

SUPPLEMENTAL TABLES/FIGURES

Supplemental Table 1: Current version of high (>92%) and low SpO2 delays used in alarm logic

Saturation (%)	Monitor Alarm Delay (sec)	Middleware Delay (sec)	Total Delay (sec)	Alarm Acuity
> 92	300	0	300	Medium
80-100	60	0	60	Medium
70-79	30	0	30	Medium
60-69	15	0	15	Medium
<60	0	0	0	High

“High” acuity refer to critical alarms requiring immediate attention, such as ventricular tachycardia.

“Medium” acuity refer to warning alarms requiring prompt attention, such as elevated heart rates.

“Low” acuity refers to advisory alarms, such as low ability to sense SpO2 or lead detachment.

Supplemental Table 2: Generation 2 non-alerting General Electric system alarms filtered by Connexall

ACC VENT	NBP MAX TIME	NURSE CALL	SENSOR
ARTIFACT	NBP MODULE	PVC	SPO2 ARTIFACT
BIGEMINY	NBP OVER PRES	R ON T	SPO2 PROBE
CONNECT PROBE	NO BREATH	RR LEADS FAIL	SPO2 SENSOR
NBP FAIL	NO ECG	RSP HI	SPO2M LO

Supplemental Table 3: Generation 3 non-alerting Philips system alarms filtered via Connexall

!!Check Patient ID	AO No Transducer	ARTs xx > yy	CPP HI
3D Desat Idx 6	AO Noisy Signal	awRR xx < yy	CPP Interrupted
3D Desat Idx 7	AO Overrange	awRR xx > yy	CPP LOW
A Lead Off	AO Unplugged	Batt Empty	CPP Measure Failed
ABP Artifact	AO Zero+Check Cal	Batt Incompat	CPP No Pulse
ABP Change Scale	AoD HI	Batt Low	CPP No Transducer
ABP Chk Sources	AoD LOW	Batt Malfunction	CPP Noisy Signal
ABP Cuff Overpress	AoD xx < yy	Brady/P LO	CPP Overrange
ABP Deactivated	AoD xx > yy	Brady/P xx < yy	CPP Unplugged
ABP Disconnect	AoM HI	Cannot Analyze ECG	CPP xx < yy
ABP Equip Malf	AoM LOW	Cannot Analyze QT	CPP xx > yy
ABP Interrupted	AoM xx < yy	Cannot Analyze ST	CPP Zero+Check Cal
ABP Measure Failed	AoM xx > yy	Cannot Analyze STE	Cuff Not Deflated
ABP No Pulse	AoS HI	Charger Malfunc	CVP Artifact
ABP No Transducer	AoS LOW	Check ECG Source	CVP Change Scale
ABP Noisy Signal	AoS xx < yy	Check Equipment	CVP Chk Sources
ABP Overrange	AoS xx > yy	Check Keyboard	CVP Cuff Overpress
ABP Unplugged	ART Artifact	Check Patient ID	CVP Deactivated

Supplemental File 1

ABP Zero+Check Cal	ART Change Scale	Check Settings	CVP Disconnect
ABPd HI	ART Chk Sources	Check Touch Input	CVP Equip Malf
ABPd LOW	ART Cuff Overpress	Check Touchscreen	CVP Interrupted
ABPd xx < yy	ART Deactivated	Check Watertrap	CVP Measure Failed
ABPd xx > yy	ART Disconnect	Chk ECG Settings	CVP No Pulse
ABPm HI	ART Equip Malf	Chk ECG Sync Cable	CVP No Transducer
ABPm LOW	ART Interrupted	Chk MSL Connection	CVP Noisy Signal
ABPm xx < yy	ART Measure Failed	Chk SyncOut Cable	CVP Overrange
ABPm xx > yy	ART No Pulse	CO2 Auto Zero	CVP Unplugged
ABPs HI	ART No Transducer	CO2 Change Scale	CVP Zero+Check Cal
ABPs LOW	ART Noisy Signal	CO2 Deactivated	CVPd HI
ABPs xx < yy	ART Overrange	CO2 Equip Malf	CVPd LOW
ABPs xx > yy	ART Unplugged	CO2 No Tubing	CVPd xx < yy
Agent Mixture	ART Zero+Check Cal	CO2 Occlusion	CVPd xx > yy
Align Watertrap	ARTd HI	CO2 Overrange	CVPm HI
AO Artifact	ARTd LOW	CO2 Pump Off	CVPm LOW
AO Change Scale	ARTd xx < yy	CO2 Purging	CVPm xx < yy
AO Chk Sources	ARTd xx > yy	CO2 Sens Warmup	CVPm xx > yy
AO Cuff Overpress	ARTm HI	CPP Artifact	CVPs HI
AO Deactivated	ARTm LOW	CPP Change Scale	CVPs LOW
AO Disconnect	ARTm xx < yy	CPP Chk Sources	CVPs xx < yy
AO Equip Malf	ARTm xx > yy	CPP Cuff Overpress	CVPs xx > yy
AO Interrupted	ARTs HI	CPP Deactivated	dSpO2 Chk Sources
AO Measure Failed	ARTs LOW	CPP Disconnect	E Lead Off
AO No Pulse	ARTs xx < yy	CPP Equip Malf	ECG Check Cable
ECG Noisy Elec LA	ICPm xx > yy	Meas, Deactivated	No Data T-Mon
ECG Noisy Elec LL	ICPs HI	Missed Beat	Non-Sustain VT
ECG Noisy Elec RA	ICPs LOW	MMS Ext, Unplugged	P Unplugged
ECG Noisy Elec V	ICPs xx < yy	MMS Ext, Unpowered	P Artifact
ECG NoisySignal	ICPs xx > yy	MMS Ext, Equip Malf	P Change Scale
ECG Out Equip Malf	imCO2 xx < yy	MMS Extension Malf	P Chk Sources
ECG/Arrh AlarmsOff	imCO2 xx > yy	MMS Malf	P Cuff Overpress
EcgRsp Deactivated	Insert Battery	MMS Msmf Malf	P Deactivated
Event:Sat LOW	IPI Check Pat, Age	MMS Unplugged	P Disconnect
ExtBat Missing	IPI Check Sources	MMS Unsupported	P Equip Malf
FMS Unplugged	IPI xx < yy	MSL Power Overload	P Interrupted
FMS Unsupported	IPI xx > yy	Multiform PVCs	P Measure Failed
GM Alarm Suppress	Irregular HR	NBP Artifact	P No Pulse
GM Standby	LA Lead Off	NBP Change Scale	P No Transducer
GM Unplugged	LAP Artifact	NBP Chk Sources	P Noisy Signal
GM Warmup	LAP Change Scale	NBP Cuff Overpress	P Overrange
GM Zero Running	LAP Chk Sources	NBP Deactivated	P Zero+Check Cal
Grade ? Unknown	LAP Cuff Overpress	NBP Disconnect	Pacer Not Capt
HR High	LAP Deactivated	NBP Equip Malf	Pair PVCs
HR Low	LAP Disconnect	NBP Interrupted	PAP Artifact
I Lead Off	LAP Equip Malf	NBP Measure Failed	PAP Change Scale
ICP Artifact	LAP Interrupted	NBP No Pulse	PAP Chk Sources
ICP Change Scale	LAP Measure Failed	NBP No Transducer	PAP Cuff Overpress
ICP Chk Sources	LAP No Pulse	NBP Noisy Signal	PAP Deactivated
ICP Cuff Overpress	LAP No Transducer	NBP Overrange	PAP Disconnect
ICP Deactivated	LAP Noisy Signal	NBP Unplugged	PAP Equip Malf
ICP Disconnect	LAP Overrange	NBP Zero+Check Cal	PAP Interrupted
ICP Equip Malf	LAP Unplugged	NBPd High	PAP Measure Failed

Supplemental File 2

ICP Interrupted	LAP Zero+Check Cal	NBPd LOW	PAP No Pulse
ICP Measure Failed	LAPd HI	NBPd xx < yy	PAP No Transducer
ICP No Pulse	LAPd LOW	NBPd xx > yy	PAP Noisy Signal
ICP No Transducer	LAPd xx < yy	NBPm High	PAP Overrange
ICP Noisy Signal	LAPd xx > yy	NBPm LOW	PAP Unplugged
ICP Overrange	LAPm HI	NBPm xx < yy	PAP Zero+Check Cal
ICP Unplugged	LAPm LOW	NBPm xx > yy	PAPd HI
ICP Zero+Check Cal	LAPm xx < yy	NBPs High	PAPd LOW
ICPd HI	LAPm xx > yy	NBPs LOW	PAPd xx < yy
ICPd LOW	LAPs HI	NBPs xx < yy	PAPd xx > yy
ICPd xx < yy	LAPs LOW	NBPs xx > yy	PAPm HI
ICPd xx > yy	LAPs xx < yy	No 3D Desat Index	PAPm LOW
ICPm HI	LAPs xx > yy	No Central Monit,	PAPm xx < yy
ICPm LOW	Leadset Unplugged	No Data Monitor	PAPm xx > yy
ICPm xx < yy	LL Lead Off	No Data Tele	PAPs HI
PAPs LOW	RAPd xx > yy	SpO2l ReplaceSensr	SpO2r Searching
PAPs xx < yy	RAPm HI	SpO2l Searching	SpO2r Sensor Malf
PAPs xx > yy	RAPm LOW	SpO2l Sensor Malf	SpO2r Unplugged
Pause	RAPm xx < yy	SpO2l Unplugged	SpO2r xx < yy
Pd xx < yy	RAPm xx > yy	SpO2l xx < yy	SpO2r xx > yy
Pd xx > yy	RAPs HI	SpO2l xx > yy	ST High
Perf High	RAPs LOW	SpO2po Chk Sensor	ST Low
Perf Low	RAPs xx < yy	SpO2po Chk Sources	ST Multi aVF,I
Perf xx < yy	RAPs xx > yy	SpO2po Equip Malf	ST Multi aVF,II
Perf xx > yy	Repl, Tele Batt	SpO2po Low	ST Multi aVF,III
Perfl xx < yy	Resp Leads Off	SpO2po Low Perf	ST Multi aVL,I
Perfl xx > yy	RL Lead Off	SpO2po No Pulse	ST Multi aVL,II
PerfPo xx < yy	R-on-T PVCs	SpO2po Poor Signal	ST Multi aVL,III
PerfPo xx > yy	RR High	SpO2po ReplaceSensr	ST Multi aVR,I
PerfPr xx < yy	RR Low	SpO2po Searching	ST Multi aVR,II
PerfPr xx > yy	RR xx > yy	SpO2po Sensor Malf	ST Multi aVR,III
PPV bad ART Signal	Run PVCs High	SpO2po Unplugged	ST Multi I ,aVL
PPV Chk Sources	S Lead Off	SpO2po xx < yy	ST Multi I ,aVR
Pulse High	Some ECG AlarmsOff	SpO2po xx > yy	ST Multi II ,aVF
Pulse Low	Speaker Malfunct	SpO2poInterference	ST Multi II ,aVR
Pulse xx < yy	SpO2 Chk Sensor	SpO2pr Chk Sensor	ST Multi III,aVF
Pulse xx > yy	SpO2 Chk Sources	SpO2pr Chk Sources	ST Multi III,aVR
QT High	SpO2 Equip Malf	SpO2pr Equip Malf	ST Multi V3 ,V4
QT Low	SpO2 High	SpO2pr Low	STE aVF ,I
RA Lead Off	SpO2 Interference	SpO2pr Low Perf	STE aVF ,II
RAP Artifact	SpO2 Low	SpO2pr No Pulse	STE aVF ,III
RAP Change Scale	SpO2 Low Perf	SpO2pr Poor Signal	STE aVL ,I
RAP Chk Sources	SpO2 No Pulse	SpO2pr ReplaceSensr	STE aVL ,II
RAP Cuff Overpress	SpO2 Poor Signal	SpO2pr Searching	STE aVL ,III
RAP Deactivated	SpO2 ReplaceSensr	SpO2pr Sensor Malf	STE aVR ,I
RAP Disconnect	SpO2 Searching	SpO2pr Unplugged	STE aVR ,II
RAP Equip Malf	SpO2 Sensor Malf	SpO2pr xx < yy	STE aVR ,III
RAP Interrupted	SpO2 Unplugged	SpO2pr xx > yy	STE I ,aVF
RAP Measure Failed	SpO2 xx < yy	SpO2prInterference	STE I ,aVL
RAP No Pulse	SpO2 xx > yy	SpO2r Chk Sensor	STE I ,aVR
RAP No Transducer	SpO2l Chk Sensor	SpO2r Chk Sources	STE II ,aVF
RAP Noisy Signal	SpO2l Chk Sources	SpO2r Equip Malf	STE II ,aVL
RAP Overrange	SpO2l Equip Malf	SpO2r Interference	STE II ,aVR

Supplemental File 3

RAP Unplugged	SpO2l Interference	SpO2r Low	STE III ,aVF
RAP Zero+Check Cal	SpO2l Low	SpO2r Low Perf	STE III ,aVL
RAPd HI	SpO2l Low Perf	SpO2r No Pulse	STE III ,aVR
RAPd LOW	SpO2l No Pulse	SpO2r Poor Signal	ST-I xx < yy
RAPd xx < yy	SpO2l Poor Signal	SpO2r ReplaceSensr	ST-I xx > yy
ST-II xx < yy	Tesoph xx > yy	UAP No Pulse	UVPs LOW
ST-II xx > yy	TesophNoTransducer	UAP No Transducer	UVPs xx < yy
ST-III xx < yy	Tnaso Deactivated	UAP Noisy Signal	UVPs xx > yy
ST-III xx > yy	Tnaso Equip Malf	UAP Overrange	V Lead Off
ST-MCL xx < yy	Tnaso High	UAP Unplugged	V1 Lead Off
ST-MCL xx > yy	Tnaso Low	UAP Zero+Check Cal	V2 Lead Off
ST-V xx < yy	Tnaso NoTransducer	UAPd HI	V3 Lead Off
ST-V xx > yy	Tnaso Overrange	UAPd LOW	V4 Lead Off
SyncOut Equip Malf	Tnaso xx < yy	UAPd xx < yy	V5 Lead Off
Tachy/p High	Tnaso xx > yy	UAPd xx > yy	V6 Lead Off
Tachy/p xx > yy	Trect Deactivated	UAPm HI	Vent Bigeminy
Tart Deactivated	Trect Equip Malf	UAPm LOW	
Tart Equip Malf	Trect High	UAPm xx < yy	
Tart High	Trect Low	UAPm xx > yy	
Tart Low	Trect NoTransducer	UAPs HI	
Tart NoTransducer	Trect Overrange	UAPs LOW	
Tart Overrange	Trect xx < yy	UAPs xx < yy	
Tart xx < yy	Trect xx > yy	UAPs xx > yy	
Tart xx > yy	Tskin Deactivated	Unsupported LAN	
Tcore Deactivated	Tskin Equip Malf	UVP Artifact	
Tcore Equip Malf	Tskin High	UVP Change Scale	
Tcore High	Tskin Low	UVP Chk Sources	
Tcore Low	Tskin NoTransducer	UVP Cuff Overpress	
Tcore NoTransducer	Tskin Overrange	UVP Deactivated	
Tcore Overrange	Tskin xx < yy	UVP Disconnect	
Tcore xx < yy	Tskin xx > yy	UVP Equip Malf	
Tcore xx > yy	Tven Deactivated	UVP Interrupted	
Tele Battery Low	Tven Equip Malf	UVP Measure Failed	
TELE Weak Signal	Tven High	UVP No Pulse	
Temp Deactivated	Tven Low	UVP No Transducer	
Temp Equip Malf	Tven NoTransducer	UVP Noisy Signal	
Temp High	Tven Overrange	UVP Overrange	
Temp Low	Tven xx < yy	UVP Unplugged	
Temp NoTransducer	Tven xx > yy	UVP Zero+Check Cal	
Temp Overrange	UAP Artifact	UVPd HI	
Temp xx < yy	UAP Change Scale	UVPd LOW	
Temp xx > yy	UAP Chk Sources	UVPd xx < yy	
Tesoph Deactivated	UAP Cuff Overpress	UVPd xx > yy	
Tesoph Equip Malf	UAP Deactivated	UVPm HI	
Tesoph High	UAP Disconnect	UVPm LOW	
Tesoph Low	UAP Equip Malf	UVPm xx < yy	
Tesoph Overrange	UAP Interrupted	UVPm xx > yy	
Tesoph xx < yy	UAP Measure Failed	UVPs HI	

Supplemental Table 4: Generation 3 Philips system alarms that alert after a 120 second delay implemented by Connexall

ECG Leads Off	SpO2l No Sensor	SpO2po Sensor Off	SpO2r No Sensor
SPO2 PROBE OFF	SpO2l Sensor Off	SpO2pr No Sensor	SpO2r Sensor Off
SpO2 No Sensor	SpO2po No Sensor	SpO2pr Sensor Off	

Supplemental Table 5: SAFE scoring algorithm used as monitoring parameter and balancing measure

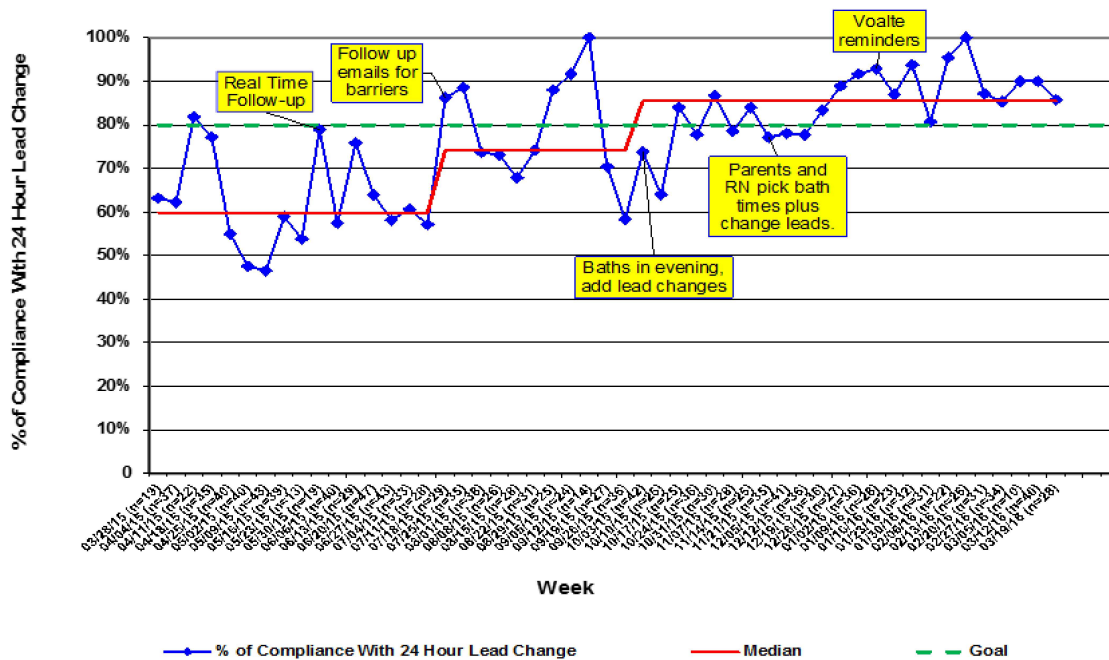
ACCU SAFE TOOL		Patient Label	
Date:	Time:		
Room:			
Nurse's Last Name:			
Watcher: YES NO			
Circle: Watcher/High Risk Therapy/Communication Concern/Family Concern			
Circle: A. Single ventricle B. Post transplant			
C. Cardiomyopathy D. VAD			
E. Other cardiac F. non-cardiac G. cath pt	Rating		Rating
Heart Rate/Rhythm:		Behavioral Level of Consciousness/NOT RELATED TO HOSPITAL ANXIETY	
Sinus rhythm or baseline rhythm, HR WNL or parameters	0	Relaxed, content, resting appropriately	0
Arrhythmias with stable VS & perfusion (reviewed by Fellow-no concern)	1	Slightly anxious/slightly irritable	1
Persistent brady or tachy outside of baseline or ordered parameters	2	Reassured by occasional touching, hugging, talking to, distractible	
New/increased arrhythmias with fellow/RN heightened concerns	3	Anxious, irritable, decreased activity	2
Arrhythmias with unstable VS or perfusion	4	Increasingly difficult to distract or console or stay asleep	
		Very Anxious, Very irritable	3
		Unable to console, unable to rest, or increasing drowsiness	
Perfusion: (FOR VAD DEVICES)		Lethargic, confused	4
Pink and/or cap refill ≤/≥ 2 seconds (FILL or FLOW at BASELINE)	0	Minimally responsive or unresponsive to pain	
Pale and/or cap refill 3 seconds	1		
Grey or cap refill > 4 seconds	2		
Gray/mottled or cap refill >5 sec (DECR FILL OR FLOW, INCR POWER)	3	Concerns from pt., family (R/T DETERIORATING MEDICAL STATUS):	
Decreased peripheral pulses, cool to touch, cyanotic,	4	No Concerns or not present	0
		Slight Concerns and/or Family not engaged	1
		Family with increasing concerns	2
Respiratory Effort:		Family uncomfortable regarding concerns	3
Normal for age	0	Family very uncomfortable regarding concerns	4
Resp. Rate MILDLY INCREASED YET EASY	1		
Resp. Rate MODERATELY INCREASED YET EASY	2		
Resp. Rate increased with effort mild to moderately labored	3	Nursing Concerns FOR DETERIORATING MEDICAL STATUS	
Resp. Rate increased with effort moderate to severely labored	4	Rate 0 for no concerns	0
			1
			2
			3
Current Oxygen Therapy			
Room Air or stable on home oxygen dose	0	Rate 4 for highly concerned	4
Oxygen use is stable or in process of weaning	1		
Intermittent episodes of O2 usage	2		
New or Increased continuous oxygen requirement	3		
Unable to maintain ordered sats within reasonable O2 delivery	4		
		FOR PATIENTS SCORING 7 OR ABOVE:	
GI Concerns		1. RESIDENT IS TO BE NOTIFIED that pt scored 7 or above each time scored and document that patient scored 7 or above and why in notification log	
No concerns, NPO for procedure, or tolerating PO/enteral feeds	0		
Tolerating feeds, but unable to progress feeds or Poor appetite	1	2. RESIDENT IS TO EVALUATE PT.	
Vomiting some of feeds and/or complaints of nausea	2	3. FOCUSED Q2H Vital Signs-- and chart	
Vomiting ≥/≤ half of feeds (fussy with feeds), n/v &/or abd. distention	3	4. FOCUSED Q2H Assessments-- and chart	
Increasing abdom distention, increasing nausea/emesis, blood in stool	4		

Supplemental Figure 1: Current RN escalation algorithm

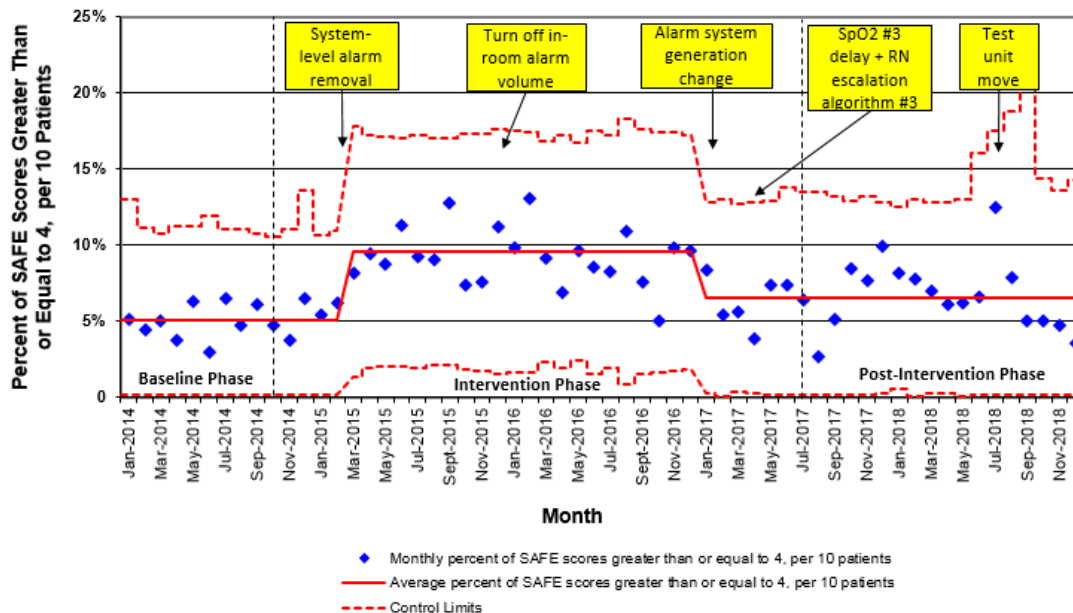
Alarm Acuity	Initial Notification Recipients	Secondary Notification Recipients	Tertiary Notification Recipients
High	Primary RN Charge RN	Primary RN Buddy RN	All staff
Medium	Primary RN	Primary RN Buddy RN	Primary RN Buddy RN Resource RN Charge RN
Low	Primary RN	Primary RN Buddy RN	Primary RN Buddy RN

“High” acuity refer to critical alarms requiring immediate attention, such as ventricular tachycardia.
 “Medium” acuity refer to warning alarms requiring prompt attention, such as elevated heart rates.
 “Low” acuity refers to advisory alarms, such as low ability to sense SpO2 or lead detachment.

Supplemental Figure 2: Percentage of patients with ECG leads changed every 24 hours by week



Supplemental Figure 3: Percent of SAFE scores greater than or equal to 4, per 10 patients, by month.



Supplemental Figure 4: METs and floor-to-ICU transfers per 1000 patient days by month.

