

Supplementary Online Content

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eAppendix. Specific Feedback Related to Failure Mode Analysis and Lessons Learned

eTable. Baseline Patient Characteristics

This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix. Specific Feedback Related to Failure Mode Analysis and Lessons Learned

Initial failure mode analysis identified baseline anesthesia environmental contamination (failure of terminal cleaning) in the first case of the pair (APL Valve and Dial) leading to subsequent contamination of the anesthesia assistant provider hands, the patient nasopharynx at start and end, anesthesia assistant provider hands at case end, and ultimately stopcock contamination (**Figure 1**). This typical pattern was continued into the next case in the same operating room (OR) due to failure of routine, between-case cleaning [adjustable pressure-limiting (APL) valve and agent dial] linked to anesthesia assistant, patient 2 at case start and end, anesthesia assistant case 2 end, contamination of the APL valve and dial at case 2 end, and injection into the stopcock case 2 end. Residual patient axilla and groin contamination that was not linked to environmental or hand contamination events was also identified (**Figure 1**).

Response to surveillance feedback included; 1) protocol adjustment to include spraying surfaces and equipment with the quaternary ammonium compound followed by wiping with a dry microfiber cloth after air drying according to instructions, and using a top down, clean to dirty approach, 2) OR provider education regarding indications and proper use of each bundle component supported by a poster attached to the catheter care station in the OR, 3) re-enforcement of the need for ultraviolet light (UV-C) robotic cleaning of previously affected areas, 4) review and encouragement of continued use of proper nasal povidone iodine (cleaning nose before application and liberal use), and 5) discussion of internal review board modifications for chlorhexidine use to address residual contamination of patient axillary and groin skin sites.

Repeat failure mode analysis identified a reduction in environmental involvement but persistent involvement of residual patient contamination, highlighting the need for continued focus on improved use of preoperative povidone iodine (asking the patient to clean their nose prior to use and applying a liberal amount). Repeat failure mode analysis identified patient decolonization

and ward nursing hand hygiene failures. Team feedback resulted in utilizing the educational tool described above for recovery unit nursing staff. This involved frequent discussion/teaching of the floor nursing staff by the research team. Use of 2% chlorhexidine gluconate cloths (Sage, Chicago, IL) on the morning of surgery was implemented. Repeat failure mode analysis again identified failure of recovery unit nursing hand hygiene and vascular care as significant issues. Recovery unit staff were informed of the failure mode analysis and educational materials reviewed. Residual patient colonization continued to be a persistent issue. Use of chlorhexidine wipes on the morning of surgery in addition to the surgical protocol was reviewed for proper technique and encouraged, and plans were made to augment patient nasal and skin decolonization. The impact of feedback on *S. aureus* transmission over the one-year study period is shown in **Figure 2**.

Figure Legend:

Figure 1: OR PathTrac Proactive, Prospective Analysis of Perioperative *S. aureus*

Transmission. Reservoirs falling within the 90th percentile of contributing reservoirs to transmission events are shown in red. Contribution over time is mapped across 12 temporally-associated time-points. As shown, the adjustable pressure-limiting (APL) valve and the agent dial of the anesthesia machine were identified as the earliest reservoir source mapped to provider hand, patient skin, and intravascular device transmission locations (red lines). Residual contamination of the case 1 APL valve and dial was linked to case 2 transmission. Automated failure mode analysis indicated targeted improvements which were communicated to the research team and provider end-users to generate improvements.

Figure 2: *S. aureus* Transmission Over Time Stratified by Treatment Assignment with

Indicators for Feedback Interventions. The symbol ^ shows feedback to team regarding suboptimal environmental cleaning related to stopcock contamination and creation of poster-based educational tool for improved intraoperative compliance with bundle elements along plans for addition of use of 2% chlorhexidine cloths on the morning of surgery. The symbol & indicates feedback to team regarding proper use of nasal povidone iodine (cleaning prior to use and liberal application). The symbol # shows feedback regarding need for hand hygiene, vascular care, and environmental improvement, especially on the hospital floor units, educational tool created for the floor regarding bundle elements and proper use. The symbol % feedback to team regarding high rate of residual patient *S. aureus* colonization, especially axillary, better chlorhexidine wipes use and continued focus on recovery unit hand hygiene and vascular care. Plans for patient outreach to augment decolonization made. * Number of cases with *S. aureus* transmission detected for February-May was less than November-January (3/38 cases vs. 11/38

cases, Fisher's exact test, $P=0.036$). There was no difference between February-May and June-August (data not shown). There were only two cases enrolled in September, 1 treatment/1 control, both were negative for *S. aureus* detection.

Figure 1

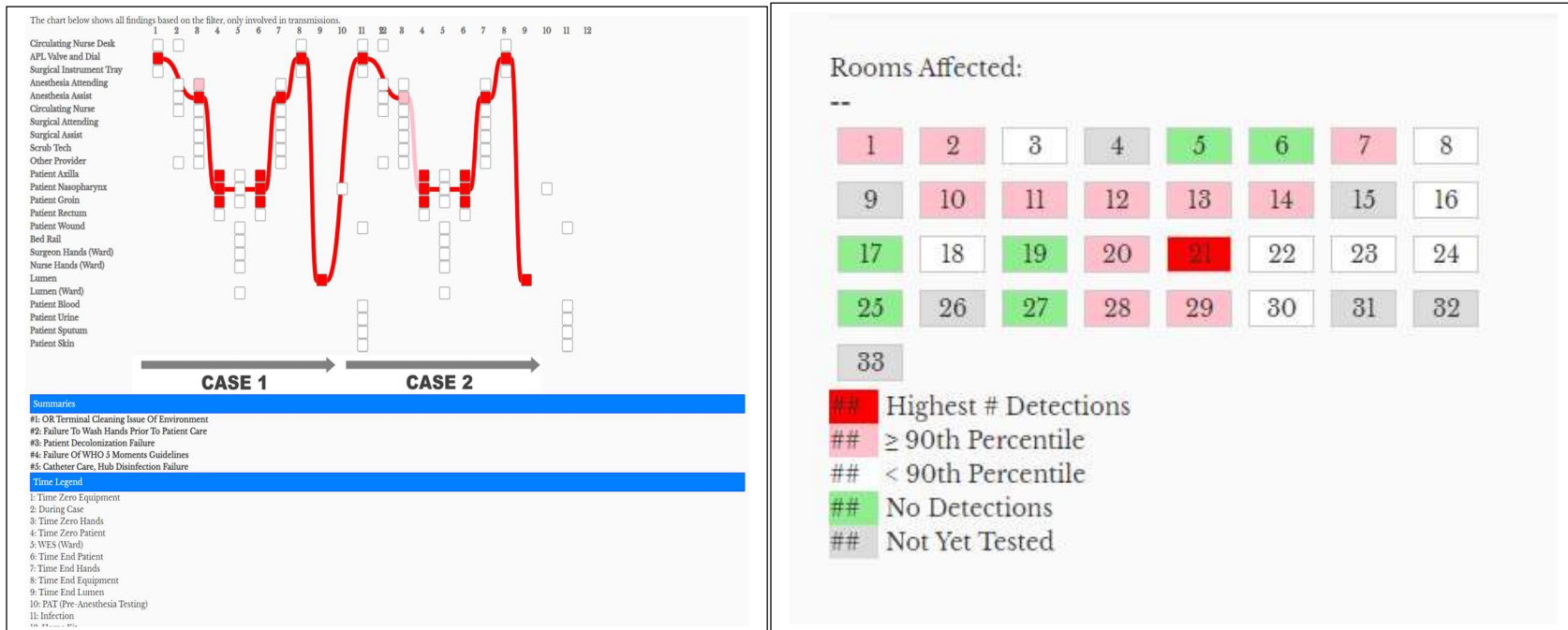
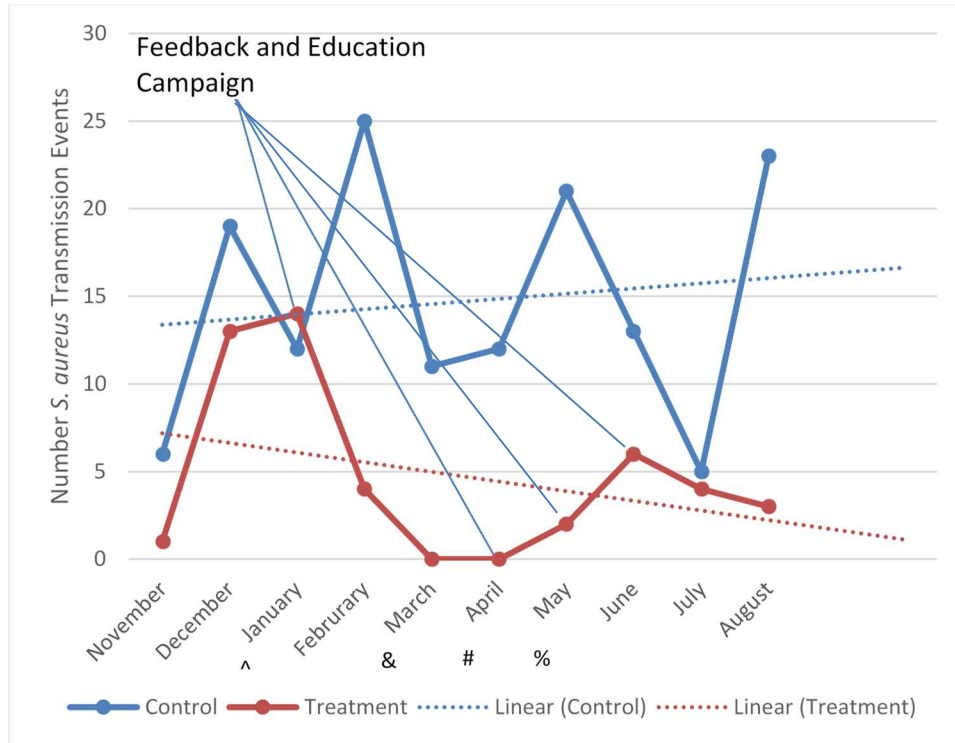


Figure 2



eTable. Baseline Patient Characteristics

Characteristic	No. (%)	
	Treatment (n = 106)	Control (n = 130)
Age >50 y	88 (83.02)	81 (62.31)
Women	43 (40.57)	113 (86.92)
ASA score >2	62 (58.49)	44 (33.85)
Dirty or infected site	3 (2.83)	6 (4.62)
Surgery duration >2 h	97 (91.51)	119 (91.54)
Surgery		
Plastic	1 (0.94)	27 (20.77)
Orthopedic	27 (25.47)	20 (15.38)
General abdominal	5 (4.72)	6 (4.62)
Preoperative decolonization strategy		
Nasal mupirocin and chlorhexidine for 5 d	27 (25.47)	20 (15.38)
Chlorhexidine for day before and morning of surgery	55 (51.89)	80 (61.54)
No protocol	24 (22.64)	30 (23.08)
Discharge location		
Same day	27 (25.47)	54 (41.54)
Floor	69 (65.09)	73 (56.15)
Intensive care unit	10 (9.43)	3 (2.31)