Program evaluation of the Methicillin Resistant *Staphylococcus aureus* (MRSA) Program at the VA Puget Sound Health Care System.

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Abstract

Program evaluation of the Methicillin Resistant *Staphylococcus aureus* (MRSA) Program at the VA Puget Sound Health Care System

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Methicillin Resistant *Staphylococcus aureus* (MRSA) is among the most common and costly hospital-acquired infections, and a major target of quality improvement efforts. A bundle of infection control practices has been reported to dramatically reduce hospital acquired MRSA colonization transmissions. The bundle includes active, prospective screening to identify MRSA carriers, initiation of infection control precaution measures, and methods to modify cultural perceptions. However, little is known about the implementation of specific infection control practices, and their effect on MRSA colonization transmissions.

Objective: Our objective is to describe the implementation of the MRSA Program at VA Puget Sound Health Care System (VAPSHCS), and test the association of two specific implementation interventions with hospital infection control practices and MRSA colonization transmission rates: a hospital Director's performance measure directed at improving MRSA screening rates, and an electronic patient record flag directed at improving use of infection control precautions.

Setting: The study took place at a 432 bed Veterans Health Administration hospital which provides tertiary, acute, critical, and surgical healthcare.

Methods: Student's t-test was used to compare the difference in compliance with infection control practices for the 3 month pre-intervention period and 3 month post-intervention period for each intervention, and Pearson's chi-square analysis was used to compare the rate of MRSA colonization transmissions for the same 3 month pre-intervention period and 3 month post-intervention periods. Descriptive statistics summarize compliance with infection prevention improvement strategies and MRSA colonization transmission rates over time.

Results: The MRSA Program was initiated in March 2007, and surveillance data were collected from 10,333 unique inpatients through May 2011. It took a total of 12 months after initiation of MRSA Program in the critical care unit to achieve compliance rates of 90%, 21 months for acute care to achieve the same target, and 13 months following initiation of documented observations to achieve 90% for initiation of infection-control precautions. Active MRSA screening increased from 88.1% in the 3 months before initiating the Director's performance measure, to 89.1% in the 3 months after (p=0.36). Initiation of infection-control precautions increased from 93.9% in the 3 months before initiation of an electronic patient record flag, to 95.8% in the 3 month post-intervention period (p<0.05). MRSA colonization transmissions rates increased from 1.7 per 1,000 patient days before the Director's performance measure to 2.0 per 1,000 patient days after (p=0.36); and decreased from 2.7 transmissions per 1,000 patient days of care before the electronic patient record flag to 1.5 transmissions per 1,000 patient days of care after (p<0.05).

Conclusion: Overall, it took more than 12 months to achieve stable compliance for two key components of the MRSA Program elements: active screening and initiation of infection control precautions. An electronic patient record flag was associated with improved compliance with infection control precautions, which may affect the rate of MRSA colonization transmissions. Use of a hospital Director's performance measure might be hypothesized to have influenced rapid change by engaging staff toward systematic solutions; however, use of a Director's performance measure was not

associated with increased screening or a decrease in transmission rates. Future research should examine differences in implementation of MRSA Program elements among sites.

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Specific Aims

Numerous multifaceted intervention programs have been reported to reduce Methicillin Resistant *Staphylococcus aureus* (MRSA) colonization transmissions in the hospital setting. However, little is known about implementation of specific bundle activities and their association with interruption of MRSA colonization transmissions.

This study seeks to describe the implementation of the MRSA Program at VA Puget Sound Health Care System (VAPSHCS), and the association of two implementation interventions with subsequent changes in staff practices in managing patients colonized or infected with MRSA. This study addressed four specific Aims: 1) To describe the temporal progression of implementation of the MRSA Program at VAPSHCS as outlined by the national VHA MRSA Program initiative, 2) to examine MRSA screening rates among admitted patients before and after implementation of the Director's performance measure on MRSA screening rates, 3) to examine compliance with infection control precautions before and after implementation of an electronic patient record flag for infection control precautions, 4) to assess the association of a) the MRSA Director's performance measure, and b) the electronic patient record flag with MRSA colonization transmission rates.

Introduction

MRSA remains one of the most significant nosocomial pathogens today and causes substantial hospital-associated morbidity and mortality (Jernigan, Clemence et al. 1995; Whitby, McLaws et al. 2001; Blot, Vandewoude et al. 2002; Cosgrove, Sakoulas et al. 2003; Engemann, Carmeli et al. 2003; Melzer, Eykyn et al. 2003; Cosgrove, Qi et al. 2005). Between 1999 and 2005, MRSA associated hospitalizations in the US increased from 127,036 to an estimated 278,203 hospitalizations, often with longer lengths of stay and more expensive treatments when compared to Methicillin Sensitive S*taphyloccus aureus* associated infections. These additional hospitalizations lead to substantial attributable costs to healthcare facilities (Cosgrove, Sakoulas et al. 2003; Engemann, Carmeli et al. 2003; Cosgrove, Qi et al. 2005; Kuehnert, Hill et al. 2005; Klevens, Edwards et al. 2006; Klein, Smith et al. 2007; Klevens, Morrison et al. 2007). MRSA infections (i.e., skin and soft tissue infections such as abscesses or more serious infections such as invasive bloodstream infections) represent a subset of the population who are MRSA colonized or carriers (i.e., having MRSA bacteria on the skin but without an infection). MRSA colonization transmissions of patients in the hospital setting appear to primarily result from transient colonization on the hands of hospital staff or a contaminated environment, such as reusable medical equipment, and can be dramatically reduced through careful infection control practices (Albrich and Harbarth 2008; Snyder, Thom et al. 2008). Several studies have demonstrated the effectiveness of a bundle of infection control measures, notably systematic screening for MRSA colonization via nasal swabs to identify patients at admission and discharge who are colonized, and subsequent use of infection control precautions for patients who screen positive or have a history of MRSA colonization(i.e. donning a protective gown, gloves, and hand hygiene before and after entering a patient room)(Jernigan, Clemence et al. 1995; Huang and Platt 2003; Huang, Yokoe et al. 2006; Muder, Cunningham et al. 2008; Snyder, Thom et al. 2008; Ellingson, Muder et al. 2011; Jain, Kralovic et al. 2011).

Beginning in 2007, the Veterans Health Administration (VHA) initiated a national, multifaceted infection prevention strategy, the VHA MRSA Program, aimed at the

reduction of MRSA colonization transmissions and infections among Veterans (Muder, Cunningham et al. 2008; Ellingson, Muder et al. 2011). Unlike programs which only target specific high-risk patients, such as intensive care or surgical units, the VHA MRSA Program focuses on universal MRSA screening of all acute and critical care hospital inpatients. The bundle includes active, prospective screening to identify MRSA carriers, initiation of infection control precaution measures, close attention to hand-hygiene practices, and modifying the cultural perception of healthcare professionals toward increased awareness of infection prevention through processes such as the Toyota Production System methodology and peer-peer involvement via inpatient ward MRSA champions(Muder, Cunningham et al. 2008).

The Veterans Health Care Administration reported that the MSRA Program was associated with national decreases of 62% and 45% in the VHA critical care and acute care settings, respectively, between October 2007 and June 2010, and a reduction by 61% in hospital associated transmissions and infections over 7 years at a pilot facility(Ellingson, Muder et al. 2011).

However, effective implementation of the bundle is a non-trivial undertaking. It is currently not clear how long it takes to implement the bundle and achieve a long-term, sustainable decrease in the burden of MRSA. Furthermore, while national trends in compliance, transmission and infection rates have been documented(Jain, Kralovic et al. 2011),there are currently no published studies addressing specific implementation interventions to foster compliance with the bundle.

The purpose of the present study is to describe the implementation of the MRSA Program at VA Puget Sound Health Care System (VAPSHCS), and to test the association of two specific implementation interventions with subsequent changes in hospital compliance with components of the MRSA Program. This study will add to our understanding about the process of implementing the VHA MRSA Program, and the association of specific

policy changes with active MRSA screening rates, initiation of infection control precautions, and MRSA colonization associated transmissions.

Methods

Setting and sample

VAPSHCS is a 432 bed facility which provides tertiary, acute and critical medical and surgical health care. The MRSA Program was initiated at VAPSHCS in a single critical care unit in March 2007 and facility wide, except for Mental Health, beginning March 2008. Bundle elements included active, prospective screening for MRSA colonization via nasal swabs, use of infection control precautions for patients with a history of MRSA within a year of admission, improvement of environmental care standards aimed at decreasing nosocomial pathogens on frequently touched surfaces, and cultural transformation of health care professionals' perception of infection prevention.

Implementation interventions

VAPSHCS used a number of interventions to support implementation of the MRSA Program, notably two interventions directed at improving specific elements of the bundle. The first implementation intervention was a Director's performance measure to improve screening for MRSA colonization, initiated in October 2009. It was part of a broader performance management system in which annual performance contracts are used to establish institutional priorities and expectations of managers, and hold management accountable for achieving specific targets on performance measures(Kizer and Dudley 2009).National targets for screening rates were established by the VHA MRSA Program, and increased over time, beginning at 80% in 2007; 85% in 2009; 94% in 2010; and 90% in September 2011.

The second implementation intervention was an electronic patient record flag, initiated in January 2011, to improve compliance with infection control precautions for patients screening positive for MRSA colonization or with a history of MRSA colonization or

infection. Following review of daily infection control microbiology surveillance reports, the electronic patient record flag was initiated by the MRSA Program coordinator. The flag was placed with a review date one year beyond the culture date, reinstated if the patient had subsequent positive MRSA cultures and discontinued if a year passed with no additional MRSA-associated laboratory results. The flag was visible to all health care professionals accessing the patient record, where the flag guided the provider to use infection control precautions for inpatients or adherence to hand hygiene for outpatients.

Study Measures and Data

The independent variables are the dates of implementation interventions (the Director's performance measure and use of the patient record flag). Dates were obtained from VAPSHCS MRSA Program's administrative records.

The dependent variables were two process measures of the implementation of specific elements of the MRSA Program, and a clinical measure of MRSA colonization transmission.

The first process measure was the MRSA screening rate, defined as the percentage of all patient admissions per month with a nasal swab collection within 24 hours of admission. The number of swabs collected and the number of patients with positive MRSA swabs and clinical cultures were assessed from data available from monthly infection control reports, which are extracted from the electronic health record (VISTA) and subsequently submitted to the VHA Inpatient Evaluation Center (IPEC).

The second process measure was compliance rates for the initiation of infection control precautions when a patient screened positive for MSRA or was identified as having a history of MRSA within the past year. Data for this measure came from reports of documented noncompliance during daily rounds by the MRSA Program Coordinator. Compliance rates with the initiation of infection control precautions was measured as the

proportion of patients documented with the appropriate personal protective equipment (PPE) cart outside the patient's room and a Contact Precautions sign adjacent to the patient's door, where the denominator is the number of patients found to have a history of MRSA from any source within the past year and expected to be placed on infection control precautions. Rates for initiation of infection control precautions were measured and reported in aggregate by month. Compliance with precautions was documented during infection control rounds by the MRSA Program Coordinator based on the inpatient Infection Control surveillance reports, recorded as observation days.Use of PPEs by health care professionals was not documented routinely for each patient during these rounds and is not reported.

The clinical outcome measure was the rate of transmission of new MRSA colonization. This was measured by examining the frequency of a positive nasal swab collected at least 48 hours after admission from a patient with no previous history of MRSA from any source during the previous 365 days. We defined the rate of transmission as the total number of MRSA colonization transmissions per 1,000 patient days.

We also assessed MRSA prevalence rates over the study period, to ensure that changes in underlying prevalence were not inadvertently influencing transmission rates. Facility-wide MRSA prevalence rates were calculated as the total number of inpatients with a history of MRSA from any clinical source or anterior nasal surveillance swab within 365 days of hospitalization per 100 inpatient admission days on the 7 acute and 2 critical care units, excluding the Mental Health Unit.

Procedure and Human Subjects

Approval for this study was obtained from Institutional Review Boards at VA Puget Sound Health Care System (IRB record number 00460) and the University of Washington (41717).

Analytical Methods

For Aim 1, MRSA screening rate trends are described separately for acute and critical care units because the MRSA Program was initiated at different time periods. For Aim 2, we did a pooled analysis of swab compliance rates for critical care and non-critical care units since the Director's performance measure was based on overall facility performance, not unit-specific performance. For Aim 1, we calculated descriptive statistics on MRSA colonization transmission rates, and process measures (i.e., MRSA screening rates and compliance with infection control precautions) across the entire study period from 2007 to 2011. For Aims 2 and 3, we used a two-sided Student's t-test to compare the facility-wide change in MRSA screening rates, and the change in the initiation of infection control precautions, before and after the initiation of the Director's performance measure and use of the patient record flag, respectively. For Aim 4, we use a chi-square to test the independence of pooled MRSA colonization transmission rates before and after the implementation activities. For Aim 1, we reported process measures for critical care, acute care, and pooled facility wide rates because the MRSA Program bundle was implemented first in the critical care units and subsequently in all other acute care units except Mental Health. For Aims, 2-4, we reported pooled analyses because the Director's performance measure and the electronic patient record flag were implemented hospital-wide and affected all units. The pre-intervention and post-intervention activity periods for each implementation intervention were defined as the 3 months before and 3 months after the intervention. This period was chosen to focus on short-term change that we would expect to have the strongest association with the implementation activity. Sensitivity analyses were also conducted using 1 month and 5monthpre-intervention and post intervention intervals. All analyses were carried out with SPSS10. All statistical tests were 2-tailed, with $p<0.05$ considered to be statistically significant.

Results

MRSA Program implementation

Figure 1 depicts findings for Aim 1. Between March 2007 and June, 2011, VA Puget Sound collected 45,021 nasal swabs from 10,333 unique inpatients for MRSA screening. Monthly screening rates in critical care units ranged from 36.5% to 100% of patients receiving screening, and consistently reached the 90%threshold in March, 2007, or12 months after initiation of the active screening program. Monthly screening rates in acute care units ranged from 56.2% to 93.3%, and consistently reached the 90% threshold beginning in December 2010, or 21 months after initiation of the program (Figure 2).Compliance with initiation of infection control precautions ranged from 76.6% to 98.5% of known MRSA positive patients, observed at least 2 times per week for appropriate management with infection control precautions, and consistently reached 90% by March 2008(Figure 3). Overall, the rate of MRSA colonization transmissions increased as screening increased (Figure 4), from 0.65 per 1,000 patient days in 2007, 0.94 per 1,000 patient days in 2008, 1.8 per 1,000 patient days in 2009, 2.3 per 1,000 patient days in 2010, and decreased to 1.7 per 1,000 patient days in 2011.

MRSA Screening and the Director's performance measure

Table 1 and Figure 2 depict findings for Aim 2. Screening for MRSA colonization was not significantly different in the three months after the implementation of the Director's performance measure in October 2009 relative to the three months before. The number of hospital admissions and prevalence of MRSA were similar. In sensitivity analyses, we compared pre-intervention and post-intervention periods of 1 and 5 months, and found screening rates (Aim 2) decreased from 89.6% to 85.4% 1 month (p=0.04) but significantly increased when comparing 5 month intervals, from 87.5% to 91.4% (p<0.01).

Infection control precautions

Table 2 and Figure 3 depict findings for Aim 3. Compliance with infection control precautions increased from 93.6% prior to implementation of the patient record flag to 96.3% in the 3 months after. In sensitivity analyses, significant increases were also observed when comparing pre-intervention and post-intervention periods of 1 and 5 months.

MRSA colonization transmissions

Table 3 and Figure 4 depict findings for Aim 3. MRSA colonization transmission rates were not significantly different in the 3 month periods before and after implementation of the Director's performance measure, but were significantly lower in the 3 month period after implementation of the patient record flag, from 2.7 per 1,000 patient days of care to 1.5 per 1,000 patient days of care. However, the rate of transmissions increased again 5 months after implementation of the patient record flag to 2.2 per 1,000 patient days of care (Figure 4). The number of hospital admission and prevalence of MRSA were similar in the three month periods before and after each bundle activity.

Discussion

Overall, it took more than a year for all of the bundle elements to be implemented, following several quality improvement cycles aimed at increasing MRSA screening rates and to increase initiation of infection control precautions (Figure 3). The implementation of active screening, in the acute care units took approximately the same amount of time (12 months) as the critical care units to reach screening rates above 80%, even though a year of MRSA prevention discussions were actively taking place. This in turn is longer than the overall implementation period reported for the majority of VHA facilities (8 months) to implement active screening programs at a similar 80% nasal screening rate for admitted patients (Jain, Kralovic et al. 2011).Reaching the required 90% screening rate took considerably longer, 21 months, for the acute care compared to 12 months for the

critical care. However, this time period may reflect a largely fixed amount of time needed to implement similar infection prevention bundles at large tertiary health care facilities.

Introduction of the Director's performance measure did not appear to have a significant association with hospital compliance for MRSA screening. This was likely due at least in part to the high levels of screening achieved by the time the performance measure was initiated. Quality improvement cycles, use of transformative process such as positive deviance, and in-services on performance trends to staff nurses likely contributed to the gradual increase in MRSA screening rates, and the hospital likely would have achieved the required threshold without additional administrative pressure brought about by the Director's performance measure.

Introduction of the patient record flag was associated with a significant increase in compliance with initiation of infection control precautions. As with MRSA nasal swab screening, the compliance rate for infection control precautions was already relatively high when the patient record flag was initiated.

A potential reason the patient record flag was associated with significantly changing staff behavior, when the Director's performance measure was not, may have to do with it being more proximal to the action needing to be taken. The patient record flag would ostensibly be seen by the clinician who needs to take action to put the patient on infection control precautions, whereas the Director's performance measure would have an effect via actions taken by the hospital Director to influence those clinical staff who are actually responsible for compliance with MRSA screening. Use of a facility level Director's performance measure required the MRSA Program coordinator, who was responsible for the overall program implementation, to provide monthly reports to the Clinical Executive Board on rapid cycle methods aimed at improving MRSA screening rates. While these data were reported, the MRSA Program coordinator had no direct authority or responsibility over nursing staff that collected the MRSA screening cultures

The rate of MRSA colonization transmissions was not associated with the implementation of the Director's performance measure in October 2009 but had a statistically significant reduction associated with initiation of the electronic patient record flag in January 2011. It is possible that the electronic patient record flag contributed to decreased MRSA colonization transmissions given the documented significant association with compliance with infection control precautions, and the fact that increased compliance with infection control precautions should theoretically directly reduce MRSA transmissions (unlike the increase in compliance with MRSA screening, which provides critical information on infection control but does not directly reduce colonization transmissions).However, the significant p-value notwithstanding, we think it likely that this association is chance, since the baseline rate of infection control precautions was above 90% when the electronic patient record flag was implemented (and therefore there was limited opportunity for improvement) and the hospital wide MRSA colonization transmissions were relatively unstable.

This study has several limitations, including program implementation threats associated with internal and external validity. First, as the swab screening was poor the first 2 years, we do not have complete data and may bias prevalence estimates or possibly missed hospital associated MRSA colonization transmissions. The quality improvement data which documents appropriate placement of patients on infection control precautions does not include observations of healthcare professionals actually donning and doffing personal protective equipment. While this is required by hospital infection control policy, frequency of use cannot be analyzed for this study. It is also not possible to control for the influences of other programs conducted prior to or simultaneously with the implementation of the MRSA Program guidelines, such as a central line blood stream prevention bundle. In part, behavior changes associated with the MRSA Program will be difficult to separate from parallel infection prevention education provided through peer to peer training or provided by the hospital infection control staff members. In addition to a

Hawthorne effect (http://en.wikipedia.org/wiki/Hawthorne_effect), there exist threats associated with a valid inference, including attrition. Second, this study is of a single VHA medical center implementing the VHA MRSA Program. Implementation of the MRSA Program guidelines may differ for each of the participating facilities; however, each facility is required to meet specific Director's performance measures. This analysis may not be generalizable to all populations and healthcare systems which do not require universal screening for MRSA, based on the facilities' Infection Control risk assessment.

In spite of these limitations, this study makes several important contributions to the literature on MRSA control by reporting on implementation efforts. First, we provide a description of the time required to achieve consistent levels of compliance with key components of the MRSA Program, and find that a period of approximately 12 months may be necessary to implement this type of infection control program. Second, we find significant improvements in compliance with infection control precautions associated with an electronic patient record flag, which could be used by other systems implementing hospital-wide infection prevention programs. Proper planning to include each of the bundle elements is recommended, as implementation of these elements after the initial beginning may cause additional challenges and confusion.

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FIGURES

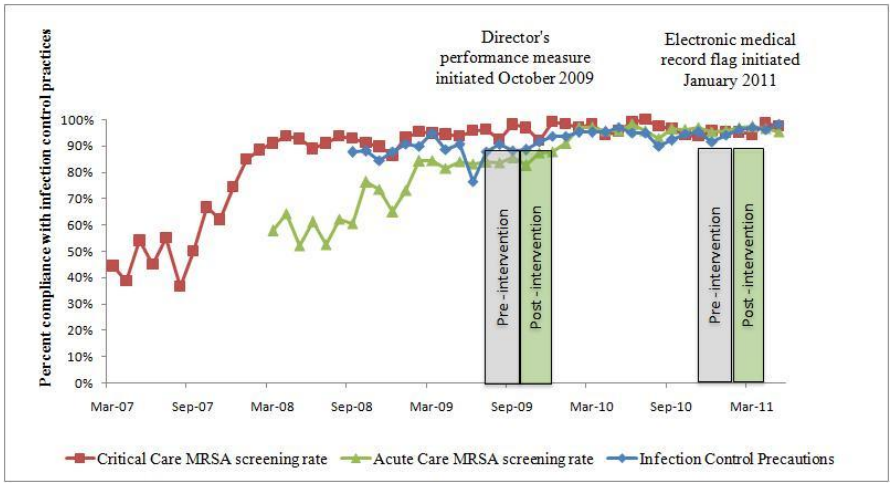

Figure 1: VA Puget Sound Health Care System's initiation of MRSA screening in the critical and acute care wards and documented facility-wide infection control precautions. MRSA screening was initiated at separate time periods, whereas the infection control precautions were initiated but not documented until 2008.

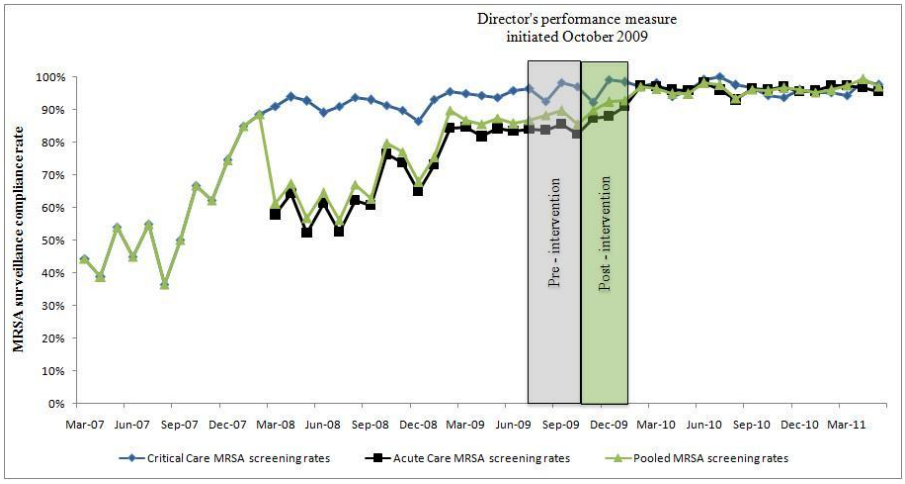

Figure 2: MRSA screening rate trends for the critical care, acute care wards, and facility wide pooled MRSA screening rates, superimposed over the pre-intervention period and post-intervention period Director's performance measure intervention. Pooled MRSA swab collection upon admission did not significantly improve (p=0.36) by comparison of the 3 months pre-intervention and post-intervention of the Director's Performance Measure.

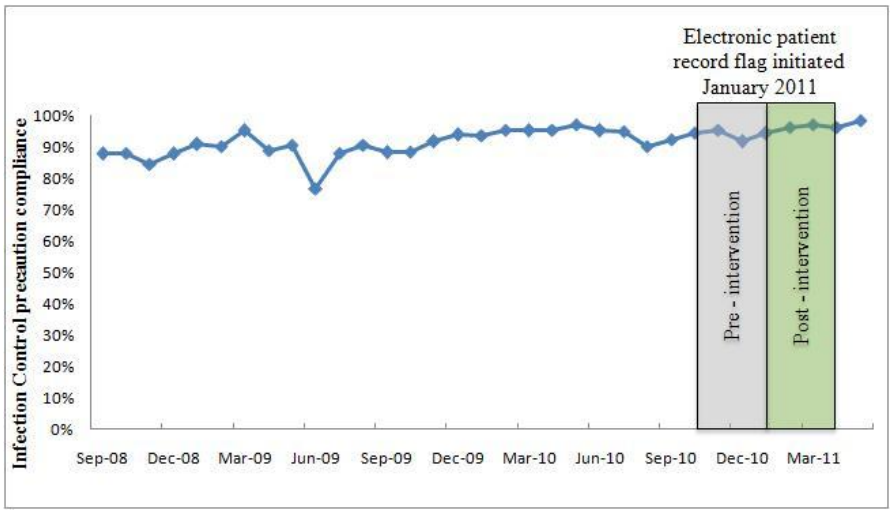

Figure 3: Implementation of the electronic patient record flag was evaluated by comparing the pre-intervention period and post-intervention period for initiation of infection control precautions. Comparing the 3 months pre-intervention and post-intervention, there was an increase in the initiation of infection preventions.

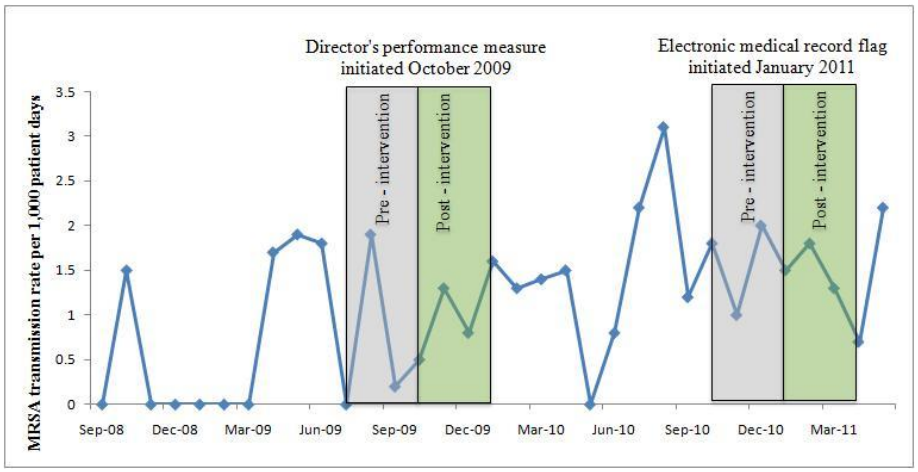

Figure 4: MRSA colonization transmission rates relative to implementation of two process improvement methods. Interventions were evaluated by comparing the per-intervention period and post-intervention period of the Director's performance measure and the electronic medical record flag. Comparing the 3 months pre-intervention and post-intervention, there was no significant decrease in transmissions surrounding the Director's Performance Measure ($p = 0.36$); however, there was an association with transmissions and the implementation of the patient record flag ($p < 0.05$).

TABLES

Table 1: Comparison of pooled MRSA screening rates before and after implementation of the Director's Performance Measure in October, 2009.

Location	Pre-Intervention			Post- Intervention			
	No patient hospital admissions*	% Patients screened for MRSA	Prevalence of MRSA among admitted patients**	No patient hospital admissions*	% Patients screened for MRSA	Prevalence of MRSA among admitted patients **	*p****
1 months	541	89.6%	15.7%	567	85.4%	16.2%	**0.04**
3 months	1677	88.1%	15.7%	1657	89.1%	16.4%	0.36
5 months	2700	87.5%	16.5%	2745	91.4%	16.0%	**<0.01**

* Patients admitted to acute and critical care units; Mental Health Unit was excluded from MRSA screening.
** Prevalence includes MRSA cultured on admission or any history of MRSA within 1 year of admission.
***Two sample t-test, two tailed-probability.

Table 2: Comparison patients placed on infection control precautions before and after implementation of the electronic patient record flag.

Location	Pre-Intervention			Post- Intervention			*p**
	Observation days	Expected #patients for Infection Control Precautions	% patients placed on Infection Control Precautions	Observation days	Expected # patients for Infection Control Precautions	% patients placed on Infection Control Precautions	
1 month	15	565	**91.2%**	18	433	**95.6%**	< **0.01**
3 months	59	1773	**93.6%**	42	1178	**96.3%**	< **0.01**
5 months	90	2542	**93.1%**	79	2054	**97.0%**	< **0.01**

*Two sample t-test, two tailed-probability.

Table 3: Evaluation of hospital-wide MRSA colonization transmission rates 3 months before and 3 months after implementation of the Directors performance measure and electronic patient record flag.

	Pre-Intervention			Post- Intervention			
	No patient hospital admissions*	Transmissions per 1,000 patient days of care	Prevalence of MRSA among admitted patients**	No patient hospital admissions*	Transmissions per 1,000 patient days of care	Prevalence of MRSA among admitted patients**	*p****
Directors Performance Measure	1677	1.70	15.7%	1657	2.02	16.4%	0.36
Electronic patient record flag	1636	2.74	16.5%	1669	1.52	16.3%	<0.05

* Patients admitted to acute and critical care units; Mental Health Unit was excluded from MRSA screening.
** Prevalence includes MRSA cultured on admission or any history of MRSA within 1 year of admission.
***Chi-square test, exact p-value