Recovery

Acknowledgements

Not Applicable.

Authors' contributions

Conceptualization– MK, ST, SAB. Methodology – CRW, MK, ST, SAB. Data Collection – CRW, SAB. Data Analysis – CRW, SAB. Funding acquisition – MK, ST, SAB. Project administration – AR, AG. Supervision – MK, ST, AK, SAB. Writing original draft – CRW, SAB. Writing – review and editing – All authors.

Funding

This study was funded by the Duke Endowment Fund [7056-SP].

Data availability
De-identified data from this study are not available in a public archive. De-identified data from this study will be made available (as allowable according to institutional IRB standards) by emailing the corresponding author.

Declarations

Ethics approval and consent to participate
This study was approved by the Wake Forest University School of Medicine IRB (IRB00087673, approved 10/14/2022).

Consent for publication
Not applicable.

Competing interests
The authors do not have any competing interests to report.

Author details
[1]Department of Implementation Science, Wake Forest University School of Medicine, Winston-Salem, NC, USA. [2]Department of Internal Medicine, Section on Hospital Medicine Wake Forest University School of Medicine Center for Health System Sciences, Winston-Salem, NC, USA. [3]Division of Hospital Medicine University of Michigan, Ann Arbor, MI, USA. [4]Center for Health System Sciences Atrium Health, Winston-Salem, NC, USA. [5]Department of Internal Medicine, Section on Hospital Medicine Wake Forest University School of Medicine, Winston-Salem, NC, USA.

Received: 27 February 2025 Accepted: 24 April 2025
Published online: 07 May 2025

References

1. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA. 2016;315(8):801–10.
2. Rhee C, Dantes R, Epstein L, et al. Incidence and trends of sepsis in US hospitals using clinical vs claims data, 2009–2014. JAMA. 2017;318(13):1241–9.
3. Prescott HC, Iwashyna TJ, Blackwood B, et al. Understanding and enhancing sepsis survivorship. Priorities for research and practice. Am J Respir Crit Care Med. 2019;200(8):972–81.
4. Shankar-Hari M, Rubenfeld GD. Understanding long-term outcomes following sepsis: implications and challenges. Curr Infect Dis Rep. 2016;18:1–9.
5. Taylor SP, Bray BC, Chou S-H, Burns R, Kowalkowski MA. Clinical subtypes of sepsis survivors predict readmission and mortality after hospital discharge. Ann Am Thorac Soc. 2022;19(8):1355–63.
6. Taylor SP, Morley C, Donaldson M, et al. Characterizing program delivery for an effective multicomponent sepsis recovery intervention. Ann Am Thorac Soc. 2024;21(4):627–34.
7. Prescott HC, Angus DC. Enhancing recovery from sepsis: a review. JAMA. 2018;319(1):62–75.
8. Taylor SP, Chou S-H, Sierra MF, et al. Association between adherence to recommended care and outcomes for adult survivors of sepsis. Ann Am Thorac Soc. 2020;17(1):89–97.
9. Kowalkowski MA, Rios A, McSweeney J, et al. Effect of a transitional care intervention on rehospitalization and mortality after sepsis: a 12-month follow-up of a randomized clinical trial. Am J Respir Crit Care Med. 2022;206(6):783–6.
10. Taylor SP, Murphy S, Rios A, et al. Effect of a multicomponent sepsis transition and recovery program on mortality and readmissions after sepsis: the improving morbidity during post-acute care transitions for sepsis randomized clinical trial. Crit Care Med. 2022;50(3):469–79.
11. Kowalkowski M, Eaton T, McWilliams A, et al. Protocol for a two-arm pragmatic stepped-wedge hybrid effectiveness-implementation trial evaluating Engagement and Collaborative Management to Proactively Advance Sepsis Survivorship (ENCOMPASS). BMC Health Serv Res. 2021;21(1):544.
12. Terrana A, Viglione C, Rhee K, et al. The core functions and forms paradigm throughout EPIS: designing and implementing an evidence-based practice with function fidelity. Front Health Services. 2024;3: 1281690.
13. Kirk MA, Haines ER, Rokoske FS, et al. A case study of a theory-based method for identifying and reporting core functions and forms of evidence-based interventions. Translational Behavioral Medicine. 2021;11(1):21–33.
14. Brewer SK, Corbin CM, Baumann AA, et al. Development of a method for Making Optimal Decisions for Intervention Flexibility during Implementation (MODIFI): a modified delphi study. Implementation Science Communications. 2024;5(1):64.
15. Wahlen MM, Schroeder MC, Johnson EC, et al. Identifying core functions of an evidence-based intervention to improve cancer care quality in rural hospitals. Frontiers in health services. 2022;2: 891574.
16. Wheeler SB, Birken SA, Wagi CR, et al. Core functions of a financial navigation intervention: an in-depth assessment of the Lessening the Impact of Financial Toxicity (LIFT) intervention to inform adaptation and scale-up in diverse oncology care settings. Frontiers in health services. 2022;2: 958831.
17. Kirk MA, Moore JE, Wiltsey Stirman S, Birken SA. Towards a comprehensive model for understanding adaptations' impact: the model for adaptation design and impact (MADI). Implement Sci. 2020;15:1–15.
18. Nilsen P, Birken SA. Handbook on implementation science. Cheltenham: Edward Elgar Publishing; 2020.
19. Birken SA. Selecting and applying implementation theories, models, and frameworks. Veterans Affairs Health Systems Research Cyberseminars. 2021.
20. Birken SA, Wagi CR, Peluso AG, et al. Toward a more comprehensive understanding of organizational influences on implementation: the organization theory for implementation science framework. Frontiers in Health Services. 2023;3:1142598.
21. Glaser BG, Strauss AL. The discovery of grounded theory: strategies for qualitative research. Piscataway: Aldine Transaction; 1967.
22. Borgatti SP, Halgin DS. On network theory. Organ Sci. 2011;22(5):1168–81.
23. Granovetter MS. extend access to American Journal of Sociology. Am J Sociol. 1973;78(6):1360–80.
24. Kilduff M, Brass DJ. Organizational social network research: core ideas and key debates. Acad Manag Ann. 2010;4(1):317–57.
25. Podolny J, Page K. Network forms of organization', annual review of sociology, 24, 57–76. Int Lib Crit Writ Econ. 2005;186(1):481.
26. Livet M, Blanchard C, Richard C. Readiness as a precursor of early implementation outcomes: an exploratory study in specialty clinics. Implementation Science Communications. 2022;3(1):94.
27. Eaton TL, Taylor SP. Health system approaches to providing posthospital care for survivors of sepsis and critical illness. Curr Opin Crit Care. 2023;29(5):513–8.
28. Bunger AC, Chuang E, Girth AM, et al. Specifying cross-system collaboration strategies for implementation: a multi-site qualitative study with child welfare and behavioral health organizations. Implement Sci. 2024;19(1):13.
29. Anderson DM, Birken SA, Bartram JK, Freeman MC. Adaptation of water, sanitation, and hygiene interventions: a model and scoping review of key concepts and tools. Frontiers in Health Services. 2022;2:896234.

Publisher's Note