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Nicholas Clark

Children's Mercy Hospital

Kathryn Kyler

Children's Mercy Hospital

Geoffrey L. Allen

Children's Mercy Hospital

Andrew Ausmus

Children's Mercy Kansas City

Kathleen Berg

Children's Mercy Hospital

See next page for additional authors

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Authors

Nicholas Clark, Kathryn Kyler, Geoffrey L. Allen, Andrew Ausmus, Kathleen Berg, Jeremy Beyer, Ryan Centanni, Christine Claeys, Matthew Hall, Andrea Miles, Ginny Nyberg, and Lindsey Malloy-Walton

Variations in Rates of Clinical Alarm Burden, Source, and Cause Across Inpatient Unit Types at a Children’s Hospital

Nicholas A. Clark MD^{1,2}; Kathryn Kyler MD^{1,2}; Geoff Allen MD^{1,2}; Andrew Ausmus MD^{1,2}; Kathleen Berg MD^{1,2}; Jeremy Beyer MD¹; Ryan Centanni³; Christine Claeys RN, BSN, CCRN-K¹; Matthew Hall, PhD^{1,4}; Andrea Miles APRN, MNsc, CPNP-AC¹; Ginny Nyberg MSN,RN¹; Lindsey Malloy Walton DO, MPH^{1,2}

1. Children’s Mercy Kansas City; 2. University of Missouri- Kansas City School of Medicine; 3. Kansas City University College of Osteopathic Medicine; 4. Children’s Hospital Association

Background

Clinical alarms are frequent, often non-actionable, and, if excessive, pose threats to patient safety by creating alarm fatigue.

Prior pediatric studies were time limited and may have not accurately captured the degree of alarm burden in the hospital setting.

We aimed to describe alarm burden over a 1-year period and explored variations in unit-level alarm rates stratified by unit type, alarm source, and cause.

Discussion/Conclusions

Retrospective study of internal clinical alarm and patient census data at Children’s Mercy from January 2019 through December 2019.

Included 8 inpatient units:

- 6 medical/surgical units
- 1 mixed pediatric/cardiac intensive care unit
- 1 neonatal intensive care unit (NICU)

Unit-level alarm rates were calculated per patient day.

Rates were stratified by unit type, alarm source (e.g., pulse oximetry probe), and cause (e.g., apnea).

Poisson regression determined *p*-values for comparisons. *p* <0.05 was considered significant.



Results

84,077 patient days; 7,934,997 alarms; 216 different alarm types

Overall rate = 94.4 alarms per patient day (95% confidence interval [CI] 94.3 to 94.4)

Significant variability existed across inpatient unit types for alarm rates and by source and cause (Tables 1-3).

Table 1. Alarm Rates by Unit Type

Unity Type	Total Alarms (N)	Patient Days (N)	Rate (95% CI)	p-value
NICU	3,141,014	26,735	117.49 (117.36, 117.62)	<.001
PICU/CICU	1,267,203	13,980	90.65 (90.49, 90.8)	
Medical/Surgical	3,526,780	43,362	81.33 (81.25, 81.42)	

CI, Confidence interval. CICU, Cardiac intensive care unit. PICU, Pediatric intensive care unit.

Table 2. Alarm Rates by Unit Type and Source*

Source	Overall	Medical/Surgical	PICU/CICU	NICU	p-value
Pulse Oximetry Probe	54.36 (54.31, 54.41)	37.56 (37.5, 37.62)	33.26 (33.17, 33.36)	92.64 (92.53, 92.76)	<.001
Cardiorespiratory Lead	31.03 (30.99, 31.07)	40.05 (39.99, 40.11)	31.4 (31.31, 31.5)	16.2 (16.15, 16.25)	<.001
Arterial Line	3.86 (3.84, 3.87)	0 (0, 0)	16.63 (16.57, 16.7)	3.43 (3.41, 3.45)	<.001
Blood Pressure Cuff	2.64 (2.63, 2.65)	2.4 (2.38, 2.41)	7.41 (7.36, 7.45)	0.55 (0.54, 0.56)	<.001
Invasive Vascular Line	1.39 (1.38, 1.4)	0 (0, 0)	0.77 (0.75, 0.78)	3.97 (3.94, 3.99)	NE
Patient Monitor	0.99 (0.98, 0.99)	1.26 (1.25, 1.27)	1 (0.99, 1.02)	0.53 (0.52, 0.54)	<.001
End Tidal CO2 Monitor	0.02 (0.02, 0.02)	0 (0, 0)	0 (0, 0)	0.07 (0.06, 0.07)	<.001
Invasive Intracranial Line	0.01 (0.01, 0.01)	0 (0, 0)	0.08 (0.08, 0.08)	0 (0, 0)	<.001
Temperature Probe	0 (0, 0)	0 (0, 0)	0.01 (0.01, 0.01)	0 (0, 0)	NE

*Rate (95% confidence interval). NE, non-estimable.

Table 3. Alarm Rates by Unit Type and Cause*

Cause	Overall	Medical/Surgical	PICU/CICU	NICU	p-value
Oxygen Saturation Low	43.37 (43.33, 43.42)	26.25 (26.21, 26.3)	27.14 (27.05, 27.22)	79.63 (79.52, 79.73)	<.001
Technical	16.33 (16.3, 16.35)	24.5 (24.45, 24.54)	15.75 (15.68, 15.81)	3.38 (3.36, 3.4)	<.001
Heart Rate High	8.79 (8.77, 8.81)	11.44 (11.41, 11.47)	5.62 (5.58, 5.66)	6.14 (6.11, 6.17)	<.001
Heart Rate Low	6.53 (6.52, 6.55)	8.3 (8.27, 8.33)	3.68 (3.64, 3.71)	5.16 (5.13, 5.19)	<.001
Arrhythmia	6.46 (6.44, 6.47)	6.6 (6.58, 6.63)	13.02 (12.96, 13.08)	2.78 (2.76, 2.8)	NE
Blood Pressure High	4.95 (4.94, 4.97)	1.49 (1.48, 1.5)	16.81 (16.74, 16.87)	4.36 (4.34, 4.39)	NE
Oxygen Saturation High	3.67 (3.66, 3.68)	0.2 (0.19, 0.2)	0.54 (0.53, 0.56)	10.93 (10.89, 10.97)	<.001
Apnea	2.05 (2.04, 2.06)	1.95 (1.93, 1.96)	2.55 (2.53, 2.58)	1.96 (1.94, 1.98)	<.001
Blood Pressure Low	1.9 (1.89, 1.91)	0.13 (0.13, 0.14)	5.31 (5.28, 5.35)	2.98 (2.96, 3)	NE
Respiratory Rate High	0.22 (0.22, 0.23)	0.38 (0.38, 0.39)	0.1 (0.09, 0.11)	0.03 (0.03, 0.04)	NE
Respiratory Rate Low	0.09 (0.08, 0.09)	0.09 (0.08, 0.09)	0.05 (0.04, 0.05)	0.11 (0.1, 0.11)	<.001
Intracranial Pressure High	0.01 (0.01, 0.01)	0 (0, 0)	0.06 (0.05, 0.06)	0 (0, 0)	<.001
Carbon Dioxide High	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0.01)	<.001
Carbon Dioxide Low	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.01 (0.01, 0.01)	<.001
Intracranial Pressure Low	0 (0, 0)	0 (0, 0)	0.02 (0.02, 0.03)	0 (0, 0)	<.001
Temperature High	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	NE
Temperature Low	0 (0, 0)	0 (0, 0)	0.01 (0, 0.01)	0 (0, 0)	NE

*Rate (95% confidence interval). NE, non-estimable.

Results Cont.

NICU had the highest rate of alarms per patient day (Table 1).

Pulse oximetry probe alarms had the highest rate by source and was primarily driven by the NICU (Table 2).

Cardiorespiratory lead alarms had the second highest rate by source with medical/surgical units having the highest rate across inpatient unit types.

“Oxygen Saturation Low” had the highest overall alarm rate by cause and was primarily driven by the NICU (Table 3).

“Technical” alarms were the second most common cause with medical/surgical units having the highest rate.

Discussion/Conclusions

Inpatient units experienced very frequent clinical alarms with wide variability in alarm rates across unit types.

Pulse oximetry monitoring was the most significant contributor to clinical alarm burden, and efforts should be aimed at reducing non-actionable pulse oximetry alarms.

A one-size-fits-all approach may not be effective in reducing alarm burden. Efforts should be customized to each unit based upon its alarm rates.

