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Implementation of an Innovative Early Warning System: Evidenced-based Strategies for Ensuring System-wide Nursing Adoption

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Abstract

Early deterioration in adult medical-surgical patients is associated with increased intensive care unit and hospital mortality (Goldhill, 2001). Failure to recognize deterioration is a preventable patient safety and quality issue. To address this problem, since 2013, Kaiser Permanente Northern California (KP NCAL) has piloted Advance Alert Monitor (AAM) at two hospitals. This early warning system employs a set of predictive models developed by the KP NCAL Division of Research, which automatically predicts patient deterioration within the next 12 hours based on a complex algorithm of laboratory and clinical data points. Improvements in mortality and length of stay have been realized at the two pilot hospitals. In anticipation of expansion to additional NCAL facilities, major changes to the AAM workflows and processes were developed that increased the sensitivity of the patients identified at risk for clinical deterioration, as well as the timeliness and clarity of clinical response. Expansion to two additional pilot hospitals using these revised processes rely on the evidence-based implementation strategies found in this Doctor of Nursing Practice project. This paper examines the planning, assessment, and implementation of early warning systems at two NCAL facilities using Rogers' diffusion of innovation theory and Greenhalgh's extension of Rogers' theory. Key attributes need to be considered from a cultural and organizational perspective to both start and sustain an implementation. The success of AAM implementation is validated using specific outcome and process measures, including compliance with documentation and timeliness of workflows.

Keywords: early warning system (EWS), implementation, rapid response teams (RRTs), change management, diffusion of innovation, medical emergency team (MET

Section II. Introduction

Problem Description

Acute deterioration of hospitalized patients outside of the intensive care unit (ICU) is a quality and patient safety issue that may be preventable and is "associated with excess mortality and serious adverse events such as cardiac arrests" (Alam et al., 2014, p. 587). Acute deterioration is often preceded by changes in a patient's breathing, pulse, oxygenation, and other clinical triggers, which can manifest six to 24 hours prior to clinical deterioration (Boniatti et al., 2013; Ludikhuize, Smorenburg, de Rooij & de Jonge, 2012; Mapp, Davis, & Krowshuk, 2013; Smith, Prythereh, Meredith, Schmidt, & Featherstone, 2013). The failure to recognize, communicate, or act on these early changes can lead to delays in care and adverse events, including unplanned admissions to the ICU and unexpected deaths (Mitchell et al., 2010). As described in the 2007 National Patient Safety Association (NPSA) report:

> The acutely unwell may suffer delays in response because their deterioration is not recognized, not appreciated, or not acted upon sufficiently quickly. Communication and documentation are sometimes poor, experience may be lacking and provision of critical care expertise … may be delayed (Luettel, Beaumont, & Healey, 2007, p. 5).

Although there is increasing literature and research supporting the value of an early warning system (EWS) in reducing mortality and length of stay (LOS), there remains little evidence to describe the steps organizations need to take to assess and plan for the implementation of an innovation, such as an Advance Alert Monitor (AAM). Attempts to apply previously developed models of technology acceptance and diffusion of innovation have weaknesses, particularly within the complex health environment, due to the wide variation of

systems, people, and culture that can influence adoption acceptance, and diffusion of the innovation (Ward, 2013). According to Damschroder et al. (2009), some estimates indicate, "Two-thirds of organization's efforts to implement change fail" (p. 2). Although, Greenhalgh, Robert, MacFarlane, Bate, and Kyriakidou (2004) acknowledged that many innovations are "never adopted at all [and] others are subsequently abandoned" (p. 587), they do support the concept that there are key attributes of innovations which have clear advantages to promote more consistent adoption rates of implementation.

In order to successfully implement an evidence-based innovation, such as AAM, Rogers' (2003) framework for diffusion of innovation pointed to these questions:

- How can this EWS be successfully implemented across a multi-hospital system?
- What factors need to be considered from a cultural and organizational perspective to both start and sustain an implementation?
- What assessments can indicate that a facility is ready for implementation?
- What steps can a healthcare organization take to move toward a state of readiness to participate in an initiative?
- How can innovations such as AAM be adapted to be perceived as more strategically beneficial, more harmonious with prevailing norms and values, less complex to the user, more results oriented, and with greater capacity for local reinvention?
- How can this overall process be supported and enhanced?

Setting

The setting for this DNP project was the Kaiser Permanente Northern California (KP NCAL) acute care medical centers located in the San Francisco Bay Area. Kaiser Permanente is the largest not-for-profit integrated health care system in the United States. The NCAL region

spans 233 miles and is comprised of 21 acute care medical centers; there are 16,000 RNs, 9,000 physicians, and approximately 3.9 million members in NCAL. Regional offices are based in Oakland, California and provide leadership, support, and oversight to the individual medical centers. The two original alpha pilot medical centers, where AAM was initially implemented in 2013 and 2014, are South San Francisco and Sacramento. The two pilot medical centers, which are the focus of this paper, are Walnut Creek (beta 1) and Santa Clara (beta 2).

Available Knowledge

Several studies have documented that the risk of ICU death is highest among patients transferred from general medical-surgical units (Ludikhuize et al., 2012; Hillman, 2002). National studies have reported raw death rates for general medical-surgical inpatients transferred unexpectedly (unplanned transfers) to the ICU in the 20% to 40% range (Buist, Bernard, & Anderson, 2002; Hillman et al., 2005); these patients also have a much higher risk-adjusted mortality rate (Escobar, Laguardia, Turk, Kipnis, and Draper, 2012).

In a study of over 6.5 million patient records from a large northern California hospital system, Escobar, Gardner, Greene, Draper, and Kipnis (2013) found that a small percentage (3% to 5%) of hospitalized patients who transfer unexpectedly to the ICU account for 24% of all ICU admissions and 13% of all hospital deaths, 12.5% of all hospital days, and have an 8 to12 day longer LOS than those who were not transferred from general medical-surgical units to the ICU. According to NPSA, an analysis of 576 deaths reported in 2005 over a one-year period corroborated Escobar et al.'s findings by identifying that 11% were as a result of deterioration not recognized or acted upon (Luetell et al., 2007).

What is AAM?

Through the Kaiser Permanente Division of Research (KP DOR), which is one of the nation's largest research organizations outside of a government or university setting, Escobar et al. (2012) developed innovative, scientifically derived clinical algorithms that can be used to trigger an automatic AAM alert. AAM is a set of predictive models for early detection of impending physiologic deterioration of hospitalized patients. The AAM system calculates in real time the risk of patient deterioration within the next 12 hours. The AAM model is based on a severity of illness and a comorbidity score, as well as physiologic and other data, utilizing predictive algorithms developed by DOR. This is a validated algorithm which calculates the risk of deterioration by looking back through the past year of each individual patient's electronic medical record (EMR) for diagnoses that contribute to their chronic disease burden (comorbidity point score or COPS2), as well as reviews the current and past 72 hours of vitals and laboratory data (laboratory and physiology score or LAPS2). None of the core components of the AAM score (LAPS2 and COPS2) are proprietary, and Escobar, Turk, Ragins, Ha, Hoberman, LeVine, Ballesca, Liu and Kipnis (2016) suggest that these algorithms "could be replicated by any entity with a comprehensive inpatient EMR" (p. S20). The statistical performance of the DOR final equation is "based on approximately 262 million individual data points from 650,684 hospitalizations in which patients experienced 20,471 deteriorations" (Escobar et al., 2016, p. S21), which is the largest patient database ever employed specific for EWS.

The combined scores and other factors are calculated in real time through Java webservers and displayed back in the EMR. Every six hours, the rapid response team (RRT) registered nurse (RN) actively *case finds* the patients who trigger an AAM alert ≥8% by sorting every hospitalized patient by their AAM score and displaying basic labs and vitals. Once the

AAM score is ≥8%, the RRT RN prioritizes and assesses the patient with the primary nurse, communicates the findings to the hospitalist (HBS) and/or surgeon, and applies the appropriate interventions as ordered (see Figure 1). Unique to the KP model is the early involvement of palliative care and social work, depending on specific COPS2 scores, to identify the patient's decision maker and to ensure that their preferences for life sustaining efforts are confirmed and honored. See Appendix A for detailed description of AAM.

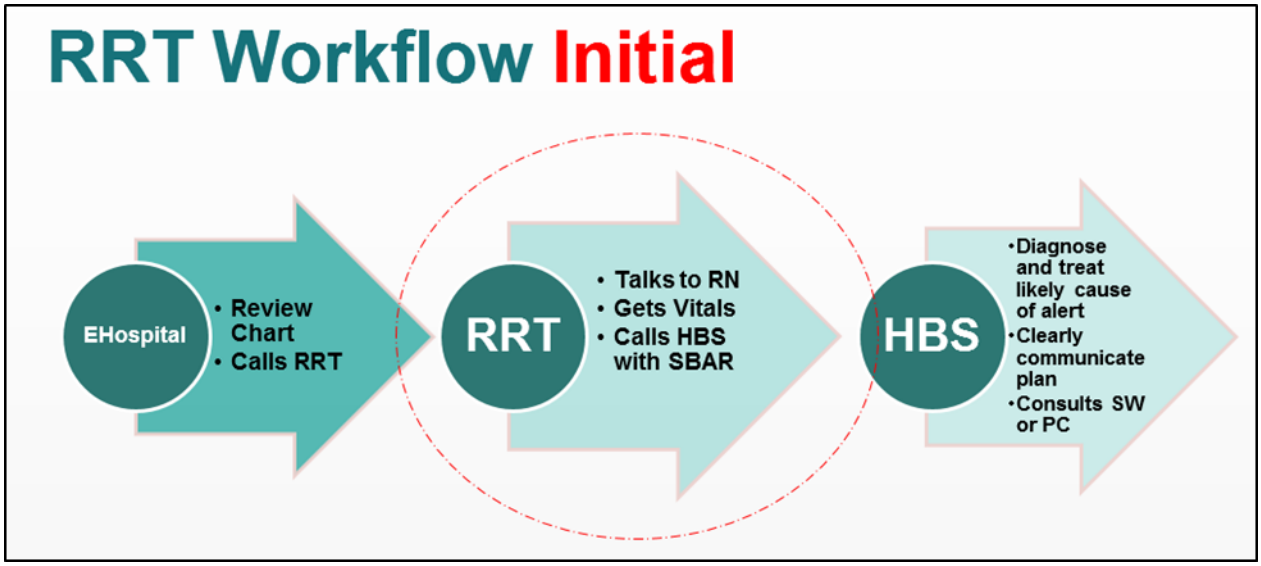


Figure 1. RRT workflow.

Although, there are other health care systems and private enterprises that have developed EWSs, the KP AAM system is unique for several reasons: (a) the algorithms are based on the largest denominator, (b) benchmarking is internal to KP data, (c) it automatically pulls complex data from the EMR that drives the algorithms, (d) it includes a remote nursing command center (eHospital) for greater clinical oversight, and (e) it incorporates supportive care services as an integral part of the AAM workflow.

To date, data from the DOR analysis of the pilots found that AAM was associated with reductions in mortality and LOS. In the first three years of this alpha pilot, the AAM intervention

showed a definite trend towards being mortality-favorable, with a 28% risk reduction in inpatient mortality, 31% risk reduction in 30-day mortality, and an 18% risk reduction in 90-day mortality. The AAM intervention shows a definite trend towards being LOS-favorable, with an average 32.9 hour decrease in hospital LOS with AAM (statistically significant) and an average 6.8 hour decrease in ICU LOS (Escobar et al., 2016).

Based on regional trends and using a generalized linear model on matched cases and controls, Escobar et al. (2016) extrapolated that approximately 50 lives had been saved. It is projected that 400 lives per year and 8,910 patient days will be saved if this program is expanded to all 21 NCAL facilities. It is also possible that a significant reduction in mortality (approximately 110 to 400 deaths per year) may be achieved (Escobar, unpublished 2016). A doubling of the proportion of high-risk patients is anticipated, in whom proper attention is given to eliciting updated goals of care, including identification of surrogate decision makers. Assuming that a mean LOS reductions comparable to those observed in the pilot is achieved, full deployment would be associated with a savings of approximately 8,910 patient days per year [(32.9 hours*6,500 patients alerted)/24 hours]. The DOR analyses also suggest there may be cost savings of up to $26.8 million per year associated with the intervention. Based on these positive outcomes, further testing of AAM at two to three beta sites and then expansion of AAM to all KP NCAL is warranted.

In addition to the actual AAM predictive analytics tool, the AAM operational workflow relies on consistent RRT RN staffing (one per shift, not assigned to patient care) and standardized workflows that include proactive rounding on medical-surgical patients using specific patient criteria to identify high risk, integrated with the AAM response process.

Critical Summary and Appraisal of Evidence

PICOT Statement

In medical-surgical hospitalized adult patients in a northern California integrated health care system (P), what evidence-based strategies can be used by nurses that (I) results in successful AAM implementation as demonstrated by (a) reduced ICU mortality, (b) reduced LOS outcomes, and (c) compliance with workflow process measures (O), as compared to outcomes for matched age, sex, and diagnoses patients at non-AAM facilities within the same NCAL integrated health care system (C), when evaluated over a 6-month period of time (T)?

Search Strategy

In 1997, Morgan, William, and Wright introduced EWS in the United Kingdom (UK) as a guide to quickly determine the degree of illness of a patient, based on changes triggered within a single parameter of five cardinal vital signs: Respiratory rate, temperature, blood pressure, heart rate, or level of consciousness. EWS is a physiologic scoring system typically used in medical surgical units before patients experience a catastrophic event. (Duncan, McMullan, Mills, 2012). Variations of EWS exist, including the modified EWS (MEWS) which assigns points based on the sum of additional vital sign parameters, with protocolized interventions based on the higher scores (AHRQ, 2014).

A comprehensive review of the literature was conducted in order to assess evidence for implementation of EWSs or MEWSs using database searches of the Cochrane and Joanne Briggs Institute databases of systemic reviews, Medline (1966-present), CINAHL, Pubmed, Fusion, and Google Scholar. The search was limited to adults and to studies that were written or translated in English only. Search terms included *implementation + early warning system, modified + early warning system, track and trigger, early warning score, rapid response team(s), medical*

emergency teams (MET teams), change management, innovation spread. This search generated a body of literature outlining the development and impact of RRT and MET teams, as well as significant studies related to the impact of EWS, but there was scarce literature specific to the implementation of EWS in the adult population, either in the United States or internationally.

In their systematic analysis of modified early warning systems (MEWS), Kyriacos, Jelsma, and Jordona (2011) described the "paucity of data on the validation, implementation, evaluation and clinical testing" (p. 311) of MEWS/EWS. According to Ludikhuize et al. (2014), only one other study (Shearer et al., 2012) had shown insight into the importance of individual and bedside sociocultural factors in implementation of rapid response system protocols. Since 2014, both Umscheid et al. (2015) and Dummet et al. (2016) have examined EWS implementation and have provided practical strategies to guide clinicians in its development, implementation, and evaluation.

Fifty-four full text articles were retrieved that had relevance to the PICOT question. Evidence in this review was evaluated using the Johns Hopkins nursing evidence-based practice appraisal tool (see Appendix B for a detailed summary of the articles and results). Of the 54 articles, 18 were identified as being more relevant to the PICOT because they more specifically included elements of implementation versus only the clinical value of EWS or MEWS. In critically appraising the 18 articles specific to this topic, most of the studies attempted to evaluate the impact of critical care outreach services (RRT and EWS) on hospital mortality rates, ICU admission patterns, length of hospital stay, and adverse cardiac or respiratory events in adult patients on general hospital wards (McGaughey et al., 2007). Each of the studies considered the impact of EWS on the outcomes identified, but each had differences in how they defined the

RRT team, what clinical indicators were used to determine clinical instability, and what constituted an EWS.

Nine articles that directly discussed implementation of EWS in the adult population are profiled in this paper (Claussen, Garner, & Crow, 2013; Dummett et al., 2016; Kyriacos, 2011; Ludikhuize et al., 2014; Page, Blaber, & Snowden, 2008; Sanders et al., 2013; Shearer et al., 2012; Umscheid et al., 2015; Ward, 2013). Only three articles offered descriptions granular enough for clinicians to replicate putting EWS into practice (Dummett et al., 2016; Page et al., 2008; Umscheid et al., 2015).

Using the Johns Hopkins nursing evidence-based practice appraisal tool, Table 1 is an abbreviated table that describes the 18 studies, their evidence level, and their quality grade.

Table 1

Johns Hopkins Nursing Evidence-Based Practice Appraisal Tool: Evidence Table

Evidence Level Level 1-V	**Quality A-C**	**# Studies**	**Authors**
Level 1	A	5	Kyriacos et al., 2011 McGaughey et al., 2007 Mitchell et al., 2010 Niven et al., 2014 Smith et al., 2014
Level II	B	3	Lusikhuize et al., 2014 McNeill & Bryden, 2013 Ward, 2013
Level II	C	2	Butcher, Vittinghoff, Maselli, & Auerbach, 2013 Guirgis et al., 2013
Level V	A	1	Umscheid et al., 2015
Level V	B	5	Dummett et al., 2016 Page et al., 2008 Patterson et al., 2011

			Race, 2015 Shearer et al., 2012
Level V	C	2	Claussen et al., 2013 Sanders et al., 2013

The five Level V, Grade B, articles (Dummett et al., 2016; Page et al., 2008; Patterson et al., 2011; Race, 2015; Shearer et al., 2012) on the Johns Hopkins evidence-based practice scale all addressed the importance of sociocultural elements, as they described how staff involvement in the change management process of consultation, piloting, testing, training, and education were key to successful implementation. All papers had limitations due to the sample size or lack of substantive data. The key attributes that Rogers (2003) and Greenhalgh et al. (2004) described as advantageous to implementation success align with the factors these author's identified as critical to the success of implementation; however, none of the papers referred to all 11 of the key attributes (see Evidence of Synthesis Table in Appendix C).

Kyriacos et al. (2011) performed a systematic analysis of 534 papers reporting MEWS/EWS systems for adult inpatients covering 1998 to 2011, identifying 14 of the papers as containing useable data on the development and utility of MEWS/EWS. Kyriacos et al. expressed concern that there was no implementation studies of MEWS/EWS based on clinical trials. The authors described the suboptimal care of the medical and surgical patients, the failure to monitor basic clinical and physiologic parameters, and poor communication and delays in responding to deteriorating vital signs as key issues that reliable systems of safety, which include early recognition systems and systematic communication systems, could address. Kyriacos et al.'s systematic review using Johns Hopkins nursing evidence-based practice appraisal tool is graded Level I, Quality A, but the authors did little to answer the PICOT question, because the focus was on clinical validity of various MEWS/EWS systems. There were no actual

descriptions of EWS implementation in the article.

Ludikhuize et al. (2014) performed a 3-month quasi-experimental study at a hospital in Amsterdam to study the effect of protocolized measurement (three times each day) of the MEWS on the implementation of the rapid response system (RRS). The author concluded that detection of physiologic abnormalities was better in protocolized wards at 70% versus in non-protocolized wards (4%). Ludikhuize et al. also concluded that protocolized measurements support more reliable RRT activations. This study was conducted in a 1,000-bed Amsterdam university hospital, covering over 18 units, of which 10 were randomized to the protocolized measurements and eight were control wards. Johns Hopkins nursing evidence-based practice appraisal tool rating is Level II, Quality B.

Umscheid et al. (2015) performed a multi-center quasi-experimental study at three hospitals at the University of Pennsylvania Health System (UPHS), with a capacity of over 1,500 beds and 70,000 annual admissions. Using the criteria for severe sepsis, EWS criteria was established and two rapid response coordinators developed the operational response, which included a three-question follow-up assessment in the electronic health record (EHR). The authors described specific criteria and workflows for implementation and reducing alarm fatigue. The study examined the impact of the EWS response system across the UPHS and at each of the hospitals (Umscheid et al., 2015). The Johns Hopkins nursing evidence-based practice appraisal tool rating is Level V, Quality A.

Dummet et al. (2016) described the implementation process at the two pilot KP hospitals that first deployed EWS, identifying important structured processes, pre-implementation preparatory work, early workflows, and response protocols that form the basis of this implementation project. Dummett et al. framed the EWS tool as a means to improve situational

awareness, as well as "replace medical intuition with analytic, evidence-based judgment of future illness" (p. s26). The authors examined the sociocultural aspects of adoption, which included staff engagement in revising the workflows and documentation, education of staff regarding the key clinical contributors to clinical deterioration, and promotion of the use of RRT RN proactive rounds in addition to the EWS to optimize clinical care. In comparison to other EWS implementation studies, which focused on statistics behind detection or on the quantification of the process and outcome measures, Dummett et al. suggested that "careful consideration of clinician's needs and responsibilities, particularly around ownership of patients and documentation, is essential" (p. s30) to successful implementation. The Johns Hopkins nursing evidence-based practice appraisal tool rating is Level V, Quality B.

Page (2008) described the implementation of a manually calculated MEWS within an Australian private hospital, piloting a nursing tool that had a color-coded algorithm to support early identification of and rapid response to clinical deterioration on the adult medical-surgical ward. Page specifically wrote that the design of a manual MEWS tool was purposefully created as one that was "easy to understand" and "did not produce extra work for the nurses" (p. 58). Page reinforced the importance of advanced training and discussion with the nurses, so the tool and accompanying workflows could be used accurately and completely. Page was more descriptive than other authors in including sociocultural aspects that influenced adoption, such as the opportunity of staff to revise workflows to improve care, and in measuring the value staff placed in the tool for improving care (87% of the nurses believed the MEWS either improved care a great deal [26%] or improved care [61%] compared to the previous system, related to the ability to identify the deteriorating patient). Because of the small sample size of the study, which occurred in a single acute care hospital in two units (a 30-bed neurovascular ward and 41-bed

orthopedic ward) over two months, using Johns Hopkins nursing evidence-based practice appraisal tool, this study is graded Level V, Quality B.

Shearer et al. (2012) explored the causes of failure to activate the RRS using a multi-method study at 570 beds across four teaching hospitals in Melbourne. The authors identified the importance of implicit staff cultural rules within the clinical environment that influenced the staff's resistance to activating the Rapid Response System (RRS) and suggested that more effort in understanding individual and bedside cultural issues would benefit plans to implement RRS in the future (Shearer et al., 2012). Johns Hopkins nursing evidence-based practice appraisal tool is Level V, Quality B.

Race (2015) reported on implementation of a MEWS screening tool on a single unit in a 520-bed tertiary care hospital in Pennsylvania over a 2-month period. This was defined as a performance improvement project, with a focus on staff education and reference cards to help reinforce the use of the MEWS tool and how to calculate the MEWS score. Due to the small sample size ($N = 50$) and minimal outcome data (compliance with MEWS scoring every 4 hours, number of cardiac arrests, unplanned ICU admissions), this study was graded Level V, Quality B using the Johns Hopkins nursing evidence-based practice appraisal tool.

Claussen et al. (2013) completed a retrospective chart review at a 100-bed rural hospital in east Texas over a 6-month period in 2012, with the purpose of identifying if there were early warning signs regarding patient decline before the RRT or Code Blue call. The authors' description of the implementation focused on education of the staff and staff participation in evaluating and providing feedback regarding a MEWS tool within the EHR that could alert the staff when a patient's vital signs and observation documentation indicated a decline in condition. Claussen et al. described the tool as aligning with the staff's clinical judgment. Observability of

the processes served as a catalyst for understanding the value of the tool and enhanced adoption of the tool. Claussen et al. considered implementation successful because of "improved situational awareness" (p. 16), reduction of RRT and code blue calls, and number of appropriate up-transfers to the ICU. The sample size and the lack of substantive data scored this study as Level V, Quality C on the Johns Hopkins nursing evidence-based practice appraisal tool.

Sanders et al. (2013) reported on the implementation of an electronic MEWS at a 523-bed acute care hospital in Portland, Oregon. Sanders et al. described the repeated educational efforts to get nurses and physicians to follow the protocol for responding to alerts as critical to the implementation success. The authors also described the importance of what Greenhalgh (2004) would call *observability*—the repeated publicizing of success stories, sharing unit-specific performance, sending feedback emails, providing one-on one mentorship so the staff had the knowledge to use the tool, and ensuring the benefits of the tool were visible to the clinicians. Sanders et al. indicated that the outcome measures of mortality rate, code blue events, and transfers to ICU had decreased, but there was little data provided in terms of sample size or process and other outcome measures. The sample size and the lack of substantive data scored this study as Level V, Quality C.

Rationale

Conceptual and Theoretical Framework

Many of the models that attempt to explain whether an innovation will be adopted have been based on Rogers' (2003) diffusion of innovation theory. Rogers' diffusion of innovation theory and Greenhalgh et al.'s (2004) comprehensive review of innovation were selected as this project's conceptual and theoretical framework because both examine the complex processes involved in successful implementation of new technology, such as AAM. Rogers argued that

each adopter's willingness and ability to adopt and share in innovation would depend on their awareness, interest, evaluation, trial, and adoption. The author proposed a five-stage model for the diffusion of innovation that is relevant to the implementation of AAM at the pilot sites and as AAM is expanded to all of NCAL:

1. Knowledge (learning about the existence and function of the innovation)
2. Persuasion (becoming convinced of the value of the innovation)
3. Decision (committing to the adoption of the innovation)
4. Implementation (putting it to use)
5. Confirmation (the ultimate acceptance [or rejection] of the innovation)

Expanding on Rogers' (2003) model, Greenhalgh et al. (2004) attempted to draw together further research on diffusion of innovations and integrated work from a variety of paradigms into an exhaustive conceptual model that sought to encompass 11 key attributes that support successful innovations (see Table 2). These key attributes are relative advantage, compatibility, low complexity, trialability, observability, reinvention, fuzzy boundaries, risk, task issues, knowledge requirements, and augmentation/support. While these key attributes are contributing, they are not "sure determinants of their adoption or assimilation" (Greenhalgh et al., p. 598). The interplay between these attributes and the intended adopter's individual traits associated with their willingness to try new innovations and their motivation, values, and learning style determine the individual or organizational behavior change.

Table 2

Attributes to Successful Innovation

Key Attribute to Successful Innovation	Description
Relative advantage	Innovations with a clear, unambiguous benefit and cost-effectiveness over existing practice are more easily adopted and implemented.

Compatibility	The innovation is in sync with the adopter's values, norms, and their perceived needs and their social systems.
Low complexity	Innovations perceived as simple to understand and use.
Trialability	Ability for experimentation and use on trial basis.
Observability	Benefits that are visible to others.
Reinvention	If potential adopters can adapt or modify to suit their own needs.
Fuzzy boundaries	Similar to concept of reinvention, complex organizations need the adaptiveness of a *soft periphery* (versus *hard core,* where elements cannot be modified).
Risk	Less risk or the greater balance between the risks and benefits increases likelihood of assimilation.
Task issues	Relevance to the adopter's work and potential for work performance improvements improves the chance of successful adoption.
Knowledge requirements	Ease of knowledge transfer within various contexts supports adoption.
Augmentation / support	Providing additional support to the technology (e.g., training and support, customization) enhances assimilation.

Greenhalgh et al., 2004

System readiness. Greenhalgh et al.'s (2004) synthesis further expanded on Rogers' (2003) model by describing specific critical elements of system readiness that were evaluated for this AAM project:

- Tension for change (the urgency for change in the current system)
- Innovation-system fit (whether the innovation fits with the organizational or individual perceived norms and values)
- Assessment of implications (whether the implications of the innovation have been fully assessed and anticipated)
- Support and advocacy (whether there are adequate numbers of supporters of the innovation that outnumber the opposition)
- Dedicated time and resources (whether the allocation of resources is sufficient and continuing)
- Capacity to evaluate the innovation (whether the organization has the skills to monitor and evaluate the impact of the innovation).

Each of the articles profiled for this paper have been correlated to Greenhalgh et al.'s

(2004) 11 key implementation attributes, which can be found in the Evidence of Synthesis Table (Appendix C). For example, key implementation attributes in Dummett et al.'s (2016) article include Greenhalgh et al.'s attributes:

- *Relative advantage*: EWS was messaged as a clear and unambiguous advantage in proactively identifying patients at risk for clinical deterioration.
- *Compatibility*: A chart review on current patients identified the direct evidence of compatibility of the target EWS population with the same patient population as the local clinicians, thereby validating the compatibility with the intended adopter's values, norms and perceived needs.
- *Complexity*: Through *reinvention*, staff were able to accept that the developing EWS processes were relatively easy to use and they were engaged in making needed changes.
- *Trialability:* Staff were involved in testing the early EWS workflows
- *Augmentation/support*: Staff were provided training and support to learn the system.

Page (2008) also emphasized the ease of use (complexity), the ability of the staff to revise the algorithm (reinvention), and the ability to test the system (trialability) as key elements of successful implementation. Page measured the success of implementation by evaluating compliance with documentation and nurse's satisfaction.

From Rogers' (2003) original and Greenhalgh's et al. (2004) synthesis on theories of diffusion, it is clear that in addition to structural processes, having an intimate understanding of the human side of change management—the alignment of the organization's culture, values, people, and behaviors—is integral to long-term structural transformation and acceptance of innovation.

Definition of Terms

Implementation. The term implementation refers to those specific plans and actions undertaken to make an intervention become part of clinical practice (Bukenborg, Poulsen, Samuelson, Ladelud, & Akeson, 2016).

Innovation. Rogers (2003) described innovation as,

> An idea, practice, or object that is perceived as new by an individual.… The perceived 'newness' of the idea for the individual determines his or her reaction to it. If an idea seems new to the individual, it is an innovation. Newness of an innovation may be expressed in terms of knowledge, persuasion, or a decision to adopt (p. 12).

AAM is new technology; although, its use is well known in clinical laboratory and vital signs data. AAM is a new concept and a new paradigm of thinking; although, MEWS are well documented. AAM uses new knowledge; it is an automatic predictive analytics system to identify patients at risk for clinical deterioration within 12 hours that is not based on clinician judgment and is scalable to expand.

Diffusion. Per Rogers (2003), diffusion is "the process in which an innovation is communicated through certain channels over time among members of a social system" (p. 11).

Specific Aim

Smart Goal

By June 2017, standardized and consistent AAM workflows and processes will be successfully implemented at two NCAL pilot medical centers, using Roger's (2003) diffusion of innovation, Greenhalgh et al.'s (2004) key attribution concepts, and an original Implementation Playbook co-developed by this author as the NCAL Regional Nursing Clinical Operational Leader on the KP AAM implementation team.

Section III. Methods

Context

KP NCAL regional executive leadership prioritized this project as one of their top quality initiatives for 2016/2017. The plan was to build from the learnings from the alpha sites, identify outcome targets, critically review the evidence, and synthesize the findings and gaps between the evidence in order to apply relevant learnings to the first beta site. Stakeholders would be identified in this practice change, the key attributes for successful adoption of innovation to implement this new practice would be utilized, methods to support standardization of the new practices would be developed, and the process and outcome measures for the purposes of scaling and expanding AAM to all NCAL facilities would be continually evaluated.

This technology is part of KP's cutting edge approach to provide the highest quality care and to deliver the right care at the right time. It aligns with the Kaiser Triple Aim drivers of quality, safety, and affordability and with the KP mission: KP exists to provide high-quality, affordable health care services and to improve the health of our members and the communities we serve. Clinician and stakeholder education of this new practice is accomplished through consistent messaging, frequent in-person and telephone conferencing methods, and through role modeling the new practices. Process measures data will be collected by regional data analysts and shared weekly and monthly to each local facility through in-person meetings, conference calls, and through a regional AAM intranet website. Based on DOR data analysis, the regional AAM implementation team will expand to a second and third beta site and then spread this AAM program in a staggered manner to all 21 facilities in northern California in 2017 through 2018. This writer is the regional clinical operational nurse leader who is partnering with a clinical

operational physician leader, Dr. Alex Dummett, and an AAM steering committee to implement the AAM program throughout NCAL.

One of the first decisions made by the AAM Steering Committee at implementation was to replace the current workflows used at the alpha sites with the introduction of a remote command center, eHospital, staffed by Kaiser Quality nurses with critical care background and one physician. There are several benefits of employing the eHospital model in implementation. First, by creating a PUSH instead of a PULL alert system, frontline RRT RNs do not need to independently filter and case find the patients who have triggered the AAM alert. Secondly, eHospital RNs can monitor the AAM alert more frequently, which increases the sensitivity of the alarms, while mitigating alert fatigue for frontline providers. Increasing the frequency of the clinical alert notifications to the RRT RN from every six hours to every hour increases the sensitivity of the alarms from 20% to 25% at the alpha sites to 49% at the beta sites (Escobar & Dellinger, 2016). Third, eHospital serves as a safety net to ensure that timely and appropriate action is taken to strengthen the patient's treatment plan. They provide hourly surveillance of the AAM alert and initial EMR case review, directly communicate to the RRT RN by phone all initial AAM clinical alerts from a custom website displaying the score trends, and add the patient to a shared electronic patient list. The eHospital nurses re-escalate the alert to RRT RN if the patient continues to deteriorate.

Specific required personnel and equipment resources are dependent upon workflows, phases of implementation, and whether the resource requirements are regional or local. In all cases, sufficient funding is required in order to ensure resources are available. Grant funding has provided specific data analyst and program support personnel, but this is time-limited to end in 2018. A review of the program will be ongoing, and executive leaders will make a determination

if these costs will be incorporated into operations or if additional time-limited funding will be pursued.

Regional Resource Requirements

What is unique about this project is the implementation using a KP regional implementation team. Key resources required for clinical implementation include the executive sponsors, two physician and nurse operational leaders, the eHospital program RNs and physicians, KP Health Connect (KPHC), regional palliative care / social worker leads, program consultants, a data analyst team, and DOR support (see Appendix D).

If the eHospital model is adopted for NCAL, an increase in eHospital staffing to support 24/7 coverage will be required before full deployment. Current eHospital coverage has been in place for several years from 4:00 pm to 12 midnight for oversight of quality care gaps; this was expanded to 8:00 am to 12 midnight for the purposes of this AAM pilot at the beta sites only. At the time of this writing, due to the success of implementation at the two beta pilot sites, eHospital has been given authorization to hire additional quality RNs to support 24/7 coverage.

Standardized RRT workflow and staffing. Standardized RRT workflow and staffing are requirements for successful AAM implementation. Regional patient care services staffing operations allocated one RN 24/7 or 4.2 full-time equivalents (FTEs) to each local ICU for an RRT/monitored transport assignment; however, many facilities did not utilize the FTE in this manner and simply added this resource to their ICU staffing. A July 2016 survey to all adult service directors in NCAL indicated that there is significant variability in RRT roles and processes across the region. Eighteen out of 21 medical centers have an RRT RN who is not assigned to patient care while they are in the RRT RN role. Other hospitals have a mature RRT program, with consistent workflows that include proactive rounding on high-risk patients and

consistent nursing assessment and documentation practices. Adoption of AAM in these mature programs is more likely due to alignment with the key attributes of compatibility, low complexity, observability, knowledge required to use, and task issues.

Inconsistency of the RRT RN role's alignment with the RRT workflows at some NCAL facilities is a potential resource barrier. At beta sites 1 and 2, the current RRT RN role is compatible with the new RRT RN workflows through the AAM program; beta site 3 has an RRT RN assigned to patient care, and part of their facility preparation is revising their staffing and workflows to standardize to the regional AAM model. As the nurse clinical leader, oversight of the RRT model, development of standardized RRT RN competencies and workflows, and advocacy for a consistent regional staffing model has been completed as part of the overall AAM project, but is out of the scope of this DNP project.

Technological workflow. Key resources needed for successful technological workflow implementation and sustained use include KPHC EMR functionality, KP information technology (KPIT) hardware infrastructure, functional Java webserver custom website, and the DOR database.

Data and analytics workflow. Key resources needed for successful data and analytics workflow include DOR physician leader and data analysts, the clinical operational leaders, and regional KPHC and KPIT personnel and equipment. Paralleling the innovative and sophisticated nature of the AAM program, a full-time dedicated analytic data consultant enabled the rapid development, testing, and implementation of reporting tools and analyses in support of program piloting, refinement, and full regional spread. Through this AAM initiative, a classic hospital operations translational research is being created, operationalizing an experimental model to practical real world application. The initial phase of analytic work has required the design of a

comprehensive measurement strategy, including implementation, process and outcomes, and balancing measures. Consulting and collaborating with a variety of clinical, technical, and operational subject matter experts, the analytic consultant has facilitated the gathering and transforming of business requirements into detailed specifications for a variety of reporting and analytic tools designed to monitor and track the performance of the program through each phase of its life cycle.

Communication workflow. Key resources needed for successful communications workflow include the regional medical and nursing chairs, the clinical operations leaders, and the DOR leaders, as well as the clinical excellence (CE) and quality operations support (QOS) business consultants. Both of the clinical operations leaders are master trainers for TeamSTEPPS, a patient safety communication strategy that supports coaching and team facilitation using evidence-based teamwork tools to optimize patient outcomes. Utilizing the TeamSTEPPS tools supports implementation by reinforcing knowledge transfer, reducing the complexity of the new workflows so they are more easily assimilated, and strengthening the relative advantage of AAM over current workflows.

Local Resource Requirements

A structured local implementation team (see Appendix E) for the local resources is needed. From a clinical delivery and communication perspective, this includes the local facility sponsors and leaders, physician and nursing champions, and key frontline clinicians, including the hospitalist, intensivist, surgeon, ICU RN manager, RRT RNs, inpatient social worker, palliative care team, quality director, and performance improvement director. From a technological and data perspective, local KP Information Technology (KPIT) and KP Health Connect (KPHC) personnel and systems must be engaged and the equipment functional. Teams

must be in place who will provide data collection (if collected manually), as well as interpret data shared by the region specific to their facility process, implementation, and outcome measures. Service specific educators/champions must be available to share knowledge and to augment clinical training for all of the specialties involved. Clear roles and expectations for each of the team members were developed to reduce role overlap and promote coordination (see Appendix F).

Information Flow Requirements

At the regional level, maintaining consistent information flow is a critical component of planning and implementation of this innovative project. This information flow must occur dynamically and is both horizontal, as well as bi-directional, in nature. A regional workgroup with representation from all stakeholder groups to refine and standardize AAM workflows has been convened, an email distribution list that includes all stakeholders has been created, weekly AAM planning meetings has engaged stakeholders, and an internal shared drive (Sharepoint) where all relevant communication is maintained by the project consultants has been created. In addition, the QOS team created a KP intranet website (see Appendix G), which is maintained by data analyst but accessible to the pilot sites. This website houses weekly and monthly data, as well as relevant implementation and update materials.

Consultation with local stakeholders during the weekly AAM steering committee meetings, during regular training at the local facility, and at monthly collaborative calls supports successful adoption, promotes sharing of best practices, and enhances implementation. The use of templates for the monthly collaborative calls provides a consistent framework for reporting out facility status and needs. As noted earlier in the discussion regarding Greenhalgh et al.'s (2004) and Rogers' (2003) diffusion of innovation conceptual models, important prerequisites

for adoption are that the adopters are aware of the innovation, have continuing access to information about the innovation, are provided sufficient training and support on task issues, and have sufficient opportunity, autonomy and support to refine the innovation. Having regional leader visibility at the local facility and facilitating a reliable and consistent information flow with the local stakeholders are key factors that support successful implementation.

Strategic Messaging Plan

The strategic messaging plan is to provide consistent messaging and promote acceptance of pilot implementation of the AAM system. It is important for all stakeholders to understand what AAM is and how it benefits patient care.

Communication Objectives

In communicating information about this pilot program, the goals are to:

1. Obtain support from internal leaders, stakeholders, and the nursing union to obtain the resources needed and reduce barriers to implementation.
2. Distribute information to help physicians, nurses, and support care services respond to patient questions and concerns about AAM.
3. Sustain excitement and ownership of the AAM pilot.
4. Inform patients about the AAM and the high-quality care it reflects.
5. Improve and strengthen the perception of KP as a health care leader.

Stakeholder Demographics

Selling the message effectively requires targeting communication to the appropriate audiences. A message map describes the category, stakeholder group, purpose of communication, and key messages for each of the categories (see Appendix H).

Key Messages by Stakeholder

Messaging cascades to all stakeholders from the core message, with customized variations based on the stakeholder. For example, the core message that "AAM provides early recognition of clinical deterioration and saves lives" is the consistent thread through all of the messages. For the executive messages, the message focuses on how these benefits reduce LOS, save money, and build reputation. For the clinicians, the message is on their role in saving lives and how their participation in this pilot makes a difference in creating workflows that will be used in all of NCAL. A communication strategy was approved by a patient and family advisory committee for the stakeholders and includes suggested scripting, considerations for the messenger, and potential stakeholder objections to the message and to the AAM concept (see Appendix I).

Various platforms are utilized to promote the message and all of them begin with a patient story that hones the value of AAM as a tool to save lives. An implementation readiness checklist, an Implementation Playbook, a website with AAM information including FAQs, and several weeks of training and shadowing clinicians are strategies in place to support the communication plan. Attendance by the two regional clinical physicians and nurse operational leads at local staff meetings, informal clinician meetings, daily debrief calls, and weekly steering meetings are part of the multi-pronged approach to providing consistency in messaging and practice (see Appendix J).

Data Dictionary

Understanding the terminology of AAM is critical to developing data measurements that are measurable and aligned between all stakeholders. A data dictionary developed collaboratively between the AAM regional implementation team and the local facility beta sites

is presented in Appendix K. The data dictionary is dynamic and continually reviewed and revised as new situations or questions arise between stakeholders. Changes are noted in the weekly AAM dashboard, as well as the historical context of the change is indicated in the AAM KP intranet website.

Interventions

Planning the Intervention

Process breakdown structure. The steps used to implement the AAM pilot program at beta site 1 can be found in the process breakdown structure (see Appendix L). The timeline for implementation is detailed in Appendix M.

Assessments of readiness. Assessment of readiness to implement the AAM pilot formally begins with the dissemination of the Pilot Readiness Checklist (see Appendix N). This checklist is included in an invitation letter to the facility leaders to participate in the pilot, and assessment of this checklist continues on an ongoing basis through discussions at steering committee meetings and informal contacts with leadership and staff.

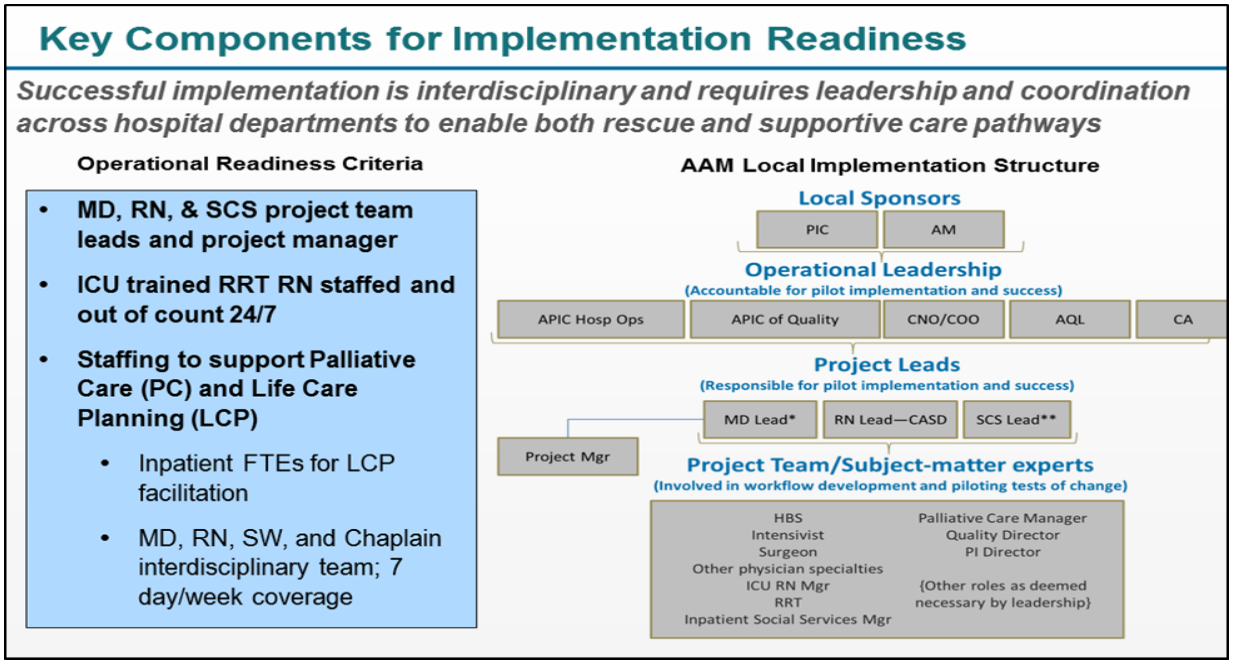


Figure 2. Key components for implementation readiness

Table 3

Definition of terms for the AAM Local Implementation Structure

Acronym	Description
PIC	Physician-in-Chief
APIC	Assistant Physician in Chief
CNO/COO	Chief Nursing Officer / Chief Operating officer
CASD	Clinical Adult Services Director
SCS	Supportive Care Services
HBS	Hospital Based Services (Hospitalist)
PI Director	Performance Improvement Director
SW	Social Worker

The AAM implementation team has organized the regional workflows necessary for implementation into four workflow categories: clinical delivery, technology, data and analysis, and communication (see Appendix O). Each of these workflows has specific tasks associated with them; all of these tasks align with Greenhalgh's et al. (2004) conceptual model of innovation, with particular emphasis on knowledge and ease of knowledge transfer, compatibility of the innovation to the adopter's values and norms, the meaning of AAM by the individual matching the meaning attached by top management and other stakeholders, and reinvention or the ability to adapt the AAM work processes to suit their own needs.

While availability of the AAM score in the inpatient setting was associated with improved patient outcomes, critical factors in successful implementation have included the involvement of the frontline staff in developing and testing optimal workflows to ensure that the right resources are provided to the right patients at the right time. A phased implementation that uses established performance improvement approaches (e.g., Institute for Healthcare Improvement Plan-Do-Study-Act, PDSA) to test, modify, and optimize workflows has been proposed. A swim lane diagram that depicts the proposed workflow reflected the complexity of the AAM process (see Appendix P). These workflows have some *hard peripheries* that frontline staff were instructed must be maintained for efficacy of the AAM program, but there were many *soft peripheries* that could be revised by the stakeholders to fit the organization. Color coding the various steps allowed clinicians to visually see which steps were hard peripheries and which could be revised by the stakeholders. Greenhalgh et al. (2004) and Rogers (2003) agreed that allowing potential adopters to adapt, refine, or otherwise modify the innovation supports its reinvention and assimilation into the organization.

Phases of implementation planning. The scope of work was divided into four planning phases, three of which are the focus of this paper. It is anticipated that support will differ based on project phase. Work involving KPIT, KPHC, and the DOR will take place concurrently during these four phases; all phases are coordinated by the clinical operations leaders and the AAM implementation team. Throughout this implementation, the concepts of diffusion of innovation theory are incorporated in order to ensure the maximum capacity for implementation success.

- Pre-Deployment Phase: Assessment of facility and stakeholder readiness and planning for implementation**.** During this phase, assessment of the current state,

facility readiness, and organizational, leadership and cultural infrastructure occurs. Preparatory work is completed by the AAM implementation team.

- Phase I: Beta1 pilot go-live with AAM workflows**.** For this phase, workflows continue to be tested and optimized, including incorporation of eHospital, which was not used at the two alpha pilot sites.
- Phase II: Implement AAM at a beta 2 hospital. Based on learnings from the beta pilot 1, AAM will be implemented at a second beta medical center, testing the effectiveness of the Implementation Playbook developed based on experience. Depending on the learnings from the beta 2 implementation, this phase may be extended to include another hospital to further test the Implementation Playbook.
- Phase III: Regional deployment of AAM in all hospitals. Once the effectiveness of AAM workflows with eHospital in beta pilot site(s) has been proven (approximately three months for outcomes data following the beta 1 launch), concurrent spread of optimal AAM workflows to multiple hospitals will begin. Implementation will proceed in geographic clusters of two to three medical centers in order to ensure control sites for evaluation purposes; however, at this stage the rate of spread is anticipated to accelerate. Examination of this phase is not within the scope of this paper.

Plans for Project Control

As a NCAL quality priority initiative, AAM has the sponsorship of the highest executive leaders in the NCAL organization. Regional leaders participate in the AAM steering committee, and formal controls exist to inform regional peer groups and NCAL executive leadership of the status of the AAM project and to seek guidance, as needed.

The AAM steering committee meets monthly, the AAM planning committee meets weekly, and assigned project managers from the clinical effectiveness team and the QOS team coordinate the work and maintain communication between all team members. Specific deliverables and the status of the project are reviewed in detail at these meetings. Communication is further facilitated through use of an internal Sharepoint on the KP website for the AAM steering committee members. An intranet portal for the Kaiser pilot sites (as shown in Appendix G) has been created to house FAQs, workflows, meeting minutes, and relevant plot site data.

Lines of authority and responsibility. The AAM project is considered a priority for NCAL KP. The regional implementation team structure has been described and has been detailed in Appendix D. Although, there is not direct line authority, the regional teams cascade the authority and responsibility for implementation to the local facility teams and their leadership

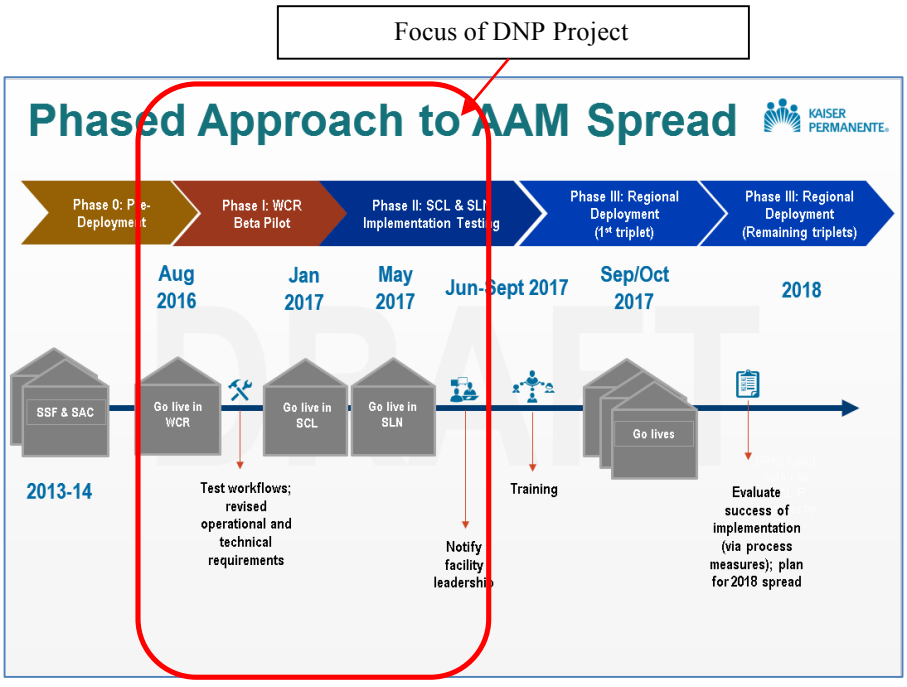


Figure 3. Phases of implementation.

SCL: Santa Clara; SLN: San Leandro; SSF: South San Francisco; SAC: Sacramento

Implementation of the Project

Pre-deployment phase: Assessment of facility and stakeholder readiness and planning for implementation (eight months of initial beta site, three months at beta 2). Pre-deployment preparation, socialization, assessment, planning, and refinement of the AAM process began approximately eight months prior to go-live at the first beta site.

Pre-deployment socialization. The socialization phase began prior to the official beta site kick-off through regional presentations of AAM to key medical center administrative and quality leaders and dissemination of the early, improved mortality and LOS results from the alpha pilot sites by the clinical operations leaders. Messaging the clear, unambiguous relative advantage (Greenhalgh et al. 2004) of AAM as an innovation that saves lives and reduces LOS created a sense of "I want in!" at the medical centers, with several medical center leaders expressing early interest to participate as a pilot site for future expansion. Once the pilot sites were selected by KP executive leadership and the executive medical facility leaders formally accepted their invitation to be a pilot site, communication and socialization of the AAM concepts to multiple stakeholder groups occurred early and often.

Assessment of readiness to change. A regional conference call facilitated by the clinical operations leaders, followed by an in-person regional kick-off meeting, socialized the concepts of AAM with key physician, nursing, and palliative care stakeholders from the beta site facilities and laid the groundwork for this innovation. A sense of urgency was created, and the formal case for change and the creation of a new reality where patient lives were saved through early detection was articulated. A pilot readiness checklist was developed, with key regional and local stakeholders identified, roles created, expectations clarified, and governance structure determined. Agreement was reached to begin this journey together, with local facility leadership

accepting the responsibility for being champions for the AAM program. Specific roles and responsibilities for each key stakeholder were read aloud by each service leader (see Appendix F), which reinforced their multidisciplinary accountability to the success of the AAM implementation. (Key attributes: tension for change, compatibility, knowledge, champions).

Assessing the institutional resources and capacity for change. A survey of all facilities to determine their current RRT staffing and practices was completed, as well as shadowing and interviewing of the current alpha site facility RRT process by the clinical operations leaders and business consultants to gain deeper understanding of current process. A risk assessment was completed in collaboration with the beta site leaders, and the pros and cons of implementing AAM, as well as the timing, were reviewed and discussed (see Appendix Q). Because the Walnut Creek facility was anticipating a major accreditation survey, and the eHospital team needed to hire and train clinicians to support the workflows, the actual implementation was delayed for several months to allow these to occur. (Key attributes: compatibility, complexity).

SWOT analysis. As a framework for identifying and analyzing the internal and external factors that can have an impact on the viability of AAM implementation, a SWOT analysis was developed. Strengths, weakness, opportunities, and threats are identified in Figure 4. This served to ascertain if the project was worth pursuing, as well as what was required to make it successful. This matrix also helped KP match its resources to the environment, with consideration of mitigating potential weaknesses and threats. The primary strengths identified included: DOR resources/expertise, competence of the AAM implementation team, alignment with KP strategy, executive support, preliminary data success that motivates leaders to participate in expansion, data analysts dedicated to this project, and early integration of supportive services. The primary weaknesses identified included: KPIT timelines and workload, high touch needed for scalability,

exposure of local system gaps, inconsistent RRT RN staffing, and possible alarm fatigue. The primary opportunities identified included: lives saved, reduction in LOS, expansion to all 21 NCAL facilities, and standardization of RRT staffing and workflows. Finally, the primary threats identified included: potential sudden change in direction from AAM to another new priority, possible legal liability concerns, uncertainty regarding nursing union resistance, potential local refusal to fully staff RRT RNs and supportive services, and lack of service agreements between surgical and medical physicians regarding ownership of the AAM alerts.

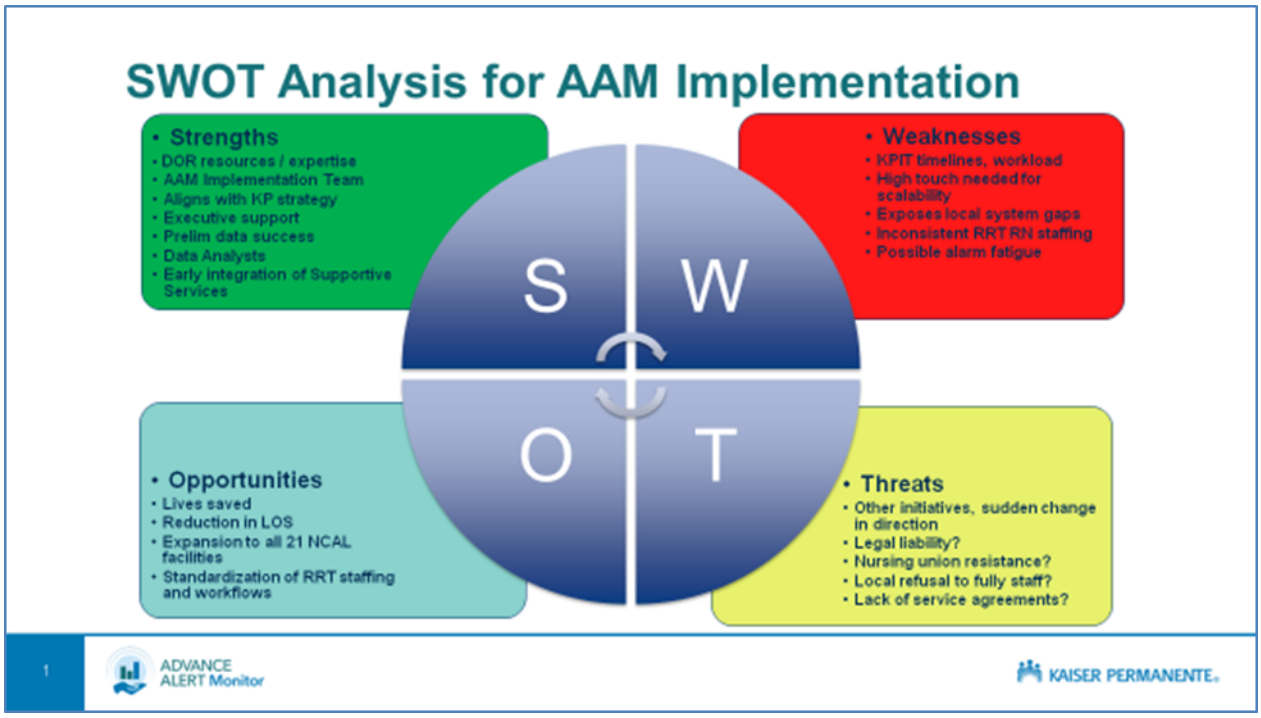


Figure 4. SWOT analysis.

Planning. To facilitate planning, regional and parallel local AAM steering committees and working groups were created, with bi-directional workflows established and leadership support clearly articulated. (Key attributes: knowledge, augmentation/support). Iterative discussions were held within the regional team to more clearly define the role of the eHospital

team, develop norms and definitions, and create the initial communication and flow process that would be revised using the PDSA improvement model throughout the pilots. Questions were asked, such as: How do we get the AAM score from eHospital to the RRT RNs? How will we staff the eHospital during the beta pilot? How do we handle repeat firings of the AAM—are all alerts called to the RRT RN? Are there any scenarios that can be suppressed to reduce alarm fatigue? What kind and what frequency of documentation will be required for both the eHospital and the local clinicians? Local guidance was provided with checklists, such as Table 4, so the project manager and local leadership could anticipate next steps of the implementation. Go-live generally takes approximately seven to eight weeks from the first kick-off meeting.

Table 4

Weekly Timeline for Local Implementation

Implementation Step	2 weeks before kick off	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Ongoing
Identify MD, RN, SCS Leads, project manager, & implementation team members										
Hold Kick off meeting										
Weekly Local Implementation Team Meeting										
Assess facility readiness & interdepartmental agreements for hospital escalation										
Review AAM workflows & establish agreements across stakeholder groups										
Develop communication & change management plan										
Develop training plan										
Cascade communication										
Train staff on workflows & documentation										
Simulation & “test runs”										
Go live										
Evaluation & ongoing performance Improvement										
Attend Regional Collaborative Calls										

During pre-phase, the implementation team worked toward gently pushing responsibility for design and implementation in a downward cascade, so that the staff and leaders who are identified and trained are aligned with the vision of AAM were equipped to execute their roles with knowledge of AAM and were motivated to make change happen. Subsequent beta 2 site preparation built on the learnings from the first beta site; due to the holiday season, the timeline required 12 weeks from first kick-off (October 31, 2016) to go-live (Jan 18, 2017).

Socialization. Interactive formal presentations were provided by the clinical operations leaders at RRT, ICU, staff nurse, hospitalist (HBS), nursing union, anesthesia, palliative care, social work, and family advisory meetings; informal clinical operations leader rounding with individual RRT RNs and stakeholders supported consistent messaging and the assimilation of AAM into the culture of the facility. The AAM alerts were introduced during this pre-implementation period to both validate the workflow process and provide training for the frontline clinicians. Key local facility clinicians had access to the external Java server to view the alerts in preparation for go-live, but formal notifications were not called to the RRT RN. This period was used to socialize the clinicians to the volume and type of initial alerts and to allow both the regional and local teams to estimate the tool's alerting sensitivity, predictive value, and likelihood of alerting compared to the local clinician's knowledge of current patient acuities.

Grant funds were used to create a distinctive AAM logo, with a hand holding bar data inside a crystal ball, which reflected the predictive analytic nature of the tool (see Figure 5). Badge holders, pens, and lunch bags with the AAM logo were also purchased with these funds for the clinical staff at each facility. After training, vests with the AAM logo were provided for the RRT nurses to create a sense of teamwork and purpose. (Key attributes: knowledge, observability).

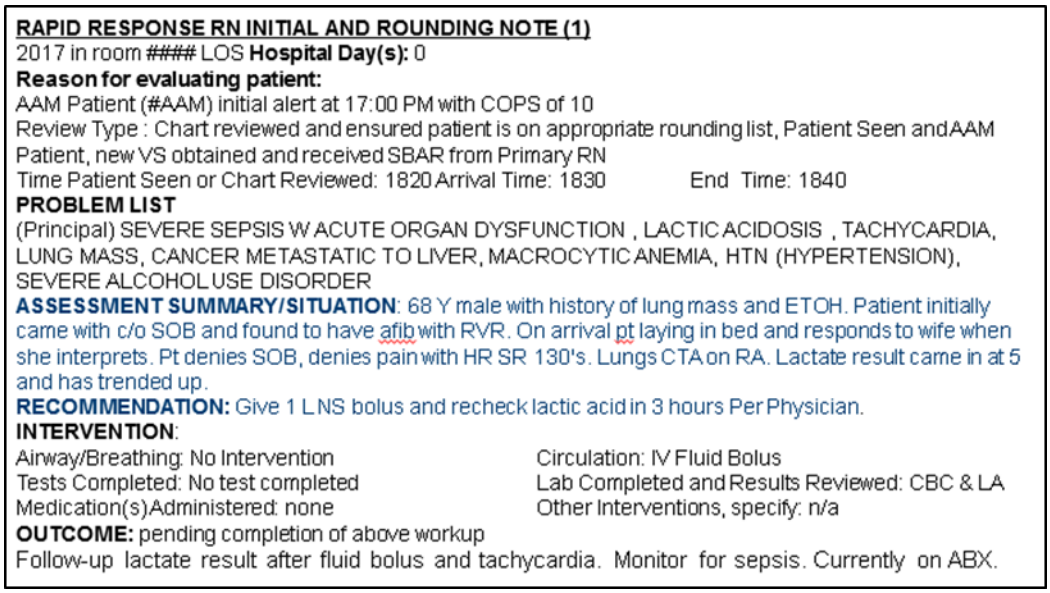
Figure 5. AAM logo.

Refinement. Operations leaders and eHospital team members provided regular opportunities to test the workflows with the beta site clinicians, starting four weeks prior to go-live. In coordination with the beta site team, several times weekly, the key clinicians (HBS, RRT RN, ICU manager/educator) gathered in a room or via telephone conferencing with the clinical operational leaders and eHospital clinicians. AAM *fire*s were simulated using actual patient data from the KPHC and DOR server. Clinicians were able to practice receiving the eHospital call, using closed loop communication to validate the message, documenting in the KPHC, contacting the primary nurse and the HBS, and testing the communication and documentation processes in a safe and confidential environment.

Daily huddles. Daily huddles were held with the clinical operation leaders, RRT RNs, local nursing and physician leads, and project manager to learn what worked and what needed adjustment from the frontline staff perspective. These huddles built trust in the AAM process; clarified workflow, escalation, and documentation expectations; and promoted understanding of the appropriate clinical responses. Actual patient scenarios were reviewed, clinical decision making was discussed, and recognition for any gains in compliance to documentation and workflows were celebrated. The frequency of the huddles decreased as the local clinicians expressed comfort with the implementation and assimilation of the processes. (Key attributes: trialability, knowledge, augmentation /support).

Workflows and standardized documentation. Workflows and standardized documentation smart phrases (preformatted phrases, EPIC) were developed with input from the

clinicians, and a *clinical sandbox*, with 30 actual clinical scenarios created in the KPHC to provide clinicians with simulations that can be tested within a safe training environment. These smart phrases are preformatted electronic documentation that allow the clinicians to use short cuts to easily insert data or text into their note. Using the PDSA performance improvement cycles, several iterations of the workflows and documentation smart phrases were performed until the clinicians felt their processes were ready for formal dissemination. As noted in Figure 6, only the text in blue needed to be entered by the RRT RN; the text in black auto-populated from KPHC, which promoted ease of use. (Key attributes: reinvention, low complexity, augmentation/support, fuzzy boundaries, champion).



RAPID RESPONSE RN INITIAL AND ROUNDING NOTE (1)
2017 in room #### LOS **Hospital Day(s):** 0
Reason for evaluating patient:
AAM Patient (#AAM) initial alert at 17:00 PM with COPS of 10
Review Type : Chart reviewed and ensured patient is on appropriate rounding list, Patient Seen and AAM Patient, new VS obtained and received SBAR from Primary RN
Time Patient Seen or Chart Reviewed: 1820 Arrival Time: 1830 End Time: 1840
PROBLEM LIST
(Principal) SEVERE SEPSIS W ACUTE ORGAN DYSFUNCTION , LACTIC ACIDOSIS , TACHYCARDIA, LUNG MASS, CANCER METASTATIC TO LIVER, MACROCYTIC ANEMIA, HTN (HYPERTENSION), SEVERE ALCOHOL USE DISORDER
ASSESSMENT SUMMARY/SITUATION: 68 Y male with history of lung mass and ETOH. Patient initially came with c/o SOB and found to have afib with RVR. On arrival pt laying in bed and responds to wife when she interprets. Pt denies SOB, denies pain with HR SR 130's. Lungs CTA on RA. Lactate result came in at 5 and has trended up.
RECOMMENDATION: Give 1 LNS bolus and recheck lactic acid in 3 hours Per Physician.
INTERVENTION:
Airway/Breathing: No Intervention
Circulation: IV Fluid Bolus
Tests Completed: No test completed
Lab Completed and Results Reviewed: CBC & LA
Medication(s)Administered: none
Other Interventions, specify: n/a
OUTCOME: pending completion of above workup
Follow-up lactate result after fluid bolus and tachycardia. Monitor for sepsis. Currently on ABX.

Figure 6. Smart phrase EPIC RRT documentation sample developed by stakeholders and clinical operational leaders.

Training and practice sessions. Specialized training and practice sessions for the eHospital team were conducted to ensure inter-rater reliability of the electronic chart reviews; to ensure consistency in critical decision making, such as suppressing repeat AAM fires if there is a

documented intervention in the KPHC; and to practice closed loop communication with the RRT RNs.

Educational tools. Educational tools that supported clinician training and communication were created. These included educational slide decks and role cards for the HBS, eHospital team, RRT RN, primary RN, nurse leader, physician leader, and palliative care/social work that provided a sequential step-by-step process for each of the workflows specific to their role. The role cards included scripts for the RRT RN, primary RN, HBS, and leaders and was developed with guidance from a patient advisory board. Scripting provided clinician guidance in communicating a consistent message to the patient in a sensitive manner about their AAM alert without alarming the patient. Additional educational tools included a 15-minute video titled *What is AAM?* created by the clinical operational leaders, which was required for staff to review, and a 1-page information sheet that summarized the purpose and key benefits of AAM. (Key attributes: relative advantage, low complexity, knowledge, augmentation /support.

Phase I: Beta 1 pilot go-live with AAM workflows. AAM went live for beta site 1 on August 1, 2016, upon which new alerts resulted in notification by eHospital to the local RRT RN. For this phase, the regional AAM implementation team tested and optimized workflows incorporating eHospital, which was not used at the two alpha pilot site. The major advantages that accrued from employing eHospital were (a) more frequent monitoring of AAM alerts, which increases sensitivity of the system without decreasing specificity; (b) protection of clinical staff from alert fatigue; and (c) ensuring fidelity with the intervention.

In order to incorporate eHospital into the workflow, a confidential external website using a Java server was developed and optimized to support the use of the AAM score by eHospital

staff. See Figure 7 for an AAM website screenshot of a patient who alerted with an AAM score ≥8%, the threshold for RRT response.

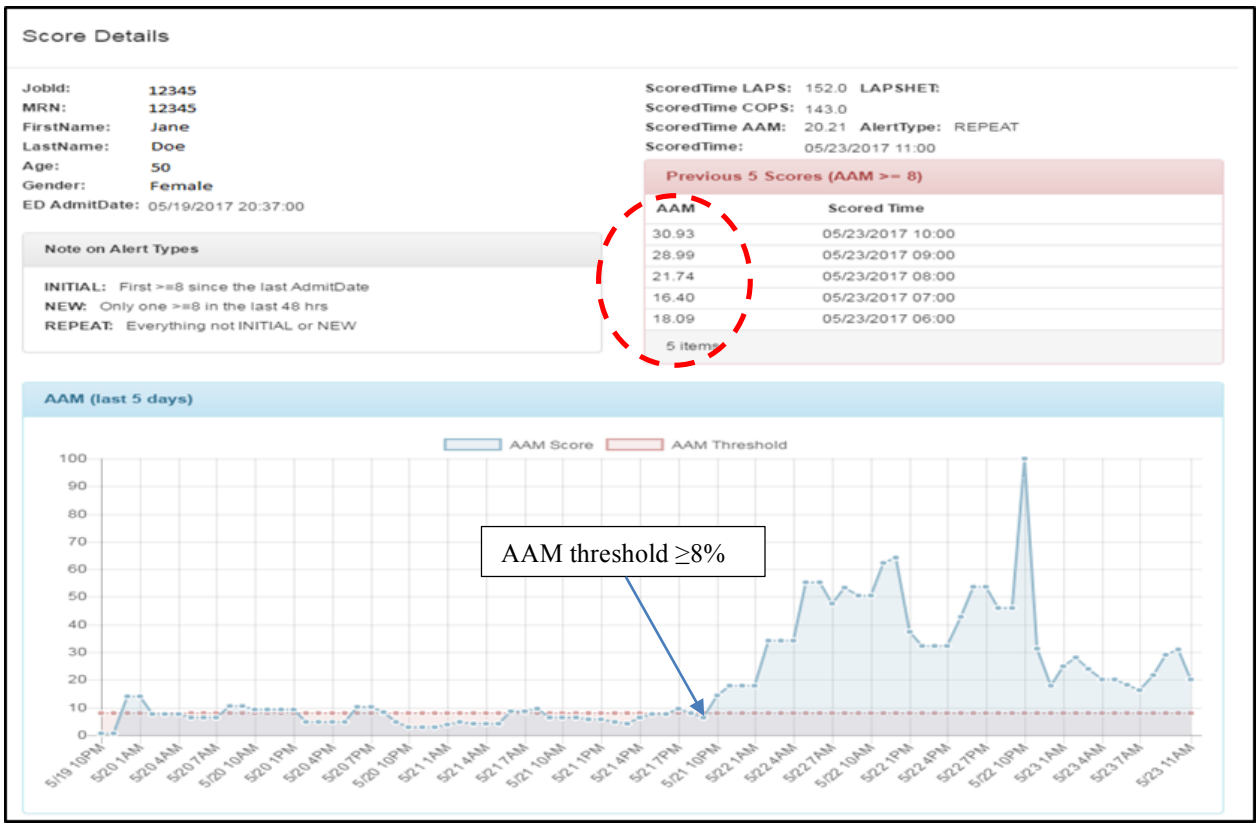


Figure 7. Sample AAM website view from Java server

Workflows to incorporate supportive care services were also developed and optimized. An Implementation Playbook was developed and tested (see Table of Contents in Appendix R). Planning, socialization, refinement, training, and educational tools that had been developed during the pre-implementation phase were continually improved using PDSA methodologies and frontline clinician input. The ability to revise workflows and KPHC documentation immediately by the physician clinical operational leader built trust and demonstrated a key attribute of trialability, which allows intended users to more readily adopt and assimilate the innovation.

Phase II: Implement AAM at a second beta hospital. Based on learnings from the beta pilot 1, AAM was implemented at a second beta medical center, testing the effectiveness of the toolkit developed based on experience. The same pre-deployment assessment, kick-off process, planning, refinement, communication strategies, clinical shadowing, and data meetings were held with the Santa Clara team. Unique cultural and operational issues were uncovered that needed escalation to executive sponsors for resolution. For example, one learning was that Santa Clara had more complex surgical subspecialty departments than Walnut Creek. These subspecialties with admitting privileges often had their own covering physicians and escalation service agreements and did not want the hospitalist to manage their patients; ICU was staffed 24/7 and consulted, as well. Likewise, there was hesitation from the hospitalists to manage surgical patients as primary responders to AAM alerts; the hospitalists preferred the surgeons to manage their own patients due to many reasons. Santa Clara had Stanford surgical residents and in-house surgeons 24/7, and early identification of clinical deterioration is vital for their education. Regional recommendations based on experience (to promote consistency of practice due to the volume of patients seen) is for the hospitalists to be the primary AAM responders for those non-surgical specialty patients who do not already have dedicated surgical coverage. Communication and coordination between the services is a delicate and culturally-based issue that continues to be discussed.

Santa Clara already had a mature RRT RN program and had a process for proactive rounding. The RRT RNs were a select and experienced group and responded well to the early AAM socialization by the clinical operational leaders. With their strong local leadership support, it was anticipated that this team would accept this innovation well, as all of Greenhalgh et al.'s (2004) key attributes of innovation were present.

Adding to the learnings from the beta 2 implementation, this phase was extended to include a third hospital to further test the Implementation Playbook.

Study of the Interventions

Measures

Process measures were studied on a weekly basis, ensuring weekly data reflected all of the steps in the workflow to understand gaps or breakdowns in the process. Small tests of change often required substantial stakeholder alignment, slowing the process of quick iterations. All of the measures were de novo specific for this AAM effort, and measures were regularly added based on weekly stakeholder requests. At times, due to the direct communication of the frontline staff and leaders to the clinical operational leaders, just-in-time additions were made to the process measures, sometimes daily. Clarification of definitions were regularly needed, as the frontline teams (nurses, physicians and supportive care services) thoroughly investigated and reported out on each patient whose clinical path did not conform to expected workflows; this ensured accuracy of each entry on the measurement dashboards. The data analyst for the team regularly attended the weekly local calls, as well as the monthly collaborative calls, and was able to make immediate revisions in the dashboards. All revisions to the dashboard were tested and validated by the data analyst prior to dissemination. It is anticipated that once the beta pilots are finalized, a stable measurement dashboard will be spread as the project expands. For details, see Appendix S for the data measurement dictionary.

Analysis

Formal analysis of the outcome measures has been done by the DOR. Programming code development has involved connecting and drawing data from multiple source systems, including KPHC backend storage relational database (Clarity), as well as KPIT computing analytic Java

web service and a Microsoft relational data base (MSSQL), a quality eHospital MIDAS database. Raw data from these source systems have been transformed and loaded into data tables that underlie a variety of reporting and analysis instruments. Reports have been developed and produced to facilitate aggregate-level regional program oversight, track performance trends over time, and supply detailed case-level information to hospital care improvement teams on a weekly basis. Advanced analytic techniques have been employed, including probability modeling, comparative time-series analyses, and severity of illness risk adjustments.

Ethics

Implementing an innovative technology such as AAM brings inherent risks and legal/ethical issues that must be evaluated and addressed. The DOR project itself was approved by the KP Medical Care Program Institutional Review Board for the Protection of Human Subjects. There were no ethical issues specific to this AAM implementation project; IRB approval for this DNP project was not required. A statement of determination as a non-research project was approved by the University of San Francisco faculty. Both facility support and a statement of determination as a non-research project approval can be found in Appendices T and U.

Cohen, Amarasingham, Shah, Xie, and Lo (2014) described the advances in technology and the EMR making it possible to leverage decades of work in statistics, computer science, and clinical decision support to identify patients at high or low risk for serious complications or adverse clinical events, preventing those adverse events and optimally allocating scarce resources. Cohen et al. argued that predictive analytics models make care recommendations designed to improve overall population health outcomes, but may do so in conflict with an individual patient's best interests. AAM does not support exclusions from care to the high-risk

and vulnerable population. However, Cohen et al. described situations where doctors might withhold potentially effective treatments from patients based on lower probability statistics that they might benefit. Doctors who rely on such models could face an increased risk of liability.

Another ethical issue brought forward by Cohen et al. (2014) was the potential for risks to privacy, consent, and fairness with the use of big data. Histories of abuses with research models that utilize big data, such as abuses involving African Americans, people with disabilities and a loss of decision-making capacity, and other vulnerable groups, contribute to fears that predictive modeling can lead to abuses, as the data could be used to identify vulnerable high-risk, high-cost patients and exclude them from care.

Escobar and Dellinger (2016) argued that there might, in fact, be harm from early detection. Transferring a patient from the ward to the ICU as a preventative measure after an AAM alert may tie up an ICU bed, for example. The ICU bed may be unavailable for a new patient in the emergency department; to mitigate these risks, Escobar et al. suggests there is a need to couple early detection with systems that monitor bed capacity proactively. Furthermore, as EWS becomes standard of care, if an alert is issued and clinicians do not take action and do not document that decision, EWS may expose both individuals and healthcare institutions to medical-legal risk.

This project aligns with the Jesuit values of the University of San Francisco regarding care of the whole person, as well as the ANA Code of Ethics for Nurses. The ethical obligations of all RNs, as described by Winland-Brown, Lachman, and Swanson (2015), involves respect for human dignity, relationships with patients, promotion of patients' health, and the right to self-determination and accountability for nursing practice. Nursing is a critical component of AAM, and adherence to these ethical principles supports nursing practice in a manner consistent with

quality and the ethical obligations of professional nursing.

Data storage and security. All data are stored securely through encrypted IT servers, so patient medical health information confidentiality is assured. The regional data team has access to the AAM database within KPIT. Access to KPIT servers is managed by IT. The KPIT servers store AAM data from the two alpha sites and the two beta pilot sites only. In contrast, the DOR has access to a secure and encrypted database within the DOR. These data are only accessible by the DOR analysts and contain AAM data for all 21 NCAL facilities (see Appendix V).

Section IV. Results

Initial Steps of the Intervention and Evolution Over Time

Engagement of the frontline staff has been a key factor for the success of this implementation. From the start of the implementation process, frontline RRT RNs and the frontline physicians were involved in the design and testing of the AAM workflows and documentation. Workflows were regularly reinvented in PDSA cycles. In order to combat alarm fatigue for both the eHospital staff and the local RRT RNs, for example, significant revisions in processes and documentation were implemented after multiple tests of change. Considering the key attribute of complexity, Greenhalgh et al. (2004) postulates "innovations that are perceived by key players as simple to use are more easily adopted" (p. 596). Although, initial alerts called from the eHospital to the RRT RN might only be four or five per 16-hour period, hourly automated alerts could trigger until the patient stabilizes. This could result in repeat alerts that could cause alarm fatigue, which could be a patient safety concern. The RRT RNs voiced frustration over repeated alerts by eHospital regarding patients who had a plan of care in place, were new transfers from the ICU, and had an expected temporary course of clinical instability or were receiving scheduled procedures that had known transient clinical variability.

Developing *snooze* criteria in collaboration with the frontline RRT RNs and eHospital staff (key attribute: reinvention) was iterative but essential to reducing complexity and increasing the compatibility of AAM as an innovation that aligned with the adopter's values and norms of patient care and reduced unnecessary alerts. Based on specific clinical criteria and their clinical judgment, the eHospital nurse snoozed the alarms to the RRT RNs, so only those alerts which required RRT RN intervention were called (see Appendix W). This reduced the alarm fatigue and enhanced adoption for the RRT RN, the eHospital RNs, and the physicians who would

otherwise be called by the RRT RN for further assessment. Figure 10 reflects pre- and post-implementation data that show the date on the *x* axis and the number of RRT-managed patients on the *y* axis. The timeframe January 2016 to August 2016 shows the median number of patients seen by the RRT RNs during proactive round, as evidenced by their documentation in KPHC, before AAM implementation was 12.0. AAM shadowing (noted in red) began the last two weeks of July and preceded actual go-live implementation on August 1, 2016. With AAM implementation, the number of patients increased from a median of 12.0 per day to 17.4 per day, which includes the additional five patients attributed to AAM alerts. The impact of incorporating the snooze criteria on February 14, 2017 is evident in the 60% median reduction of AAM patients seen from five per day to three per day. Staff expressed satisfaction that their workload was reduced and the snooze criteria was consistent with their clinical judgment of the acuity of their patients.

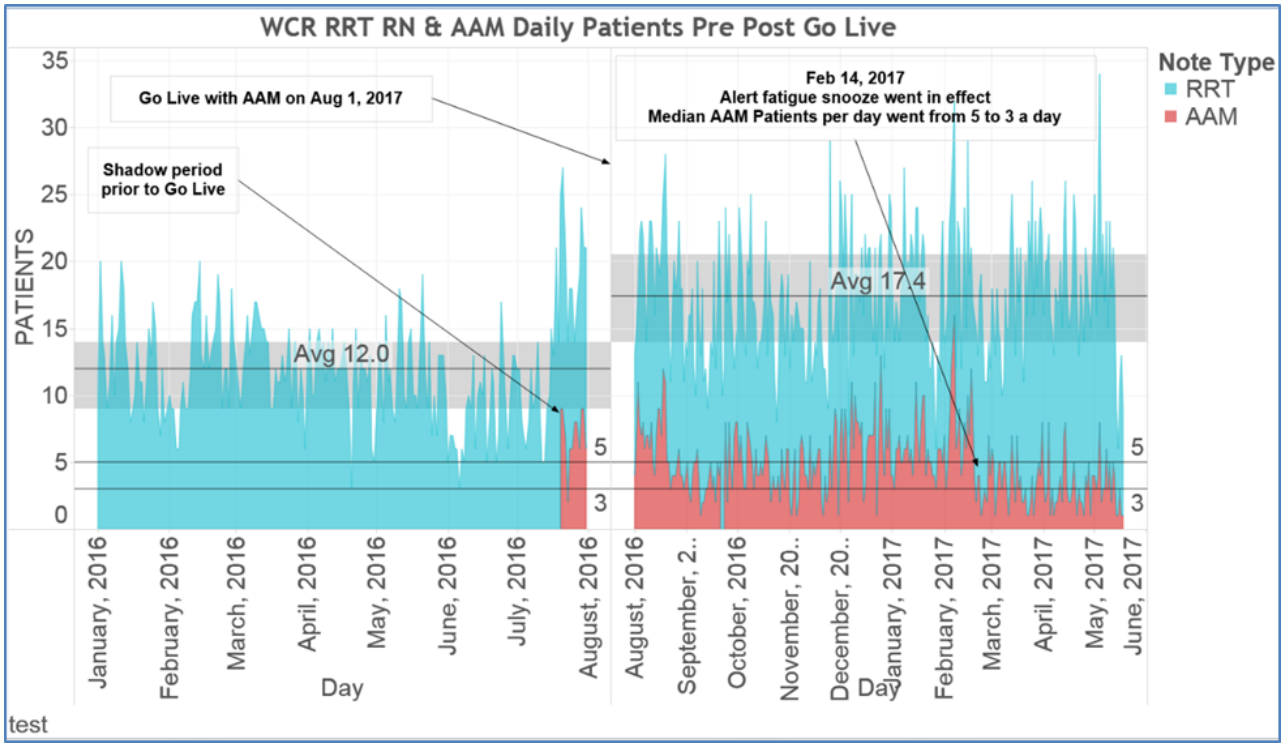


Figure 8. Walnut Creek RRT RN and AAM daily patients after snooze criteria implemented.

Likewise, based on discussions with Walnut Creek, the snooze criteria was implemented in Santa Clara (beta site 2) within two days of Walnut Creek. As Figure 8 demonstrates, by doing so, the median number of AAM patients per day decreased from 5.5 (pre-snooze) to 3.5 (post-snooze). There were no increases in patient harm as evidenced by code blues or rapid response calls at either facility due to snoozing alerts of patients who met the snooze criteria.

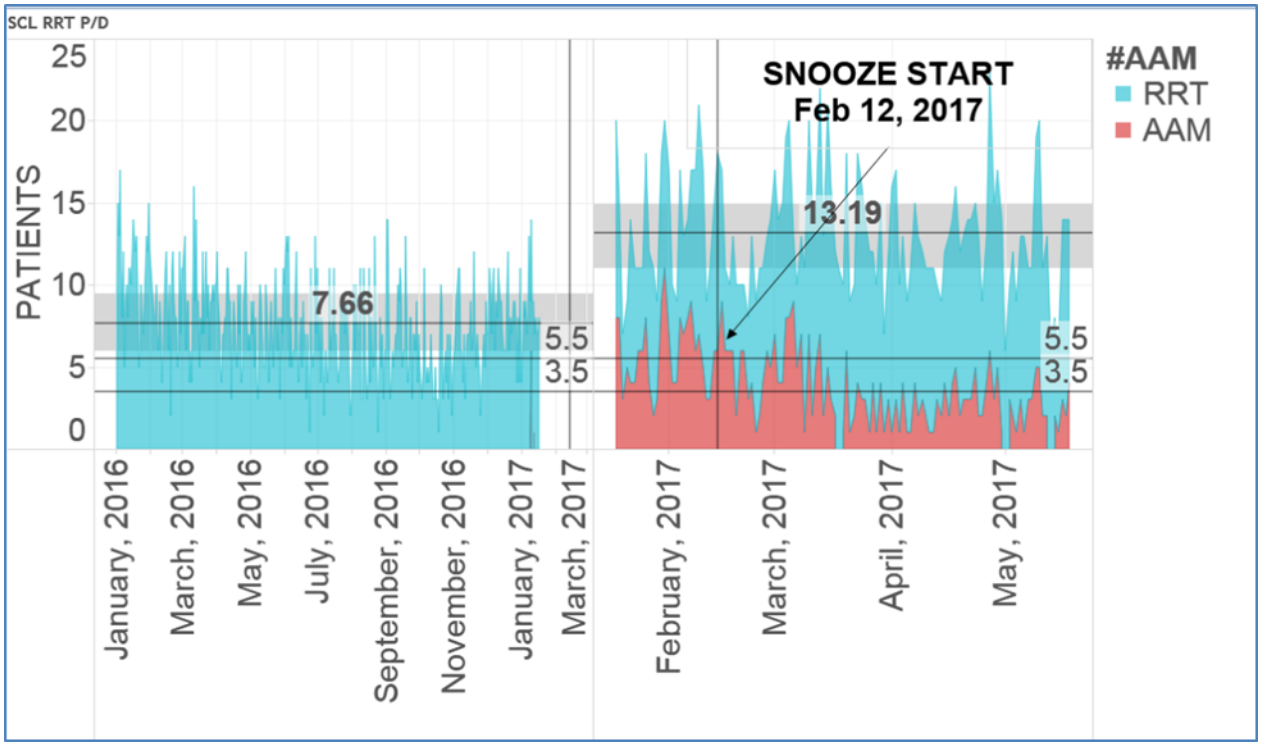


Figure 9. Santa Clara RRT RN and AAM daily patients after snooze crteria implemented.

Planning the Study of the Intervention

Proposed Evaluation Criteria

Implementation outcome is valuable for clinicians and researchers to appropriately interpret and understand interventional outcome. The purpose of this paper was to evaluate the implementation process based on the following outcome and process measures, compared with pre-implementation data, if available (see Table 6).

Table 6

Proposed Evaluation Criteria

Process Measures	Outcome Measures
1. # of patients per day with AAM alerts ≥8%	Adjusted odds of inpatient death with AAM
2. # of RRT RN notes per day	Adjusted odds 30-day mortality with AAM
3. % eHospital response within 1 hour of initial alert between 8am and 11pm	Mean reduction in hospital LOS (hours) with AAM
4. % RRT response within 3 hours of initial alert time between 8am and 11pm	Mean reduction in ICU LOS with AAM (hours)
5. % MD notes for AAM alerts within 6 hours (initial fires)	Outcome measures will include completion of an AAM Implementation Playbook
6. # of patients with medications ordered after initial alert documented within 6 hours	
7. % of AAM patients with Palliative Care (PC) consults ordered for COPS2 score ≥65	
8. % of AAM patients with PC or LCP (Life Care planning) notes present (depending on COPS2 score)	
9. % of AAM patients with COPS2 score < 65 with Medical Decision Maker identified	
10. % of up-transfers to the ICU preceded by AAM note with no prior RRT note	

Methods of Evaluation

Proposed Reporting Requirements

Evaluation of the AAM implementation occurs through ongoing daily oversight of specific process, implementation, and outcome measures; bi-weekly AAM steering pilot calls between the pilot site and the regional team; and DOR analysis of the data. Unique AAM

dashboards were developed that pull information automatically from the KPHC Clarity database, as well as from the KPIT server. Reports are analyzed by the AAM steering team in collaboration with DOR, and formal presentations occur at the regional, local executive, and staff level, so that the benefits are visible to others (key attribute: observability). Weekly AAM measurement meetings are held with the data analyst and the clinical operational leaders to review data and to revise dashboard measurements, as needed. Different dashboards were created for frontline clinicians to view individual and aggregate patient level data on a weekly and monthly basis. Comparison data between the pilot site hospitals were developed by the QOS data analyst to provide further context of weekly changes in process measures, and executive level dashboards were created for the executives to view current status and progress at a glance. See a small section from the sample weekly report from AAM dashboard (Figure 11) and AAM executive dashboard (Figure 12).

Walnut Creek Medical Center

Local Weekly Operational Report

Summary of Initial Alerts by Week

Week	Facility	# ICU Up-transfers	# Full Code Ward Patient Deaths	% ICU Up-transfers with an AAM Alert (n)	% Patient deaths with AAM Alerts (n)	# Patients with AAM Alert or AAM Alert >24 hrs After ICU Downgrade	Total # Patients with Initial Alert	# patients that ehospital called on initial Alert or # of patients with an initial alert for non-ehosp sites	% eHospital response within 1 hour of initial Alert (n)	Median time from initial alert to ehospital call	% Patients with RN Initial Notes (n)
04JUL2017 TO 10JUL2017	WCR	6	1	66.7% (4)	0.0% ()	28	31	25	60.0% (15)	0.78	80.0% (20)
27JUN2017 TO 03JUL2017	WCR	7	0	71.4% (5)	0.0% ()	21	25	18	77.8% (14)	0.43	77.8% (14)
20JUN2017 TO 26JUN2017	WCR	0	0	0.0% ()	0.0% ()	26	28	20	65.0% (13)	0.83	85.0% (17)
13JUN2017 TO 19JUN2017	WCR	1	0	0.0% ()	0.0% ()	37	39	33	103.0% (34)	0.33	90.9% (30)

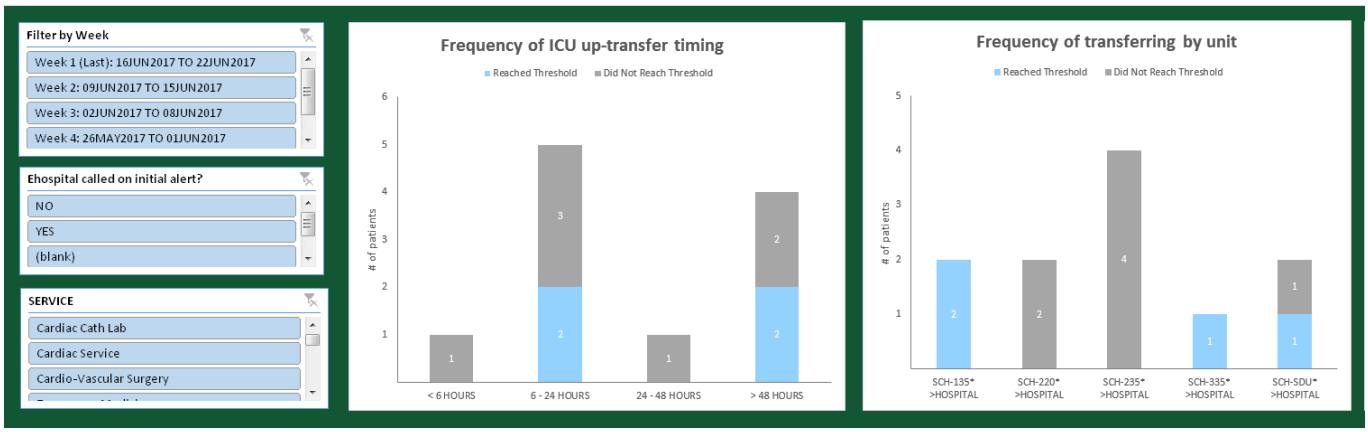


Figure 11. Sample sections from weekly AAM dashboard.

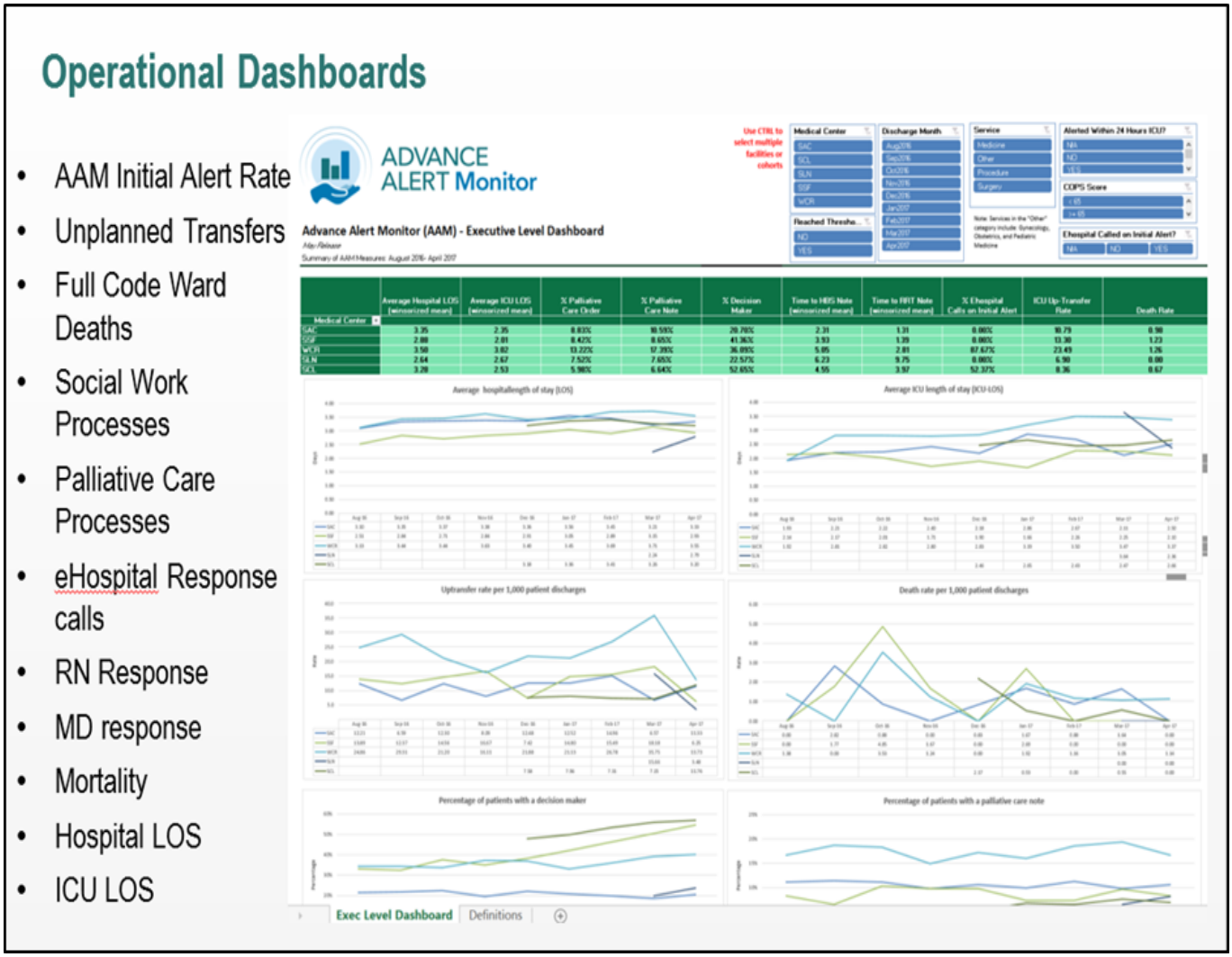


Figure 12. Executive level AAM dashboard.

Outcome Results

The DOR analysis incorporates matching to adjust for population differences based on sex, age, membership status, prior ICU stay, and prior code status. Initial evaluation from DOR (August through December 2016 analysis) for Walnut Creek showed trending in a positive direction for reduction of mortality and LOS, but results were inconclusive due to small sample size. The most current evaluation from DOR (August 2016 through February 2017 analysis) showed statistically significant reductions in inpatient mortality, 30-day mortality, hospital LOS, and ICU LOS for patients with AAM in Walnut Creek, in comparison to patients at non-live hospitals:

- Adjusted odds of inpatient death with AAM were 46% less
- Adjusted odds 30-day mortality with AAM were 32% less
- Mean 35.5 hour reduction in hospital LOS with AAM
- Mean 19.1 hour reduction in ICU LOS with AAM

As of this writing, there is not yet sufficient sample size at Santa Clara to determine preliminary outcome results.

Process Results

The positive trajectory of the process results reflect compliance with the AAM processes. See Appendix X 1-10 for details on process measures. In each of these metrics, the timeframes correspond to one year of pre-implementation (if available) until May 31, 2017. The starting dates will differ, since the go-live of Walnut Creek was August 1, 2016 and the go-live for Santa Clara was January 18, 2107. Specific process targets have not been established, as the AAM Steering team believes trends provide the most meaningful data as to whether the facilities are compliant with the workflows. All process data are based on direct KPHC information extracted

from individual patient records using KPIT servers by the data analyst and clinical operational physician leader.

As AAM is a unique program and relatively uncommon in healthcare, there are no specific industry benchmarks to compare the process measures against. The AAM Steering team shares these process measures with all of the pilot hospitals, and each hospital compares their progress relative to themselves as well as to their comparative hospitals.

1. # of RRT RN notes per day with AAM alerts ≥8% (See Appendix X Figure 1)

Description: This describes the number of RRT RN notes documented in KPHC per day.

Results: The number of RRT RN notes per day at Walnut Creek increased from 22.06 average per day pre go-live to 29.38 average per day post go-live. At Santa Clara, the number of RRT RN notes per day increased from 8.50 average per day pre go-live to 14.83 average per day post go-live, reflecting compliance with the use of the RRT type RN notes.

2. # of RRT RN notes per day (See Appendix X Figure 2)

Description: This is an average of the distinct count of the number of RRT notes documented by RRT RNs for both Walnut Creek and Santa Clara.

Results: The *x* axis represents time and the *y* axis represents the number of RRT RN notes documented in KPHC. The blue represents the total number of notes; the red represents those notes specific for AAM alerts. There is an increase in the average of RRT RN notes for both beta facilities, but an appropriate reduction in the number of notes when snooze was implemented to reduce alarm fatigue on February 12, 2017 for both facilities.

3. # eHospital response within one hour of initial alert between 8am and 11pm (See Appendix X Figure 3)

Description: This reflects the percentage of time the eHospital responded by calling the RRT RN with an initial alert, during the time they are activated only (between the hours of 8am to 11pm). A one hour response time was selected by the AAM Steering Committee after careful assessment of eHospital workflows balanced with the urgency of communicating the alert to the RRT in a timely manner.

Results: Based on the trends, eHospital response within one hour was initially 91.76% in August 2016. With the addition of Santa Clara in January 2017, the eHospital response within one hour of alert has decreased to 69.2% as of May 2017. This supports the business plan request for full 24-hour eHospital coverage, a plan that has been approved for funding by the executive sponsors.

4. % RRT response within three hours of initial alert time between 8am and 11pm (See Appendix X Figure 4)

Description: This reflects the compliance with RRT assessment and documentation of that assessment, within three hours of the initial alert time after eHospital call. Three hours was selected based on the DOR recommendation of the value of timely interventions for AAM response, but with recognition that the AAM alert is less urgent than a Rapid Response Team call, or a Code Blue call.

Results: Response within three hours at Walnut Creek is 63.71% as of May 2017, which is relatively consistent. Response within three hours at Santa Clara is similar at 67.93%.

5. % MD notes for AAM alerts within six hours (initial alerts) (See Appendix X Figure 5)

Description: This reflects the percentage of MD notes for AAM alerts within six hours after the initial alert and contact by the RRT RN. Six hours was selected based on allowing the provider three hours after notification by the RRT RN (see metric #4).

Results: MD documentation on AAM patients at both Walnut Creek and Santa Clara is 18.47% and 51.38%, respectively. The MD documentation varies due to operational issues that are being improved. For example, at times, the MD may have assessed the patient prior to the AAM alert triggered and initially did not get *credit* for having documented prior to the RRT RN informing them of the alert. Drill downs on any outliers have led the team to examine ways to give the physician credit for an abbreviated AAM note that acknowledges the AAM alert but does not require duplicate documentation.

6. # of patients with medications ordered after initial alert documented within six hours (See Appendix X Figure 6a)

Description: This process metric attempts to identify whether the patient required medications as part of the initial assessment and intervention. Six hours was selected because it correlated with the six hours allowed for the physician to assess the patient, write orders as appropriate and document using the smartphrases in the EMR.

Results: The utility of this metric is not specific to whether the implementation was successful. From the start of the data capture (August 2016), there is a clear trajectory upwards in the number of medications documented as administered within six hours. Additional data (see Appendix X, Figure 6b) indicates that simple interventions, including intravenous saline, oxygen, and medication categories of cardiac drugs, antibiotics, and analgesics are commonly provided as a response to the AAM alert. However, the non-medicine interventions to demonstrate all of the medicine and non-

medicine interventions that were provided to each individual patient post-AAM alert were not able to be captured.

7. % of AAM patients with Palliative Care (PC) consults ordered for COPS2 score ≥65 (See Appendix X Figure 7)

Description: As indicated in the metric description, this attempts to examine compliance with the number of PC consults ordered for those patients who meet threshold (COPS2 score ≥65) for a high comorbidity.

Results: Santa Clara has a higher rate of PC consults ordered (82.14%) than Walnut Creek (48.78%). This could be due to the differences in demographics, lower PC physician staffing at Walnut Creek, culture (greater reluctance to refer patients to PC at Walnut Creek), and the fact that the Santa Clara baseline was higher. There is a difference in how the supportive care services are receiving their alerts from eHospital: At Santa Clara, their supportive care services team agreed that eHospital will send alerts directly to a KPHC group email box to be picked up by the appropriate team member. At Walnut Creek, on a daily basis the regional data analyst sends a group email regarding the patient list to be prioritized by their team. Attempts at standardizing the process for consistency and scale is in process.

8. % of AAM patients with PC or LCP (life care planning) notes present (depending on COPS2 score) (See Appendix X Figure 8).

Description: This metric reflects compliance with workflows specific to the presence or absence of PC or LCP notes in KPHC.

Results: Documentation in KPHC for Walnut Creek shows a positive trajectory, with documentation from 48.48% in September 2016 to 70.81% in May. For Santa Clara,

KPHC documentation started at 89.8% in January 2017 and has remained high with May at 92.67%.

9. % of AAM patients with COPS2 score < 65 with medical decision maker surrogate identified (See Appendix X Figure 9).

Description: As described, this reflects the social worker compliance with identifying a medical decision maker surrogate for those patients with lower comorbidity scores (COPS2 <65).

Results: In Walnut Creek, for the time period August 2016 to May 2017, with an average number of patients of 27.8, the percentage of AAM patients with a surrogate named demonstrates a relatively flat 47.05% to 49.40%. In contrast, Santa Clara started with a higher baseline 88.19% in January 2017 and with a higher average of 35.8 patients, their May data showed 90.34%.

10. % of up-transfers to the ICU preceded by AAM note with no prior RRT note (See Appendix X Figure 10)

Description: This metric attempts to identify the up-transfers to the ICU that occurred as a direct result of the AAM alert and the assessment that followed.

Result: Of all patients who up-transferred from the medical-surgical unit to the ICU in Santa Clara, the majority of them (58%) did not meet the threshold for an AAM trigger. This is consistent with the sensitivity of AAM of 49%; AAM will not alert on all patients and is expected to miss patients for many reasons. For example, if timely vitals are not entered into the KPHC so their abnormal vital signs are not able to , if the patient has a stroke or has new onset Atrial Fibrillation, Of the patients who up-transferred, AAM alerted on 33% to 62% of the patients prior to transfer, i.e., AAM predicted the transfer

need. For Walnut Creek, up to 63% of patients who up-transferred did not meet the threshold for an AAM trigger. Of the ones who up-transferred, AAM alerted on 26% to 52% of them prior to transfer.

Table 7

Results of Process Measures

Number	METRIC	Walnut Creek (WCR) Go-Live Aug 1, 2016		Santa Clara (SCL) Go-Live Jan 18, 2017	
		Pre Go-Live 1/2016 - 8/2016	Post Go-Live 8/2016 - 5/2017	Pre Go-Live 1/2016 – 1/2017	Post Go-Live 1/2017 - 5/2017
1	# of patients per day with AAM alerts ≥8%	5 Shadow period	5.7→3.8	5 Shadow period	5.5→>3.5
2	# of RRT RN notes per day	22.06 Average to May 2017	29.38 Average to May 2017	8.50 Average to May 2017	14.83 Average to May 2017
3	# eHospital response within 1 hour of initial alert between 8am and 11pm	NA	May 2017 69.92% N = 86	NA	Combined with WCR
4	% RRT response within 3 hours of initial alert time between 8am and 11pm	NA	May 2017 63.71% *N* = 78	NA	May 2017 67.93% *N* = 50
5	% MD notes for AAM alerts within 6 hours (initial alerts)	NA	May 2017 75.61%	NA	May 2017 51.35%
6	# of patients with medications ordered after initial alert documented within 6 hours	NA	Combined WCR and SCL: 61→112	NA	Combined WCR and SCL: 61→112
7	% of AAM patients with Palliative Care (PC) consults ordered for COPS2 score ≥65	NA	May 2017 48.78% *N* = 20	NA	May 2017 82.14% *N* = 23
8	% of AAM patients with PC or LCP (life care planning) notes present (depending on COPS2 score)	NA	May 2017 70.81% Average 27 patients	NA	May 2017 92.67% Average 29.4 patients
9	#of AAM patients with COPS2 score < 65 with Medical Decision Maker identified	NA	May 2017 49.4% Average *N* = 27.8	NA	May 2017 90.34% Average *N* = 28.4
10	% of up-transfers to the ICU preceded by AAM note with no prior RRT note	NA	AAM alerted on 26%-52% of patients who up-transferred	NA	AAM alerted on 33% -62% Of patients who up-transferred

Appropriate Variance Controls

Variance outliers are evaluated by physicians, the eHospital, and quality during the individual *drill downs* that occur with each up-transfer from the ward to the ICU. Validation of the data occurs prior to go-live, during the pilot, and systematically by DOR, with recalibration occurring at least every three to six months.

Analysis

AAM is a predictive tool that can accurately identify non-ICU patients at increased risk for clinical deterioration and death. Using evidence-based strategies, successful implementation of EWS to screen patients in real time for deterioration and to trigger electronically a timely, robust, multidisciplinary bedside clinical evaluation and early supportive services consultation was demonstrated. Compared to pre-implementation data, AAM resulted in an improvement in early management of patients at risk for clinical deterioration through outcomes data: transfer to the ICU, reduction in ICU mortality, and through process measures, as evidenced by compliance with AAM workflows for nursing, physician, palliative care, and social services.

This project is unique in that it was implemented across a multi-hospital health system, which has identical EHRs, but diverse cultures, populations, staffing, and practice models.

Section V. Discussion

Summary

Key Findings

AAM has been successfully implemented in two NCAL beta facilities and, based on the outcomes of reduced mortality and LOS, will be expanded to the other 21 NCAL facilities. It is clear that implementation of any evidence-based initiative requires concrete implementation steps, but attention to the human, cultural, and organizational factors as key attributes to a successful implementation is also critical. This paper has described how diffusion of innovation by Rogers (2003) and Greenhalgh et al. (2004) can help in understanding key factors that appear to have the greatest influence on the success of the implementation of AAM.

There must be an *urgency for change* from the current system, which was created by consistent messaging about the critical value of AAM in saving lives, as well as by sharing data from the original alpha pilot site with key executive leaders across NCAL. For innovation of this magnitude, there must be executive sponsor support for the innovation as a key driver for organizational quality. Facilities must be *ready to accept the innovation*; the innovation must be of *low complexity,* easy to understand, and be *compatible* with and fit the user's norms and cultural values; the innovation must show a *relative advantage* (benefit) to the users and these benefits must be *visible to others*; and the more engaged the staff is with being able to *reinvent* or modify the innovation, the more successful the adoption. *Relevance* of the innovation to the user's work, understanding the innovation (*knowledge*), and having *support* (clinical support and/or tools such as the Implementation Playbook), enhances assimilation. However, Greenhalgh et al. (2004) indicated that these key attributes are not "stable features of the innovation nor sure

determinants of their adoption or assimilation. Rather, it is the interaction among the innovation, the intended adopter(s), and a particular context that determines the adoption rate" (p. 598).

For this AAM implementation, specifically, the unique factor of having a dedicated regional implementation team has allowed greater focus and intentionality for incorporating the key attributes and ensuring stakeholder adoption. An additional unique feature in this AAM implementation is that it was implemented across a multi-hospital health system, which has identical KPHC system, but diverse cultures, populations, staffing, and practice models.

As nursing is the largest group of users within the AAM workflow, their acceptance of this innovation, as well as the individual, organizational, cultural, and assessments and practices that influence the adoption of AAM, is critical. Specific implementation steps have been outlined to support successful implementation in conjunction with the key human factors. A toolkit has been developed that can serve as a valuable reference for hospitals who are interested in systematically implementing an automatic EWS. This EWS can be scalable to other hospitals and healthcare systems.

Interpretation

Because there is scarce literature specifying the steps of implementation of AAM, and in general, implementation of EWS at the scale of an integrated health care delivery system such as Kaiser Permanente is not common, there are few benchmarks to compare the KP AAM processes against. The outcome and process measures defined for this AAM program have been developed iteratively with stakeholder input, to take maximal advantage of the EMR, KP technology and implementation strategies to transition research methods into operational quality measurements. Preliminary reductions in mortality and LOS from Walnut Creek exceeded initial expectations, and reflect strong compliance with standardized workflows.

Although many hospitals lack comprehensive EMRs, Escobar, Gardner, Greene, Draper, Kipni, (2013) suggest that many hospital systems could replicate the AAM model now. Escobar et al. (2013) reveals that "Our models' diagnosis and comorbidity components are in the public domain, as are the algorithms we used for formatting physiologic data; none are specific to any one EMR" (p. 452). Escobar has described the algorithms associated with AAM as a "commodity", and implementation the greater challenge. As described in this paper, incorporation of the key attributes of implementation and the comprehensive program that has been developed to support the operational and clinical engagement and workflows, are the "secret sauce" that distinguishes the KP AAM and other EWS efforts that have been less successful. Scaling the implementation to expand to multiple centers is the next phase of this project, although not in the scope of this DNP paper. Regardless, the learnings from this work will support the scale, spread and nursing adoption of AAM throughout KP NCAL.

Barriers to Implementation

Risks and vulnerabilities regarding the implementation of the AAM pilot have been thoughtfully assessed during regional AAM workgroup and local AAM steering meetings, as described earlier in Appendix R. Utilizing Hopkin's (2015) risk register as a mechanism to record identified risks, significant risks facing the implementation of this project related to process and operations include facility readiness risk, infrastructure risks, labor risks, reputational risks, financial risks, and legal risks. For each of the risks, the risk likelihood (chances) and magnitude (severity) of the event, should the risk materialize, were assessed, and mitigation strategies were actively pursued to minimize the risks. A four Ts approach was used to determine the response for control of the risk (Hopkin 2015) and an action plan to mitigate the risks was developed: 1) Treat the risk to reduce impact or exposure: Appropriate for risks that

can be treated by corrective controls; 2) Terminate the activity generating the risk: Appropriate for risks not acceptable to the organization; 3) Transfer the risk to another: Appropriate for risks outside the risk appetite, organization wishes to transfer, or share the risk; 4) Tolerate the risk and its impact: Appropriate when the level of risk is within the risk appetite.

Limitations

Other limitations specific to AAM implementation include infrequent and incomplete monitoring and recording of vital signs on general wards. As discussed by Goldhill (2006) and reinforced by Oliver (2010), the discovery of nurse's inaccurate entry of vital signs and respiratory rates can preempt early identification of deterioration in a patient's condition or cause false positives in the AAM alert. For example, incorrectly entering the oxygen saturation number of 96 as16 or incorrectly transcribing the respiratory rate of 14 as 24 in the EMR can cause a false positive or can miss early identification of a respiratory compromise. Likewise, holding onto their patient's vital signs until the end of their shift without manually entering them in the EMR can reduce timely response to signs of deterioration. Education and reinforcement of the importance of entering vital signs into the EMR immediately after taking them is included in the nurses training and is a culture shift that necessitated clearly explaining the rationale to staff in order to impact a change in the nurse's behaviors. This is a change in behavior for many of the bedside RNs and may conflict with Greenhalgh et al.'s (2004) compatibility attribute; nurses may not feel that this change in practice is compatible with their existing norms. To track compliance with this process measure, the frequency of KPHC-entered vital signs by the bedside RNs for patients who have an AAM alert is monitored by the eHospital staff. Gaps in documentation are called to the unit assistant nurse manager by the eHospital RN.

Finally, significant vulnerabilities to implementation are the inconsistencies of the RRT RN staffing and workflow at some facilities, as well as the labor environment that could resist changes in work practice. As indicated earlier, a nursing survey of all 21 NCAL facilities revealed that not all facilities have budgeted RRT RNs who are not already caring for patients. Not all facilities have RRT RNs who perform a systematic proactive rounding to support non-AAM alert patients who are at risk for deterioration. Creating a standardized RRT competency, developing reliable RRT workflows and documentation, and defining consistent proactive rounding criteria that integrates with the AAM monitoring criteria and is compatible with the nursing union was completed as required infrastructure for successful AAM implementation. Achieving consistent staffing has regional executive level approval, but requires local executive acceptance. Engaging the local nursing union in AAM implementation at the outset has mitigated formal union resistance to this program. However, further examination of these elements are out of scope for the DNP project.

Limitations to implementation include KPIT time to incorporate required changes into the KPHC documentation. Due to KPIT timelines for approvals, funding, and workload to expand the KPHC's functionality from a pilot to an enterprise wide system, while this does not impact the pilots, there are delays in the ability to seamlessly expand AAM with full KPHC integration to future facilities. For beta site 3, this has actually been their advantage, because there has been additional time to work with this site on their pilot readiness, since they did not have a mature RRT RN program prior to Regional involvement.

Conclusion

Nursing practice and workflow has become an essential focal point for successful implementation of this new innovation. AAM data supports the value of the combination of the

predictive algorithm with hourly oversight *plus* the use of the Rapid Response team RN to provide optimal proactive management and improved patient safety. AAM has demonstrated such important benefits to reducing ICU and hospital mortality, as well as reducing LOS, that expansion of this work to all 21 NCAL KP facilities has been approved by Senior Executive leadership. Nursing adoption of AAM has been positive, as RRT RNs have been engaged in the development and testing of the AAM workflows and required documentation at each pilot site (*key attributes: trialability, knowledge, reinvention, support*).

From a nursing perspective, nurses have reported that the AAM program has improved the relationship between the RRT RN and the bedside RNs. Benin, Borgstrom, Jenq, Roumanis, Horwitz (2013) found that the positive impact of the RRT expedited effective care for acutely ill patients, ensured other patients were not neglected, improved morale and perhaps retention of nurses, facilitated hospital throughput and provided learning opportunities for nurses and physicians. The RRT RNs had been asked to use the AAM alert response opportunity to mentor and teach the bedside RNs, and feedback from the medical surgical nurses and their managers have described a significantly improved collegial relationship. Since only 5-10% of the patients on the medical surgical units will up-transfer to the ICU, the AAM Implementation Team has encouraged the bedside nurses to stay with the RRT RN and participate in the patient assessment and stabilization. The bedside nurses, instead of stepping away from the bedside upon the arrival of the RRT RN, now stay with the RRT RN and they work collaboratively in performing those proactive interventions that are less acute than if the interventions occurred during a Rapid Response or Code Blue call. Data has shown that the most common interventions required in response to an AAM alert are IV fluid, antibiotics, oxygen, or cardiac medications (see Appendix Figure X6.b). Bedside nurses, especially the less experienced nurses, have described their

appreciation of the RRT RNs for their proactive-ness, responsiveness, and their willingness to educate regarding the patient diagnosis and the clinical signs to watch for. The culture has shifted from reactive to proactive, as the AAM alert has given voice to caregivers to speak up for their patient in an objective manner.

Important gaps remain with respect to implementation of early detection and response systems. Future efforts will need to focus on how to use the implementation concepts to rapidly spread AAM to multiple centers at a time. The success of AAM implementation at the individual pilot sites was optimized due to the intensive attention provided by the AAM Clinical Operational leaders, but scaling implementation to three sites simultaneously requires a need to go beyond the current approach and leverage local educators and leaders to support expansion. Only through leveraging local infrastructure will there be the potential to successfully implement this EWS throughout NCAL, and achieve the meaningful sustained adherence to workflows that will allow replication of the outcomes that impact patient care.

Section VI. Other Information

Funding

Budget Narrative

Considerable budgetary resources have been assigned to this project from a regional and national KP perspective. Information regarding the actual costs specific for the implementation of this pilot is not available, so costs will be estimated or extrapolated based on known sources of funding (see Appendices Y and Z), the anticipated return on investment based on lives saved and hospitalized days saved, and the cost avoidance of litigation due to delay in treatment.

Return on Investment

Projections from the DOR indicate that AAM will decrease total hospital days, thus helping alleviate the intense pressure on current census and reducing costs an estimated $26.8 million per year, depending on the DOR calculated difference in difference (DiD) in 30, 60, or 90 day LOS from the alpha sites 1 or 2, as compared to the cumulative regional LOS. As described in Appendix Y, reduction in mortality is anticipated to be 110 to 400 deaths per year. Based on regional personnel investment of $3,068,405 minus $452,500 from the grant funds, subtracting the costs of 4.2 RRT RN FTEs and ICU and medical-surgical nursing training costs and the cost avoidance of potential litigation, the total maximum ROI is projected to be $9.2 million in savings for the first year. Adding $9.1 million per life saved increases the maximum ROI to $3.649252e9 (see Appendix AA). Second and third year savings are projected to continue, as AAM is further expanded to all NCAL facilities, and more lives are saved with continued LOS reductions. The limitations of these calculations are that these costs do not include the DOR physician and data analytic personnel, DOR server access costs, and KPIT time to develop new KPHC programs needed to integrate AAM into KPHC.

Conclusion

When AAM is implemented to all 21 NCAL facilities, the anticipated financial ROI yearly benefit is approximately $9.2 million (including cost avoidance), based on current analysis by the KP DOR. With a savings of approximately 400 lives per year, at the cost of one life set by the EPA at $9.1 million, the ROI can be projected to be $3.649252e9. This program has solid executive level financial support and aligns with KP national and regional priorities.

If AAM is fully deployed, the DOR predicts 6,500 patients a year will reach the threshold requiring intervention (Escobar et al., 2013). If a similar average mortality reduction is extrapolated, about 110 to 400 patient lives will be saved and 8,910 patient days per year could be saved [(average hospitalized hours saved was 32.9hrs*6,500 patients alerted per year)/24 hours]. KP financial experts indicate that this could translate to a savings of up to $26.8 million per year.

Predictive analytics systems in health care, such as AAM, are expected to become community standard in the future (Slabodkin, 2014). Implementation of AAM can also support cost avoidance by reducing the errors caused by a delay in detection of clinical deterioration. Patients currently seek arbitration on the grounds of diagnostic error, delay in recognition, delay in escalation, and inappropriate initial triage from ED to admission in the ward instead of ICU (Pozgar, 2012). Assuming 0.1% of cases = ~7 patients per year, and an average of $30,000 to $1,000,000, then an expected savings of up to $7,000,000 can realized by widely deploying AAM.

Grant funding was requested and received for a data analyst and a business consultant at a total cost of $452,500 over three years (2016-2018). Other sources of funding include

$1,325,245 from the DOR, national KPIT of $326,600, budget enhancement of $306,320, and regional support of $657,760.

From a nursing perspective, this writer's cost as the nursing clinical operations leader is not captured separately, since this cost is budgeted as a salaried employee of the organization. Local nursing costs for innovation implementation are not typically budgeted into the local facility as a separate line item. Similar to the regional model, the majority of the members on the local implementation team are salaried, except for the RRT RNs and the social workers/palliative care nurses who may be part of a labor union. Specific funding (4.2 FTEs) was allocated to each local facility for the 2016 budget to cover 24/7 RRT RN dedicated to be *out of count,* at a cost of $1,000,000, including taxes and benefits. Educator costs may also be incurred, as KP educators are considered non-union, non-exempt employees who may earn overtime for working outside their scheduled hours, but will need to support training on off shifts, as well as the day shift. Costs for overtime due to AAM related clinical training or staff meetings, participation in workflow revision groups, and implementation meetings are the primary costs incurred at each local facility during the implementation phase. Social worker and palliative care staffing to fully support the AAM program is being defined by the regional and local leaders. Hosting the kick-off celebration and any unit-based recognitions is an additional cost that is borne by the local facility.

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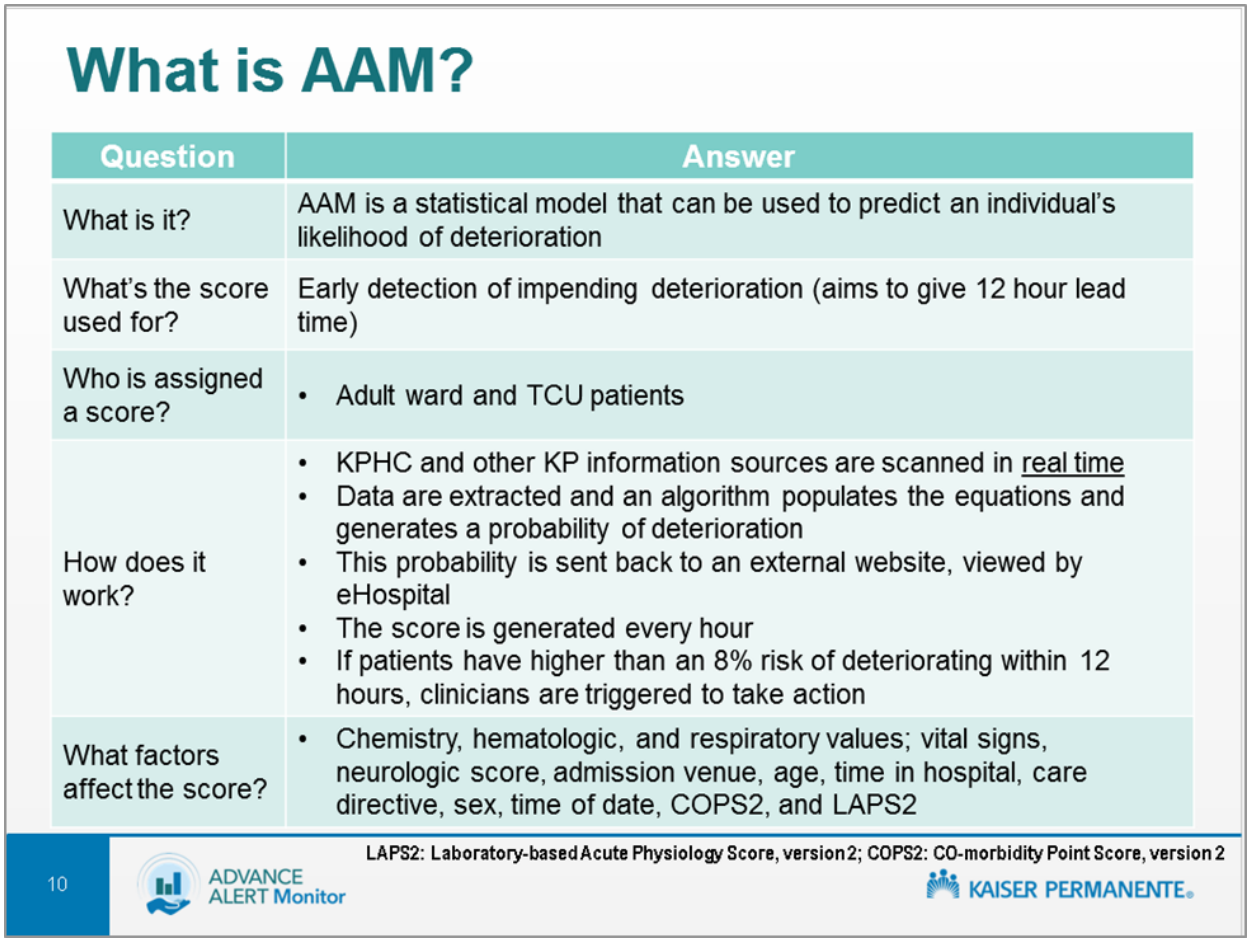
Section VIII. Appendices

Appendix A

What is AAM?



TCU = Transitional Care Unit

Appendix B

Evidence Table

Template from Melnyk and Fineout-Overholt (2015, p. 552)

*What evidence exists regarding the implementation of a *MEWS/EWS and the impact of this innovation on nursing practice and adoption?*

*MEWS/EWS: Modified Early Warning Systems/ Early Warning Systems
**John Hopkins Nursing evidence based practice appraisal tool: Level of Evidence: Level 1-V, Quality Rating A-C

Author	Conceptual Framework	Design / Method	Sample / Setting	Major Variables Studied	Data Analysis	Study Findings	Appraisal
McGaughey, 2007	None Identified key adoption attributes	Cochrane Review Two cluster-randomized control trials were included. RCT1: Priestly (2004); RCT 2: Hillman (2005) Controlled clinical trials, controlled before and after studies, and interrupted time series designs of outreach utilizing EWS with outreach, with no outreach and EWS.	Potentially relevant studies: initial 2005 search 4,941 plus 1,332 studies in 2005-2006 search. Studies included in review = 22 RCT: 23 hospitals Australia, 16 wards UK Adults non ICU. Types of participants: all patients who deteriorated on general adult inpatient wards.	Mortality ICU admission Length of stay (LOS) Adverse events MET team or no MET team Composition of team EWS tools	Mortality: RCT 1: reduced in hospital mortality (OR = 0.52; 95% CI 032 to 0.85) RCT 2: no significant difference in control vs MET hospitals (1.18 vs 1.06 pts/1K admissions; adjusted p value 0.752). Unplanned ICU admissions: RCT 1: did not study.	No statistical difference between control and MET hospitals in reducing hospital mortality, unplanned ICU admissions and readmissions, LOS, or adverse events (Adjusted p value 0.640; adjusted odds ratio 0.98; 95% CI 0.83 to 1.16). Limitations of study: issues of	Level I/A

					RCT 2: no significant difference (4.68 vs 4.19/1K admissions). Length of stay: RCT1: increased mean LOS in outreach compared to control group. RCT 2: did not measure LOS. Adverse events: RCT 1: did not measure. RCT 2: increased incidence of unexpected cardiac arrests in control vs MET (1.64 vs 1.31 pt/1K admissions).	poor quality of research, difference in inclusion criteria, poor methodological quality, difference in team composition.	
Kyruacos et al., 2011	None Identified key adoption attributes	Systematic Review Published literature 1998 – 2011 reviewed to describe the need for and the development and clinical	Adult inpatients outside of the ICU or ED Studies were single-centre studies, mult-centre studies, meta analysis of 36 papers and 15 datasets from 30	Study objective Validity and reliability Outcome measures Sample size Findings	Of 534 papers reporting MEWS/EWS systems for adult inpatients, 14 contained useable data on development and utility of MEWS/EWS systems	There is no single validated scoring tool for EWS. Evidence of prospective validation of MEWS/ EWS systems is limited	Level I/A

		effectiveness of MEWS/EWS. Excluded: EWS employed in triage, medical emergency team, critical care Outreach Services 534 papers reviewed, 14 data papers 2 reviews 2 meta-analysis	hospitals in the UK, Wales.		Significant variability in MEWS/EWS systems	Evidence of validation, implementation, evaluation of MEWS/ EWS based on clinical trials is limited in general wards	
Niven et al., 2014	None Identified key adoption attributes	Systematic Review Before and after design Meta-analysis using a fixed-effect model aligned with recommendations outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and Cochrane Collaboration guidelines.	3,120 studies screened for relevance, 53 were selected for full text review; of these, nine were included in the systematic review. Eight out of nine studies took place in a single hospital setting. 16,433 patients, median of 1,516 patients per study. UK or Australia/ New Zealand	ICU re-admission In-hospital mortality associated with critical care.	Data reported as a pooled risk ratio determined through a fixed-effect model using the methods of Mantel-Haenszel or a random-effects model using the methods of DerSimonian and Laird. Statistical analysis used to examine the differences in the risk of ICU readmission across various patient and	Critical care transition teams were associated with a reduced risk of ICU re-admissions (pooled RR, 0.87 [95% CI, 0.76-0.99]; p = 0.03) but not a reduced risk of hospital mortality. Study disparities due to the different included studies, inconsistencies in data reporting, and higher risk	Level I/A

					program characteristics.	patients than MET studies included in previous meta-analysis. More studies needed.	
Mitchell, 2010	None Identified key adoption attributes	Prospective control before-after All adult patients admitted to four non ICU wards during a 4- month period: Hospital A: 820 Hospital B: 337 A sub-group underwent analysis pre-intervention (427) and post-intervention (320)	Two academic teaching hospitals in Australia All adult patients admitted to four non ICU wards during a 4-month period A subgroup of approximately 25% of patients were randomly selected for an in depth analysis of VS measurement and associated medical review documentation.	Frequency of vital sign (VS) documentation Frequency of medical review of a deteriorating patient Number of unplanned admissions to the ICU Number of unexpected hospital deaths	STAT/1C 10 was used for all data analysis. Descriptive statistics presented using means, standard deviation, counts and percentages. Comparisons of binomial proportions between two nominal periods used the Chi-squared statistic or Fisher's Exact Test. Logistic regression and comparison of frequency rates were performed using binomial regression models. Log rank test was used to compare hospital LOS.	Reductions were reported in unplanned admissions to the ICU (21/1157 [1.8%] versus 5/985 [0.5%], p = 0.006 and unexpected hospital deaths (11/1157 [1.0%] vs. 2.985 [0.2%], p = 0.03 during the intervention period. Medical reviews for patients with significant clinical instability increased (58/133 [43.6%] vs. 55/79 [69.6%], p <0.001) and the number of patients receiving a MET review increased (25/1157 [2.2%] vs. 38/985 [3.9%], p = 0.03). Mean daily frequency of	Level I/A

						documenting VS increased during the intervention period (3.4 [SE 0.17] vs. 4.5 [SE 0.17], p = 0.001).	
Smith et al., 2014	None Identified key adoption attributes	Systematic Review QUERI (Quality Enhancement Research Initiative's) Evidence Based Synthesis (ESP), Department of Veterans Affairs	Adult medical or surgical wards within the VA hospital Portland, Oregon, who had any EWS scoring designed to identify deteriorating patients. From 13,595 titles and abstracts, 129 selected for full-text review. Of these, 17 were included, 6 provided primary data on predictive values of EWS, 11 pertaining to EWS implementation.	VS compared: HR, RR, SBP, temp, urine output, O2 saturation, difficulty breathing, supplemental oxygen use, mental status.	Impact on nursing not well studied. Accuracy of nursing manually scoring on MEWS compliance: 53%; electronic calculations improved compliance to 81%-100%. The most inconsistently recorded VS was urinary output and level of consciousness (45.6% missed documenting these values). Number of clinical observations increased with the use of EWS.	There is insufficient body of evidence re: the impact of EWS on outcomes due to methodological limitations. Articles lacked adjustment for pre-intervention trends in mortality rate, unable to account for other factors that could have simultaneously impacted mortality. Noted that EWS increases the use of RRT response and unclear whether this intervention has provided the benefit rather than the EWS itself.	Level I/A

						All studies limited by biases and advances in medical technology may be the cause of outcomes.	
Ludikhuize et al., 2014	None Identified key adoption attributes	Quasi-experimental study Patients were randomized to measure the MEWS three times daily (protocolized) versus measuring MEWS "when clinically indicated" (control).	University hospital in Amsterdam between Sept and Nov 2011 Patients included who were admitted at least one overnight stay One unit randomized as control unit, dropped out of the study, losing 5,752 measurements In total, 372 patients protocolized group; 432 control patients	Process measures: Degree of implementation and compliance to set monitoring standards MD notification delay RRT activation for patients with higher MEWS	MEWS calculations of VS in protocolized patients occurred in 70% of the wards vs 2% in the control group. Compliance in protocolized group was 68% vs 4% in control group. Calls to MDs in protocolized group was 90 vs 9 in control group.	VS and MEWS protocolized to three times per day results in better detection of physiological abnormalities and more reliable activations of the RRT.	Level II/B
Ward, 2013	Diffusion of innovation models	Qualitative analysis of technology acceptance models (TAM) and	Examination of systematic literature reviews ranging from Rogers, Azen and	Comparative literature review, major variables not specified	Lack of empirical approach at looking at change processes means that evidence-	Focus on perceived usefulness is more likely to influence clinicians' user	Level II/B

	Identified key adoption attributes	diffusion of innovation theories and their influence on implementation by the healthcare workforce	Fishbein, Davis, Malhotra and Galleta, Venkatesh, Chau and Hu, Greenhalgh		based practices cannot be adopted.	acceptance and diffusion of the innovation, rather than ease of use. Socio-technical "person" factors may be more important in influencing adoption and acceptance.	
McNeill et al., 2013	None Identified key adoption attributes	Systematic review Reviewed single parameter scoring systems (2 studies) vs aggregated weighting systems (4 studies) vs MET teams (20 studies)	43 studies from Australia and UK meeting criteria included 20 studies examined medical emergency teams 22 studies examined multidisciplinary outreach teams	Unplanned ICU admissions ICU mortality ICU LOS Cardiac arrest rates	The Scottish Intercollegiate Guidelines Network (SIGN) grading system was used to evaluate the studies. Checklists were designed to assess each study and specific elements within each study. The strength of recommendation in the SIGN system is on a scale of A to D.	Only weak evidence that implementation of a single parameter triggering systems reduces cardiac arrest rates (grade D). MET team may improve survival (grade B), cardiac arrest rates (grade B) and reduce unplanned ICU admissions (grade C). Recommend a "whole system" approach. Aggregated weighted scoring system (AWSS) improves hospital survival and	Level II/B

						reduces unplanned admissions to the ICU (grade C). Evidence for nurse led response team equivocal.	
Butcher et al., 2013	None Identified key adoption attributes	Retrospective, observational Analyzed 17 months of pre-intervention (introduction of proactive rounding by an RRT) and 25 months of post-intervention data	Single academic medical center in San Francisco All adult patients discharged from the ICU at the University of California San Francisco Medical Center between Jan 2006-June 2009 11,687 patients admitted to the ICU during the study period; 10,288 were discharged alive and included in analysis 6,785 patients admitted 17 months prior to proactive rounding and RRT	ICU readmission rate ICU average LOS In-hospital mortality of patients discharged from the ICU	ICU readmission rate: no change (6.7% before vs 7.3% after = 0.24) ICU LOS: no change (5.1 days vs 4.9 days, p = 0.24) In-hospital mortality: no change (6.0% vs 5.5%, p = 0.24)	Proactive rounding did not improve patient outcomes. Limitations: Inconsistent control period and team composition (different goals in a teaching hospital). Difficult to compare the patients in the comparison groups due to no information given regarding severity of illness, diagnosis, and treatment. Impact of extraneous factors on ICU LOS.	Level II/C
Guirgis, 2013	None	Retrospective review of a	Single hospital setting: tertiary,	Non-cardiac ICU arrests	Data collected since 2005; data	PR is useful in reducing code	Level II/C

	Identified key adoption attributes	prospectively collected database	academic, level I trauma center 1,253 non-ICU pts who had cardiac arrests from 2005 to 2012 Total study = 223,267 patients 70,129 pre-proactive rounding (PR), 153,138 post-PR	Code deaths RRT intervention Transfers to higher level of care	collection and tracking differed by time period. Data collection, graphical analysis and statistical analysis done using Microsoft Excel 2010 and STATA Version 12. Pre-PR time period (2.5 years) compared with post-PR (5 years), t-tests performed.	rates and code mortality. Pre-PR code rate = 66.3, post PR = 29.5 (difference = 36.8, 95% CI, p <.001); pre-PR code deaths: 290, post PR = 141; adjusted for increase in inpt admissions and patient days. RRT intervention: pre-PR = 141, post PR = 690 (difference = 126, 95%CI, p <.001). PR allows for earlier identification of "at risk" patients, has reduced transfers to higher level of care. Limitations: Data collection incomplete at times; initially collected for quality database, not for research. Data was variable with some elements missing.	

Umscheid et al., 2015	None Identified key adoption attributes	Pre-implementation and post-implementation study of EWS sepsis tool using descriptive statistics	Urban academic healthcare system in Pennsylvania: 3 hospital systems with over 1,500 beds Adult non-ICU patients admitted to acute inpatient units Oct 1-31, 2011 for tool derivation, from June 6-July 5, 2012 for tool validation, June 6-Sept 4, 2012 pre-implementation analysis, June 6-Sept 4 2013 post implementation analysis	Time from trigger to ICU transfer, any RRT, death, or composite Pre- and post-mortality Number of encounters Number of alerts Hospital /ICU LOS	4,575 patients met inclusion criteria. Difference-in-differences and logistic regression model was used to compare odds of mortality both within each hospital and across all hospitals. Hospital and ICU LOS were similar in pre and post periods.	Statistically significant increase in early sepsis care, ICU transfer, and sepsis documentation. Decreased sepsis mortality and increased discharge to home using sepsis EWS tool. EHR can be used in real time for deterioration.	Level V/A
Dummett et al., 2016	None Identified key adoption attributes	Qualitative description of implementation of EWS	Two community acute care hospitals in northern California	Implementation processes: workflow, clinician education, documentation, unplanned transfers, ward deaths	Purpose of article was not quantitative.	Successful at embedding EWS into the Electronic Medical Record. Coordinated workflow developed. Clinician acceptance.	Level V/B

Page et al., 2008	None Identified key adoption attributes	Single center pilot of a nursing tool, comprising of a color-coded observation chart and response algorithm, to support the ward nurses in the early identification of and rapid response to deteriorating patients on two general wards.	Tertiary, acute private 323 bed hospital in Brisbane; 30-bed neuro-vascular ward and 41 bed orthopedic ward Oct to Dec 2007	Nurse satisfaction based on 16 question Likert scale survey # MET calls	# of MET calls variable but reduced from 2.75 per month to 1.5 per month on 9East and from 2.08 to 1.5 per month on 8South. Nurse satisfaction scores 66.6% (n = 30) increased to 76% that MEWS was better or far better than existing observation charts; 90% rated that MEWS improved care.	Key elements in change management: consultation process with stakeholders, piloting the MEWS and testing its effectiveness, training and education. Successful pilot, expanded to all wards. Further research needed.	Level V/B
Patterson et al., 2011	None Identified key adoption attributes	Telephone survey Reviewed via telephone survey clinical practice in London and Scotland against national guidelines NHS Quality Improvement Scotland and National Institute for Health and Clinical	25 acute care hospitals in London, 23 acute hospitals in Scotland who used an EWS at point of entry to care. Telephone surveys in London July 2010, Scotland Sept 2010 verified with faxed copies of admission observation and	Track and trigger system System initiated at admission Type of system in use Specific physio-logic para-meters Color-coded alert Response strategy	Multiple systems used. London: 11 different systems Scotland: 5 different systems. 40% of London hospitals and 70% of Scottish hospitals incorporated the minimum data set recommended by N.	Many disparities between hospitals in the NHS in the recording and interpretation of basic physiologic parameters. All hospitals incorporated a track and trigger system into standard observation. There is greater proportion of	Level V/B

		Excellence (NICE)	early warning charts.			alignment with the NICE criteria in Scotland.	
Race, 2015	None Identified key adoption attributes	Quality Improvement Single center implementation of a MEWS screening tool Steps: 1. Literature review 2. Developed MEWS tool 3. Consensus on score range 4. Staff education, roles defined Pilot implementation	Adult thoracic med-surg unit in Pennsylvania 520 bed tertiary care hospital N= 50 patients	Cardiac arrest RRT deployment Unplanned ICU admission	80% staff compliance with MEWS scoring every 4 hours. 22/50 (44%) of patients had MEWS score 3 or more, of these 18/22 (81.8% were treated per the algorithm. Zero cardiac arrests. MEWS tool did not identify one patient who was acutely short of breath, two patients had unplanned ICU admissions.	Accurate recording of vital signs and appropriate interventions per the MEWS algorithm are needed if the MEWS screening and scoring is to be effective. Barriers for PCTs (patient care techs) and bedside nurses identified and mitigated through education and workflow changes	Level V/B (low volume, Q1 project)
Shearer et al., 2012	None Identified key adoption attibutes	Qualitative study Multi-method study using a point prevalence survey to determine the incidence of abnormal simple	Four metropolitan teaching hospitals in Melbourne 570 adult inpatient beds On April 17, 2009 between 11-12, all	Compliance with treatment protocols	Incidence of instability was 4.04%. 42% of patients did not receive appropriate clinical response from staff.	Two main reasons why staff did not follow the RRS activation protocol: 1) local sociocultural factors and intra-professional hierarchies, 2)	Level V/B

		bedside observations and activation of the rapid response team by clinical staff, a prospective audit, and structured interviews of staff	adult inpatient observation charts were reviewed, if met EWS criteria, actions of staff in response were recorded. Prospective audit over an 8 week period of missed RRS* calls; all staff interviewed if RRS not activated. Interviews with staff involved in missed RRS calls. *RRS = rapid response system		Structured interviews with 91 staff identified sociocultural reasons for failure to activate RRS.	implementing these systems that alter culture takes years to implement. Decision to call for help is complex; staff are expected to handle clinical situations themselves and face peer pressure if assistance is requested through use of RRS protocols.	
Claussen et al., 2013	None Identified key adoption attributes	6-month retrospective review of the calls made for both the rapid response team and the code blue team, comparing to MEWS system Test of MEWS activation in the EHR	100 bed rural hospital in east Texas July 2012 All patients inpatient medical-surgical care unit	4 factors: systolic BP, heart rate, RR, temp Level of consciousness compared with a normal range to generate a composite score Compare to MEWS score	Post MEWS, number of code blue calls have decreased form 140 10/Q1 to <5 12/Q3 (per graph). Increase in number of RRT calls (actual numbers not provided, graph only).	Baseline: There were no trends or early warning signs before a decline inpatient condition. Post MEWS: Authors described improved communication, anecdotal increases in transfers to a	Level V/C

		MEWS tool was implemented, all members of the team were surveyed to evaluate tool				higher level of care based on the MEWS, staff acceptance of tool.	
Sanders et al., 2013	None Identified key adoption attributes	Quality Improvement Single center implementation of an electronic MEWS for 15 months prior to and 21 months post deployment	Single center 523 bed acute care hospital in Oregon	# of MEWS alerts MDS notified of % of MEWS alerts within one hour Code blue Transfers to ICUs Mortality rate	Not all data provided Average of 15 MEWS daily across 282 beds in the MEWS units MD Notification: Initial: 64% alerts Post: 82% alerts No data No data Decreased by 17% Also reduction in O/E ratio	Compliance with protocol for responding to MEWS alert required repeated education and reinforcement, reporting unit specific performance, 1:1 mentorship. Primary challenge: ensuring nurses notified physicians of every MEWs alert.	Level V/C (low volume, full data not provided)

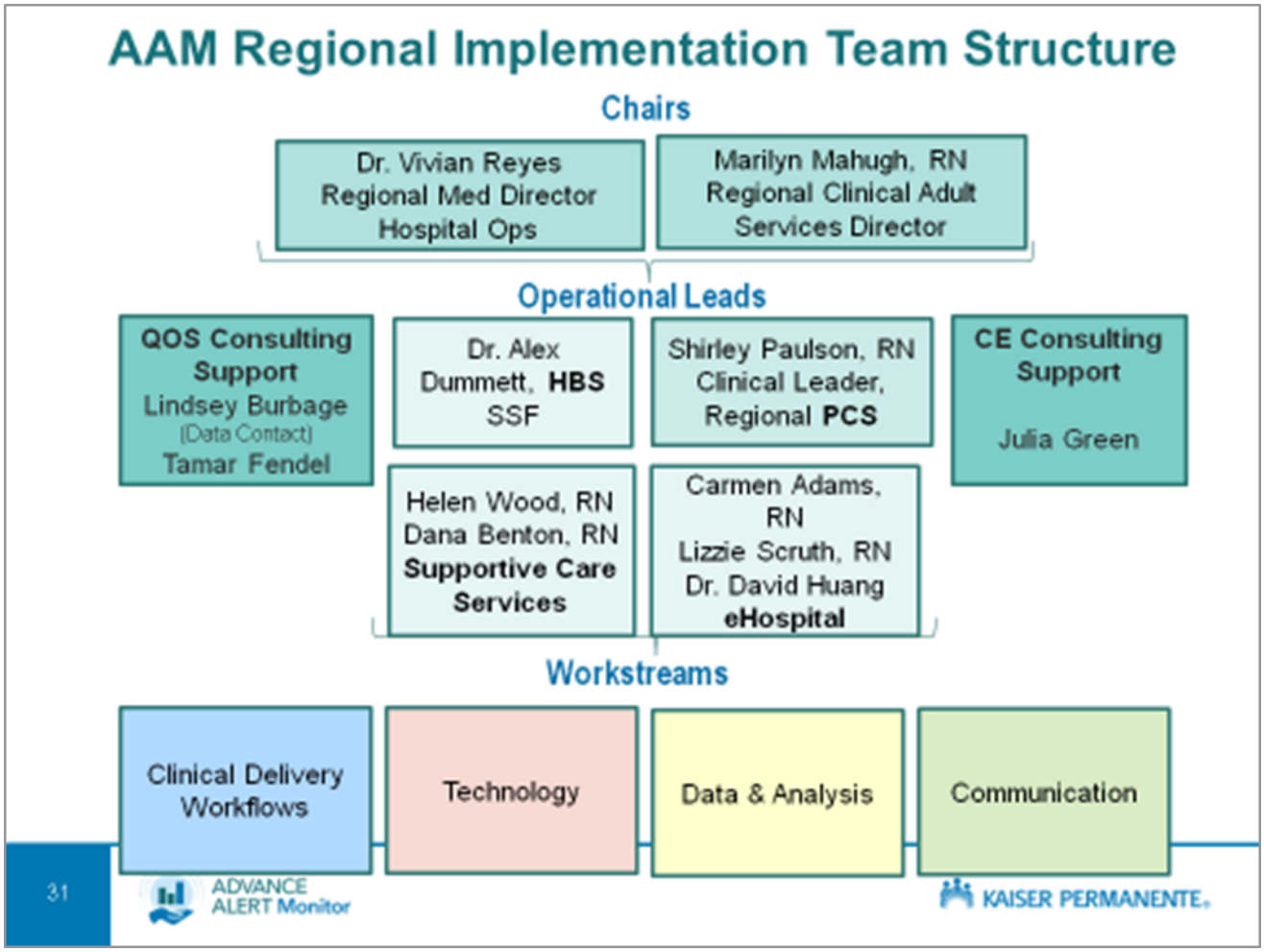
Appendix C

Evidence Synthesis Table by Intervention and Key Attributes of Innovation Adoption

Author Year	Mc Gaughey (2007)	Kyruacos (2011)	Niven (2014)	Mitchell (2010)	Smith (2014)	Lusikhuize (2014)	Ward (2013)	McNeill (2013)	Butcher (2013)	Guirgis (2013)	Umscheid (2014)	Dummett (2016)	Page (2008)	Patterson (2011)	Race (2015)	Shearer (2012)	Claussen (2013)	Sanders (2013)
Level/Quality	1/A	I/A	I/A	I/A	I/A	II/B	II/B	II/B	II/C	II/C	V/A	V/B	V/B	V/B	V/B	V/B	V/C	V/C
INTERVENTIONS																		
RRT	X		X	X		X		X	X	X	X	X		X	X	X		
Early Warning System	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Implementation of EWS		X				X					X	X	X		X	X	X	X
GREENHALGH'S KEY ATTRIBUTES: ***What specific key attributes of innovation adoption (if any) were discussed?***																		
Relative Advantage												X	X			X		X
Compatibility												X	X			X	X	
Complexity						X							X					
Trialability												X					X	
Observability													X		X	X	X	X
Reinvention											X	X	X					
Fuzzy Boundaries																		
Risk																		
Task Issues																		X
Knowledge required to use						X					X	X	X		X	X	X	X
Augmentation / Support						X						X	X		X		X	

Appendix D

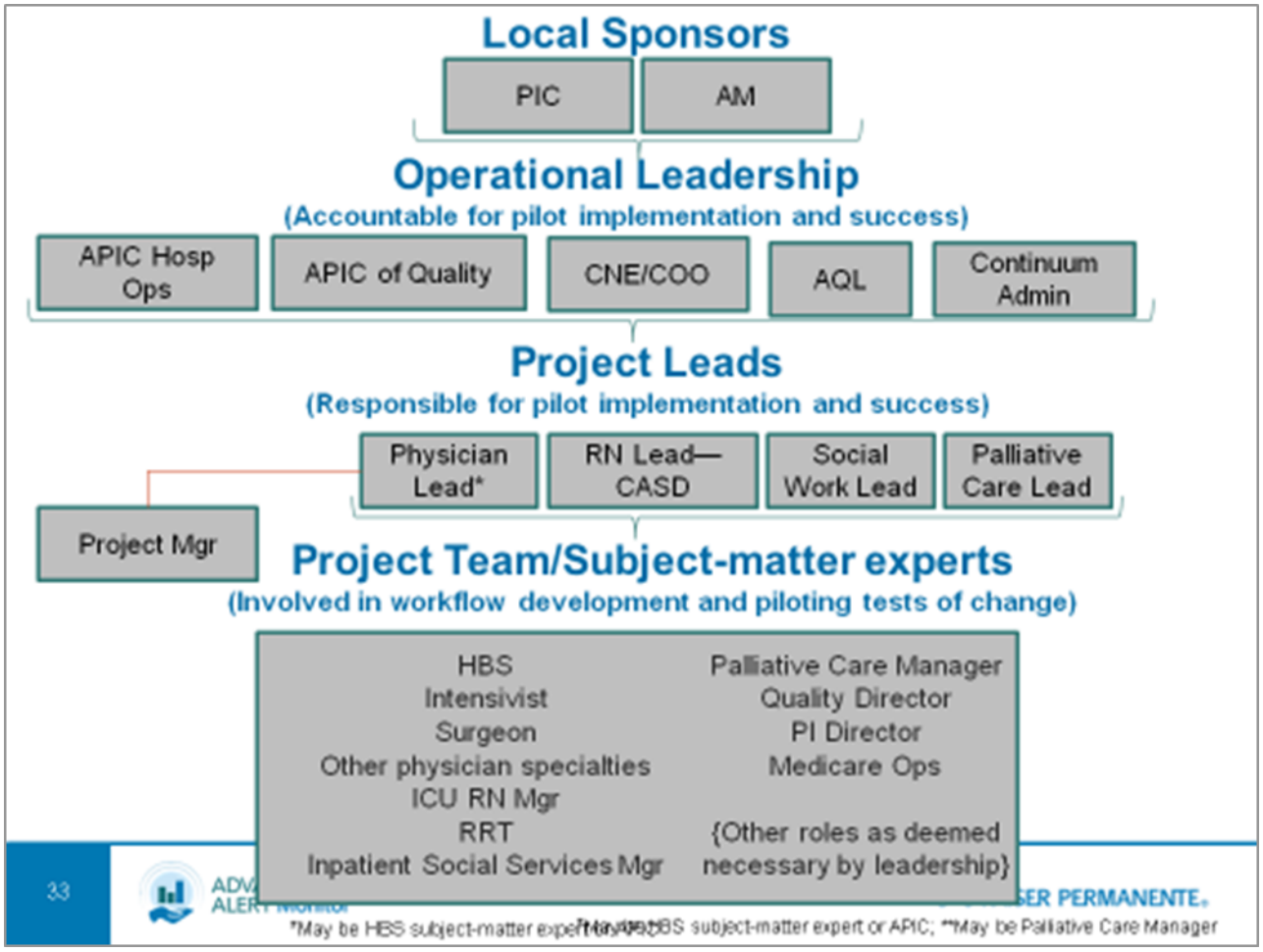
KP AAM Regional Implementation Team



Terms:
QOS = Quality Operations Support
HBS = Hospital Based Services
PCS = Patient Care Services
CE = Q

Appendix E

Local Implementation Team



Terms:
PIC = Physician in Chief
AM = Area Manager
APIC = Assistant Physician in Chief
CNE / CNO = Chief Nurse Executive / Chief Operating Officer
AQL = Area Quality Leader
CASD = Clinical Adult Service Director
HBS = Hospital Based Service (Hospitalist)
PI Director = Performance Improvement Director

Appendix F

Role and Responsibilities of Local Team Members

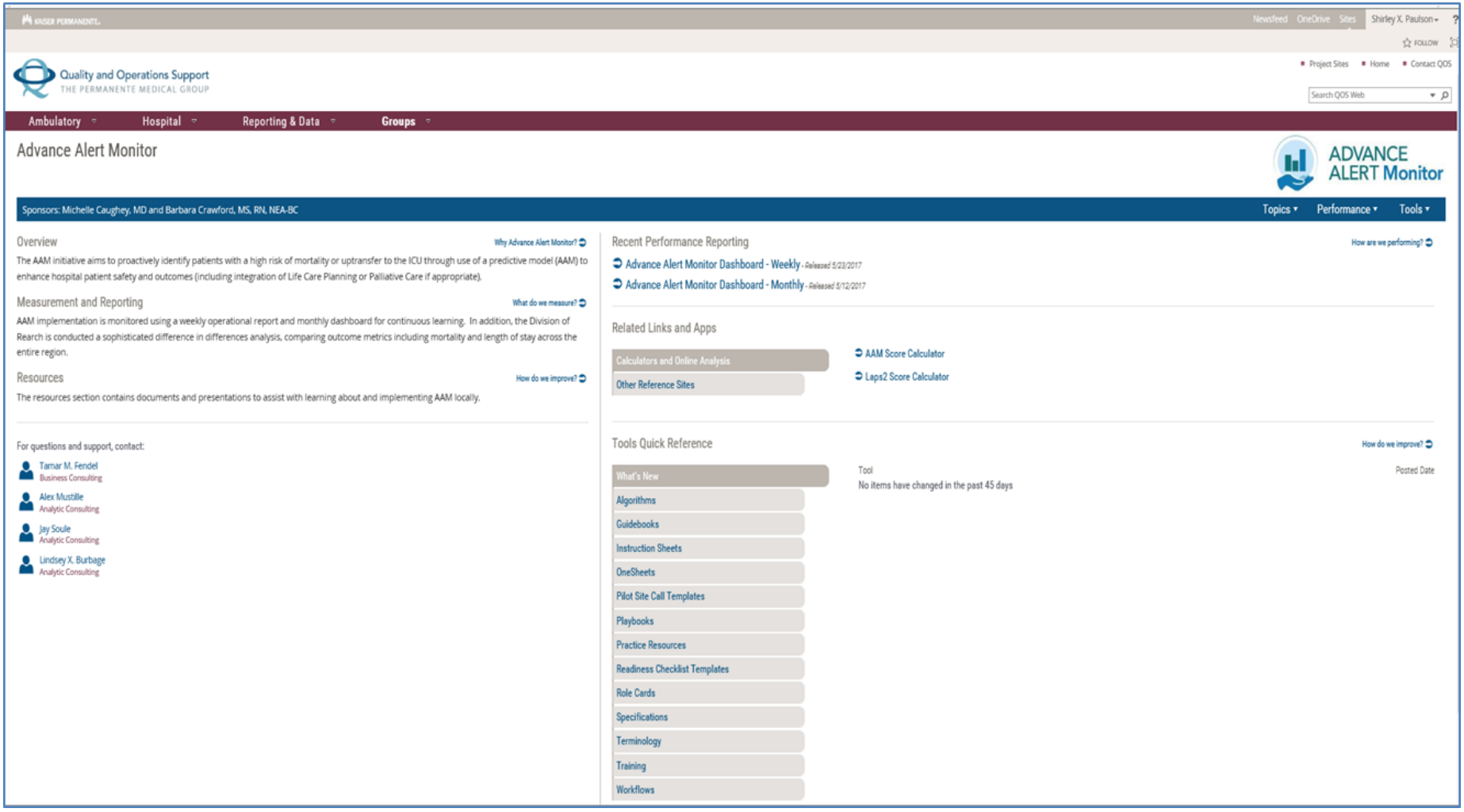
Below are recommended roles and responsibilities for each Implementation Team member. AAM involves coordination across roles within the hospital, and for the program to be successful, a lead from each discipline should be identified to participate in implementation planning and execution.

Role	Responsibilities
Sponsors and Leadership Champions	• Understands the project well • Removes barriers and allocates resources • Rewards and recognizes • Ensures sustainability
Physician and RN Operational Leads: - **Physician Lead** ***(*may also be HBS SME)*** - **RN Lead—CASD**	• Partners with co-leads to lead workgroup and ensure pilot readiness • Communicates about AAM project to hospital leadership and frontline staff • Engages other stakeholders who need to be involved / informed • Makes recommendations for AAM workflow improvements • Works with regional team to train staff • Meets with regional workgroup and eHospital representatives on a weekly basis once pilot begins to facilitate PDSAs • Review weekly and monthly AAM reports
HBS	• Makes recommendations for AAM workflow improvements • Ensures agreement with surgeons and intensivists regarding response to alert • Communicates about AAM project to HBS physicians
RRT	• Makes recommendations for AAM workflow improvements • Works with eHospital team to refine eHospital to RRT communication workflows • Communicates about AAM project to peers
Palliative Care Lead (Operational)	• Communicates about AAM project to palliative team and AAM Leads, HBS • Meets with regional workgroup and eHospital representatives on a weekly basis once pilot begins to facilitate PDSAs • Makes recommendations for AAM workflow improvements
Palliative Care Physician Lead	• Provides guidance on clinical priorities to palliative team, to AAM physician lead • Communicates about AAM project to palliative team and AAM leads, HBS • Meets with regional workgroup and eHospital representatives on a weekly basis once pilot begins to facilitate PDSAs
Inpatient Social Services Manager ***(for Life Care Planning)***	• Makes recommendations for AAM workflow improvements • Communicates about AAM project to LCP facilitators • Meets with regional workgroup and eHospital representatives on a weekly basis once pilot begins to facilitate PDSAs
Intensivist	• Makes recommendations for AAM workflow improvements • Customizes service agreement for HBS up-transfer workflows • Communicates about AAM project to intensivists

Surgeon	• Makes recommendations for AAM workflow improvements • Ensures agreement on HBS/surgery workflows • Communicates about AAM project to surgeons
Medicare Operations Lead	• Collaborates with the project lead to ensure successful implementation
Other physician specialties ***(as deemed relevant by Medical Center)***	• Makes recommendations for AAM workflows • Communicates about AAM project to peers
Quality Director	• Consults on workflow development • Works with RN and MD leadership to monitor pilot progress and implementation quality
PI Director	• Works with clinicians and AAM regional team to structure and monitor PDSA cycles for pilot
Project Manager	• Supports clinical leads in managing progress toward timelines and deliverables
APIC of Hospital Operations	• Strategic leadership for the project • Facilities agreements among specialty services • Removes barriers to success • Identifies unique facility variability requiring Exception Process

Appendix G

Quality and Operations Support (QOS) AAM Website



Appendix H

Message MAP

MESSAGE MAP *Advance Alert Monitor*

ADVANCE ALERT Monitor

Category	Stakeholder Group	Communication Purposes	Key Messages	Owner(s)
Executive Leadership	Internal Regional Leaders External Executive Leadership of Pilot medical centers (Area Manager, Chief Nurse, Assistant Physician-in-Chief)	• Inform Executive Leadership about technology and benefits of AAM • Provide overview to obtain buy in on scope, timeline, expected outcomes, and clinical, financial and reputation advantages of participating as a pilot site.	• Pilots at SSF and Sac have demonstrated ↓mortality, ↓LOS • Projected savings 110 to 400 lives per year and $9-25 million per year • Major innovation → KP is the LEADER • Plans for expansion to all 21 NCAL sites • Your facility reputation and mortality metrics benefit by participating in AAM as pilot	Sponsors: Vivian Reyes MD Regional Operational MD and Marilyn Mahugh, Regional Patient Care Services (PCS) Director
Local Facility Nursing and MD Leadership	Clinical Adult Service Director ICU Nurse Manager/ANM Ward Nurse Manager/ANM Physician Leadership AAM Steering Committee	• Inform local facility leaders of organizational and system/process changes that they will be able to influence as a pilot site; • Provide information on training, change support, and frequency of regional/local facility huddles • Keep informed of progress using data	• Unexpected transfer from the general medical/surgical ward to the ICU is a key patient safety and quality issue • **We can SAVE LIVES by implementing AAM** • Your leadership and visible support is important as we pilot AAM—what we do at your facility we will bring to all of NCAL • Region will provide structured templates for weekly check-ins and will provide data to measure progress	Shirley Paulson, Clinical Nurse Leader Regional PCS and Alex Dummett, MD Clinical MD Leader Region
Front Line Nursing Staff	RRT RNs (ICU) Ward Nurses Nursing Quality Forum (union staff nurses)	• Using different messages for ICU RNs (more clinical with focus on AAM technology) versus ward RNs (less clinical with focus on bedside care and timely documentation of vital signs in the KPHC), • Communicate the benefits of AAM, training and support provided • Reinforce their contribution to saving patient lives and impacting future workflows as this initiative is expanded.	• Unexpected transfer from the general medical/surgical ward to the ICU is a key patient safety and quality issue • **We can SAVE LIVES by implementing AAM** • **Your input is important** as we pilot AAM—what we do at your facility we will bring to all of NCAL • Using standardized workflows and streamlined documentation reduces workload and allows early intervention for high risk patients	
MDs Palliative Care	HBS (Hospitalists) Palliative Care Team / Supportive Services Intensivists	• Inform physicians regarding the technical / statistical aspects of AAM and its value in saving lives, • Reinforce the high touch Regional support, data and workflows for successful implementation, • Reinforce value of Life Care Planning for patients with COPS >65	• Identify patients who are at high risk of deterioration early on to prevent codes, specificity is 40% • **We can SAVE LIVES by implementing AAM** • **Your input is important** as we pilot AAM—what we do at your facility we will bring to all of NCAL	

Appendix I

Communication Strategy (Scripting)

Stakeholder	Suggested Messaging	Considerations	Possible Objections
General KP Staff	• "Kaiser Permanente's Division of Research has analyzed several million records to develop protocols to recognize subtle trends in how patients are doing in the hospital. This is a powerful and unique approach to support hospitalized patients' care." • "We have always been about prevention and if patients are hospitalized, we continue this commitment." • "The new technology addresses our patients' total health through every stage of life." • Appropriate clinical choices are being offered and considered on a case by case basis with specialized training for social workers. •	• Overall message about AAM • This technology is part of Kaiser Permanente's cutting edge approach to provide the highest quality care and to delivering the right care at the right time.	What not to say… AAM is: • A computer that monitors you…. • An alert system that predicts how you are doing in the next 12 hours… • Don't scare the patient or make him/her feel like death is knocking…
Rapid Response Team (RRT) RN	Keep it simple, use the following script: • "Hi Mr./Ms. X. We have been monitoring your labs and vital signs like we do on all our patients. Based on this, I wanted to check in on you to ensure your hospital stay goes well. We are going to ask you a few questions and examine you. Your doctor may decide to order a few tests."	•Important to show patient that RRT and primary RN are a team and that the patient is in good hands. •As RRT, manage up the primary RN and work collaboratively together—this is NOT a code or an RRT; you have TIME to assess and respond.	• Too much work. •No time to respond to AAM. •The ward nurses "run away" when the RRT RN comes to the patient bedside.

Stakeholder	Suggested Messaging	Considerations	Possible Objections
Primary RN	• Suggested script #1: "Hi Mr./Mrs. X., I'm just checking on you. I've noticed X [clinical symptom, e.g, you are having trouble breathing, you seem sleepier than usual, etc]. I've called for the Rapid Response nurse to help evaluate you further" • Suggested script #2: "Hi Mr./Mrs.X, I'm just checking on you. Your care is important to us. We have been monitoring you and I'm a bit concerned that your X clinical symptom [breathing/blood pressure is a bit faster/slower/more labored] than before. I'm going to take a set of vital signs now. I've called for the Rapid Response nurse to help evaluate you further. You are in good hands. We're going to continue to take good care of you."	•Important to show patient that RRT and primary RN are a team and that the patient is in good hands •As primary RN, your patient trusts you and appreciates if you provide an introduction to the other team members. •RRT RN will notify primary RN of the AAM alert and ask you to take a set of vital signs. •Go to bedside to evaluate patient; ensure new vitals collected and entered into KPHC right away. •Be supportive and do not alarm your patient. •We will provide training about AAM and the RRT will show you what he/she is assessing.	• I don't know anything about AAM. •I don't have time to deal with AAM. •If the patient is so sick that the AAM alerts, maybe he/she is too sick to stay on the ward and should be transferred now to the ICU.
Nursing Union	•Minor changes to existing workflow •Documentation is via dot phrase, auto populates •Education build capacity from frontline nurses •Support culture change •Continuous learning •Early ongoing assessment •How we can predict them before they worsen	•Minimal changes to existing workflow. •We have simplified documentation. •Nurses really like it!	•I don't like change. •This looks like a lot more work. •We may need more staff to do this.

Stakeholder	Suggested Messaging	Considerations	Possible Objections
	•Advocate for treatment and trending •Pilot hospital will help develop best practices that will be spread throughout NCAL		
Physicians	•"Hi Mr./Ms. X. We have been monitoring your labs and vital signs like we do on all our patients. Based on this, I wanted to check in on you to ensure your hospital stay goes well. As a team we will be monitoring you closely to make sure you are getting better as expected. After review of your progress, I may order some tests or treatments to help you get better faster. Any questions?" •"I will let your primary doctor know what we found"	What not to say… •A computer that monitors you… •An alert system that predicts how you are doing in the next 12 hours… •Don't scare the patient or make him/her feel like death is knocking…	• I don't have time for this. • This work may be redundant. • I don't like being told what to say. • My patients aren't ready for palliative care. • I know my patients better than you.
Patients and Family Members	• "If your physician is considering a higher level of care for you, your advance care directive and care choices will be respected." • "If you are in our hospital, we will continually monitor your vital signs (blood pressure, heart rate, and body temperature), lab tests, medications and other information specific to you with technically advanced electronic systems to support your care." • "If we notice subtle changes in your vital signs/lab tests, your doctor will be able to make clinical decisions early and may transfer you to a higher level of care." • "This program is specific to your individual vital signs and our systems are	• These comments were reviewed with a Patient Family Advisory Committee for appropriateness	• Do I still have privacy if "a computer" is watching me?

Stakeholder	Suggested Messaging	Considerations	Possible Objections
	designed to recognize very subtle changes earlier so we can provide the right care for you".		
Communication to patients and families regarding AAM	• "Kaiser Permanente is committed to prevention and when you are hospitalized, we continue this commitment. The new technology has been developed by Kaiser Permanente research scientists and our medical care teams to provide 21st century medicine to our patients at XXX Medical Center." • "Advanced Alert Monitor is a cutting edge hospital safety system. This unique data monitor is designed to recognize very subtle changes in your health earlier so your medical team can provide you the highest quality care. As with all decisions regarding your treatment, if your physician recommends testing or additional care, your advanced care directive and personal care choices are our priority."		
If patients/ family want more information	**For patients who want more detailed information, the script will add:** •"We look for certain patterns in your lab results and vital signs. Based on this information, we wanted to keep a close eye on you to make sure that nothing goes wrong in the future."		

Appendix J

Communication Planning

AAM Communications Planning for Walnut Creek

Pilot start:
August 2016

Stakeholder Group	Who needs to be informed?	When do they need to be informed?	How should they be informed?	Who delivers the communication?	Status 10/16/2016
Labor relations	Catherine Porter (NCAL Regional director PCS labor relations)	2nd week of Jan. Shirley to meet Follow up Feb, April, October	Meeting with Labor Relations, SBAR	Shirley Paulson RN	Done
APICs, CNEs, COOs	All APICs, CNOs, COOs	2/9/2016 8/11/2016 Update 11/8/2016 Update	Presentation to APIC/COO/CNE meeting	Alex Dummett MD and Shirley Paulson RN	Done
AQL (Area Quality Leaders)	AQLs	19-May-16	Quality Leaders presentation	Alex Dummett MD and Shirley Paulson RN	Done
Area Managers	All area mgrs	Feb 11, 2016 DONE	NCOM mtg presentation	Marilyn Mahugh RN and Vivian Reyes MD	Overview update about AAM. Ask for RRT permanent staff.
Clinical adult service directors	All CASDs	12/10/2016 Update monthly	Regional peer group interactive presentation	Shirley Paulson RN	Done, ongoing

ED	Chief & Directors	TBD	Jan 26 chiefs mtg--chiefs only	Vivian & Alex	Done
Stakeholder Group	**Who needs to be Informed?**	**When**	**How**	**Who delivers?**	**Status**
Floor RN	ICU and ward RNs	July	Locally Direct communication, staff meetings, role cards	Shirley RN and Alex MD	Done
Fundamental Critical Care Support (FCCS) Conference	Physicians	March 3-4, 2016	Fundamental Critical Care Support (FCCS) Conference	Greg Marelich MD	Done
HBS	Chief	12/10/2016, Updates weekly	Regional peer group, weekly/ daily meetings shadowing and giving feedback (Alex Dummett)	Alex Dummett MD & Vivian Reyes MD	Done, ongoing
ICU managers	All ICU managers	3/10/16 (Joint with CASD)	Joint CASD/ICU NM/Chiefs of Critical Care meeting, Local weekly face-to-face meetings with ICU Manager	Alex Dummett MD and Shirley Paulson RN	Done, ongoing
Inpatient social work	COCSD & SW mgrs	August	Social work mgr peer group COCSD peer group	Shirley RN and Alex MD	Done, ongoing
Intensivists	Chief	3/10/16 (Joint with CASD)	Joint CASD/ICU NM/Chiefs of Critical Care meeting	Shirley RN and Alex MD	Done
Nurse educators (includes KPHC)	Pricilla Javad (Director of RN education and informatics)	January / May/June	Developed AAM Healthstream Education modules	Shirley RN and Alex MD	Done

Nursing Union	Nursing union	June	Nursing Quality Forum: interactive presentation	Shirley RN and Alex MD	Done
Stakeholder Group	**Who needs to be Informed?**	**When**	**How**	**Who delivers?**	**Status**
Palliative care MD	Chief	January --ongoing	Direct communication, staff meetings	Alex MD and Helen Wood	Done
Palliative care RN	Palliative care director (Lynne Callen)	January--ongoing	Direct communication, staff meetings	Alex MD, Shirley RN and Helen Wood	Done
Patients	Patients and Family	July	Patient Advisory Committee	Alex, Helen Wood, Heather Brown	Done
PICs (Physician in Chiefs)	All PICs	January	Vivian Reyes discussion with PICs	Vivian Reyes , MD	Informal communica-tion to PICs Done
Resource management	Chief	January --ongoing	Meeting , SBAR	Alex MD, Vivian MD	Done
RRT (ICU trained RNs, RT, HBS)	Code blue committee chair RRTs	July, ongoing	Direct communication, staff meetings, toolkit, role cards	Shirley RN and Alex MD	Done, ongoing
RT	RT mgr	August	Direct communication, staff meetings	Through Adult Service Directors	Done

Appendix K

Data Dictionary

Data Dictionary Alert Status Terms

- Alert Status Terms:
  - *Initial Alert*: The first AAM score ≥8 that the patient has had since the beginning of their hospitalization. Basically the first time a patient has ever alerted via AAM.
  - *Overnight Initial Alert:* The first AAM score ≥8 that the patient has had since the beginning of their hospitalization that occurs between the hours of 12:00am and 8:00am when no one is monitoring AAM
  - *New Alert:* The first AAM score ≥8 that a patient has had since a period of 48 hours without any AAM score alert >8. Basically the patients has had a 48 hour period with no AAM alert.
  - *Overnight New Alert:* The first AAM score ≥8 that the patient has had since a period of 48 hours without any alerts that occur between the hours of 12:00am and 8:00am when no one is monitoring AAM
  - *Repeat Alert:* An AAM score ≥8 that has occurred within 48 hours of the previous AAM score alert.
  - *Score Jump:* An increase in the AAM score >5 from the previous hour.
  - *Continued Deterioration:* An increase in the AAM score >5 from the time the plan for the patient had been put into place
  - *Reminder:* When you call the RRT RN after the 6-Hour grace period has elapsed to remind them that a patient needs a documented plan in place preferably using the AAM template.
  - *Comfort Care:* When a patient is made a comfort care status we no longer need to call regarding their AAM scores. The HBS should utilize the comfort care order set and that will cease AAM score triggers for that patient however, if they do not use that order set they may continue to have AAM alerts at which point you would consider them a "Do Not Call"
  - *Clinical Judgment:* (Refers to repeat alerts only when score is greater than 5 from previous score)

- A decision may be made to either call RRT RN regarding a patient or forego calling the RRT RN when aligned with the workflow. If you decide to call or not call you must enter a MIDAS entry and explain your rationale in the comments section why you did or did not call. You would select "Clinical Judgment" as your care gap.

Example of clinical judgment call on a repeat alert:

- New problem is causing the repeat alert and the primary HBS team is not aware
- Condition the patient currently admitted for – appears to have significantly worsened
- If you are doubtful: CALL the RRT

❖ Workflow Terms:

- *Shared List:* This refers to adding the patient to the shared AAM patient list that is used by both AAM and RRT RN Staff
- *No Plan > 6 Hours:* 6 hours have lapsed since the AAM fire and there is no plan for the patient documented by HBS.
- *Comfort Care:* When it is determined that a patient will be placed on comfort care there is a specific order set for comfort care that HBS can use.
- *Plan in Place:* Refers to the HBS (or in some situations another physician provider) documenting an AAM note with a plan for the patient in response to their AAM score.
  - *A HBS note that does not use the template for AAM please email Dr. Dummett the name of the HBS that wrote the note.*
  - A plan is a written note by a HBS (written with AAM smart phrase or not) referring to the condition/vital signs etc. that led to the AAM alert.

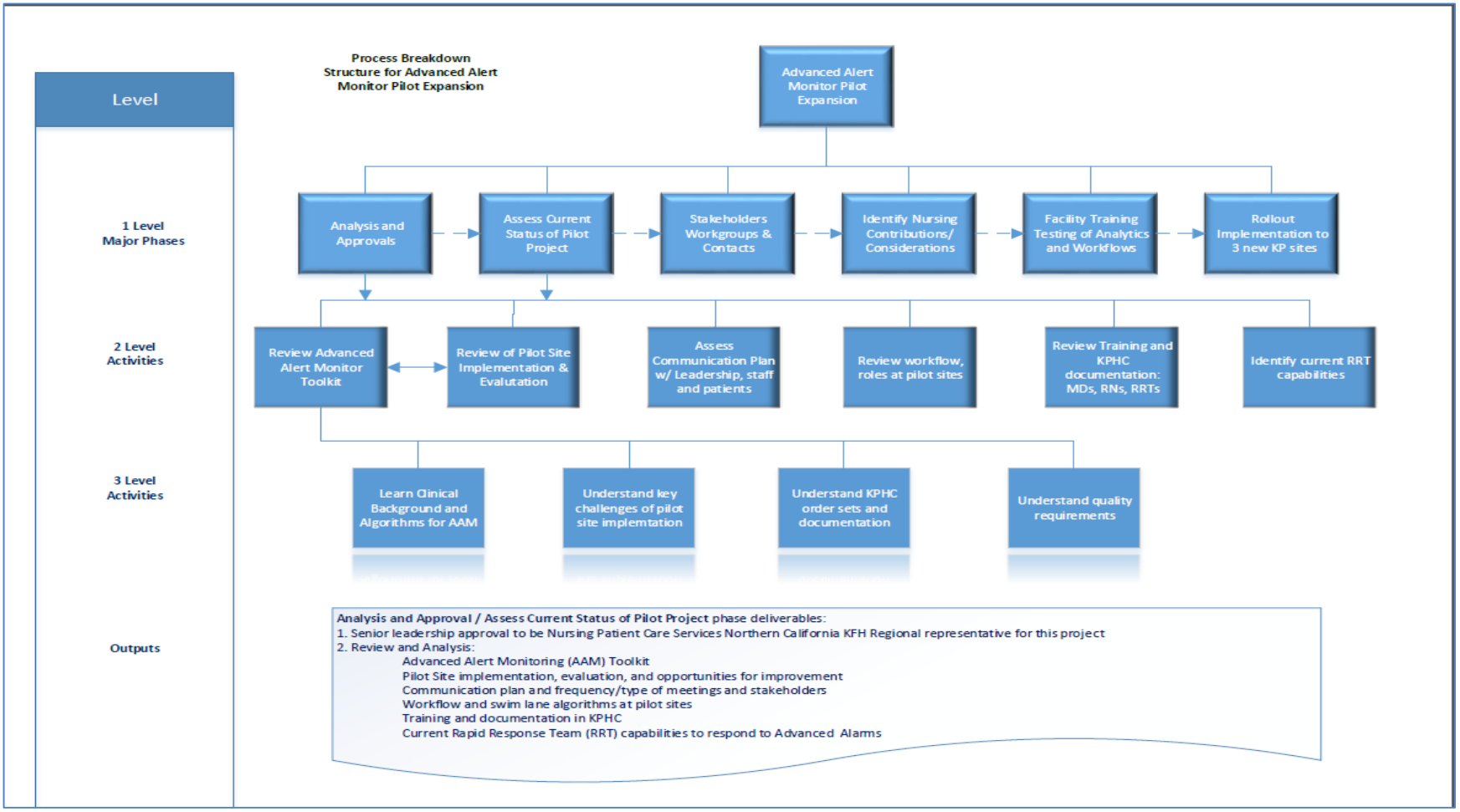
COPS SCORE: score generated based on their chronic disease (CHRONIC)
≥65 Triggers a Palliative Care Consult
≤65 Triggers a LCP
LAPS SCORE: score generated based on combination of medical history and current acute physiology score (ACUTE)

❖ eHospital Team: A remote command center of experienced clinicians who receive the AAM alert and communicate the clinical status and AAM alerts to the Rapid Response Team RN for patient intervention

❖ RRT RN: A critical care trained RN who functions as a Rapid Response Team RN, assessing patients and providing a higher level of nursing care based on clinical judgment and physician orders

Appendix L

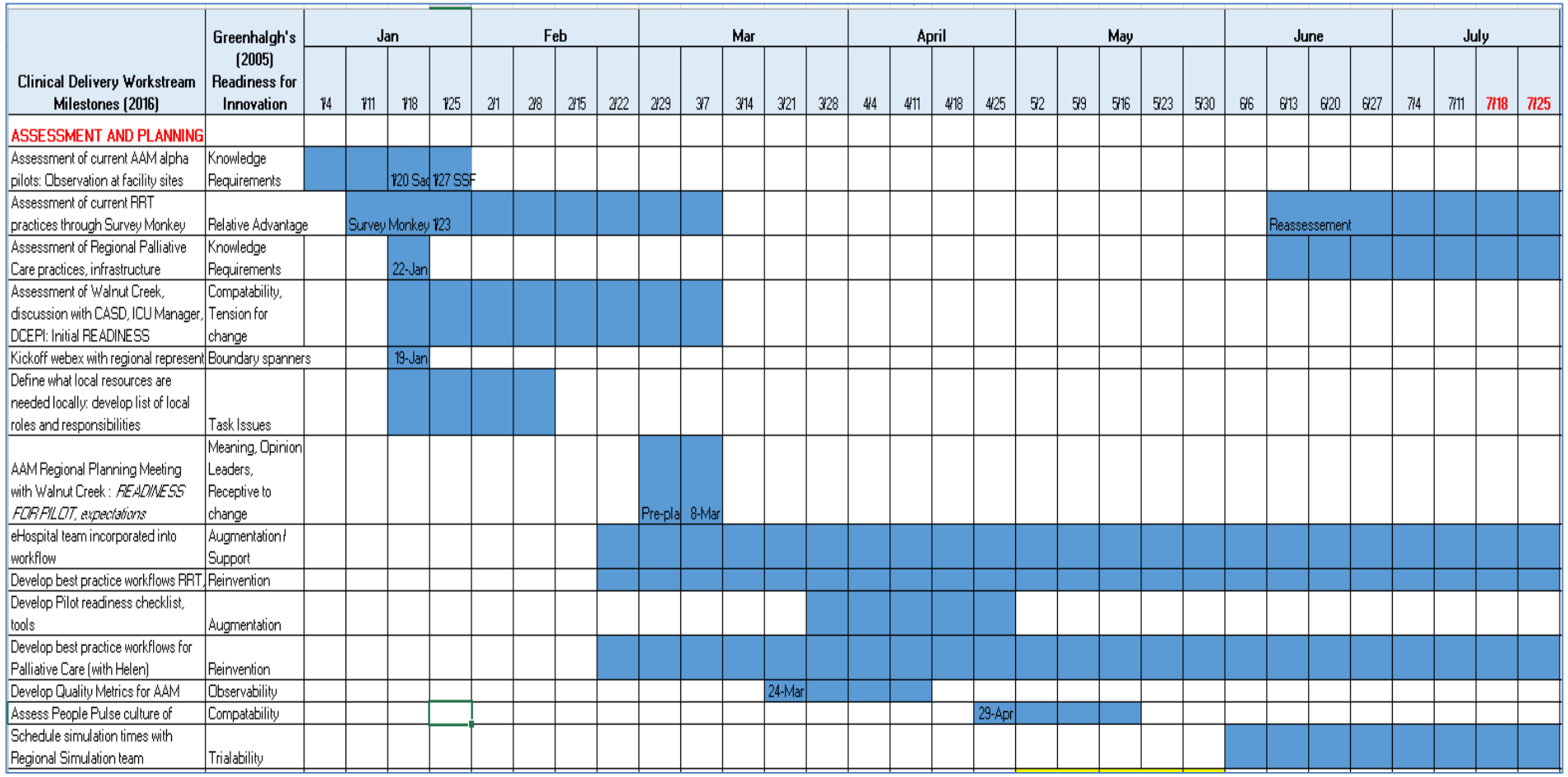
Process Breakdown Structure



Appendix M

Gantt Timeline

Clinical Delivery Part 1: Table M1



Clinical Delivery Part 2: Table M2

Clinical Delivery Workstream Milestones (2016)	Greenhalgh's (2005) Readiness for	Jan				Feb				Mar					April				May					June				July			
		1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	2/29	3/7	3/14	3/21	3/28	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25
10-12 WEEKS PRIOR to PILOT Go Live																			T-12 Wks		T-10 wks										
Obtain formal approval from facility leadership to participate in pilot	The Adoption decision												20-Mar	Approval obtained					DONE												
Obtain resources: MD Lead 7 days\week RRT 4.2 FTE out of count MSW work flow commitment Training time	Dedicated time and resources																														
8 WEEKS PRIOR to PILOT Go Live																							T-8 WKS								
Review Pilot Readiness Checklists	Knowledge, Compatability																														
Identify MD and RN champions, form local implementation team	Champions																														
Walnut Creek Kickoff	Opinion Leader's Influence															13-Apr							DONE								
Verify status of pilot readiness (checklist)	Knowledge																														
Begin presentations to all facility stakeholders (continues for 4 weeks, or as needed)	Knowledge Requirements, Relative Advantage																														
Develop clinical training plan	Knowledge, Compatability																														
7 WEEKS PRIOR to PILOT Go Live																								T-7 Wks							
Finalize facility communication strategy	Meaning, Receptive context for change																														
Finalize KPHC documentation strateg	Task Issues																														

Clinical Delivery Part 3: Table M3

Clinical Delivery Workstream Milestones (2016)	Greenhalgh's (2005) Readiness for	Jan				Feb				Mar					April				May					June				July			
		1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	2/29	3/7	3/14	3/21	3/28	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25
6 WEEKS PRIOR to PILOT Go Live																									T-6 Wks						
Finalize clinical training tools	Knowledge, Compatability																														
Finalize Pilot readiness toolkit	Knowledge, Compatability																														
Begin training	Knowledge, Reinvention																														
Clinician training RRT Nurses, ICU St	Knowledge, Reinvention																														
Clinician training HBS	Knowledge, Reinvention																														
Clinician training SWPC	Knowledge, Reinvention																														
Clinical training ANMs, Managers	Knowledge, Reinvention																														
5 WEEKS PRIOR to PILOT Go Live																										T-5 Wks					
Finalize interdepartmental agreement	Fuzzy boundaries																														
4 WEEKS PRIOR to PILOT Go Live																											T-4Wks				
Continue clinical training	Knowledge, Low Complexity																														
Verify status of pilot readiness checkl	Knowledge																														
Staff meetings to Med/Surg	Knowledge, Compatability																														
3 WEEKS PRIOR to PILOT Go Live																												T- 3 Wks			
Simulation / shadowing workflows	Augmentation / Support																														
Set up debrief calls--quality oversight	Augmentation / Support																														
2 WEEKS PRIOR to PILOT Go Live																													T-2 Wks		
Facility kick off meeting	Receptive context for change																														
Develop contingency plan for unexpected event, e.g., survey																															
Continue simulation and test runs	Augmentation / Support																														
1 WEEK PRIOR to PILOT Go Live																														T-1Wk	
Complete all training	Knowledge																														GO LI
Go LIVE																															
On site support and troubleshooting	Augmentation / Support																														
Continuous quality oversight : Ongoir	Observability																														

Appendix N

AAM Pilot Readiness Checklist

The table below details steps necessary to ensure pilot readiness.

Task	Recommended Strategy/Format	Responsible Parties	Regional Supporting Tools	Complete?
Identify MD and RN lead for pilot	N/A	WCR KFH and TPMG leadership	Implementation Structure AAM—See Appendix A	
Assemble AAM project team participants	N/A	WCR MD and RN pilot lead & KFH and TPMG leadership	Implementation Structure AAM—See Appendix A	
RRT RN staffed out of the count 24/7	N/A	WCR RN pilot lead	Role expectations from alpha sites (SSF and SAC)	
Assess current staffing for Palliative Care and Life Care Planning (LCP)	N/A	WCR MD and RN pilot lead	Regional recommendation—See Appendix B	
Review existing AAM workflows and adapt to local needs	In-person meeting in WCR with regional team members	WCR MD and RN pilot lead & project team AAM regional operational leads & eHospital	Suggested meeting agenda Workflows from alpha sites (SSF and SAC) and March 8th workshop AAM practice patient scenarios	
Develop local escalation pathways and ensure stakeholder agreement for: ○ **RRT response to eHospital call** ○ **HBS** ○ **Palliative care and LCP** ○ **Involvement of surgery / other MD specialties**	In-person meeting in WCR with regional team members Subsequent local meetings likely required	WCR MD and RN pilot lead & project team AAM regional operational leads & eHospital	Workflows from alpha sites (SSF and SAC) and March 8th workshop AAM practice patient scenarios	
Develop documentation for escalation pathways	In-person meeting in WCR with regional team members Subsequent local / regional collaborative meetings likely required	WCR MD and RN pilot lead & project team AAM regional clinical workflow representatives	Documentation from alpha sites (SSF and SAC) and March 8th workshop	

Task	Recommended Strategy/Format	Responsible Parties	Regional Supporting Tools	Complete?
Submit final local workflows & escalation pathways to regional AAM team for approval	Webex meetig to review final workflow	WCR MD and RN pilot lead AAM regional operational leads & eHospital	N/A	
Complete necessary IT requirements	Create and provide access to AAM dotphrases Submit NUIDs for those that would like access to the AAM website	WCR MD and RN pilot lead Designated IT support	Consultative support on necessary requirements Provide access to AAM website	
Cascade communication:* ○ **Nursing** ○ **HBS** ○ **Supportive care services** ○ **Surgery / other MD specialties** ○ **Other groups as relevant**	Department Meetings	WCR MD and RN pilot lead or their designees	Slide decks with background information on AAM	
Training & Simulation:* ○ **Nursing** ○ **HBS** ○ **Supportive care services** ○ **Surgery / other MD specialties** ○ **Other groups as relevant**	Meetings; patient simulations	WCR MD and RN pilot lead or their designees	Patient scenarios Slide decks with background information on AAM	
Training: Shadowing	Patient shadowing	WCR MD and RN pilot lead or their designees AAM regional operational leads & eHospital	Support with training and shadowing	
Communicate and celebrate official kick-off	N/A	WCR MD and RN pilot lead or their designees	N/A	
Convene team to participate in weekly calls to debrief PDSAs after go live	Weekly Webex	WCR MD and RN pilot lead AAM regional operational leads & eHospital	Agendas and supporting materials to facilitate debriefs on PDSAs	
Evaluate progress throughout pilot; including case reviews	Local workgroup meetings	WCR MD and RN pilot lead or their designees	Operational measurement Template for case review	

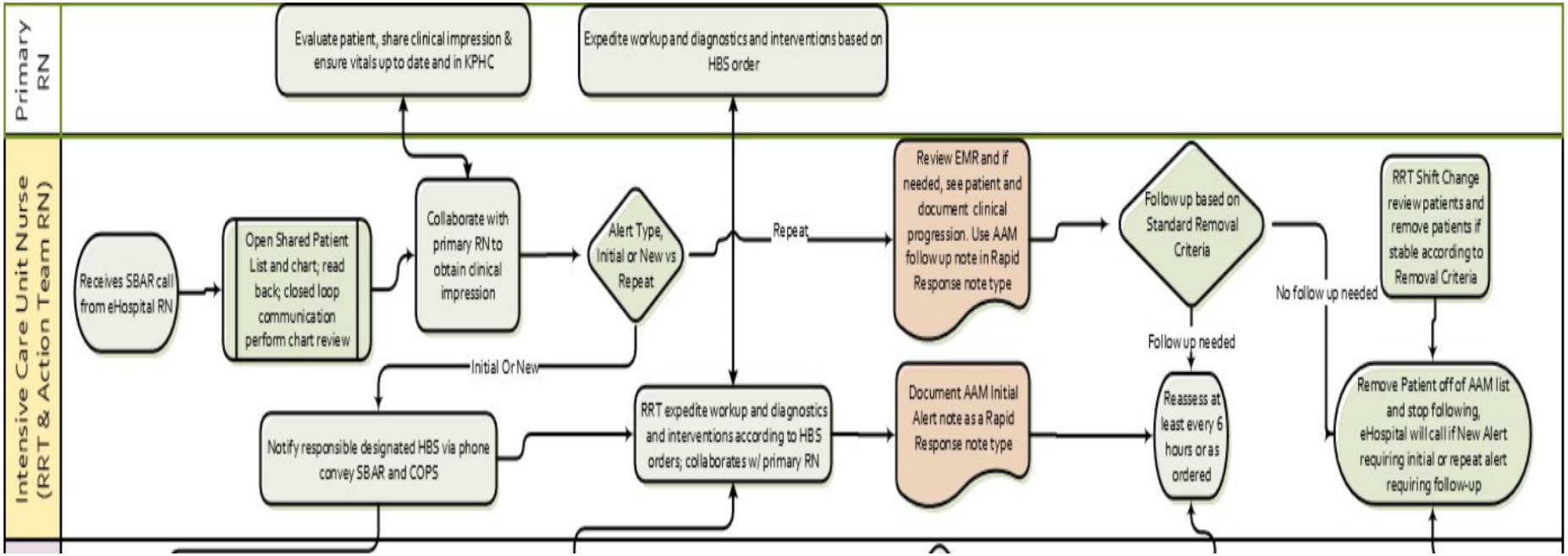
*Stakeholder groups that require communication and training will depend on WCR's workflow

Appendix O

Scope of Clinical Delivery Workflow

Appendix P

Swim Lane Diagram (Partial Section only)



The full swim lane diagram identifies specific roles for the following:
eHospital
Primary RN
Intensive Care Unit (RRT RN)
Hospitalist
Social Worker
Palliative Care

The roles of the primary RN and RRT RN are featured here.

Appendix Q

Potential Risks to Advance Alert Monitoring (AAM) Implementation

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
1.0. Legal Risks								
1.1	Use of AAM as an innovation can be seen as a deviation from the prevailing standard of care	Low	Med	Low	Tolerate	Create messaging to reinforce that AAM safely provides 1) an earlier level of response, 2) higher patient care benefits, 3) follows CPGs	Ongoing	No further action
1.2	3rd party may use development of new AAM innovation against us to determine if care was appropriate and adequate	High	Med	Med	Tolerate (the risk and its impact)	Create/ share message that AAM applies current clinical practice guidelines for clinician response	Ongoing	No further action
2.0 Facility readiness risk								
2.1	Inadequate Roger's Diffusion of Innovation Model elements present: Knowledge Persuasion Decision Implementation Confirmation	Med	Med	Med	Treat (the risk to reduce impact of exposure)	Assessment of facility readiness for change: Gaps identified and addressed Work with WCR leadership to mitigate gaps	Ongoing during pilot	Stakeholder communication related to status of implementation elements bi-weekly during Phase 1 implementation using structured report out template
2.2	Inadequate eleven key attributes for Diffusion of Innovation present (Greenhalgh, 2004): Relative advantage, compatibility, low complexity, trialability,	Med	Med	Med	Treat	Assessment of facility readiness for change: Gaps identified and addressed	Ongoing during pilot	Stakeholder communication related to status of implementation elements bi-weekly during Phase 1 implementation using structured report out template

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
	observability, reinvention, fuzzy boundaries, risk, task issues, knowledge requirements					Plan the scope of the AAM project and develop		
2.3	Insufficient training completed by stakeholders	Low	High	Med	Treat	Education plan developed with stakeholder active involvement Tools provided by Region to test workflows in training environment	Ongoing Target: 80% complete	Monitor: Discipline lead will monitor # and % of RNs, MDs, supportive services who have completed education (including training in simulation environment for RNs and MDs)
2.4	Insufficient stakeholder engagement	Low	High	Low	Treat	Leadership, staff involvement Frequent communication Staff inservices Attitude survey	Ongoing through pilot	Feedback from stakeholders and participation at bi-weekly pilot check in calls
2.5	Project not coordinated with other initiatives in the organization or external to organization Conflicts with other requirements, e.g., surveys	High	Med	Med	Treat	Contingency plans in event of survey at time of pilot implementation	Ongoing through pilot	WCR leadership to communicate with Regional team if conflicts occur with other required activities and need to suspend pilot
2.6	Project resources inadequate with insufficient staff to support project	Med	Med	Med	Treat	Walnut Creek (WCR) leadership to provide project resource support	Ongoing through pilot	WCR to ensure project support
3.0 Infrastructure risks								
3.1	KPIT build for AAM is not completed timely	High	High	High	Tolerate	Dependency to start pilot	Weekly check in	Evaluate progress of KPIT build weekly
3.2	Workflows, documentation structure do not adequately meet the process and data retrieval needs	Med	Med	Med	Treat	Workflows evolving, WCR to support with KPIT	Ongoing through pilot	Test builds to DOR and KPIT servers to ensure data capture

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
3.3	Division of Research (DOR) unable to provide needed data support	Low	Med	Low	Tolerate	DOR involved and prioritized project	Ongoing through pilot	Ongoing assessment of DOR bandwidth to support project
3.4	KPIT build for clinical training sandbox is not completed timely to support training	Med	Med	Med	Treat	Manual entry of sandbox clinical scenarios by Clinical Leads and Walnut Creek	By start of clinical training July 12	Testing of clinical sandbox by Clinical Leads will be completed by July 12
3.5	Project management arrangements unable to deliver project	Low	Low	Low	Treat	Clear project management structure in place Clear links between AAM team members to ensure a coordinated approach	Ongoing through pilot	Ongoing assessment of PM bandwidth to support project (both Regional and local)
3.6	eHospital program is not 24/7. Hours have expanded from 1600-12MN to 0800-12MN, but there is an 8 hour gap in coverage	High	High	High	Tolerate	Existing RRT workflows will continue during the night shift hours 12MN-0800 Establish proof of concept prior to expanding eHospital to 24/7	Ongoing through pilot	Assess volume of AAM fires during 11pm-0800 Evaluate number of eHospital to RRT calls between 0800-1000 Report weekly at AAM planning meetings
4.0 Labor Risks								
4.1	Changes in physician workflows regarding AAM practice ownership between surgeons and hospitalists may not be well accepted	Med	High	High	Treat	Open discussion between physician groups Medical leadership /champion support	Ongoing through pilot	Feedback / evaluation / drill down of workflow processes (including communication) at weekly AAM planning meetings
4.2	Complaints from Union nurses that this project is a	Med	High	Med	Treat	Team met with Labor Relations for guidance	Ongoing through pilot	Feedback / evaluation of RRT RN's satisfaction with

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
	"change in practice", requiring bargaining					Involved union staff at the start, include in workflow and training development		workflows and integration into current practice
4.3	Variance in RRT staffing, competencies and workflows at NCAL facilities—may not have RRT dedicated to AAM workflows	High	High	High	Treat	Involve management leadership, finance to develop standard budget and competency structure for RRT Began regional RRT competency discussions 6/13	Ongoing through Pilot 1 (WCR) and Pilot II (next beta) phases	Updated RRT survey sent June 28 Report results of survey to leadership to request support for RRT staffing
4.4	Medical Surgical nurses feel unsupported by RRT RN if AAM score fires and RRT RN "takes over" patient management	High	High	High	Treat	RRT education and reinforcement of difference between Code, RRT and AAM response	Ongoing through pilot	Feedback from Med Surg and ICU Adult Services Directors regarding concerns
4.5	Potential "bolus" of AAM alerts at 0800-0900 when eHospital RN begins his/her shift. This could be overwhelming to RRT RN and HBS physician	High	High	High	Treat	Provide access to the java website so alerts can be reviewed during the night Plan for night shift Hospitalist and RRT to round together on AAM patients at change of shift	Ongoing through pilot	Assess volume of AAM fires during 11pm-0800 Evaluate number of eHospital to RRT calls between 0800-1000 Report weekly at bi-weekly AAM pilot check in meetings
4.6	Overwhelm Palliative Care staffing given each AAM >8 and COPS2>65 currently require PC consult for appropriateness of PC or hospice or LCP may	High	High	High	Treat	Allow for rapid adjustment of referral completion upon consultation based on locally developed criteria	Ongoing through pilot	Assess volume of PC consults Assess appropriateness of PC, hospice or LCP consults

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
	overwhelm current resource allocation.							Report at bi-weekly AAM check in meetings
4.7	RRT monitoring AAM patients to the detriment of other responsibilities	Low	Low	Low	Treat Transfer	Rapidly develop criteria for removing patients off of watch shared !AAM patient list Define streamlined work duties for RRTs so their priority is AAM	Ongoing through pilot	Feedback from RRT RNs and nursing leadership regarding transfer of existing RRT RN "other" responsibilities
5.0 Reputational Risks								
5.1	Complaints that the high AAM will "scare" patients and their families	Med	Med	Med	Treat	Met with Patient advisory council for recommendations on consistent messaging to patient and family after AAM fires	Ongoing through pilot	Feedback from patients and clinicians regarding patient satisfaction with AAM process to be provided at the bi-weekly pilot check in meetings as part of structured reporting template
5.2	Misunderstanding by staff and members of the purpose of AAM (does not determine that a patient will "die")	Med	Med	Med	Treat	Develop patient facing education tools to provide consistent message about AAM benefits	Ongoing through pilot	
5.3	Changing from Full Code to DNR. DNI is not the goal; goal is sharing with their treatment team their updated wishes clearly and broadly	High	Low	Med	Treat	Educate front line providers it is the conversation we are interested in not the outcome	Ongoing through pilot	Monitor code status changes as part of individual patient drill down, reported at weekly AAM planning meetings
6.0 Financial Risks								
6.1	Overtime claims due to additional training needs	High	Med	Med	Tolerate	Chief Nurse Executive from Walnut Creek has supported additional training costs	Ongoing through pilot	Local facility to monitor OT as part of daily operations

Risk Index	Potential Risk Description	Current Level of Risk			Risk Response 4Ts*	Action to be Taken	Frequency of Control	Monitoring Plan
		Likelihood	Magnitude	Overall Rating				
6.2	Insufficient monies available through grant funding	Low	Low	Low	Treat	Provisions have been made and additional costs will be met from existing budgets	Ongoing through pilot	Closed
6.3	Inadequate funding for KPIT for initial and continuing support of deliverables: • Regional smartphrase for AAM response and follow up for RRT RN • Regional smartphrase for physician response to AAM • KPHC staff interaction with DOR and KPIT to develop statistical quality control algorithm development	Med	Med	Med	Treat	Request for funding submitted	Ongoing through pilot	Closed

Adapted from Hopkin, P. (2015). *Fundamentals of Risk Management 3rd edition*, Risk Register attached to a business plan, p. 95.

*4Ts: Treat the risk to reduce impact or exposure: Appropriate for risks that can be treated by corrective controls
Terminate the activity generating the risk: Appropriate for risks not acceptable to the organization
Transfer the risk to another: Appropriate for risks outside the risk appetite, organization wishes to transfer or share the risk
Tolerate the risk and its impact: Appropriate when the level of risk is within the risk appetite

Source: Hopkin, P. (2015), p. 53, 410

Appendix R

Implementation Playbook

ADVANCE ALERT Monitor

Advance Alert Monitor

Implementation Playbook

March, 2017

Produced by:

Alex Dummett, MD, CPPS

AAM PHYSICIAN LEAD, PATIENT SAFETY FELLOWSHIP ASSOCIATE DIRECTOR

Shirley Paulson, DNP(c), MPA, RN

CLINICAL LEADER, REGIONAL PATIENT CARE SERVICES

Helen Wood, CNS

CLINICAL PRACTICE CONSULTANT, SUPPORTIVE CARE SERVICES

Quality and Operations Support

Clinical Effectiveness

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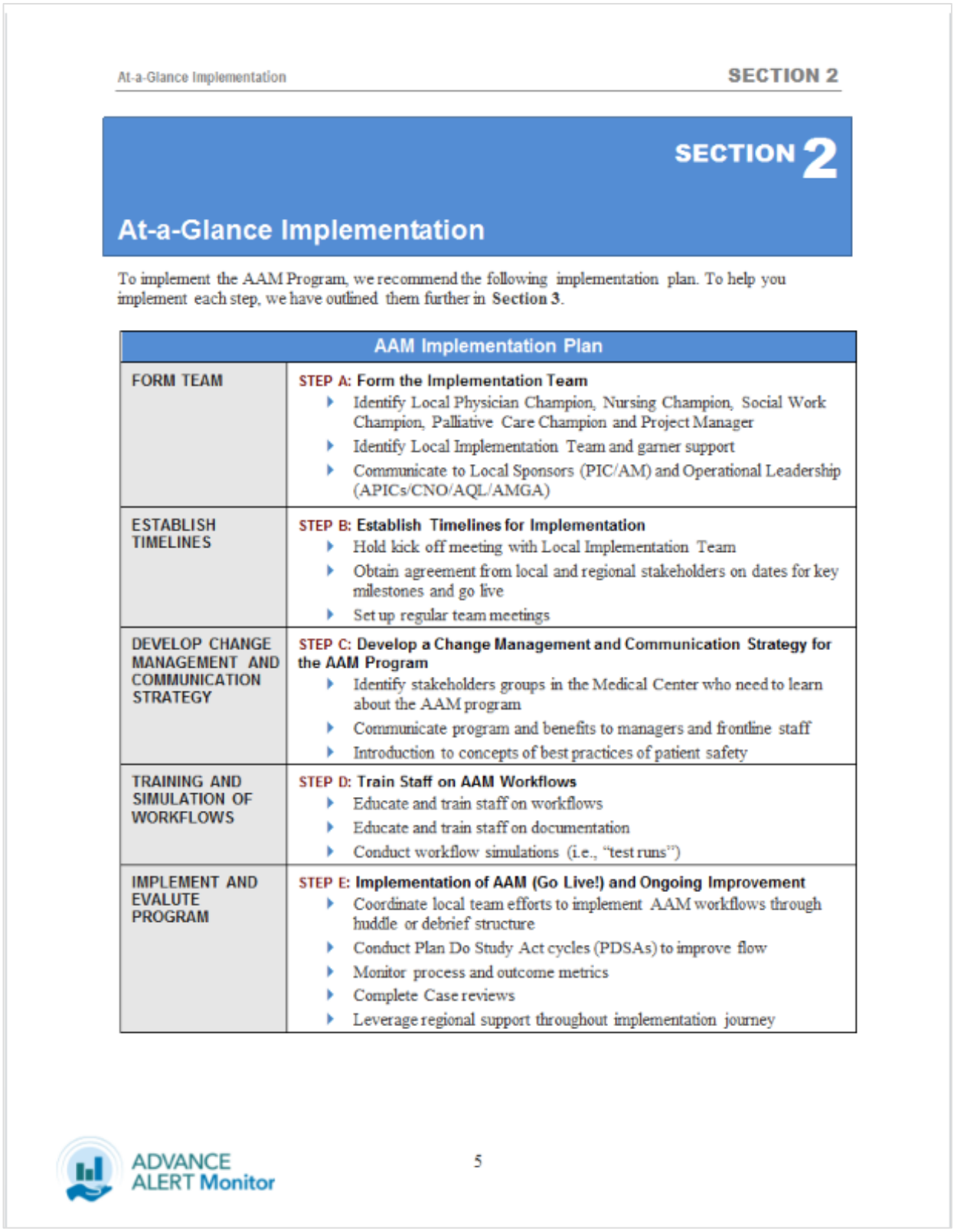

At-a-Glance Implementation SECTION 2

SECTION 2

At-a-Glance Implementation

To implement the AAM Program, we recommend the following implementation plan. To help you implement each step, we have outlined them further in **Section 3**.

AAM Implementation Plan	
FORM TEAM	STEP A: **Form the Implementation Team** ▸ Identify Local Physician Champion, Nursing Champion, Social Work Champion, Palliative Care Champion and Project Manager ▸ Identify Local Implementation Team and garner support ▸ Communicate to Local Sponsors (PIC/AM) and Operational Leadership (APICs/CNO/AQL/AMGA)
ESTABLISH TIMELINES	STEP B: **Establish Timelines for Implementation** ▸ Hold kick off meeting with Local Implementation Team ▸ Obtain agreement from local and regional stakeholders on dates for key milestones and go live ▸ Set up regular team meetings
DEVELOP CHANGE MANAGEMENT AND COMMUNICATION STRATEGY	STEP C: **Develop a Change Management and Communication Strategy for the AAM Program** ▸ Identify stakeholders groups in the Medical Center who need to learn about the AAM program ▸ Communicate program and benefits to managers and frontline staff ▸ Introduction to concepts of best practices of patient safety
TRAINING AND SIMULATION OF WORKFLOWS	STEP D: **Train Staff on AAM Workflows** ▸ Educate and train staff on workflows ▸ Educate and train staff on documentation ▸ Conduct workflow simulations (i.e., "test runs")
IMPLEMENT AND EVALUTE PROGRAM	STEP E: **Implementation of AAM (Go Live!) and Ongoing Improvement** ▸ Coordinate local team efforts to implement AAM workflows through huddle or debrief structure ▸ Conduct Plan Do Study Act cycles (PDSAs) to improve flow ▸ Monitor process and outcome metrics ▸ Complete Case reviews ▸ Leverage regional support throughout implementation journey

ADVANCE ALERT Monitor

5

Appendix S

Data Dictionary Measurement

Description	Numerator	Denominator	Population
Inpatient admits who are in the ward/TCU/telemetry who were not comfort care only		-	-
Defined as hours between 11:05 p.m. and 7:05 a.m.			
Unplanned transfer rate of patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	# of unplanned transfers over the period	1000 patient discharges	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of unplanned transfers stratified by population	# of patients with an unplanned transfer	# of patients in the population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
Unplanned death rate of full code ward patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	# of full code ward deaths over the period	1000 patient discharges	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
AAM initial alert threshold reached rate among AAM eligible patients	# of AAM fires over the period	1000 patient discharges	AAM eligible patients who reached alert threshold
Rate of social work consults ordered of patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	# of social work consults ordered	1000 patient discharges	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
Rate of palliative care consults ordered of patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	# of palliative care consults ordered	1000 patient discharges	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of unplanned transfers among AAM eligible patients who reached alert threshold	# of unplanned transfers with AAM fire	total # of unplanned transfers	AAM eligible patients who reached alert threshold

Description	Numerator	Denominator	Population
In medical centers with eHospital response team, the % of eHospital calls that occurred within one hour of a patient reaching alert threshold	# of patients with eHospital responses that occur within one hour of initial fire	# of patients with initial fire	AAM eligible patients who reached alert threshold
In medical centers with eHospital response team, the % of patients with RN note(s) created within 6 hours of ehospital contact	# of patients in population with initial RN notes recorded within 6 hours of eHospital contact	total # of patients with ehospital response	AAM eligible patients who reached alert threshold
In medical centers with eHospital response team, the % of patients with MD note created within 6 hours of ehospital contact	# of patients in population with MD notes recorded within 6 hours of ehospital contact	total # of patients with RN notes	AAM eligible patients who reached alert threshold
% of patients with a Palliative Care consult ordered	# of patients in population with Palliative Care consult ordered	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of patients with a Social Work consult ordered	# of patients in population with Social Work consult ordered	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of patients with an agent named in Navigator, previous or current encounter	# patients in population with an agent named in the Navigator	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of patients with next steps in Navigator, previous or current encounter	# of patients in population with next steps in Navigator	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
% of patients with advanced steps in Navigator, previous or current encounter	# of patients in population with advanced steps in Navigator	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients
Inpatient mortality among AAM eligible patients	total # inpatient deaths	total # of patients in population	AAM Eligible
Average length of stay of patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	total # of days spent in ICU	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients

Description	Numerator	Denominator	Population
Average length of stay of patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients	total # of days spent in hospital	total # of patients in population	Patients who reached alert threshold versus patients who did not reach alert threshold among AAM eligible patients

Appendix T

Facility Letter of Support

KAISER PERMANENTE

Patient Care Services
1950 Franklin Street, 19th Floor
Oakland, CA 94612

June 29, 2016

University of San Francisco School of Nursing
2130 Fulton Street
San Francisco, CA 94117-1080

To Whom it May Concern,

I am writing to express support for Shirley Paulson's proposed evidence based change of practice in partial fulfillment of her Doctor of Nursing Practice degree through the University of San Francisco's Executive Leadership DNP Program.

The project, entitled, "Planning for Advance Alert Monitor (AAM) Implementation", will focus on the steps for planning the implementation of an automated early warning systems at a large integrated health care system. The project will review factors that need to be considered from a cultural and organizational perspective to both start and sustain an implementation, using the Innovation of Diffusion theory to guide the implementation process. Shirley is the Regional Clinical Leader for this AAM program, and has translated the application of this complex and innovative research to nursing workflow and clinical practice.

As the Regional sponsor for this program and Shirley's direct supervisor, I am very aware of, and support, this innovative project. This predictive early warning system has implications for saving lives and reducing mortality as this pilot is expanded from two alpha sites to a third and fourth beta site, before expanding to all 21 Northern California facilities.

This letter also verifies that Kaiser Permanente has an existing contract with University of San Francisco School of Nursing.

Sincerely,

Marilyn Mahugh, RN, MS
Regional Director Patient Care Services, Kaiser Permanente
1950 Franklin Street
Oakland, CA 94612

Appendix U

Statement of Determination

UNIVERSITY OF SAN FRANCISCO | School of Nursing and Health Professions

DNP Statement of Non-Research Determination Form

Student Name: Shirley S. Paulson

Title of Project: Implementation and socialization of an Advanced Alert Monito (AAM) early warning clinical trigger system to identify Adult Medical Surgical patients prospectively at risk for clinical deterioration, using the local Rapid Response Team (RRT) ICU RN and eHospital remote monitoring process, at three Northern California (NCAL) beta site hospitals.

Brief Description of Project:

A) Aim Statement: To implement and socialize an Advanced Alert Monitoring early warning system which identifies Adult Medical Surgical patients prospectively at risk for clinical deterioration, using the local Rapid Response Team (RRT) ICU RN and eHospital remote monitoring process, at three Northern California (NCAL) beta site hospitals by July 2017.

B) Description of Intervention: Advance Alert Monitor (AAM) utilizes complex laboratory and co-morbidity algorithms developed by the Division of Research at a large NCAL hospital system to calculate, in real time, the risk of patient deterioration within the next 12 hours to reduce the likelihood of unplanned transfers to the ICU. A patient with an elevated AAM score >8% triggers a remote electronic medical record (EMR) evaluation by the off site eHospital team, comprised of experienced critical care trained

RNs and specially trained physicians. The eHospital team contacts the Rapid Response Team (RRT) intensive care unit (ICU) trained RN at the local hospital to assess the patient. Depending on whether this is a new or repeat clinical trigger, the RRT nurse or eHospital team will contact the covering Physician, who is responsible for the work up and treatment plan. The RRT RN will carry out the treatments as ordered by the physician. This team also engages Social Services and Palliative care to proactively identify patients with a high risk of mortality.

From two pilot sites outcomes that began in 2013 and 2014, approximately 50 lives have been saved and the ICU length of stay (LOS) has decreased although the total number of uptransfers from the Medical Surgical units to the ICU has increased. Estimates are that if spread regionally, this program can save between 110 to 400 lives per year and save $9 to $25 million per year. A significant difference in the beta site expansion we are planning is that the alpha sites did not have the eHospital team notifying the RRT RN that a AAM score had triggered a clinical alert; at the alpha sites a best practice alert was generated in the electronic medical record (EMR) based on the AAM algorithms and the RRT nurse manually checked for the alerts in the EMR at six hour intervals.

With support from Executive sponsors, we plan to spread the AAM program to all 21 medical centers over the next 18 months, with plans for implementation at the first beta spread site in late Spring 2016. Two additional beta sites are planned, starting the end of 2016 and early 2017. Clinical Workflows, Technology, Data & Analysis, and Communication work streams will be developed to support this initiative. As Regional

Clinical Operations Nursing Lead for this project, my responsibility will be to have oversight over all aspects of execution in collaboration with a Physician co-lead and the AAM Regional Steering Team.

There is little existing literature that describes the implementation of an early warning system, nor how the system can be successfully operationalized and socialized at a large integrated health care system. Specifically, for this DNP project my focus will be on the implementation and socialization process: how was this new technology operationalized and socialized at three beta site facilities in Northern California? What change management theories were utilized to introduce and socialize the AAM project with the multidisciplinary team? What was the pre, intra, and post implementation work? What impact did these interventions have in the acceptance of this new technology by the RRT RNs? How were the workflows developed and how did we define the quality metrics used to evaluate the success of the AAM project? Can we measure a change in patient safety culture through the use of the annual People Pulse patient safety culture survey? What is the impact of the AAM program on ICU mortality and ICU length of stay?

C) How will this intervention change practice? Serious adverse events such as acute deterioration in hospitalized patients can be prevented by early recognition of signs of instability and rapid intervention. By closely monitoring changes in physiological observations using an early warning score (EWS), deteriorating patients are more likely to be identified before a serious adverse event occurs. Delays in care are associated with increased mortality and unplanned transfers to the intensive care unit. The AAM program

addresses a key patient safety and quality issue: high mortality among hospitalized patients transferred unexpectedly to the ICU from general Medical/Surgical units. The role of the RRT RN is critical in the AAM workflow process, as he/she is the recipient of the initial and repeat alerts from the eHospital team.

Currently, there is great variability in the team compositions, response workflows, process for proactive rounding, use of clinical triggers, and timeliness of response at all 21 NCAL hospitals within the hospital system. Understanding how to create, operationalize and implement consistent workflow responses to AAM clinical triggers and standardizing best practices with a consistent a Rapid Response Team (RRT) practice will contribute to our ability to effectively detect and respond to patient deterioration, and can help us target efforts to improve the quality and safety of this acutely unwell vulnerable population.

D) Outcome measurements:

ICU Mortality

ICU length of stay

Full implementation of AAM program at beta site hospitals

E) Process Measurements:

# of AAM fires

Uptransfers (transfers of patients from the Medical Surgical wards to the ICU)

Matches (uptransfers with AAM fires)

Action taken by eHospital for each initial and repeat alert btw 8am and 12am & include whether connected w/ RRT RN

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RRT RN acknowledges eHospital call HBS takes action on initial trigger Nurse's attitude towards the use of the AAM program

To qualify as an Evidence-based Change in Practice Project, rather than a Research Project, the criteria outlined in federal guidelines will be used: (http://answers.hhs.gov/ohrp/categories/1569)

☑ This project meets the guidelines for an Evidence-based Change in Practice Project as outlined in the Project Checklist (attached). Student may proceed with implementation.

☐ This project involves research with human subjects and must be submitted for IRB approval before project activity can commence.

Comments:

EVIDENCE-BASED CHANGE OF PRACTICE PROJECT CHECKLIST *

Instructions: Answer YES or NO to each of the following statements:

Project Title:	**YES**	**NO**
The aim of the project is to improve the process or delivery of care with established/ accepted standards, or to implement evidence-based change. There is no intention of using the data for research purposes.	X	
The specific aim is to improve performance on a specific service or program and is a part of usual care. ALL participants will receive standard of care.	X	
The project is **NOT** designed to follow a research design, e.g., hypothesis testing or group comparison, randomization, control groups, prospective comparison groups, cross-sectional, case control). The project does **NOT** follow a protocol that overrides clinical decision-making.	X	
The project involves implementation of established and tested quality standards and/or systematic monitoring, assessment or evaluation of the organization to ensure that existing quality standards are being met. The project does **NOT** develop paradigms or untested methods or new untested standards.	X	
The project involves implementation of care practices and interventions that are consensus-based or evidence-based. The project does **NOT** seek to test an intervention that is beyond current science and experience.	X	

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The project is conducted by staff where the project will take place and involves staff who are working at an agency that has an agreement with USF SONHP.	X	
The project has **NO** funding from federal agencies or research-focused organizations and is not receiving funding for implementation research.	X	
The agency or clinical practice unit agrees that this is a project that will be implemented to improve the process or delivery of care, i.e., **not** a personal research project that is dependent upon the voluntary participation of colleagues, students and/ or patients.	X	
If there is an intent to, or possibility of publishing your work, you and supervising faculty and the agency oversight committee are comfortable with the following statement in your methods section: *"This project was undertaken as an Evidence-based change of practice project at X hospital or agency and as such was not formally supervised by the Institutional Review Board."*	X	

ANSWER KEY: If the answer to **ALL** of these items is yes, the project can be considered an Evidence-based activity that does NOT meet the definition of research. **IRB review is not required. Keep a copy of this checklist in your files.** If the answer to ANY of these questions is **NO**, you must submit for IRB approval.

*Adapted with permission of Elizabeth L. Hohmann, MD, Director and Chair, Partners Human Research Committee, Partners Health System, Boston, MA.

STUDENT NAME (Please print): Shirley S. Paulson

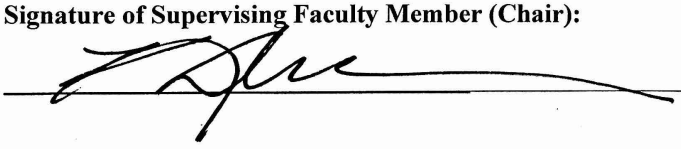
Signature of Student:

Shirley S. Paulson **DATE** 4/16/2016

SUPERVISING FACULTY MEMBER (CHAIR) NAME (Please print):

Keith Dawson, DNP, MS, RN

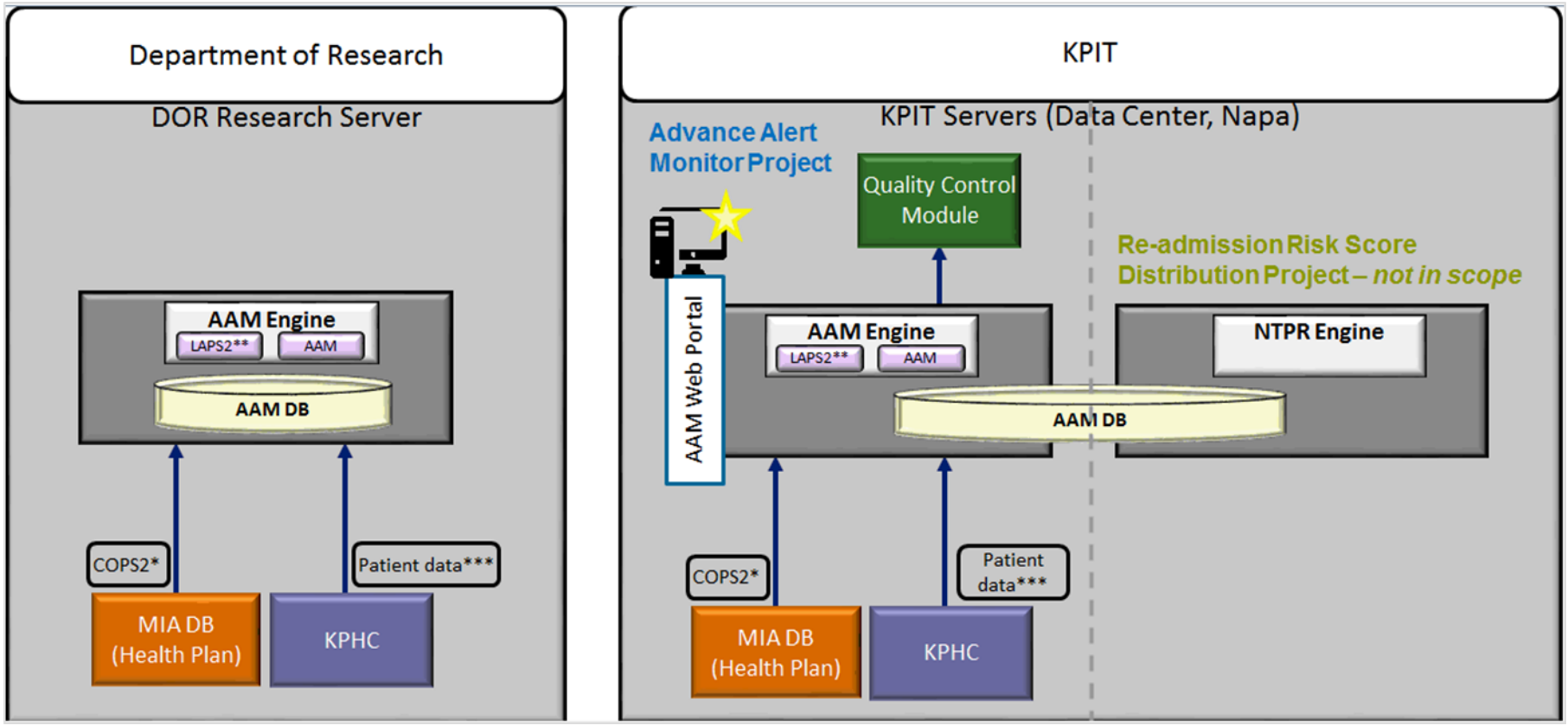
Signature of Supervising Faculty Member (Chair):



DATE 4/16/2016

Appendix V

Division of Research and KP IT Servers (used by Regional data analysts) Visual Depiction of Data Collection and Processing

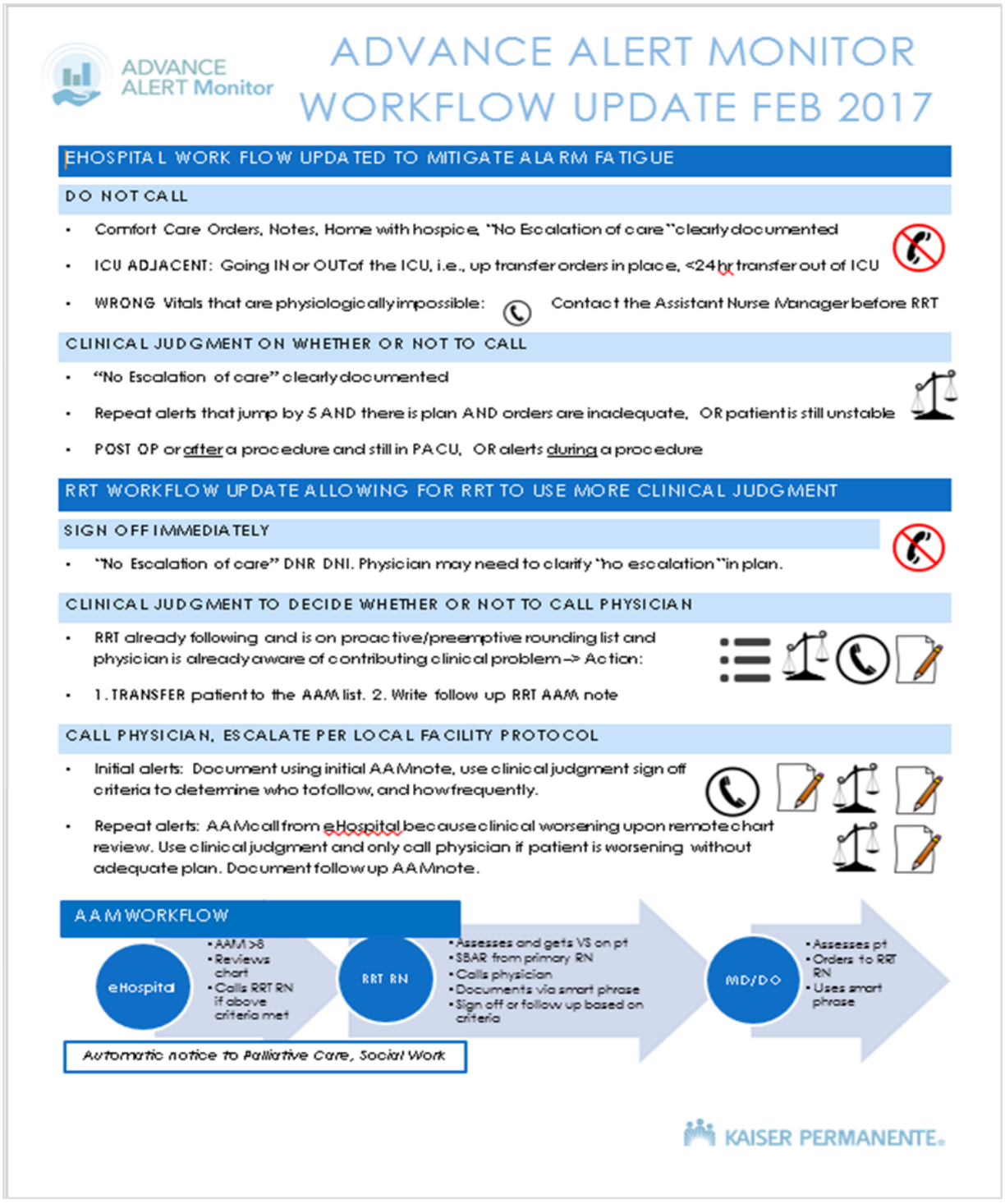


DB = database

Appendix W

Mitigation of Alarm Fatigue: Snooze Criteria Workflow

Update Page 1



Update Page 2

ADVANCE ALERT Monitor

ADVANCE ALERT MONITOR WORKFLOW UPDATE FEB 2017

STANDARDIZED CLINICAL JUDGMENT - RRT TO NO LONGER FOLLOW PATIENTS IF THE FOLLOWING CRITERIA IS MET

- ✓ >24 hrs from ICU Transfer
- ✓ VS stable for >8hrs
- ✓ NON pulmonary patients with decreasing O2 demand
- ✓ PNA or PULM patients at baseline: supplemental O2, RR, Sat, and work of breathing
- ✓ Labs improved or chronically abnormal but VS significantly improved or normalized
- ✓ LA<2 (or not related to SEPSIS)
- ✓ GI bleed HH stable with stable BP HR
- ✓ Pain patient controlled and NOT overly sedated
- ✓ CIWA patient < 12
- ✓ "No escalation of care" clearly documented and communicated with team and DNR DNI doctor
- ✓ RRT and doctor agree to signoff even though above criteria not met

AAM SHAREPOINT:
https://sites.sp.kp.org/pub/qps/Pages/topicabout.aspx?barea=aow4_54

Legend

	Call Hospital to RRTor, Call RRT to doctor
	Do Not Call Hospital to RRTor, Do Not Call RRT to doctor
	Note
	Clinical judgment: if other scenarios arise, please bring them up so we can make explicit what is implicit. We want standardized simplified best practices.
	AAM shared patient list

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Appendix X

Process Outcome Graphs

Figure X.1 **# of patients per day with AAM alerts ≥8% Santa Clara (SCH) and Walnut Creek (WCR)**

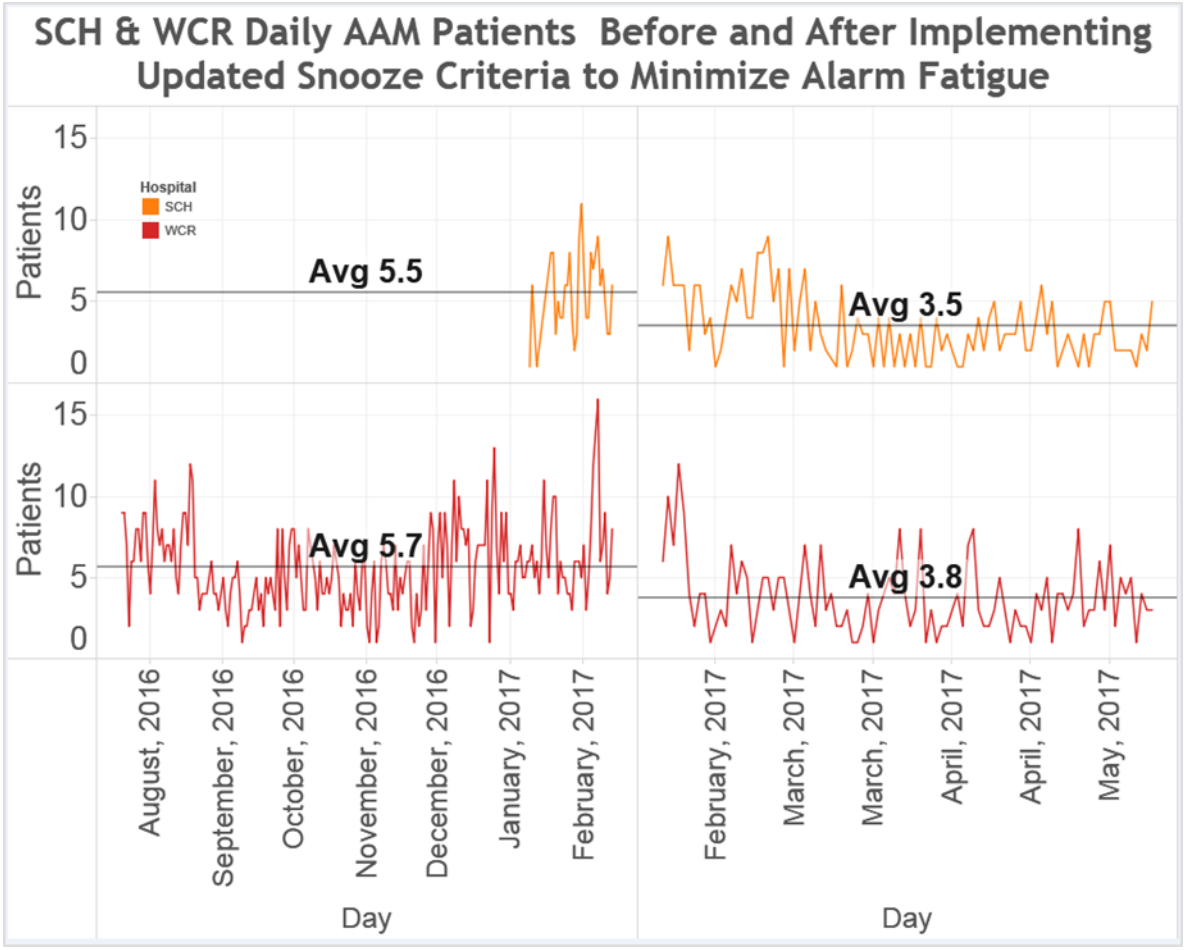
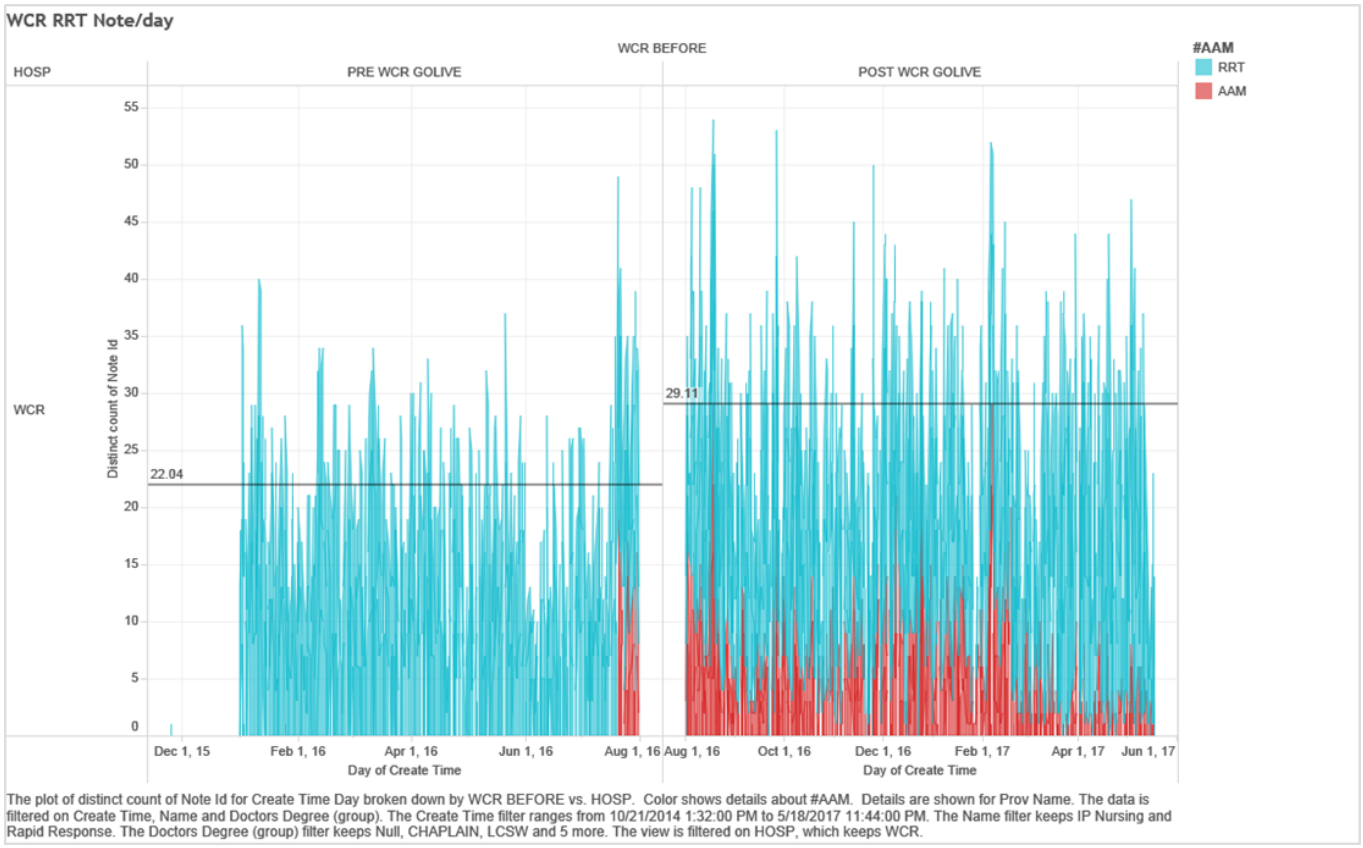
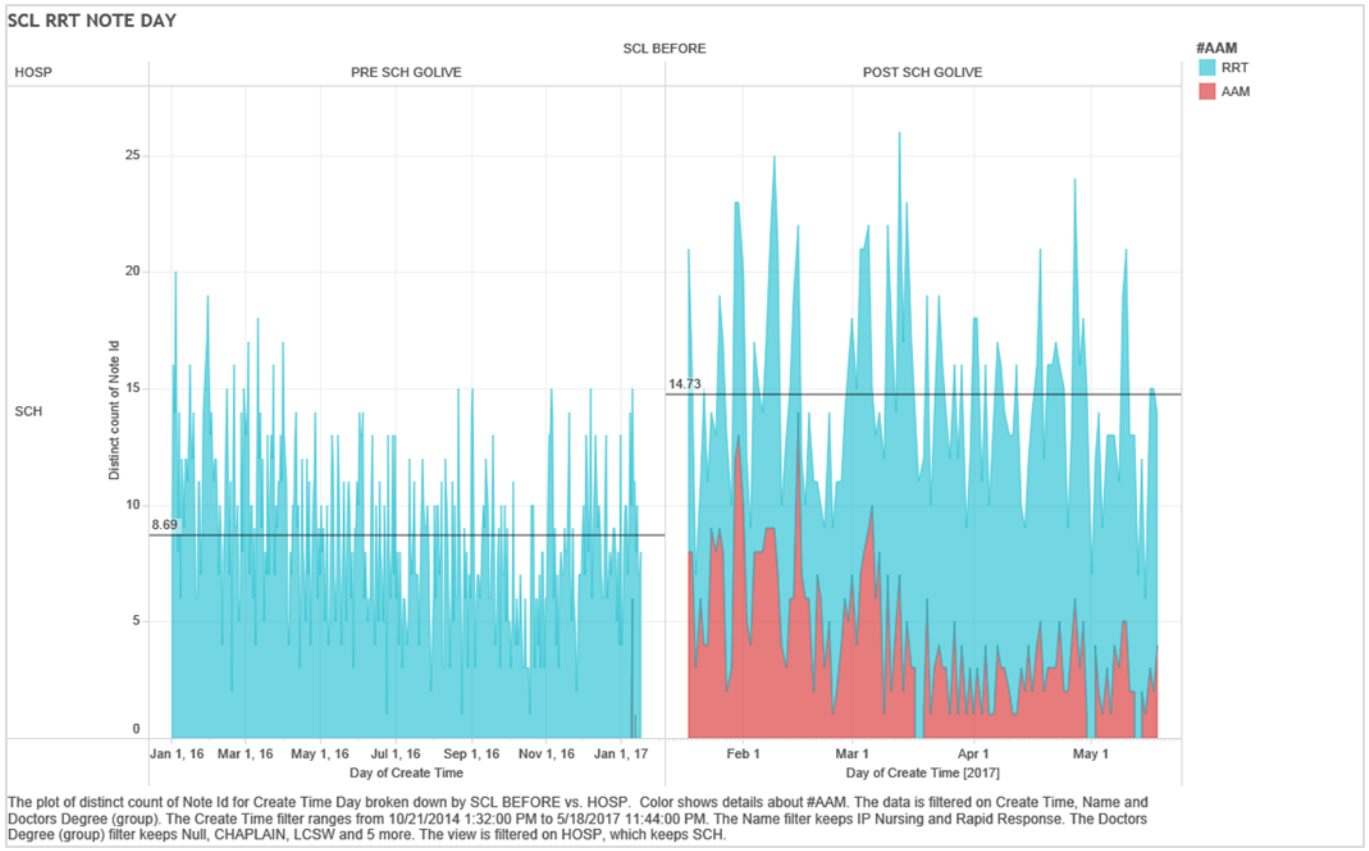


Figure X.2a **# of RRT RN notes per day Walnut Creek, January 2016 to May 2017**



Walnut Creek Pre: 22.04, Post: 29.11

Figure X.2b. **# of RRT RN notes per day Santa Clara (SCH), January 2016 to May 2017**



Santa Clara Pre: 8.69, Post: 14.7

Figure X.3 **% eHospital response within 1 hour of initial alert between 8am and 11pm**

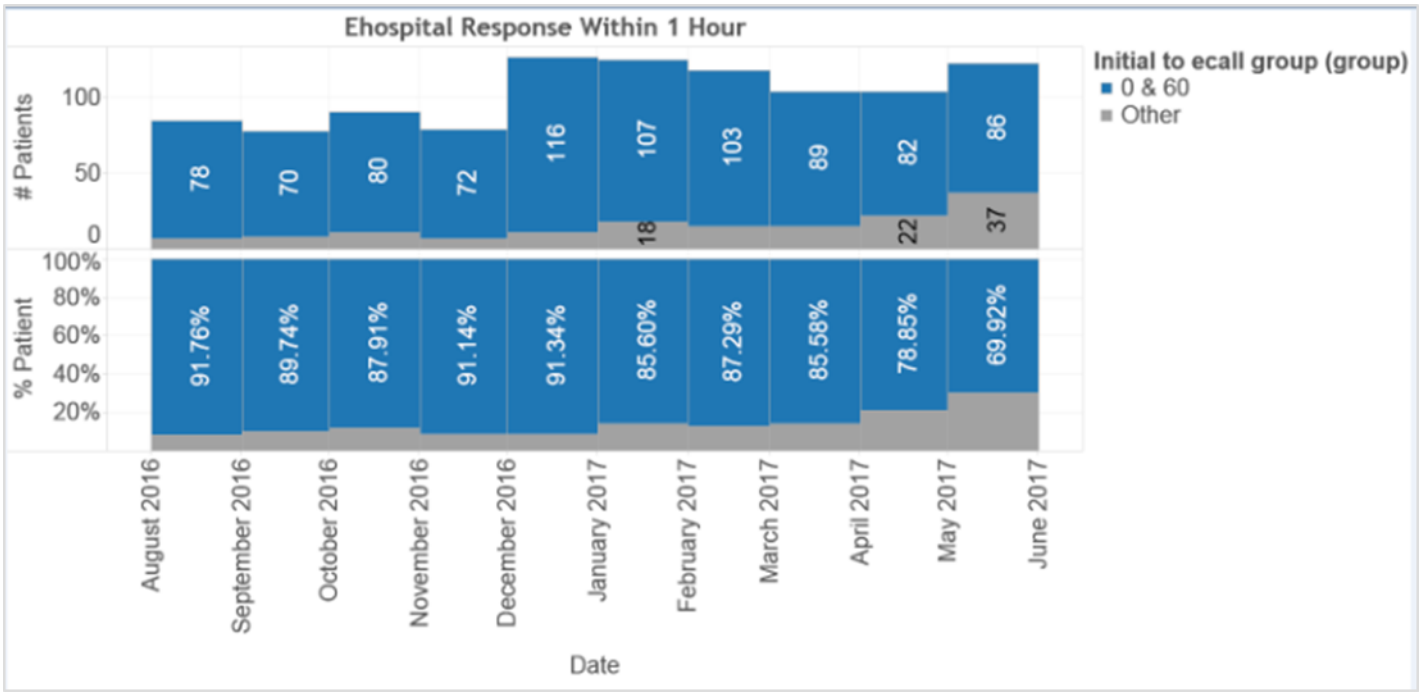
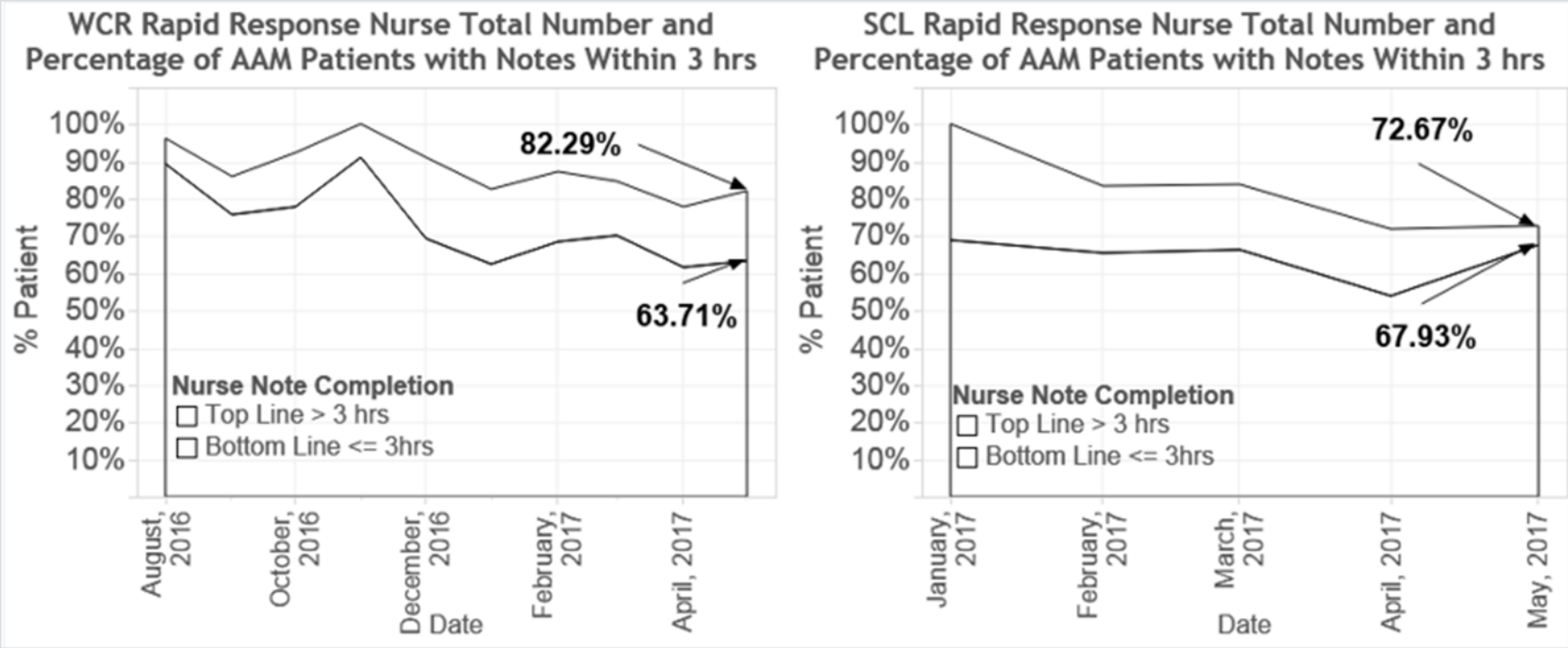


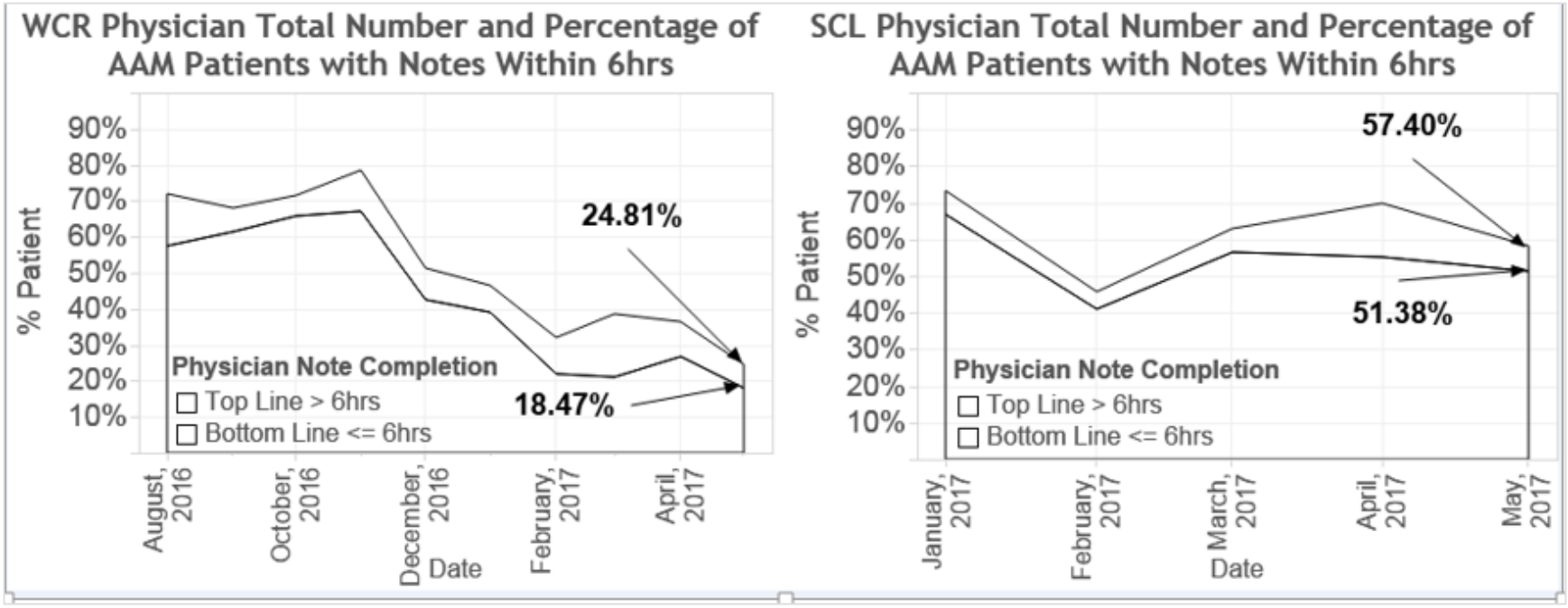
Figure X.4 **%RRT response within 3 hours of initial fire time between 8am and 11pm Walnut Creek (WCR) and Santa Clara (SCL)**



Results: Walnut Creek 63.71%, Santa Clara 67.93% documented their assessment within 3 hours

Figure X.5 **% MD notes for AAM alerts within 6 hours (initial fires)**

<



Results: At Walnut Creek 18.47%, and at Santa Clara 51.38% of physician AAM notes were documented within the expected 6 hours

Figure X.6a **Number of medications after initial alert documented within 6 hours**

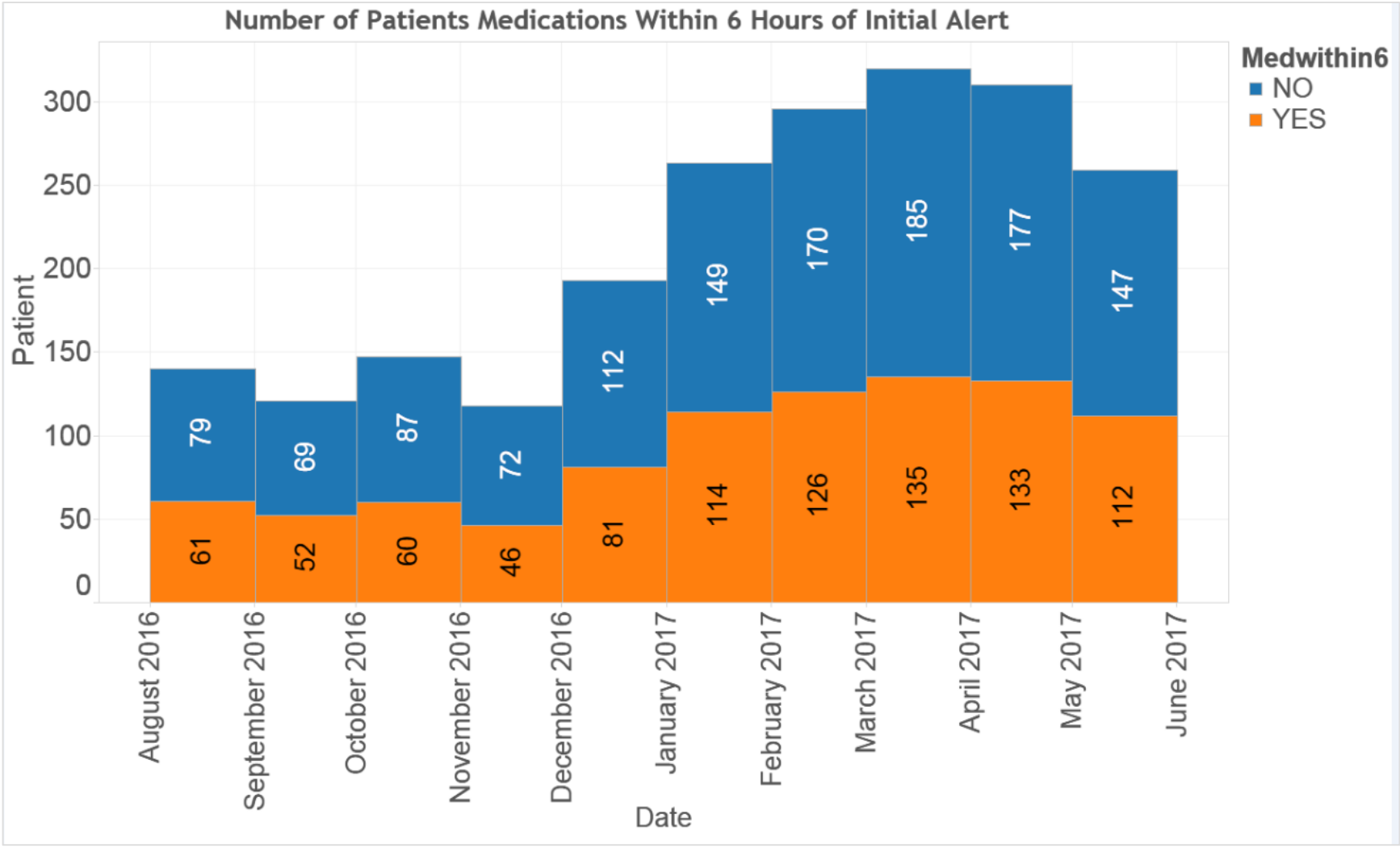


Figure X.6b **Categories of medications after initial alert documented within 6 hours**

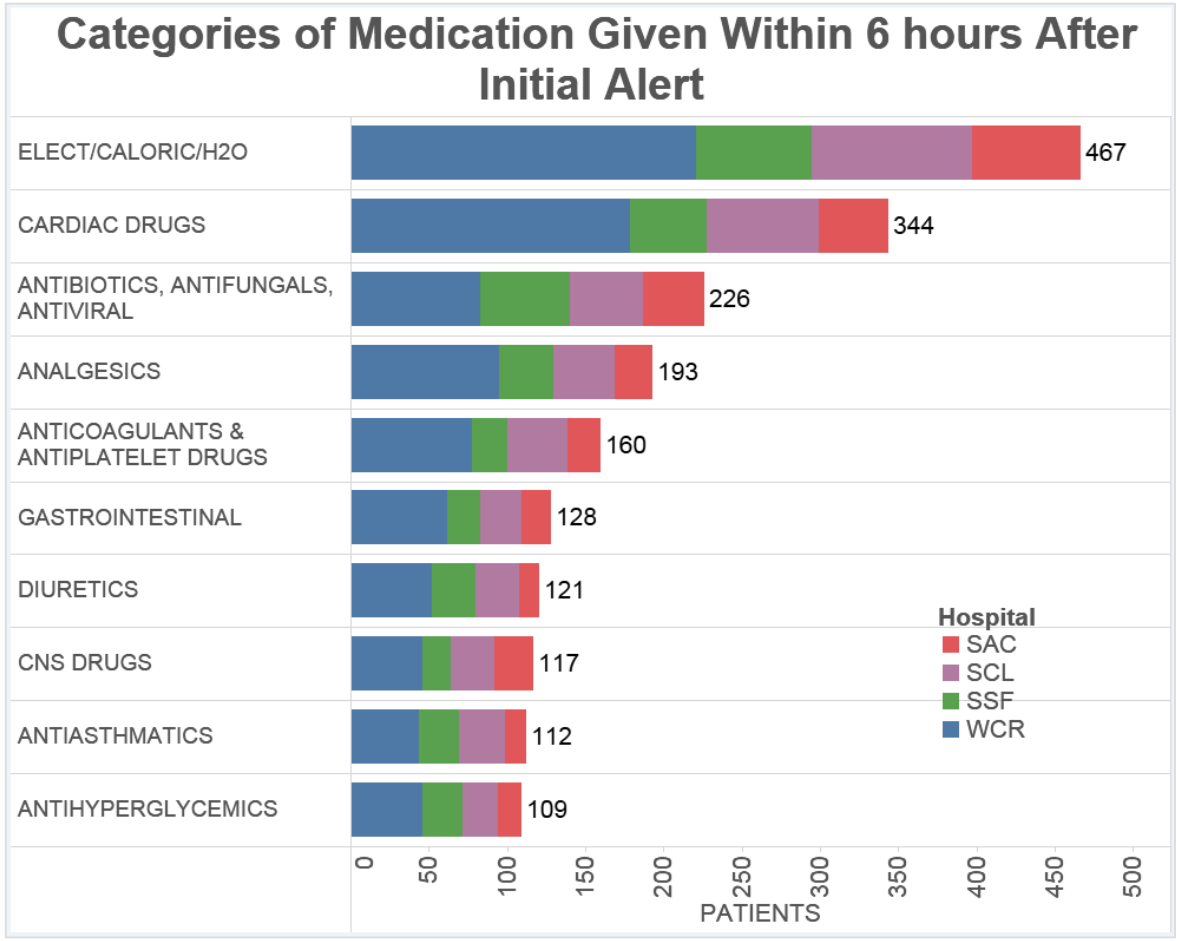


Figure X.7a **% of AAM patients with Palliative Care (PC) consults ordered for COPS2 score ≥65**

Walnut Creek

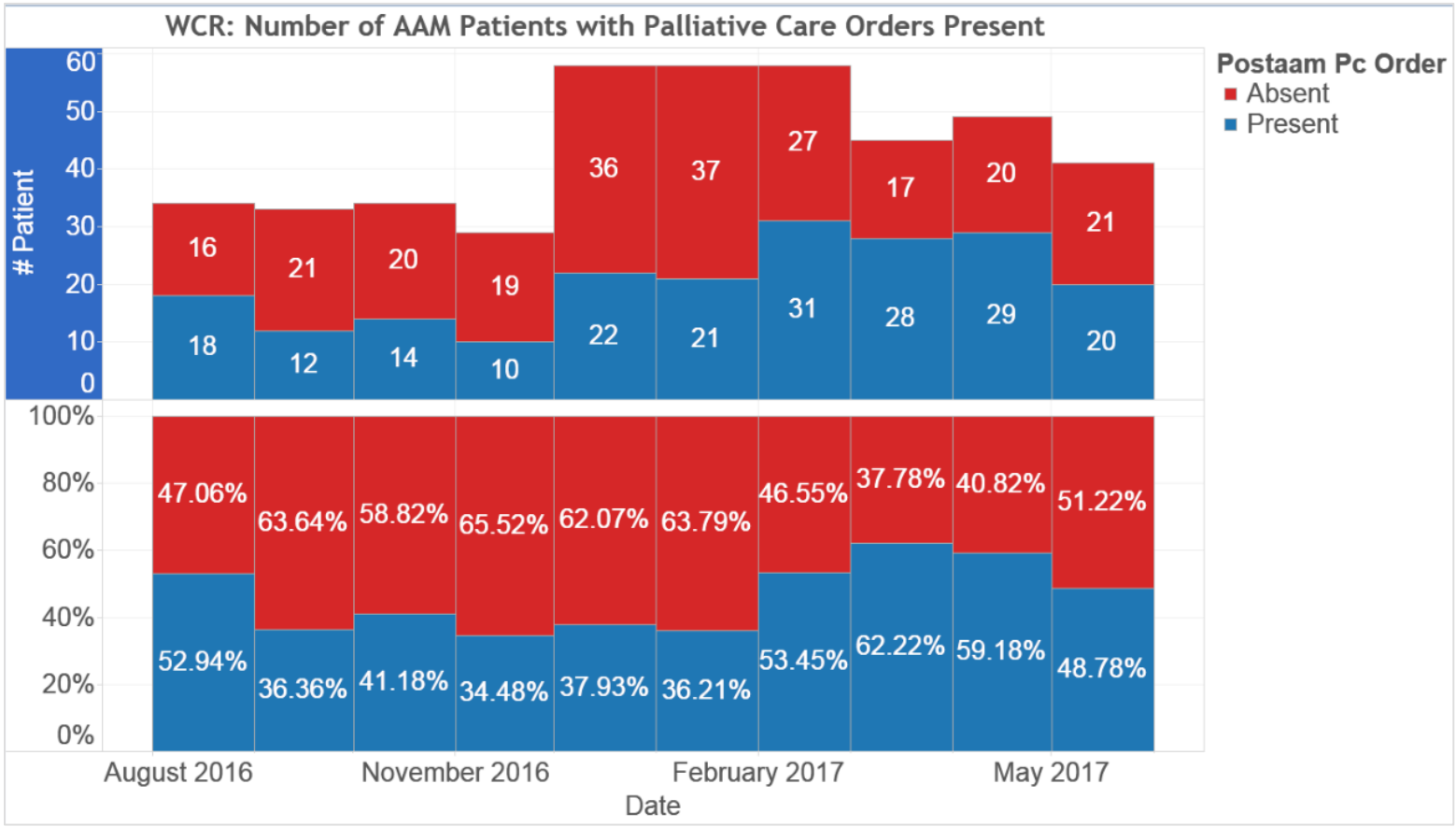


Figure X.7b **% of AAM patients with Palliative Care (PC) consults ordered for COPS2 score ≥65**

Santa Clara

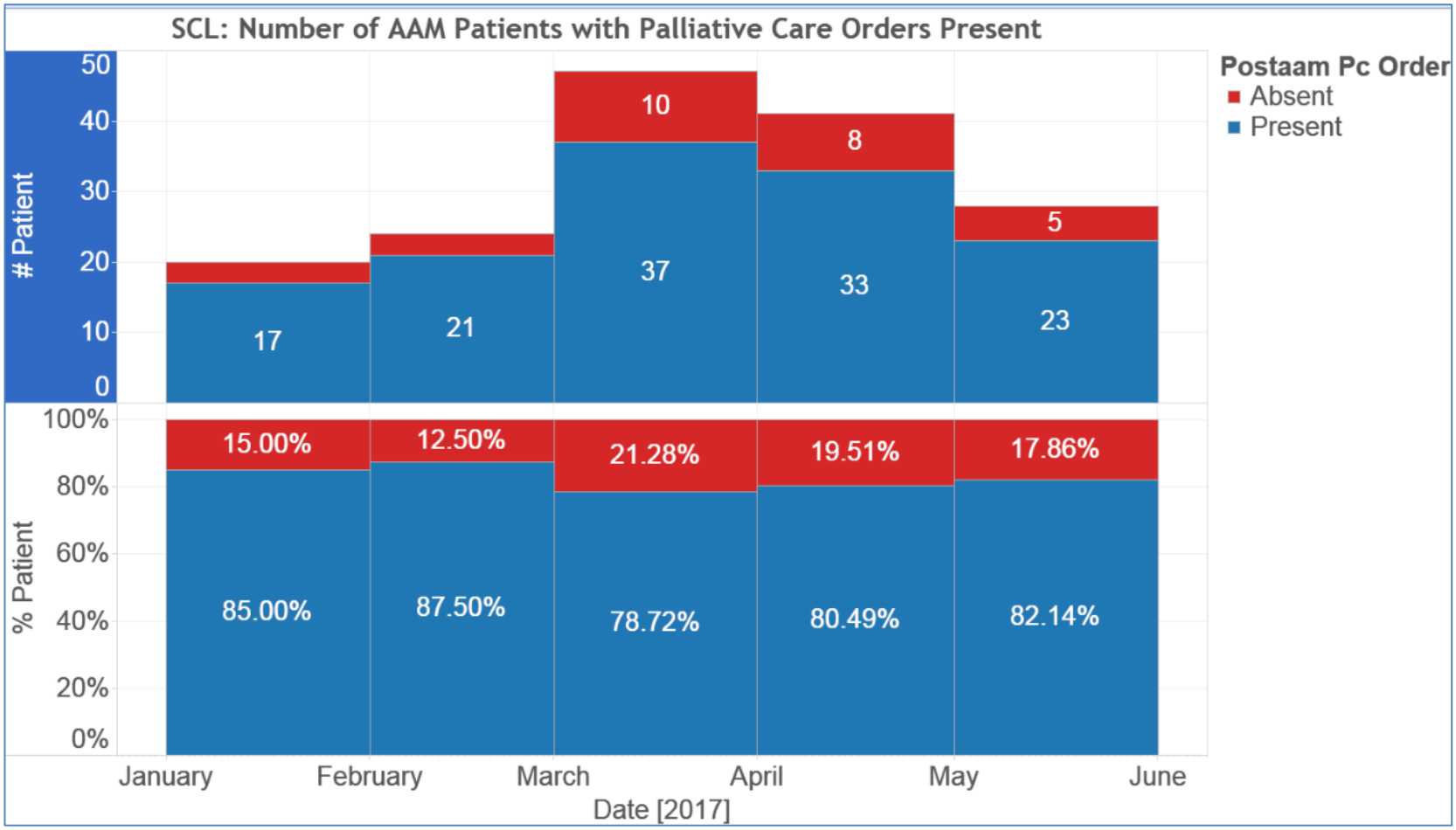


Figure X.8 **% of AAM patients with PC or LCP (Life Care planning) notes present (depending on COPS2 score)**

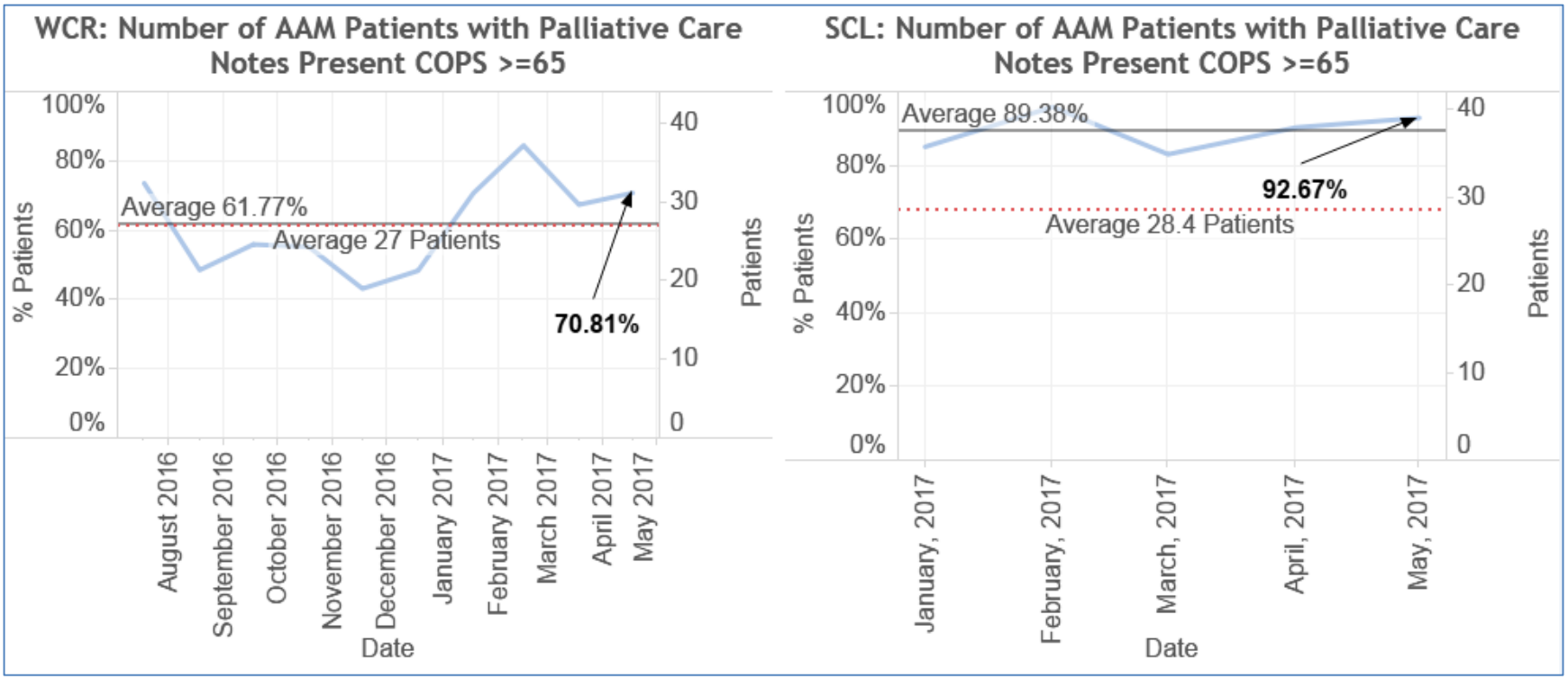


Figure X.9 **%of AAM patients with COPS2 score < 65 with Medical Decision Maker Surrogate identified**

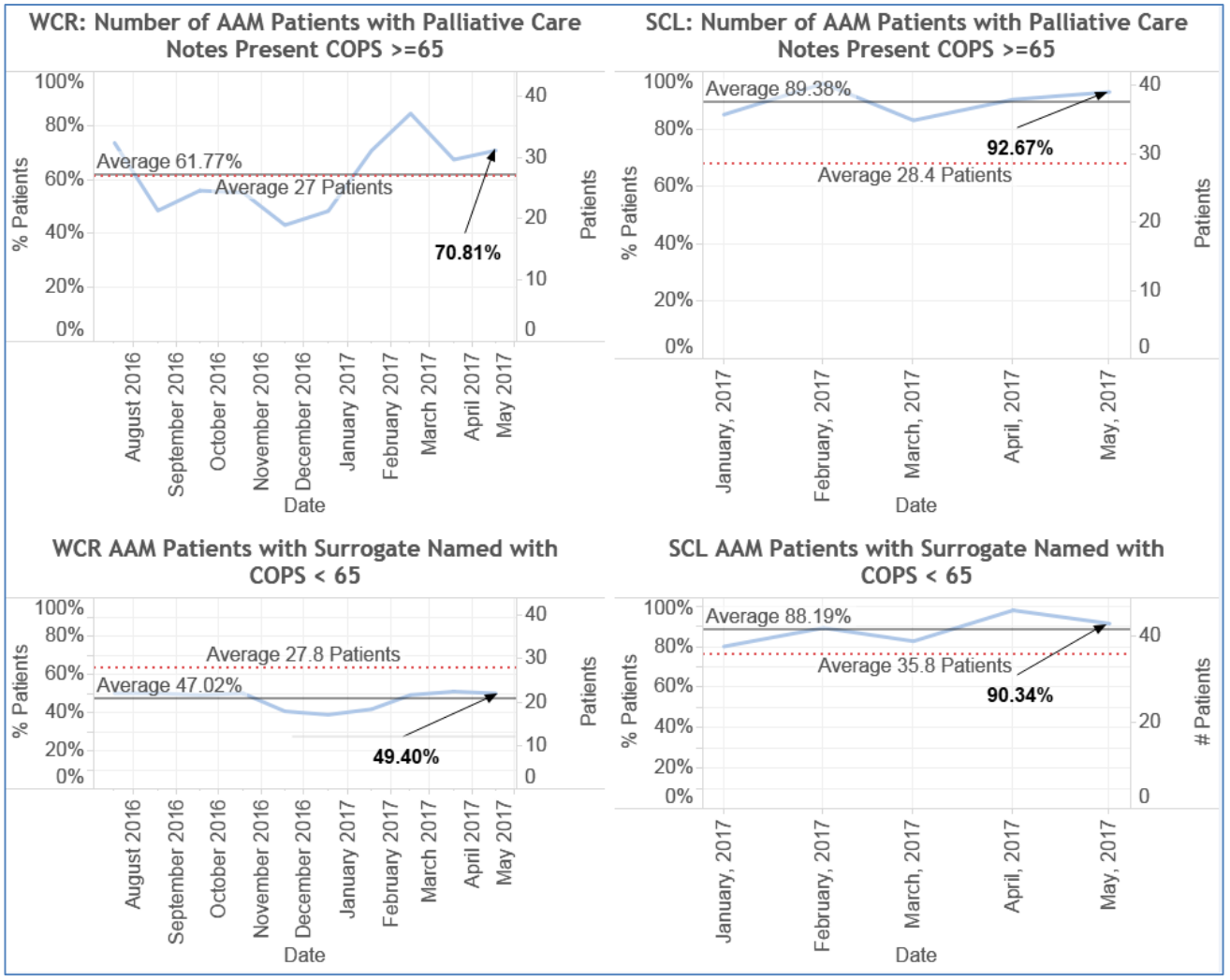
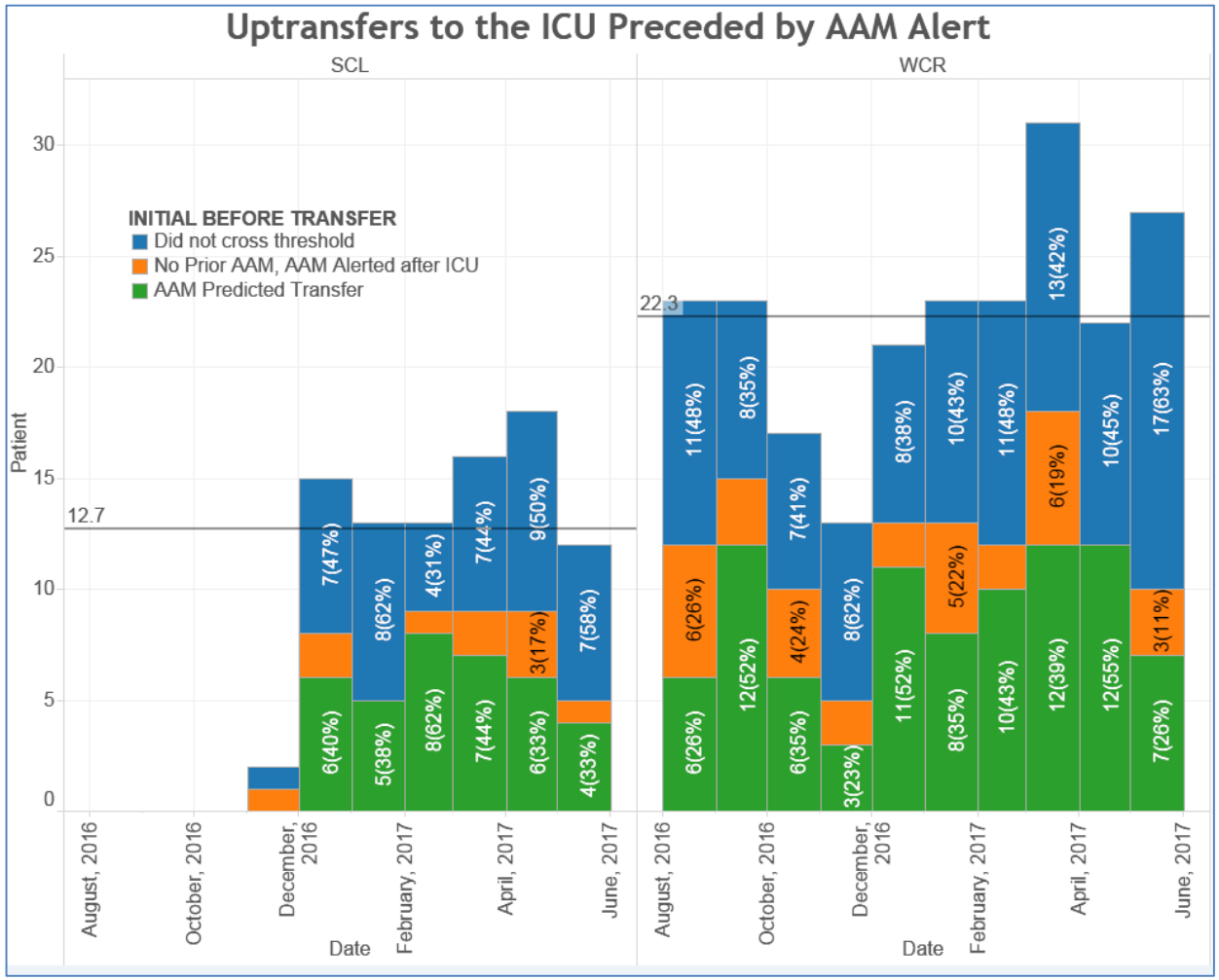


Figure X.10 **% of uptransfers to the ICU preceded by AAM note with no prior RRT note**



Appendix Y

Budget for AAM

REGIONAL		
Description	**Cost**	**Details**
DOR non-physician budget:	$1,325,245	
National KPIT	$326,600	
Enhancements budget (IT, KPHC)	$306,320	To improve predictive analytics
Regional KFH	$200,000	0.5 business consultant (2 years)
Regional QOS budget	$124,000	0.3 business consultant (2 years)
Regional QOS budget	$124,000	0.3 senior analyst (2 years)
Local Entities KPHC	$209,760	
Subtotal Budget	**$2,615,925**	
Grant Lokahi **offset** request	$205,000	1.0 Data Analyst (3 years)
	$247,500	0.6 Project Manager (2 years)
Total Grant	**$452,500**	
Total Budget	**$3,068,405**	

Nursing Personnel and Training		
Local Rapid Response RN 24/7 per facility	$1,000,000	4.2 FTEs per facility allocated 2016 budget; recurring personnel costs
ICU Nursing Training costs	$44,375	Not coded specifically for AAM; estimate based on average salary ICU Staff Nurse II, step 6: $71/hour x 4 hours training (staff meetings and formal orientation) x 50 RNs average per ICU unit + 1 hour Med Surg Training ($71 x 5 hours (ICU+ MS) x 125 RNs = $44,375
Total LOCAL	**$1,044,375**	
REGIONAL (21 facilities)	*21	Multiply by 21 NCAL facilities
	$21,931,875.00	**Total cost of personnel and training all NCAL**

Definitions: **KPIT**: Kaiser Permanente Information Technology; **KPHC:** Kaiser Permanente Health Connect (electronic medical record)

QOS: Quality, Operations, and Safety: a division of Kaiser Quality; **KFH:** Kaiser Foundation

Appendix Z

Cost Benefit Analysis

Division of Research inferences based on detailed analysis of alpha pilot site data (Escobar et al., 2015)

Assumption: based on 6,500 patients reaching the alert threshold each year (sick enough outside of the ICU to cross the threshold to activate an AAM alert). This is projected to increase as the KP population increases.

Multiple variables analyzed by the Division of Research include RaR and DiD to determine total cost savings

RaR = Ratio of relative risks: measures the relative risk of death in the "post" period compared to that of the previous period
A rate ratio < 1 denotes a favorable effect for pilot facilities (larger decrease in mortality at pilot facilities relative to control facilities)

DiD = Difference in Difference: compares the rate of change observed at the intervention sites to the rate of change observed at 19 other sites. Specific to length of stay (LOS) in this calculation

	RaR for 90 day mortality	**Mortality Reduction projected based on alpha site results**	**Cost savings based on DOR calculated length of stay DiD of**	**Total Cost LOS savings projected"** $DiD x 6500 patients alerted per year	**Cost of each life per Environmental Protection Agency (2011)***	**Cost avoidance (cost of life x mortality reduction projected)**
Alpha site 1	0.92 (p value 0.57)	110 deaths per year	$1,500	$9.7 million	$9.1million	$1.001e9
Alpha site 2	0.65 (p value 0.02)	400 deaths per year	$4,123	$26.8 million	$9.1million	$3.64e9

LOS = length of stay
*Source: Portnoy (2012)

Appendix AA

Return on Investment (ROI)

The ROI from AAM will be based off of savings from decreased LOS and lives saved. The reduction in mortality (lives saved) is a primary clinical quality benefit. Cost of life is based on Environmental Protection Agency (EPA) definition of $9.1 million per life (Portnoy, 2012).

Investment:

Costs:

Regional budget:	$3,068,405
Minus grant fund (3 years total):	- (452,500) total recurring personnel costs
	$2,615,905 per Region non-recurring costs
Total RRT and Nursing Education costs:	**$21,931,875** NCAL (Appendix Y)
Total Regional and Local costs:	**$24,547,780**

Return:

	MAX	**MIN**
Projected Cost of Days saved:	$26,800,000	$9,700,000
Cost of avoidance litigation:	$ 7,000,000	$ 210,000
Subtotal:	$33,800,000	$9,910,000
Projected Lives saved:	$3.64e9	$1.001e9
	$3.6738e9	**$1.01091e9**

MAX ROI: $33,800,000 - $24,547,780 = $9,252,220 (without lives saved included)

MAX ROI: ($33,800,000 +$3.64e9) - $24,547,780 = $3.649252e9 (with lives saved included)

MIN ROI: ($9,910,000 + $1.001e9) - $24,547,780 = $986,362,220