Demonstrating Accelerated Dissemination & Implementation across HVHC and Beyond

Sally Kraft, Lucy Savitz, Lisa Weiss, Chrissie Gorman, James Weinstein

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High Value Healthcare Collaborative
Hanover New Hampshire | Portland Maine
hvhc.tdi.program.office@dartmouth.edu
1. **Overview**

This white paper describes the activities completed to develop an approach for rapid cycle, Collaborative supported dissemination and implementation (D&I). Working with High Value Healthcare Collaborative (HVHC) subject matter experts, and informed by a review of a purposive sample of the literature, a standard nomenclature was established and an organizing framework for shared learning around D&I was developed. We then conducted a series of in-person visits consisting of a series of in-depth discussions with staff at three HVHC member systems to actively engage members in the refinement of our Collaborative approach. Formal site visits using a semi-structured qualitative research approach to all member sites in Year 1 allowed for further enhancement of our approach. Large-scale test of the HVHC conceptual model for accelerated D&I focused on implementation of the three-hour sepsis bundle across 12 member systems. Below we describe the background and significance of this work together with details of our approach and conceptual model.

2. **Background and Significance**

Health systems are challenged to consistently disseminate and implement new evidence. Too often, our healthcare delivery systems function as a collection of silos; excellent care provided at one location but not another even within the same integrated delivery system or hospital. For decades, the Dartmouth Atlas has demonstrated variation in quality of care; research confirms that the greatest source of variation results from differences in practice patterns not differences in patient preferences or patient conditions. This has led to the well-known aphorism in health services research: “when it comes to health care, geography is destiny.”

Collaboratives offer the promise of accelerating dissemination and implementation of evidence-based care across health systems by sharing experiences, demonstrating what is possible, providing access to expertise and resources, and creating “peer pressure” for improvement. Despite the increased use of collaboratives as a method of disseminating best care, there is a paucity of detailed, real-world examples of effective promoters of reliable spread.

This white paper describes the activities completed through the generous funding provided by the Laura and John Arnold Foundation to develop an approach for rapid-cycle, collaborative-supported dissemination and implementation (D&I). Working with High Value Healthcare Collaborative (HVHC) subject matter experts, and informed by a review of the literature, we developed a standard nomenclature was established and an organizing framework for shared learning around D&I. We then conducted a series of in-person visits consisting of in-depth discussions with staff at three HVHC member systems to actively engage members in refining our Collaborative approach. Formal site visits using a semi-structured qualitative research approach to all member sites in Year 1 allowed for further enhancement of our approach. We conducted large-scale tests of the HVHC conceptual model for accelerated D&I by disseminating and implementing the 3-hour sepsis bundle across 12 member systems. We relied on a highly participatory process of informing and adjusting activities both internally among HVHC Members and externally through other health care systems, publications, and public policies (see schematic).

In the following sections, we describe how we developed the HVHC shared learning infrastructure, applied it to the HVHC sepsis 3-hour bundle implementation, and iteratively developed a generalized conceptual model for accelerated D&I gleaned from the qualitative portion of our mixed methods evaluation.
3. **Why Start With Sepsis As a Test Case?**

In the case of sepsis, the phrase “save lives” is not arbitrary. Sepsis is an infection that has run rampant through the body and may cause a cascade of organ failures. Yet if recognized early, it can be treated successfully in a wide variety of hospital and ambulatory settings. More specifically:

- Sepsis is a leading cause of hospital mortality, afflicting more than one million Americans annually, killing over 250,000 of them, and leaving thousands of survivors with permanent, life-changing aftereffects.  
  More Americans die each year from sepsis than from HIV, breast cancer, and colon cancer combined.  

- As already noted, this condition can be treated with the 3-hour sepsis bundle, a set of practices that can dramatically change the course of the illness when identified early. The sepsis bundle relies primarily on the timely administration of antibiotics and fluids.

- Sepsis can be treated in community hospitals and urgent care centers, which means that the practice of the bundle lends itself to widespread adoption beyond tertiary care hospitals.

- Sepsis affects children, adults, and the elderly – see Figure 7 below for the age ranges of patients diagnosed with severe sepsis or septic shock in 2015 across HVHC member delivery systems.
The combination of these crucial considerations—contribution to avoidable mortality, availability of an evidence-based practice to reduce unwarranted morbidity and mortality, and prevalence of the condition—combined to convince us that this diagnosis would be an excellent first test for our model of how to achieve rapid, large-scale dissemination and implementation.

Figure 7. Breakdown of Age Ranges for Patients in Sepsis Cohort

4. **Approach to Designing D&I Model**

We began by assembling a team of subject matter experts in D&I and quality improvement with staff from the HVHC Program Management Office (PMO). We recruited Subject Matter Experts (SMEs) from member systems based on their expertise and experience from across our participating members:

- Beth Israel Deaconess Medical Center
- Baylor, Scott and White Health
- Dartmouth-Hitchcock Medical Center
- Denver Health
- Hawaii Pacific Health
- Intermountain Health System
- Mayo Clinic
- Northwell Health
- Providence St Joseph Health
- University of California, San Diego
- Virginia Mason Medical Center
**Common Vocabulary**

From initial meetings, it was clear that experts used different terms to describe dissemination and implementation efforts. Based on our review of the literature and in-person meetings with HVHC Planning Team experts, we recognized that the variation in language complicated discussions and work. Members of the project planning team established a standard vocabulary. HVHC planning team acknowledged the fact that individual health systems would continue to use the vocabulary they had adopted at their home institutions but HVHC communications used the following terms consistently:

- **Dissemination**: the active and targeted distribution of information or interventions. Dissemination is a formal and planned process with the intent of spreading knowledge and associated evidence-based interventions with the goal of adoption into routine practice. Dissemination is a necessary but insufficient antecedent of adoption and implementation.

- **Implementation**: the use of strategies to adopt and integrate evidence-based health interventions and change practice patterns within specific settings.

**Literature Review**

Experts in quality improvement and D&I were contacted and asked to identify the most important peer-reviewed articles in their respective areas of expertise. External experts consulted included: Dr. Mary Dixon-Woods, RAND Professor of Health Services Research, University of Cambridge, internationally recognized for health services research focused on implementation and the role of collaboratives; Dr. Amy Kind, UW physician researcher and lead implementation expert of C-TraC; Ms. Karen Timberlake, then Director of the UW Population Health Institute; Dr. Patrick Remington, Associate Dean for Public Health UW; Dr. David Gustafson, Professor UW Industrial and Systems Engineering and Director UW Center for Health Enhancement System Studies; Margaret Minnock, Director, Northern New England Pediatric Quality Improvement Network. This purposive sample of articles was then summarized and distributed to the planning team as an annotated bibliography (see Appendix X); and selected D&I frameworks and conceptual models were discussed during team meetings.

**Voice of the Customer: Current Practice Assessments & Site Visits**

We used a highly participatory approach in designing our approach. A team from the HVHC PMO visited three member systems to understand how the HVHC could provide value to systems already engaged in improving sepsis care. In depth conversations were completed with senior leaders, administrators, and frontline care teams. All three PMO team members took notes during conversations and reviewed these together during debriefing meetings after each visit (see Appendix X). Information from these visits was used to refine and revise HVHC D&I infrastructure and collaborative learning processes put in place to support member HVHC healthcare systems working on improvements in sepsis care.

When asked how an HVHC D&I model could provide value to an organization with a mature improvement and implementation infrastructure, one senior leader replied,

“...The most important role of the collaborative is not to teach people what to do but to teach them how to do it....”

Most people interviewed felt that the value of being a member of HVHC was the ability to share lessons learned and feel “safe” talking about failures. Constructing an implementation model that utilizes technology and information science to accelerate knowledge sharing will be highly valued by members.
Reflecting the variation within a single system, leaders remarked that there is variation in the dissemination and implementation competencies across their sites. Variation exists between hospitals in the same system (especially when considering affiliated hospitals) and between care units within the same hospital. HVHC D&I resources should initially focus on support for the delivery sites that are less ‘mature’ in implementation skills; high performing HVHC members will be valuable mentors to lower performers.

There is a lack of a common vocabulary or ‘mental model’ for dissemination and implementation work. This makes it difficult to efficiently share lessons learned from one organization to the next. The proposed HVHC approach was expected to help organize information for members with the goal of accelerating implementation by using a standard nomenclature and organizing framework.

**Designing the D&I Model**

Our Planning Team combined theory, evidence from research, and experience from the “real world” to form the HVHC D&I approach along two constructs:

- Conceptual model: ideas and resources organized to describe and clarify D&I phenomena;
- Change model: resources provided to logically guide change.

The HVHC D&I planning team reviewed information from these visits to guide the design of the HVHC approach. During an in-person meeting in Boston, September 24-25, 2015, the planning team adjusted the organizing framework for shared tools/resources, reviewed D&I literature, and discussed HVHC members’ experience working in the collaborative over the past 3 years. Recognizing the need to continuously update implementation knowledge, as well as the actual content of HVHC- endorsed, evidence-based care models, the planning team acknowledged the need to create infrastructure and processes for ongoing knowledge management and framework updates.

*Figure 8. Conceptual Model for Collaborative-Driven D&I*
While organizations, and often individual units within organizations, vary widely, D&I of evidence-based best practices requires an understanding and consideration of the key factors within organizations at multiple levels of decision making and commonalities across organizations. Through in-depth qualitative interviews, a generalizable conceptual framework for D&I can be developed for use in accelerating the learning process and improvement of outcomes at the front line. In particular, we can identify those levers that are most useful in expediting the decision to adopt, ensuring reliable and sustained implementation of evidence-based practice, and improving outcomes for the patients that our members serve.

5. **Executing the D&I Model**

As we moved to launch our implementation activities, we sought to maintain continuity by transitioning our the Planning Team into a Core D&I team to oversee and monitor all implementation activities.

The Core D&I team recruited clinical units from the most common hospital locations: ED, ICU, and inpatient floors in our member systems to participate in the project. From earlier patient safety work, we knew that participating units would: (1) not be starting at the same place; and (2) not have the same capacity or resources. Basic quality improvement theory suggests that meaningful comparative data feedback is a key driver of change. Thus, we asked member systems to designate each unit’s study level based on its ability to submit data: full data, simple data, and dissemination-level data. Next, members completed readiness assessments during which they decided which readiness level best described their status—not yet started, planning; in progress/started; or sustaining, and asked them to create an improvement charter. Figure 9 presents the distribution of 180 participating units by unit type, baseline readiness, and study level. We next set up the implementation teams in the EDs, ICUs, and inpatient units across our member systems. This work set the stage for our planned, ongoing realistic evaluation.

In executing the D&I model, we built upon the interdependent activities—Resources & Tools, Subject Matter Expertise, Facilitation & Sharing, Performance Monitoring & Evaluation — as the “collaborative advantage” to accelerating broad-scale dissemination of evidence-based practice.

**A. Resources and Tools**

Through this grant, we were able to curate resources and develop tools to support the implementation of a sepsis care program. The literature is replete with practices, tools, and resources to guide implementation—many generic, some specific to different types of interventions. HVHC members valued the discovery of successful practices used by their peers. Members can confer with colleagues across the Collaborative, delving into the nuances of successful implementation. HVHC data provided the “proof” that practices were indeed
successful and conferences and webinars provided the opportunity to understand important factors that impacted successful (and failed) implementation efforts.

✓ **D&I Resources:** Blending literature and learning from experts from our member systems, we defined an organizing framework for cataloguing tools and resources. We then collected these from members and grouped them into four categories consistent with the D&I literature: leadership and culture; tools and technology; roles and responsibilities; knowledge and learning. Two, in-person meetings of experts from Dartmouth-Hitchcock, Intermountain Healthcare, Mayo Clinic, and Providence Health & Services were convened to help synthesize this material and further refine this organizing framework crucial to effective D&I—both in general and specific to the three-hour sepsis bundle.

✓ **D&I resources portal:** We designed, built, and launched our beta version of the D&I website. This website provides evidenced-based, current materials related to sepsis care that is vetted by experts for all HVHC members to use in their home systems or to share more broadly. We can track what clinicians look at and download, allowing us to continuously monitor and improve on what we offer there. The portal also offers a discussion board to communicate with other experts in the field, relevant video and webinar recordings for Members to refer to as well as a robust “playbook” designed for new Members to use in implementing a best practice sepsis care team at their site.

✓ **Vantage reporting portal:** We know from quality improvement theory that meaningful feedback and benchmarking are critical elements of any change initiative. We also learned from earlier patient safety work that not everyone starts on an implementation journey at the same “place”—some are just getting started, some working hard, some routinized and sustaining gains. Members involved in the implementation journey were asked to set target goals depending on where they were at the launch of our effort. We developed detailed data specification identifying data elements required for selected process and outcome measures, definitional information, and exclusion/inclusion criteria. The graph below shows an example of comparing Member-submitted data for bundle compliance over time.
Units were also asked to complete a quarterly pulse check survey consisting of ten questions related to their implementation effort. The graph below depicts an example of comparing the results of one question from the pulse check across Member health systems. The size of the bubble represents the volume of responses.

**B. Subject Matter Expertise**

**Sepsis Technical Expert Panel:** A first-line response to a major barrier theme identified in key informant interviews was the creation of a sepsis technical expert panel (TEP) to address perceived problems with the quality and changing nature of the evidence base for the three-hour sepsis bundle. A multidisciplinary technical expert panel (TEP) was convened to support D&I activities was created in early 2016 to serve as a forum to maintain the HVHC sepsis knowledge base and to discuss difficult challenges in sepsis care. Individuals were nominated by leaders at their health system or self-nominated. The following qualifications for candidates included:

- Practicing clinicians (physician nurses), data analysts, coder/abstractors, measure stewards or QI specialists
- Familiarity with caring for sepsis patients
- Experience in tracking and responding to evidence based practices in sepsis care
- Committed to reviewing and monitoring new literature related to sepsis care
- Knowledge of disseminating new practices into units at their institutions

In addition to monitoring and synthesizing the emerging evidence base around sepsis care, these experts addressed areas of practice that lacked clear evidence; created consensus statements to provide guidance in ambiguous cases, and monitored changes in national measures. Common problems were discussed and the TEP provided advice to HVHC members. Innovations in practice emerging from HVHC healthcare systems were presented and promising new practices shared between members. TEP meetings were held on a quarterly basis and covered the following topics in Year 1:

- Mayo Clinic presented on intermediate lactate values
- Best practices at Northwell Health regarding adequate fluid resuscitation and at Hawaii Pacific Health related to education and training on evidence-based sepsis care.
Dartmouth-Hitchcock discussed design and implementation of Best Practice Alerts for Sepsis.

TEP meeting at the Fall Conference covered:
  o Review of CMS value-based purchasing measures, SEP-1
  o Use of SIRS or qSOFA

In addition two case study reports were authored by TEP members and also shared on the D&I website:
  • “Importance of Nursing Leadership & Engagement for Successful Implementation of the Sepsis Bundle.” (Hiller T. February 2017)
  • “HVHC Recommendations for SEP-1 Lactate Measurement.” (Freidman I, February 2017)

Quarterly Sepsis Webinars: Additionally, we held quarterly webinars and Member experts presented on topics responsive to barriers noted in the Pulse Checks and site visits. Topics included:
  • Implementing and sustaining a sepsis prevention program, presented by Intermountain Healthcare and Providence St. Joseph
  • Nurse Driven Sepsis Protocols, presented by Virginia Mason Medical Center
  • Intermediate lactate values, presented by Mayo Clinic
  • Best practices for adequate fluid resuscitation, presented by Northwell Health
  • Education and training on evidence-based sepsis care, presented by Hawaii Pacific Health
  • Design and implementation of Best Practice Alerts (BPA) for Sepsis, presented by Dartmouth-Hitchcock
  • Review of CMS value-based purchasing measures, SEP-1, open panel discussion among all Members
  • Use of SIRS or qSOFA, open panel discussion among all Members

These webinars were recorded and later made available through both the HVHC Patient Safety Program and the D&I website.

C. Facilitation & Sharing
All of these pieces of the process—comparative analytics; tools and resources; in-depth key informant interviews and contributed subject matter expertise—have been necessary to support and sustain the learning generated throughout this 2-year grant period. Yet we have grown aware that we can maximize the collaborative advantage we see evolving with the right kind of extended support from the Program Management Office (PMO).

✔ Coaching and Monthly Calls: In 2015, HVHC PMO staff implemented monthly coaching calls to support member system’s implementation efforts. Monthly phone calls were scheduled at the same time and day every month to make it easier for members’ schedules. HVHC staff attending the calls
were usually a physician, an implementation coach, an administrative leader, and a project manager. Health system leaders attending the calls typically included the sepsis implementation leader and sepsis champions (MDs and/or other staff including nurses and project managers). The technology used to support these calls consisted of WebEx and PowerPoint slides (being sent out before the scheduled meetings), which guided the conversation. Also, WebEx allowed direct access to web-based data (e.g., Vantage and the HVHC website). The PMO maintained a communication log that was updated to contain the key talking points from each monthly call. This log was used to identify implementation challenges and/or questions that were common across members so that we could build content for quarterly webinars. Cross-cutting issues were also discussed on calls and promising practices were shared between members.

The monthly phone calls evolved over time. The initial calls focused on clarifying roles and responsibilities. Later, calls focused on resources available to support leaders (i.e., HVHC website D&I resources, webinars, Vantage) and data from Pulse Checks. The calls progressively focused on common challenges, sharing solutions, and facilitating learning between member systems. In summary, these calls served several purposes:

- Provided updates on HVHC resources available to members
- Reviewed performance data related to sepsis care
- Reviewed hospital/system-specific challenges and facilitators to implementation
- Disseminated best practices by sharing successful interventions amongst members
- Connected leaders at member systems in support of peer mentoring experiences
- Identified common barriers across health systems that were covered in webinars

The monthly HVHC calls helped maintain necessary long-term focus in support of the 3-hour sepsis bundle implementation effort.

**✓ Peer-to-Peer Sharing:** When certain members were struggling with an implementation problem, the PMO linked them with other members who had already successfully addressed those particular barriers and in many instances facilitated the conversation.

**✓ Communication and Coordination:** The PMO serves to monitor progress and deliverables, connect members through in-person and virtual meetings, and communicate information about upcoming deadlines, webinars, and other important information key to dissemination.

**D. Performance Monitoring & Evaluation**

We used a mixed-methods approach to monitor and evaluate the effectiveness of our D&I model, integrating the collection and analytics of quantitative and qualitative research. This method was specifically used to overcome the limitations of a single design. We designed a mixed-methods approach to applying D&I of the 3-hour sepsis bundle in defining a generalizable collaborative-driven conceptual model for D&I. Below highlights the work in both the quantitative and qualitative aspects of this project. The detailed methods of our approach are available in Appendix XX.
✓ **Data collection:** We defined sepsis data specifications, developed an analytic evaluation plan, reviewed it with the LJAF Director of Research, and uploaded our evaluation plan to the Open Science Framework. Members submitted patient-level data for all patients diagnosed with septic shock or severe sepsis along with the tests and treatments conducted for those patients to study the impact of our dissemination efforts and outcomes of the sepsis bundle implementation.

✓ **Comparative analytics:** We provided comparative analytics reports through a reporting portal that we will describe in the next section. Data was reported within two weeks of data processing, allowing for near “real-time” reports. These reports compare process and outcomes measures across HVHC members, hospitals, and unit types. Data is displayed in the form of graphs and tables, allowing rapid identification of differences between members as well as performance gaps. Please see Appendix C for examples of how data is displayed.

✓ **Improvement targets:** Members submitted preliminary improvement targets and were able to monitor their progress against those targets through the reporting portal and monthly “coaching” check in calls.

✓ **Pulse checks:** To monitor sepsis implementation and serve as minimal data submission for dissemination-level study participation, we designed and distributed a quarterly “pulse check,” a short, six-item query to solicit selected information about how members were progressing with implementation and possible events that may explain anomalies in submitted data (e.g., increased use of untrained float staff). The pulse checks were first administered in December 2015, and then again in March 2016. We received 104 baseline pulse checks and 138 follow-up pulse checks, some of which represented multiple units. The pulse checks serve to:

- Gather information about how members felt they were faring with adherence to the three-hour bundle
- Track training status
- Helped us understand what impedes or eases the implementation of the sepsis bundle to develop targeted peer learning offerings (see webinars described on p. 10).

✓ **Site visits and interviews:** In addition to two all-hands meetings that members attended in Washington, DC and Salt Lake City, we conducted highly informative site visits. By March 2016, we had completed all planned Year 1 site visits to inform our evolving conceptual model of collaborative-driven D&I.

Consistent use of evidence-based practices, such as those included in the three-hour sepsis bundle, have been a longstanding goal of clinical care. However, the process of reliable D&I of evidence-based practices within an organization or, more broadly, across many organizations is less well understood. The purpose of our qualitative site visits was to build off of the existing knowledge in D&I science to identify key enablers and barriers across HVHC members together with collaborative-level facilitating factors that accelerate D&I. As we have noted, the three-hour sepsis bundle is used as a test case to inform a more generalizable framework for collaborative-driven D&I on a broad scale. We use this in-depth, contextual understanding for programming and interpretation of quantitative results. Site visits were intended to answer questions about how and under what conditions the sepsis bundle was disseminated and implemented using the simplistic conceptual model above. The process worked as follows:

- Systematic, qualitative interviews were conducted via six in-person and six virtual site visits in 12 member delivery systems. A total of 74 interviews were conducted. Of those interviewed, 32% were nurses, 31% were physicians, 22% were management or QI staff, and 15% were senior leaders. In addition to the interviews, five team meetings were attended in order to obtain greater contextual understanding of the organizational work in sepsis care.
• All site visits consisted of key informant interviews with a purposive sample of up to 12 individuals using a semi-structured interview protocol guided by our simplistic D&I model.

• A two-person interview team captured interview data using audio-recorders and produced transcripts for coding and content analysis to identify key themes.

• The qualitative data collection focused on system-level antecedents together with perspective sources of exposure to sepsis bundle evidence, decision to adopt, culture/climate for change, rival activities, identification of key champions, status of the implemented innovation, and issues encountered.

Content analysis of these qualitative interviewers revealed that the key enablers were: having a nursing-driven protocol; local champions (linking agents); direct, timely feedback; senior leadership support with lead champions (conduits); reminder tools; and a bundled approach. Barriers were the changing/available evidence base, accurate documentation, fluid management, and training.

Success stories were also harvested to illustrate: the patient experience, strategies for overcoming key barriers encountered, and demonstrating what’s possible.

Using the three-hour sepsis bundle as a test case, this qualitative work identified important internal and external factors including the impact of a collaborative in facilitating accelerated D&I of evidence-based practice. Collaborative facilitation activities include:

• processing a dynamic evidence base
• delivering peer-exchange learning opportunities via webinars
• creating a web-based platform for tool/resource sharing
• leveraging demonstrated possibility across trusted partners to drive change

Further, we learned that interaction between system leadership champions (i.e., conduits) influence a multi-layer decision to adopt as well as translate evidence for essential local champions (i.e., linking agents). As a result, the generalizable conceptual framework for understanding the process of D&I has evolved to include these important contextual factors as depicted in Figure 8 above.

6. LESSONS LEARNED ABOUT D&I LEADING TO A GENERALIZABLE MODEL

One of the greatest lessons learned in this two-year journey have centered around the issues our clinicians, researchers, and administrators face in deciphering the evidence supporting best care for our patients.

• Changing evidence: One set of questions involved this concern: “what should we do and how can we disseminate information accurately, members asked, when the evidence is changing all the time?” We learned that members are interested in having HVHC assess and evaluate these issues, both to provide immediate answers and to engage regulators to discuss measures required for reimbursement, particularly when the measures are in conflict with evidence-based protocols.

• CMS measures may conflict with evidence: Clinicians have noted that their work with HVHC points in one direction, but that the measures required by regulators often point in another. As one member put it, this discrepancy often puts a team in the place where they would rather “fail the measure, not the patient.” Based on recent successful experience working with CMS, HVHC will continue to advocate for feasible and evidence-based measures to support and enable best practice care.
• **Gaps in evidence:** in addition, there are areas of treatment about which clinicians need more information. HVHC can help its members address these gaps by studying the combined data from our member sites more efficiently than individual members could with limited data and resources. Three examples are below:
  
  o Fluids are critical in the effective treatment of sepsis, but how do they affect patients who might have trouble managing such an influx, such as those with chronic heart or renal failure? This has spawned to a member-led project to study this issue, results of which will be used to inform the underlying evidence base.
  
  o Concerns exist about over-treatment. For example, if a system achieved 100% adoption of the bundle, would it mean that some patients were being over-treated, especially with antibiotics?
  
  o Members have raised questions over the quality of the evidence in support of venous lactate and blood culture elements in the bundle.

• **Synthesizing evidence and engaging in conversation.** All of the reasons above combine to make it difficult for systems to know which precise set of practices to embrace and which to discard. We have heard in the last few months that members would like HVHC to play a role in helping to resolve and review these concerns.

  o The Sepsis TEP we formed will continue to play a critical part in serving to advance these discussions of practice, gaps or conflicts in evidence, and in refining the tools they use in their home systems.

  o HVHC will also continue sharing these concerns with CMS on behalf of members. As questions emerge that determine practice and adoption, HVHC can help to answer those and also feed them forward to regulators, creating a more rapid cycling of information that potentially increases the speed with which patients receive better care.
7. APPENDICES

- Appendix A – Supporting Analytics
- Appendix B – Analytic Methods
- Appendix C – Screenshots of Vantage Reporting Tool
- Appendix D – Screenshots of HVHC Resource Portal
- Appendix E – Peer-Reviewed Publications
- Appendix F – Sample White Papers

APPENDIX A – SUPPORTING ANALYTICS

The goal of the project was to disseminate and implement best evidence-based practice across hospitals of HVHC, using care of patients with sepsis as an example. Sepsis was chosen because it is a disease with high mortality and high cost for which an established, evidence supported early intervention exists that has been shown to improve outcomes. Furthermore, the primary outcome, mortality, can be influenced in a short period of time and easily measured. Hence, sepsis was chosen to evaluate if the adoption of best evidence-based practices can improve outcomes and decrease cost.

Baseline data were collected for 2015 and improvement data for 2016 and are shown contrasting sites (patients being admitted with sepsis via the Emergency Department) that had a mature health care delivery process in place (“mature sites”) with those that did not at the start of the project (“non-mature sites”).

Three measures presented in this section include:

a) Change in compliance with the evidence-based best practice (“The 3-Hour Bundle”)
b) Change in mortality at time of discharge (“mortality”)
c) Change in CMS reimbursement (“cost”)

a) Change in Three-Hour Bundle Compliance

Data were collected and analyzed for 17,794 patients admitted with sepsis via the Emergency Department (ED) – see Appendix B for more details on Methods and Cohorts.

For non-mature sites, the 3-hour Bundle Compliance had a statistically significant improvement of 17.8% (from 74.1% to 87.3% between 2015 (n=691) and 2016 (n=718)). The 3-hour Bundle Compliance for mature sites remained unchanged between 2015 (n=6,168) and 2016 (n=5,441) with 72.4% for 2015 and 73.3% for 2016. (See Figure 2.)

Figure 2. Three-Hour Bundle Compliance per quarter for 2015 and 2016 reflecting the dissemination of evidence-based practice to non-mature sites
b) Change in In-Hospital Mortality
In-hospital mortality for non-mature sites decreased by 8% (from 18.9 to 17.4%, not statistically significant) while in-hospital mortality for mature sites remained relatively stable at 15.5% for 2015 and 15.3% for 2016 (see Figure 3). This mortality improvement translates to 35 lives saved in 2016 for participating facilities.

Figure 3. Dissemination of evidence-based practice and adoption of the 3-Hour Bundle (Figure 2 above) leading to a decrease in mortality for non-mature sites approaching that of mature sites.

<table>
<thead>
<tr>
<th>Year</th>
<th>Non-Mature</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>18.9%</td>
<td>15.5%</td>
</tr>
<tr>
<td>2016</td>
<td>17.4%</td>
<td>15.3%</td>
</tr>
</tbody>
</table>

c) Change in CMS Reimbursement ("Cost")
The cohort used in evaluating in-hospital cost (defined as CMS Reimbursement, or cost to taxpayers) is a subset of the cohort displayed above for 3-Hour Bundle compliance and in-hospital mortality because actual cost data was only available for Medicare patients (see detailed discussion on this topic in Appendix B - Methods).

For non-mature sites, CMS cost decreased by 10.3% (from $20,242 to $18,147, an average of $2,095 per patient) while mature sites decreased 3.0% (from $23,279 to $22,390, an average of $889 per patient), neither were statistically significant (see Figure 4).

If these cost savings for CMS patients were applied to the entire cohort (to include non-Medicare patients), cost savings for 2016 would be roughly $8.3 million (applying an average of $889 saved per patient to 9,361 patients) for mature sites and $1.5 million (applying an average of $2,095 saved per patient to 718 patients) for non-mature sites. This translates to approximately $9.8 million in decreased cost in 2016 for participating facilities.
Because the above cost data was limited to the Medicare population, we developed a predictive cost model to estimate costs for the non-Medicare patient population based on cost predictors included in the Member-submitted data, such as length of stay in the hospital, ICU days, and discharge disposition (see Appendix for Methods). Using this model, the costs for the non-mature sites improved by 15.7%, an average of $4,123 per patient, while mature sites decreased by 5%, an average of $1,137 per patient (see Figure 5). This translates to a total decrease in costs of $12 million in 2016 for participating facilities.

Figure 5. CMS Reimbursement for Medicare Patients + Predictive Cost Model for Non-Medicare Patients
Underlying these cost improvements, Members set performance targets and received quarterly monitoring reports based on cost drivers shown below (Figure 6).

**Figure 6. Annual Change in Member Target Measures**

<table>
<thead>
<tr>
<th>Member Type</th>
<th>N Size (survivors)</th>
<th>2015</th>
<th>2016</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Mature Sites</td>
<td>N Size (survivors)</td>
<td>691</td>
<td>718</td>
<td>3.9%</td>
</tr>
<tr>
<td></td>
<td>3-Hour Bundle Compliance</td>
<td>74.1%</td>
<td>87.3%</td>
<td>17.8%</td>
</tr>
<tr>
<td></td>
<td>IP LOS (days)</td>
<td>9.9</td>
<td>7.4</td>
<td>-25.0%</td>
</tr>
<tr>
<td></td>
<td>ICU LOS (days)</td>
<td>1.6</td>
<td>1.4</td>
<td>-15.9%</td>
</tr>
<tr>
<td></td>
<td>Discharged to Home</td>
<td>40.6%</td>
<td>41.5%</td>
<td>2.2%</td>
</tr>
<tr>
<td></td>
<td>Inhospital Mortality</td>
<td>18.9%</td>
<td>17.4%</td>
<td>-7.9%</td>
</tr>
<tr>
<td>Mature Sites</td>
<td>N Size (survivors)</td>
<td>6,168</td>
<td>5,441</td>
<td>-11.8%</td>
</tr>
<tr>
<td></td>
<td>3-Hour Bundle Compliance</td>
<td>72.4%</td>
<td>73.3%</td>
<td>1.2%</td>
</tr>
<tr>
<td></td>
<td>IP LOS (days)</td>
<td>8.9</td>
<td>8.4</td>
<td>-5.5%</td>
</tr>
<tr>
<td></td>
<td>ICU LOS (days)</td>
<td>1.8</td>
<td>1.7</td>
<td>-6.1%</td>
</tr>
<tr>
<td></td>
<td>Discharged to Home</td>
<td>37.4%</td>
<td>39.4%</td>
<td>5.3%</td>
</tr>
<tr>
<td></td>
<td>Inhospital Mortality</td>
<td>15.5%</td>
<td>15.3%</td>
<td>-1.3%</td>
</tr>
</tbody>
</table>

**Member-submitted Data Analytics – ED Patients**

**Member-submitted Patient Demographics**

<table>
<thead>
<tr>
<th>Member</th>
<th>N Size</th>
<th>Percent Male</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>ALL (Total)</td>
<td>15,440</td>
<td>53%</td>
<td>69.0</td>
</tr>
<tr>
<td>BIDMC</td>
<td>728</td>
<td>55%</td>
<td>68.5</td>
</tr>
<tr>
<td>DART</td>
<td>85</td>
<td>56%</td>
<td>68.0</td>
</tr>
<tr>
<td>HAWAII</td>
<td>1,370</td>
<td>55%</td>
<td>70.4</td>
</tr>
<tr>
<td>NWH</td>
<td>7,022</td>
<td>53%</td>
<td>72.4</td>
</tr>
<tr>
<td>PROVID</td>
<td>3,933</td>
<td>51%</td>
<td>67.6</td>
</tr>
<tr>
<td>UCSD</td>
<td>1,991</td>
<td>57%</td>
<td>59.1</td>
</tr>
<tr>
<td>VMMC</td>
<td>311</td>
<td>55%</td>
<td>69.0</td>
</tr>
</tbody>
</table>

**Member-submitted Cost Driver Outcome Measures: Average In-Patient Length of Stay**
The average inpatient length of stay has decreased from 2015 to 2016 in not mature units ($N=1,409$).
• In mature units, the average inpatient length of stay has remained stable from 2015 to 2016 ($N=11,609$).

Member-submitted Cost Driver Outcome Measures: % Discharged to Home

The percent of sepsis encounters discharged to home has a slightly increasing trend from 2015 to 2016 in both mature and not mature units ($N=15,446$).
Member-submitted Cost Driver Outcome Measures: Average Days in ICU

- The average ICU length of stay for ICU patients has slightly decreased in not mature units from 2015 to 2016 ($N=572$)
- The average ICU length of stay for ICU patients has remained stable in mature units from 2015 to 2016 ($N=4,527$)
Member-submitted Data Analytics – ED Patients with ICU Time
Two Member Systems – Mayo Clinic and Intermountain Healthcare – submitted only patients with time in the ICU. For comparative purposes, they were omitted from the primary analyses but we replicated all analytics for this subset cohort.

Member-submitted Patient Demographics – Only ED Patients with ICU Time

<table>
<thead>
<tr>
<th>Member</th>
<th>N Size</th>
<th>Percent Male</th>
<th>Age</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>(Q1, Q3)</td>
</tr>
<tr>
<td>ALL (Total)</td>
<td>7,977</td>
<td>54%</td>
<td>67.7</td>
<td>69</td>
<td>(58, 80)</td>
</tr>
<tr>
<td>BIDMC</td>
<td>456</td>
<td>55%</td>
<td>69.7</td>
<td>71</td>
<td>(59, 82)</td>
</tr>
<tr>
<td>DART</td>
<td>68</td>
<td>60%</td>
<td>67.3</td>
<td>68</td>
<td>(59, 77)</td>
</tr>
<tr>
<td>HAWAII</td>
<td>605</td>
<td>61%</td>
<td>68.3</td>
<td>70</td>
<td>(59, 81)</td>
</tr>
<tr>
<td>INTMTN</td>
<td>903</td>
<td>55%</td>
<td>61.9</td>
<td>63</td>
<td>(52, 73)</td>
</tr>
<tr>
<td>MAYO</td>
<td>350</td>
<td>56%</td>
<td>69.2</td>
<td>71</td>
<td>(58, 81)</td>
</tr>
<tr>
<td>NWH</td>
<td>3,008</td>
<td>54%</td>
<td>71.4</td>
<td>74</td>
<td>(62, 84)</td>
</tr>
<tr>
<td>PROVID</td>
<td>1,907</td>
<td>51%</td>
<td>65.6</td>
<td>67</td>
<td>(56, 77)</td>
</tr>
<tr>
<td>UCSD</td>
<td>531</td>
<td>59%</td>
<td>60.1</td>
<td>61</td>
<td>(51, 71)</td>
</tr>
<tr>
<td>VMMC</td>
<td>149</td>
<td>51%</td>
<td>69.2</td>
<td>71</td>
<td>(61, 81)</td>
</tr>
</tbody>
</table>

Only ED Patients with ICU Time: Average In-Patient Length of Stay

- The average inpatient length of stay has decreased from 2015 to 2016 in not mature units \(N=572\)
- In mature units, the average inpatient length of stay has remained stable from 2015 to 2016 \(N=5,579\)
Only ED Patients with ICU Time: Average Days in ICU

- The average ICU length of stay for patients has slightly decreased in mature and not mature units from 2015 to 2016 \((N=6,151)\)

Only ED Patients with ICU Time: % Discharged to Home

- The percent of sepsis encounters discharged to home has a slightly increasing trend from 2015 to 2016 in both mature and not mature units \((N=7,977)\)
Member-submitted Data - Tracking Actual vs. Target Measures

- **3-Hour Bundle Compliance by Organization**
  - BDIC
  - DART
  - HAWAII
  - NWH

- **Inpatient Length of Stay in Days by Organization**
  - BDIC
  - DART
  - HAWAII
  - NWH

- **Percent Discharged to Home by Organization**
  - BDIC
  - DART
  - HAWAII
  - NWH

- **Percent In-hospital Mortality by Organization**
  - BDIC
  - DART
  - HAWAII
  - NWH
## Cost Modeling Estimates – All Enrolled Patients

### Predictive Cost Model: In-Hospital Cost Change (Index Event)

**Note:** Actual applied to Medicare Patients; all others predicted

<table>
<thead>
<tr>
<th>Readiness Track</th>
<th>Member</th>
<th>Change in Average Episode Cost</th>
<th>Total Change in Cost</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature</td>
<td>Baylor Scott &amp; White Health</td>
<td>$-3,126 (95% C.I.: $-4,515 to $-1,897)</td>
<td>$-7,762,671 (95% C.I.: $-11,212,110 to $-4,712,330)</td>
<td>-16.0% (95% C.I.: -23.1% to -9.7%)</td>
</tr>
<tr>
<td></td>
<td>Beth Israel Deaconess Medical Center</td>
<td>$-4,683 (95% C.I.: $-9,077 to $-710)</td>
<td>$-1,236,296 (95% C.I.: $-2,396,343 to $-187,684)</td>
<td>-15.9% (95% C.I.: -30.9% to -2.4%)</td>
</tr>
<tr>
<td></td>
<td>Dartmouth-Hitchcock</td>
<td>$-9,036 (95% C.I.: $-29,747 to $10,388)</td>
<td>$-271,075 (95% C.I.: $-892,431 to $311,644)</td>
<td>-22.9% (95% C.I.: -75.3% to 26.3%)</td>
</tr>
<tr>
<td></td>
<td>Northwell Health</td>
<td>$-618 (95% C.I.: $-1,770 to $608)</td>
<td>$-1,575,914 (95% C.I.: $-4,518,508 to $1,552,338)</td>
<td>-2.3% (95% C.I.: -6.7% to 2.3%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>$988 (95% C.I.: $247 to $1,831)</td>
<td>$1,451,268 (95% C.I.: $363,368 to $2,689,822)</td>
<td>6.0% (95% C.I.: 1.5% to 11.2%)</td>
</tr>
<tr>
<td></td>
<td>UC San Diego Health System</td>
<td>$346 (95% C.I.: $-1,469 to $2,188)</td>
<td>$342,589 (95% C.I.: $-1,455,885 to $2,168,464)</td>
<td>1.5% (95% C.I.: -6.5% to 9.7%)</td>
</tr>
<tr>
<td></td>
<td>Virginia Mason Medical Center</td>
<td>$-550 (95% C.I.: $-2,208 to $982)</td>
<td>$-57,162 (95% C.I.: $-229,663 to $102,218)</td>
<td>-3.5% (95% C.I.: -14.2% to 6.3%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$-1,137 (95% C.I.: $-2,573 to $274)</td>
<td>$-9,109,262 (95% C.I.: $-20,341,573 to $1,924,533)</td>
<td>-5.0% (95% C.I.: -11.3% to 1.3%)</td>
</tr>
<tr>
<td>Not Mature</td>
<td>Hawaii Pacific Health</td>
<td>$-5,584 (95% C.I.: $-8,476 to $-3,007)</td>
<td>$-3,088,082 (95% C.I.: $-4,687,701 to $-1,662,996)</td>
<td>-22.2% (95% C.I.: -33.7% to -11.9%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>$992 (95% C.I.: $-273 to $2,616)</td>
<td>$163,743 (95% C.I.: $-45,169 to $431,787)</td>
<td>6.9% (95% C.I.: -1.9% to 18.1%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$-4,123 (95% C.I.: $-6,654 to $-1,757)</td>
<td>$-2,924,339 (95% C.I.: $-4,732,870 to $-1,231,208)</td>
<td>-15.7% (95% C.I.: -26.6% to -5.3%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$-1,373 (95% C.I.: $-2,895 to $113)</td>
<td>$-12,033,601 (95% C.I.: $-25,074,444 to $693,324)</td>
<td>-5.8% (95% C.I.: -12.5% to 0.7%)</td>
</tr>
</tbody>
</table>

Prediction model index-episode estimated percent-change and total-change between 2016 and 2015 (actual)
### Predictive Cost Model: Inhospital Cost Change + 7 Days Post-Discharge

<table>
<thead>
<tr>
<th>Readiness Track</th>
<th>Member</th>
<th>Change in Average Episode Cost</th>
<th>Total Change in Cost</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (95% C.I.)</td>
<td>Mean (95% C.I.)</td>
<td>Mean (95% C.I.)</td>
<td>Mean (95% C.I.)</td>
</tr>
<tr>
<td>Mature</td>
<td>Baylor Scott &amp; White Health</td>
<td>-3,286 ($-4,693 $-1,971)</td>
<td>-8,027,386 ($-11,465,431 $-4,817,341)</td>
<td>-15.6% (-22.3% -9.4%)</td>
</tr>
<tr>
<td></td>
<td>Beth Israel Deaconess Medical Center</td>
<td>-5,457 ($-9,191 $-1,327)</td>
<td>-1,413,282 ($-2,569,060 $-343,756)</td>
<td>-16.9% (-30.7% -4.1%)</td>
</tr>
<tr>
<td></td>
<td>Dartmouth-Hitchcock</td>
<td>-9,855 ($-33,287 $13,326)</td>
<td>-285,808 ($-965,335 $386,468)</td>
<td>-23.3% (-78.7% 31.5%)</td>
</tr>
<tr>
<td></td>
<td>Northwell Health</td>
<td>-685 ($-1,976 $651)</td>
<td>-1,713,618 ($-4,940,776 $1,627,883)</td>
<td>-2.4% (-7.0% 2.3%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>1,055 ($278 $1,909)</td>
<td>1,549,590 ($409,446 $2,805,128)</td>
<td>6.2% (1.6% 11.1%)</td>
</tr>
<tr>
<td></td>
<td>UC San Diego Health System</td>
<td>361 ($-1,547 $2,124)</td>
<td>355,919 ($-1,527,214 $2,185,221)</td>
<td>1.5% (-6.6% 9.4%)</td>
</tr>
<tr>
<td></td>
<td>Virginia Mason Medical Center</td>
<td>-570 ($-2,327 $1,055)</td>
<td>-58,720 ($-239,767 $108,705)</td>
<td>-3.4% (-14.0% 6.4%)</td>
</tr>
<tr>
<td></td>
<td>Hawaii Pacific Health</td>
<td>-6,064 ($-9,234 $-3,472)</td>
<td>-3,286,613 ($-5,004,872 $-1,881,838)</td>
<td>-23.0% (-35.0% -13.2%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>1,081 ($-322 $2,845)</td>
<td>178,434 ($-53,209 $469,533)</td>
<td>7.2% (-2.1% 19.0%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$-1,214 ($-2,733 $286)</td>
<td>$-9,593,305 ($-21,298,140 $1,952,308)</td>
<td>-4.9% (-11.1% 1.3%)</td>
</tr>
<tr>
<td>Not Mature</td>
<td></td>
<td>$-6,064 ($-9,234 $-3,472)</td>
<td>$-3,286,613 ($-5,004,872 $-1,881,838)</td>
<td>-23.0% (-35.0% -13.2%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-6,064 ($-9,234 $-3,472)</td>
<td>$-3,286,613 ($-5,004,872 $-1,881,838)</td>
<td>-23.0% (-35.0% -13.2%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-1,214 ($-2,733 $286)</td>
<td>$-9,593,305 ($-21,298,140 $1,952,308)</td>
<td>-4.9% (-11.1% 1.3%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$-4,446 ($-7,216 $-2,041)</td>
<td>$-3,108,180 ($-5,058,081 $-1,412,305)</td>
<td>-16.2% (-27.6% -5.9%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$-1,469 ($-3,087 $102)</td>
<td>$-12,701,485 ($-26,356,221 $540,003)</td>
<td>-5.8% (-12.4% 0.8%)</td>
</tr>
</tbody>
</table>

Prediction model index+7 days episode estimated percent-change and total-change between 2016 and 2015 (actual)
**Predictive Cost Model: In-Hospital Cost Change (Index Event) – Only Includes Patients with ICU Time**

<table>
<thead>
<tr>
<th>Readiness Track</th>
<th>Member</th>
<th>Mean</th>
<th>(95% C.I.)</th>
<th>Total Change in Cost</th>
<th>% Change</th>
<th>(95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature</td>
<td>Baylor Scott &amp; White Health</td>
<td>$-965</td>
<td>($-3,439, $1,652)</td>
<td>$-1,038,997</td>
<td>-3.1%</td>
<td>($-11.0%, 5.3%)</td>
</tr>
<tr>
<td></td>
<td>Beth Israel Deaconess Medical Center</td>
<td>$-5,202</td>
<td>($-10,017, $-625)</td>
<td>$-853,125</td>
<td>-15.3%</td>
<td>($-29.4%, -1.8%)</td>
</tr>
<tr>
<td></td>
<td>Dartmouth-Hitchcock</td>
<td>$-9,213</td>
<td>($-24,789, $5,593)</td>
<td>$-193,471</td>
<td>-22.4%</td>
<td>($-60.3%, 13.6%)</td>
</tr>
<tr>
<td></td>
<td>Intermountain Healthcare</td>
<td>$-642</td>
<td>($-3,046, $1,688)</td>
<td>$-273,458</td>
<td>-2.7%</td>
<td>($-12.8%, 7.1%)</td>
</tr>
<tr>
<td></td>
<td>Mayo Clinic</td>
<td>$-5,681</td>
<td>($-11,679, $-647)</td>
<td>$-857,851</td>
<td>-19.9%</td>
<td>($-40.8%, -2.3%)</td>
</tr>
<tr>
<td></td>
<td>Northwell Health</td>
<td>$-3,013</td>
<td>($-5,155, $-698)</td>
<td>$-2,877,430</td>
<td>-7.7%</td>
<td>($-13.2%, -1.8%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>$1,667</td>
<td>($-17, $3,495)</td>
<td>$1,151,924</td>
<td>7.3%</td>
<td>($-0.1%, 15.4%)</td>
</tr>
<tr>
<td></td>
<td>UC San Diego Health System</td>
<td>$6,427</td>
<td>($-268, $13,674)</td>
<td>$1,452,615</td>
<td>17.9%</td>
<td>($-0.7%, 38.0%)</td>
</tr>
<tr>
<td></td>
<td>Virginia Mason Medical Center</td>
<td>$5,905</td>
<td>($-9,937, $-1,491)</td>
<td>$330,667</td>
<td>-25.3%</td>
<td>($-42.6%, -6.4%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>-$1,078</td>
<td>($-3,897, $1,832)</td>
<td>-$3,820,458</td>
<td>-2.8%</td>
<td>($-12.0%, 6.5%)</td>
</tr>
<tr>
<td>Not Mature</td>
<td>Hawaii Pacific Health</td>
<td>-$9,057</td>
<td>($-14,069, $-3,892)</td>
<td>-$1,793,308</td>
<td>-22.5%</td>
<td>($-35.0%, -9.7%)</td>
</tr>
<tr>
<td></td>
<td>Providence Health &amp; Services</td>
<td>-$388</td>
<td>($-4,300, $4,032)</td>
<td>-$32,625</td>
<td>-2.2%</td>
<td>($-24.5%, 23.0%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>-$6,766</td>
<td>($-11,488, $-1,797)</td>
<td>-$1,825,933</td>
<td>-17.2%</td>
<td>($-32.3%, -1.1%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>-$1,461</td>
<td>($-4,409, $1,588)</td>
<td>-$5,646,392</td>
<td>-3.8%</td>
<td>($-13.3%, 6.0%)</td>
</tr>
</tbody>
</table>

Synthetic model estimated percent change and total change between 2016 and 2015.
Predictive Cost Model: In-Hospital Cost Change + 7 Days Post-Discharge - Only Includes Patients with ICU Time

<table>
<thead>
<tr>
<th>Readiness Track</th>
<th>Member</th>
<th>Mean</th>
<th>(95% C.I.)</th>
<th>Mean</th>
<th>(95% C.I.)</th>
<th>% Change</th>
<th>(95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature</td>
<td>Baylor Scott &amp; White Health</td>
<td>$-4,573</td>
<td>($-7,153</td>
<td>$-2,174)</td>
<td>$-4,925,557</td>
<td>(-7,704,295</td>
<td>$-2,342,253)</td>
</tr>
<tr>
<td></td>
<td>Beth Israel Deaconess Medical Center</td>
<td>$-7,797</td>
<td>($-13,173</td>
<td>$-2,302)</td>
<td>$-1,278,691</td>
<td>(-2,160,419</td>
<td>$-377,624)</td>
</tr>
<tr>
<td></td>
<td>Dartmouth-Hitchcock</td>
<td>$-8,885</td>
<td>($-34,523</td>
<td>$13,763)</td>
<td>$-186,578</td>
<td>($724,988</td>
<td>$289,035)</td>
</tr>
<tr>
<td></td>
<td>Intermountain Healthcare</td>
<td>$800</td>
<td>($-1,094</td>
<td>$2,768)</td>
<td>$340,737</td>
<td>($-466,120</td>
<td>$1,179,180)</td>
</tr>
<tr>
<td></td>
<td>Mayo Clinic</td>
<td>$434</td>
<td>($-12,499</td>
<td>$10,778)</td>
<td>$65,562</td>
<td>($-1,887,386</td>
<td>$1,627,483)</td>
</tr>
<tr>
<td>Northwell Health</td>
<td></td>
<td>$-1,995</td>
<td>($-4,497</td>
<td>$733)</td>
<td>$-1,905,005</td>
<td>($-4,295,532</td>
<td>$700,266)</td>
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<tr>
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<td>$1,834</td>
<td>($100</td>
<td>$3,976)</td>
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<td>($69,727</td>
<td>$2,747,775)</td>
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<td>$2,878</td>
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<td>$650,410</td>
<td>($-1,165,083</td>
<td>$2,524,221)</td>
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<tr>
<td>Virginia Mason Medical Center</td>
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<td>$-1,705</td>
<td>($-4,021</td>
<td>$726)</td>
<td>$-95,460</td>
<td>($-225,190</td>
<td>$40,658)</td>
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<tr>
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<td></td>
<td>$-1,687</td>
<td>($-4,971</td>
<td>$1,596)</td>
<td>$-6,066,957</td>
<td>($-18,559,288</td>
<td>$6,388,742)</td>
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<tr>
<td>Not Mature</td>
<td>Hawaii Pacific Health</td>
<td>$-9,283</td>
<td>($-20,788</td>
<td>$3,003)</td>
<td>$-1,838,125</td>
<td>($-4,116,041</td>
<td>$594,731)</td>
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<tr>
<td>Providence Health &amp; Services</td>
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<td>$1,074</td>
<td>($-1,057</td>
<td>$3,715)</td>
<td>$90,204</td>
<td>($-88,860</td>
<td>$312,091)</td>
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<tr>
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<td></td>
<td>$-6,546</td>
<td>($-15,573</td>
<td>$3,191)</td>
<td>$-1,747,921</td>
<td>($-4,204,902</td>
<td>$906,822)</td>
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<tr>
<td>Total</td>
<td></td>
<td>$-2,014</td>
<td>($-5,685</td>
<td>$1,704)</td>
<td>$-7,814,878</td>
<td>($-22,764,191</td>
<td>$7,295,565)</td>
</tr>
</tbody>
</table>

Prediction model estimated percent change and total change between 2016 and 2015 (using actual)
**APPENDIX B – ANALYTIC METHODS**

**Member-Submitted Data Specification**

Members submitted patient-level data from their internal data systems based on a common data specification for patients with severe sepsis or septic shock using the following cohort criteria:

Included populations are those that meet the following:

- Patient is aged 18 or older
- Patient has an inpatient admission, ICU or ED visit with any of the specified ICD-9 or ICD-10 Diagnosis Codes in any event diagnosis position, regardless of whether it is present on arrival (POA) or hospital-acquired

Patient meets at least one of the following:

- Systolic blood pressure value < 90 mmHg or drop in consecutive systolic blood pressure readings >= 40 mmHG
  
  OR
  
  - Lactate value > 2 mmol/L

Excluded populations are those that meet any of the following:

- Transfer in from another acute care facility
- Length of stay (discharge date minus admission date) > 120 days
- Directive for comfort care (CMO) within 3 hours of presentation
- Patients with sepsis who expire within 3 hours of presentation
- Patients receiving IV antibiotics for more than 24 hours prior to presentation

Data types included:

- Indicators for 3-hour bundle components
  - Lactate measurement
  - Blood cultures
  - Antibiotics
  - Crystalloid bolus
- Elements of inpatient stay
  - Total length of stay
  - ICU length of stay
  - Discharge disposition
- Clinical elements
  - Systolic blood pressure
  - Lactate value
Quality Control Process

The Member-submitted data were run through a rigorous quality control process. In preparation for data analysis, the data was scrubbed to ensure consistency across Members. This scrubbing process restricted the sepsis events to only:

- encounters that presented in the emergency department (given the small number of encounters for patients presenting in the ICU or general floor);
- encounter dates between Q1 2015 and Q4 2016;
- one encounter per patient; and
- facilities that reported at least one sepsis event in each of the eight quarters of the study period to allow for comparison between the baseline and intervention year.

Two Members – Mayo Clinic and Intermountain Healthcare – provided sepsis encounters only for patients who spent time in the ICU. In order to avoid a reporting bias, these Members were excluded from the total population reports and included in a separate cohort analysis.

Reports and comparisons were calculated as means, medians, proportions, and measures of variability and precision (inter-quartile range and confidence intervals).

Cohort Definitions for Analytics

All cohorts were required to meet the criteria described above in the quality control process. In addition, some analytic cohorts had additional specifications applied.

**Member-submitted Data Cohort:**

- All encounters meeting quality control criteria
- Hospitals must have reported ICU and non-ICU cases
- Analytic cohort sizes
  - Patients surviving sepsis encounter: N=13,018
  - All patients (survivors + non survivors): N=15,446
- Breakouts are shown at the aggregate annual level by maturity status

**Member-submitted Data Cohort – Patients with ICU Time:**

- The measures reported in this section are restricted to sepsis encounters for patients who were admitted to an ICU
- Analytic cohort sizes:
  - Patients surviving sepsis encounter: N=6,151
  - All patients (survivors + non survivors): N=7,977

**CMS-Linked Data Cohort:**

- The measures reported in this section include sepsis encounters that are linked to CMS claims
- Hospitals must have reported ICU and non-ICU cases
- Analytic cohort sizes:
Patients surviving sepsis encounter: \(N=2,838\)
- Patients surviving sepsis encounter with 7-Day episode: \(N=2,567\)
- Patients surviving sepsis encounter with 30-Day episode: \(N=2,267\)
- All patients (survivors + non survivors): \(N=3,458\)
- All patients (survivors + non survivors) with 7-Day episode: \(N=3,433\)
- All patients (survivors + non survivors) with 30-Day episode: \(N=3,338\)
- All patients (survivors + non survivors) with 90-Day episode: \(N=3,184\)
- All patients (survivors + non survivors) with 180-Day episode: \(N=2,917\)

**CMS-Linked Data Cohort – Patients with ICU Time:**

- The measures reported in this section are restricted to sepsis encounters for patients who were admitted to an ICU
- Analytic cohort sizes:
  - Patients surviving sepsis encounter: \(N=1,353\)
  - Patients surviving sepsis encounter with 7-Day episode: \(N=1,203\)
  - Patients surviving sepsis encounter with 30-Day episode: \(N=1,047\)
  - All patients (survivors + non survivors): \(N=1,816\)
  - All patients (survivors + non survivors) with 7-Day episode: \(N=1,806\)
  - All patients (survivors + non survivors) with 30-Day episode: \(N=1,761\)
  - All patients (survivors + non survivors) with 90-Day episode: \(N=1,710\)
  - All patients (survivors + non survivors) with 180-Day episode: \(N=1,611\)

**Predictive Cost Modeling Data Cohort:**

- Encounters are restricted to cases where data elements required for model scoring are not missing
- Hospitals were NOT required to submit data for all quarters (this allowed the inclusion of one additional Member)
- Reports are generated to two cohorts
  a. Member-submitted cohort
  b. Member-submitted cohort – patients with ICU time
- “Total” rows for change estimates were calculated using weighted averages of the value for each Member within each readiness track within the column for the comparison. The weight for each Member was the total number of episodes included in the analysis in 2015 and 2016. The exception was BSWH, who did not provide episodes for the 1st two quarters of 2015, their weight was calculated by doubling the number of included episodes in 2015 and adding it to the number of episodes provided in 2016
- Predicted costs were used for episodes where actual CMS paid amount was not available

**Readiness Track:**

- The initial readiness track level reported was used to determine mature vs. not mature status
- **Mature** units are those with “sustaining” readiness tracks
  - Beth Israel Deaconess Medical Center (BIDMC)
  - Dartmouth-Hitchcock (DART)
  - Northwell Heath (NWH)
• Providence St. Joseph Health (PROVID)
• UC San Diego Health System (UCSD)
• Virginia Mason Medical Center (VMMC)

• **Not Mature** units are those with “in-progress” or “not started” readiness tracks
  – Hawaii Pacific Health (HAWAII)
  – Providence St. Joseph Health (PROVID)

**CMS-Linked Analytics**

CMS-linked analytics were created by linking Member-submitted sepsis encounters to CMS claims through a combination of patient identifiers and service dates. In addition to the types of measures reported under Member-submitted data, the CMS-linked analytics also present adjusted values for some comparisons. Rates were adjusted for age, sex, and disease burden (based on CMS HCC score using an indirect adjustment method [http://www.dartmouthatlas.org/downloads/methods/indirect_adjustment.pdf]).

**Predictive Cost Modeling Method**

*Motivation for Using Predictive Models to Evaluate Cost*

The availability of actual paid amounts was limited to a subset of Medicare patients (approximately 8% of the eligible episodes). In order to make inferences about cost savings in the total population (Medicare + non-Medicare), the Core Team decided to develop a regression model to impute paid amounts for the non-Medicare population.

*Candidate Predictors*

Predictors for the episode-cost prediction models were limited to variables available from the episode data submitted by Members. The list of candidate predictors was created by the project Core Team and reviewed by the project Technical Expert Panel, a group of clinicians and nurses with broad experience treating sepsis at Member systems. The final list consisted of: age, index admission general-floor LOS, ICU LOS, discharge disposition (home, home-health, skilled nursing facility, other institution), 3-hour bundle compliance, and a measure of socioeconomic status based on patient ZIP Code. The distribution of each candidate predictor and its relationship with the outcome, Medicare paid amount for the episode, was evaluated using standard exploratory-data-analysis graphical and tabular methods. Results of these analyses informed how candidate predictors were parameterized for inclusion in the prediction models. Figure 9 includes an an example of the parameterization of General and ICU LOS.
**General LOS**

( = Total inpatient stay – ICU stay)

<table>
<thead>
<tr>
<th>General LOS</th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 11</td>
<td>1,614</td>
<td>$14,500</td>
<td>$18,800</td>
<td>$24,300</td>
</tr>
<tr>
<td>11 to 20</td>
<td>248</td>
<td>$19,700</td>
<td>$27,000</td>
<td>$30,300</td>
</tr>
<tr>
<td>21 to 30</td>
<td>28</td>
<td>$41,700</td>
<td>$59,500</td>
<td>$84,200</td>
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<tr>
<td>31 to 40</td>
<td>5</td>
<td>$69,400</td>
<td>$68,000</td>
<td>$83,300</td>
</tr>
<tr>
<td>41 or more</td>
<td>5</td>
<td>$145,800</td>
<td>$145,800</td>
<td>$116,500</td>
</tr>
</tbody>
</table>

**ICU LOS**

<table>
<thead>
<tr>
<th>ICU LOS</th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;6</td>
<td>1,711</td>
<td>$14,900</td>
<td>$17,500</td>
<td>$23,100</td>
</tr>
<tr>
<td>6 to 10</td>
<td>140</td>
<td>$28,200</td>
<td>$33,400</td>
<td>$52,800</td>
</tr>
<tr>
<td>11 to 15</td>
<td>39</td>
<td>$53,000</td>
<td>$60,900</td>
<td>$46,400</td>
</tr>
<tr>
<td>16 to 20</td>
<td>17</td>
<td>$61,900</td>
<td>$69,600</td>
<td>$91,500</td>
</tr>
<tr>
<td>21 or more</td>
<td>12</td>
<td>$95,000</td>
<td>$90,500</td>
<td>$91,500</td>
</tr>
</tbody>
</table>

**General Model Design and Fitting**

The prediction models were fit using a generalized linear mixed model methodology with a random intercept for Member in order to account for the clustering of observations within Members. A gamma distribution with a log link was used to model the episode cost outcomes because of their skewness and long right tails. For the general-floor and ICU LOS variables, separate models were fitted parameterizing the variables as continuous, with linear and squared terms, or as discrete categories. Both models were included in the best-fit evaluation process for each outcome. Age was included in the models as a continuous variable with both linear and squared terms, models with and without age were included in the best-fit evaluation process for each outcome. A backwards-elimination procedure was used to fit the models, all candidate predictors were included in the initial model and then the least significant predictor was iteratively removed and the model refitted until all remaining predictors had a significance level < 0.05. First-order interaction terms were then added to the model and the fitting procedure was repeated on those interaction terms. Before model fitting, a randomly selected 20% of the observations were reserved as a validation data set. The models were fit using the remaining 80% of observations. Predictive accuracy of the models was evaluated by applying the candidate models to the validation data set and evaluating a list of goodness-of-fit measures including mean absolute deviation, mean absolute percentage error, predictive ratio and an R-squared measure. The best fit model for each outcome was determined based on analyst review of the fit measures. After parameters had been estimated for each of the three outcome models, a paid amount was predicted for each outcome for all episodes where the patient was alive at the end the episode and did not have an actual Medicare paid amount. Model performance characteristics are displayed in Figures 10 and 11.
Figure 10. Strength of Predictive Cost Model: Continguous and Categorical

Index cost models

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean Observed</th>
<th>Mean Predicted</th>
<th>Mean Residual$^1$</th>
<th>MAD$^2$</th>
<th>MAPE$^2$$^2$</th>
<th>Predicted Ratio$^3$</th>
<th>R-squared$^4$</th>
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</thead>
<tbody>
<tr>
<td>Continuous Model</td>
<td>410</td>
<td>19,759</td>
<td>20,097</td>
<td>-323</td>
<td>7.123</td>
<td>36.0%</td>
<td>1.02</td>
<td>0.421</td>
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<tr>
<td>Categorical Model</td>
<td>410</td>
<td>19,759</td>
<td>19,875</td>
<td>-107</td>
<td>6.896</td>
<td>34.9%</td>
<td>1.01</td>
<td>0.517</td>
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</table>

Index + post 7-day cost models

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean Observed</th>
<th>Mean Predicted</th>
<th>Mean Residual$^1$</th>
<th>MAD$^2$</th>
<th>MAPE$^2$$^2$</th>
<th>Predicted Ratio$^3$</th>
<th>R-squared$^4$</th>
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<td>22,177</td>
<td>22,213</td>
<td>-133</td>
<td>7.391</td>
<td>35.1%</td>
<td>1.01</td>
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<td>23,077</td>
<td>21,035</td>
<td>42</td>
<td>7.330</td>
<td>34.8%</td>
<td>1.00</td>
<td>0.517</td>
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</table>

* MAD - Mean Absolute Deviation.
** MAPE - Mean Absolute Percentage Error.
$^1$ Closer to 0 is better.
$^2$ Smaller is better.
$^3$ Closer to 1 is better.
$^4$ Larger is better.

Figure 11. Strength of Model: Distribution of Observed vs. Predicted Costs

Index Cost Model

<table>
<thead>
<tr>
<th>Cost</th>
<th>N</th>
<th>Mean</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>90th</th>
<th>95th</th>
<th>99th</th>
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<td>1,947</td>
<td>$31,300</td>
<td>$9,400</td>
<td>$12,000</td>
<td>$15,900</td>
<td>$18,800</td>
<td>$43,800</td>
<td>$53,500</td>
<td>$167,800</td>
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<td>$23,400</td>
<td>$12,700</td>
<td>$14,600</td>
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<td>$22,000</td>
<td>$17,200</td>
<td>$29,800</td>
<td>$113,700</td>
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Distribution of Observed versus Predicted Index Cost

Index + Post 7-Day Model

<table>
<thead>
<tr>
<th>Cost</th>
<th>N</th>
<th>Mean</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>90th</th>
<th>95th</th>
<th>99th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Index + Post 7-day Cost</td>
<td>1,947</td>
<td>$22,800</td>
<td>$9,700</td>
<td>$12,700</td>
<td>$16,400</td>
<td>$23,700</td>
<td>$45,000</td>
<td>$55,000</td>
<td>$101,300</td>
</tr>
<tr>
<td>Predicted Index + Post 7-day Cost</td>
<td>22,386</td>
<td>$23,400</td>
<td>$13,200</td>
<td>$15,600</td>
<td>$18,200</td>
<td>$23,200</td>
<td>$59,100</td>
<td>$58,500</td>
<td>$117,200</td>
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</tbody>
</table>

Distribution of Observed versus Predicted Index + Post 7-day Cost
APPENDIX C – SCREENSHOTS FROM VANTAGE REPORTING TOOL
APPENDIX D – SCREENSHOTS FROM HVHC RESOURCE PORTAL


Use the playlists below for your health care intervention. Additional resources can be found on the Resources page.

RESOURCE CATEGORY
SOURCE INSTITUTION

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<th>TITLE</th>
<th>DESCRIPTION</th>
<th>RESOURCE CATEGORY</th>
<th>SOURCE INSTITUTION</th>
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</thead>
<tbody>
<tr>
<td>✓</td>
<td></td>
<td>A3 Implementation Template</td>
<td>A3 template to use as a guide to organize implementation</td>
<td>Tools and Technology</td>
<td>InnovateHealth</td>
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<tr>
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<td></td>
<td>Barriers to Sepsis Model Implementation</td>
<td>Possible barriers to implementing the HVHC Sepsis model</td>
<td>Knowledge and Learning</td>
<td>Dartmouth-Hitchcock</td>
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<tr>
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<td></td>
<td>Best Practice Resources</td>
<td>Detailed best practice elements checklist, adapted from the knowledge model</td>
<td>Processes and Rules</td>
<td>Mayo Clinic</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td>HVHC Sepsis Presentation From 2-2-14</td>
<td>Slide presentation from HVHC describing their sepsis improvement work (slides 5-51)</td>
<td>Tools and Technology</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td>HVHC Sepsis Poster</td>
<td>HVHC sepsis poster</td>
<td>Tools and Technology</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td>HVHC Sepsis Report Oct 2010</td>
<td>Presentation describing HVHC experience implementing the sepsis bundle. Good examples of data displays for process measures (slide 15); visual</td>
<td>Tools and Technology</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
</tbody>
</table>

Procalcitonin?

This topic contains 3 replies, has 2 voices, and was last updated by on .

Author Posts Favorite Subscribe

**Shahla Pase**

July 16, 2017 at 1:45 pm

Does anyone use Procalcitonin (PCTI) for sepsis patients? Is anyone using PCTI to help identify sepsis or for sepsis care at all? KPI is currently not using PCTI but looking into the use of it and would appreciate any feedback.

**Hi Eveyrna,**

Procalcitonin has been used for many years. It’s rumored to cost about $50 and seems like money well spent. We get 2, once at admission, and a second 24 hrs later since it can bag – but if I am not sure and we are respiratory we can feel fairly confident we have a nonrespiratory source. We use respiratory viral panels a lot in the winter as well. Most of the papers I’ve seen are for labs as in COPD but in practice our estimates use for sepsis and so we use both.

We also use PCT to de-escalate when which may be part of why our LOS is relatively short.

-Steve
APPENDIX E — PEER-REVIEWED PUBLICATIONS

Publications accepted for Supplemental Issue of The Journal for Electronic Health Data and Methods (eGEMs):

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<thead>
<tr>
<th>MS #</th>
<th>Lead author</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>202</td>
<td>Brent James</td>
<td>An Efficient, Clinically-Natural Electronic Medical Record System That Produces Computable Data</td>
</tr>
<tr>
<td>200</td>
<td>Genna Cohen</td>
<td>Leveraging Diverse Data Sources to Identify and Describe U.S. Healthcare Delivery Systems</td>
</tr>
<tr>
<td>197</td>
<td>Jordan Albritton</td>
<td>The Effect of the Hospital Readmission Reduction Program on the Duration of Observation Stays</td>
</tr>
<tr>
<td>196</td>
<td>Gavin Welch</td>
<td>Data Cleaning in the Evaluation of a Multi-Site Intervention Project</td>
</tr>
<tr>
<td>195</td>
<td>Jay Knowlton</td>
<td>A Framework for Aligning Data from Multiple Institutions to Conduct Meaningful Analytics</td>
</tr>
<tr>
<td>194</td>
<td>Friedrich von Recklinghausen</td>
<td>The Truth is in the Data - Differences in the Same Measure Based on Different Sources Among HVHC Members Using ICU Length of Stay as an Example</td>
</tr>
<tr>
<td>192</td>
<td>Andreas Taenzer</td>
<td>Dissemination and Implementation of Evidence Based Best Practice across the High Value Healthcare Collaborative using Sepsis as a Prototype</td>
</tr>
<tr>
<td>191</td>
<td>Andrew Knighton</td>
<td>Detecting risk of low health literacy in disadvantaged populations using area-based measures</td>
</tr>
</tbody>
</table>
**APPENDIX F — SAMPLE WHITE PAPERS**

**TOPIC: Lactate Measurement/Repeat Lactate**
- a. Doing the repeat for the sake of the measure or a best practice
- b. “Lactate clearance”

M. Isabel Friedman, DNP, MPA, RN, BC, CCRN, CNN, CHSE

**Intro/Summary**

This white paper will discuss the challenges faced by clinicians with regards to the SEP1 lactate and repeat lactate measures and some creative solutions to address those challenges.

Compliance with the three and six hour sepsis bundles has been fraught with challenges. The High Value Healthcare Collaborative’s (HVHC) members reviewed their CMS data to identify the top challenges for non-compliance with the three and six hour CMS bundles. Although compliance with the initial lactate measurement was not identified as an issue, the teams have identified the repeat lactate measure as one of the major reasons for non-compliance.

It is important to remember that if the patient is identified as being in severe sepsis, the three hour bundle must be successfully completed. Subsequently, if that patient remains hypotensive or has an initial Lactate level \( \geq 4.0 \) the six hour bundle elements must also be successfully completed. The Technical Expert Panel of HVHC offers some insight and suggested best practices to address the repeat lactate non-compliance dilemma. Presently, the CMS lactate re-measurement requirement is not based on available evidence and there are ongoing dynamic discussions on the efficacy of “when and how” to monitor lactate clearance measurements.

**Background/Problem**

The true value of a lactate measurement in a septic patient depends upon whom you ask. Lactate as an initial measure is recognized in landmark studies as useful in the diagnosis and treatment of septic shock\(^1\). The duration of lactic acidosis has been reported as a significant predictor of multi-system organ failure and death in septic shock patients\(^2\). It has further been opined that a decreased lactate clearance is a significant independent predictor of increased mortality, and suggested that tracking lactate clearance could be utilized as an early predictor of higher mortality\(^3\). The value of using lactate clearance as a measure of resuscitation remains controversial to this day\(^4\). When caring for a patient with suspected sepsis, using the 2016 Surviving Sepsis Campaign (SSC) guidelines indicated that a formal screen is the best approach reducing mortality\(^5\). Lactate and repeat lactate measurements are part of the SCS bundle.

Patients who have elevated lactates are in danger of higher mortality and morbidity which is further compounded by their symptomatology and a myriad of diseases. Therefore, there is little controversy on whether patients presenting with an elevated lactate should be diagnosed and treated rapidly. There is however controversy in the literature regarding the efficacy of a single lactate re-assessment. Despite this, lactate re-measurement remains in the CMS bundle elements for septic shock taking focus away from compliance with other bundle elements with well-established rationale and benefit.
It was identified by the team that the upper limit of normal of the lactate measure varies from institution to institution. The way that SEP1 is currently written clinicians are required to re-draw lactates even when the initial lactate results fall within their institutions defined normal range. Many clinicians feel that a lactate of 2.0 is too low a value to require a repeat lactate. It is further recommended that better data is needed to support the need for a repeat lactate measurement before this is made a requirement at all.

It has also been opined that there has been a distortion of the true definition of a “bundle”. It is highly recommended that a bundle have no more than five elements. SEP1 has more. A bundle is evidence based therefore, a repeat lactate would be important if the goal was clearance at a particular rate. However, most clinicians are not repeating lactates to monitor clearance; they are repeating them to comply with the SEP1 measures. We recommend that repeat lactate be removed as a bundle element until more data is needed to support the clinical benefit of a single repeat lactate measurement in this population.

The problem with Sepsis being an all or none measure has also been raised by many. For example, it is possible to fail the measure equally for not documenting a capillary refill, or repeating a lactate as it is for never having recognized sepsis at all and completely failing to provide evidence based care for a patient. This scenario negates the ultimate goal of improving patient outcomes and decreasing patient mortality. It has been theorized that adjusting clinical practice, just to fit SEP1 measures actually hinders the evolution of good detection tools and impacts early intervention in the treatment of sepsis which is the ultimate goal. A strategy employed to identify patients who were treated “too early” and therefore failed the SEP1 measure has been identified. Using this approach a clinician reviews all the charts that are identified as having failed the SEP1 measure but delivered appropriate care but too early.

**Solutions**

There have been a number of solutions attempted by our HVHC members. Many sites have automated the process of repeat lactates by embedding the order in their sepsis order sets. Other sites have instituted laboratory solutions. The first solution was generating an automatic repeat lactate whenever a lactate level is ordered. This solution brings with it its own problems. Overuse concerns were raised, so in order to prevent unnecessary lactate orders, the lab instituted an automatic discontinuation of the second lactate level if the first lactate is below 2.0. Similarly, a lab process was created to generate a repeat lactate on all lactate levels greater than 2.0 which could be cancelled if the clinician felt that there was a cause, other than sepsis, for the elevated lactate. The knowledge that a lactate of 2.0 could be the result of poor clearance, liver dysfunction or trauma should prompt the clinician to cancel the automatic repeat lactate in cases other than sepsis.

Best Practice Alarms (BDAs), Medical Early Warning Systems (MEWS), nurse-based orders, sepsis best practice alerts and early detection tools are used in various forms by different institutions to ensure the existence of bundle compliant initial and repeat lactate orders. There is a concern regarding how these tools are validated and who is notified by the alerts. When creating these tools one needs to be aware of the positive and negative predictive values as well as cognizant of potential alert fatigue. Some institutions have developed a process whereby a pager system is used to page or notify a nurse manager or clinician of the initial lactate level and subsequently prompt the need to repeat the lactate level. Many institutions have the repeat lactate order embedded in the Sepsis order sets. Also, getting nurses involved
by initiating nursing protocols that give the nurse the requisite order to draw the lactates at the appropriate time, have been successful in improving repeat lactate compliance.

**Conclusion**

The first step on the path to improved bundle compliance is realizing that we not only need to give the best possible care to our patients but also need to meet the requirements needed for documentation and compliance with the SEP1 bundle elements. Change does not occur quickly so begin by analyzing your individual challenges with repeat lactate compliance. Utilize your improvement science tools to identify your major problems and consider using one of our solutions.

Perform chart reviews to identify cases where patients were treated and received good quality care, ahead of the time when the documentation reveals they met the SEP1 criteria and were therefore penalized for it. If quantified, this data would be valuable information to be used to affect future policy change. If the identified problem is treating too well, too quickly is an, urge your clinicians to use the sepsis order set and document suspected severe sepsis and septic shock. Documenting early starts the clock on SEP1, because physician documentation trumps all.

Notwithstanding the arguments presented here lactate and repeat lactate measures are an easily obtained value which is not cost prohibited and the results can aid the clinician to act appropriately and rapidly based on the patient’s clinical sepsis presentation.

**Citations**

TOPIC: Role and Value of Nursing Leadership in Sepsis Bundle Implementation

Terra Hiller, RN, BSN, MSN Student (Pending April 2017)

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This white paper discusses the role and value of nursing leadership in regards to the Sepsis Bundle Implementation.

Sepsis is a major challenge in healthcare; it can be difficult to differentiate from other illnesses and can progress rapidly to death. Due to the high mortality rates for severe sepsis and septic shock cases, treatment for the condition became a national priority. Performance measures (SEP-1) were established with benchmarks that all hospitals in the United States need to meet as determined by Center of Medicare and Medicaid (CMS). All major hospitals are engaged in measuring performance and improving care for patients with sepsis.

The care management of sepsis is complex and the time sensitivity of treatment can be challenging. To be successful and achieve the goals of care, everyone involved with the care of the septic patient must be included to develop a standardized work process. This interdisciplinary collaborative effort needs leadership buy-in, knowledge of the goals, and support to be successful. Nurses are in a position to provide early identification, guide and complete the bundle of care in the mandatory timing. Nurse leaders can support bedside nurses by identifying and removing barriers, promote inter-disciplinary communication/teamwork provide resources, monitor progress, give and receive feedback on cases and overall provide a just culture environment.

Just culture is a “shared value of patient safety, which includes an environment where mistakes can be talked about, examined and learning can occur” (Vogelsmeier& Scott-Caviezel, 2007). Safety is a top priority in all health care systems; no health care organization or provider wants to provide subpar care. Yet, in a multidisciplinary process, like the treatment for sepsis, there are many opportunities for gaps. Errors happen for a number of reasons: human, process, environment, and system failures. Trust needs to be built amongst care teams working on units and within the organization. There needs to be a recognition that errors happen, but understanding the root cause of is key to quality improvement. A culture of safety is focused on preventing, detecting, and minimizing hazards of error without pointing blame. If errors are not identified and examined they run the risk of being repeated.

Nursing leadership can create a culture of safety around sepsis by being transparent in expectations, goals and metrics for the different elements in SEP-1 (bundle components) as well as holding staff accountable. Low compliance in one bundle component shows the need for further examination of the cause. Transparent results of these root cause analyses, encourages open discussions of the challenges and barriers existing in work processes. Mutual respect among all team members allows for structured information exchange opportunities following a miss.

Nurses play a critical role of the process of early recognition, diagnosis, completing treatment and notifying advance care providers in patients suspected of sepsis. Since nurses are responsible for obtaining or administering each step in the sepsis bundle they are in a position to gather data and provide feedback to physicians and other team members, as well as guide care and compliance in real time. Nurse leaders need to support, and empower the significance of nurses in the care of a patient with sepsis, which can often be underappreciated. Nurses are in a role to promote the most optimal outcomes.

Earlier management of patients with suspected sepsis is essential to improving patient outcomes. The Surviving Sepsis Campaign recognizes that not only are nurses critical in early identification and treatment, but they are essential to performance improvement and data collection. The critical role that nurses play in early recognition and diagnosis can be supported by the development and encouragement of using a nursing standing order for SIRS and infection source symptoms. If a patient comes in and meets SIRS criteria and has signs and symptoms of infection this should trigger a series of orders such as labs, including initial lactate and blood cultures, as well as starting 500-1000 cc of fluid. Nurse driven orders support an efficient workflow and increases compliance with the bundle components. Developing tools for screening for inpatients can aid in the early identification of sepsis. Nurses are in a position to act quickly and escalate care when needed after an assessment is made.

Nursing leaders provide an understanding of expectations, a just culture environment and encourages mutual respect and teamwork between departments and disciplines. Resources for nurses to be successful and escalate care within their
scope improve outcomes. Nursing Leadership needs to be involved with understanding and promoting the bedside nurses critical role in providing optimal care in the management of sepsis.

**Citations**


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