

JAMA Surgery | **Original Investigation**

Association of Anesthesiologist Staffing Ratio With Surgical Patient Morbidity and Mortality

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Disclosures

I am a co-investigator on project funding from the following sources to my institution:

Blue Cross Blue Shield of Michigan (BCBSM)
Patient-Centered Outcomes Research Institute (PCORI)

I am a co-inventor on patent No. 11,288,445 B2 entitled “Automated System and Method for Assigning Billing Codes to Medical Procedures,” related to the use of machine learning techniques for medical procedural billing.

Hypothesis

Anesthesiologists primarily operate in care team models in the U.S., but the association of overlapping anesthesiologist responsibilities with patient outcomes remains unexplored.

We set out to study the potential association of this overlapping care with surgical patient morbidity and mortality.

Exposure

Staffing Ratio (SR)

Ratio of an anesthesiologist to the overlapping number of rooms they cover

Each operation was classified into a single "staffing ratio" group by calculating the time-weighted average of the ratio of anesthesiologist to overlapping operations.

Exposure

Staffing Ratio (SR)

Ratio of an anesthesiologist to the overlapping number of rooms they cover

120 minutes

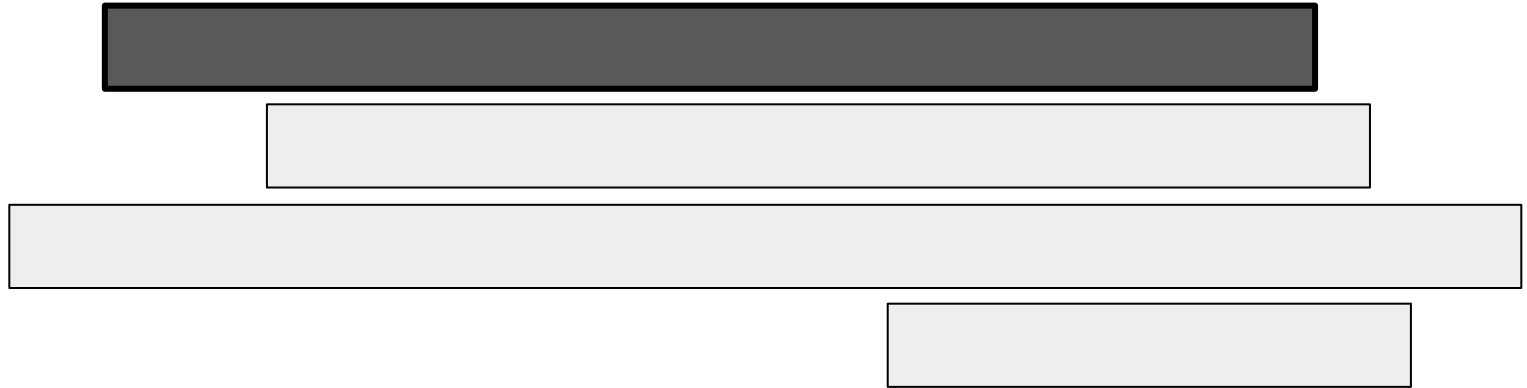


Exposure

Staffing Ratio (SR)

Ratio of an anesthesiologist to the overlapping number of rooms they cover

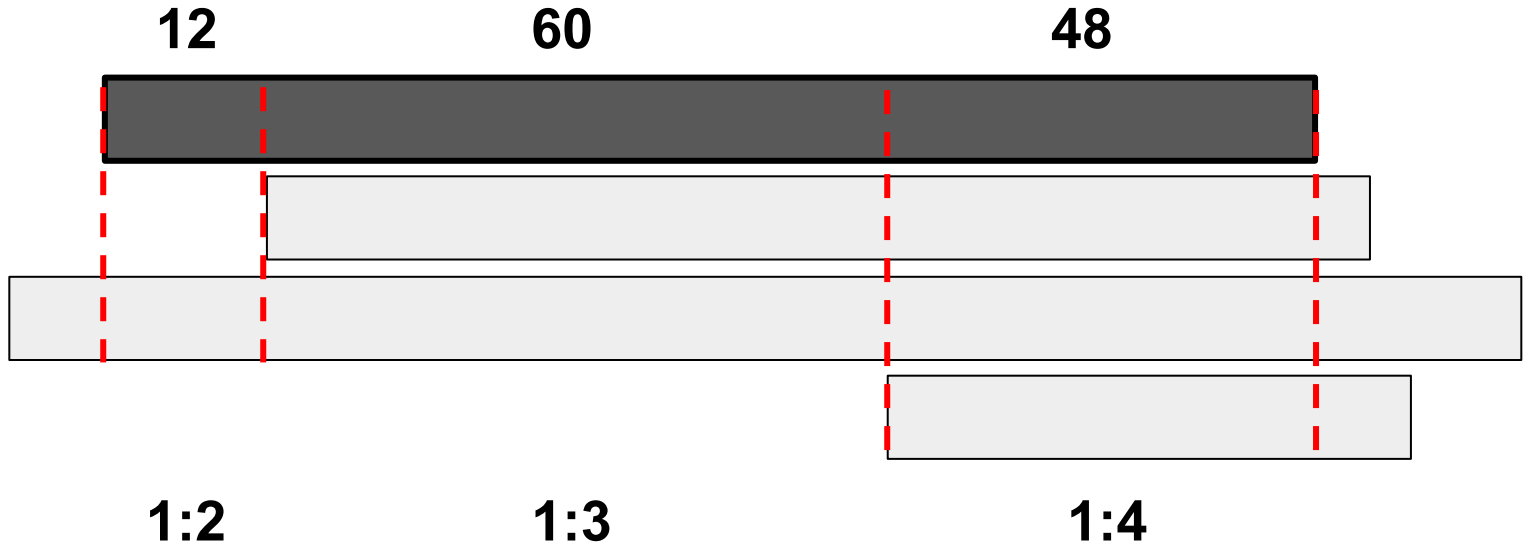
120 minutes



Exposure

Staffing Ratio (SR)

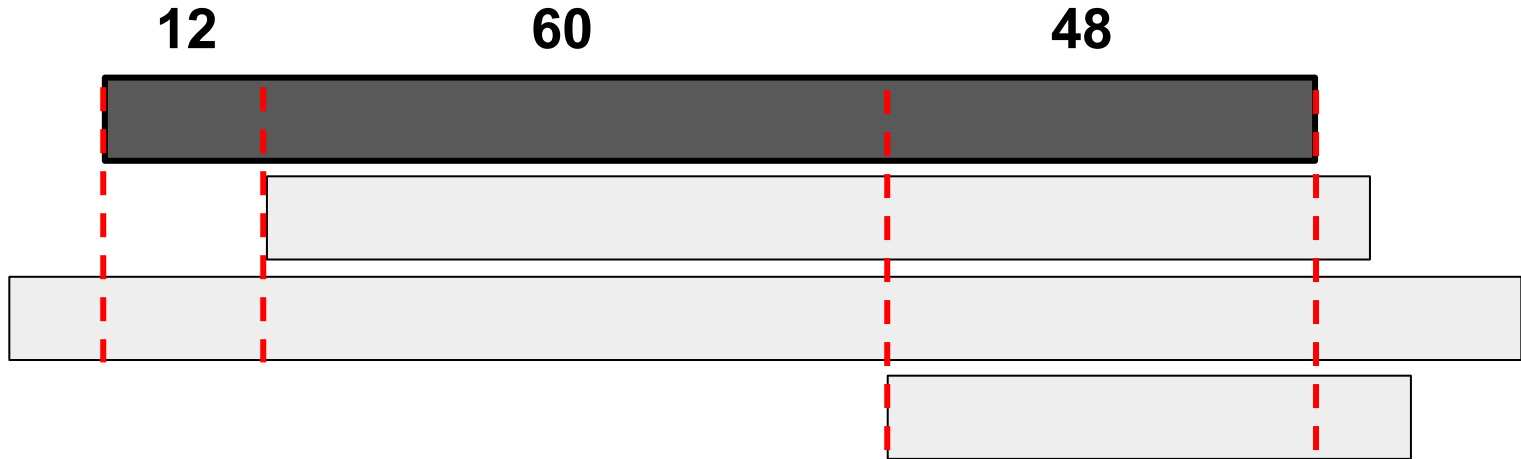
Ratio of an anesthesiologist to the overlapping number of rooms they cover



Exposure

Staffing Ratio (SR)

Ratio of an anesthesiologist to the overlapping number of rooms they cover



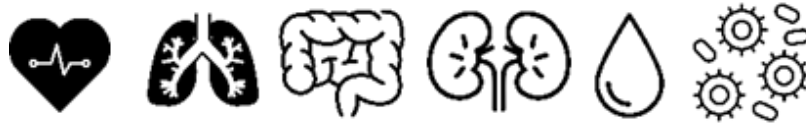
$$[(2 \times 12) + (3 \times 60) + (4 \times 48)] / 120 = 3.3$$

Primary Outcome

The **primary outcome** was a composite of mortality and

6 perioperative complication categories, defined by ICD diagnoses, derived from the Agency for Healthcare Research and Quality's (AHRQ) definitions:

- Cardiac
- Respiratory
- Gastrointestinal
- Urinary
- Bleeding
- Infection



Data

Electronic healthcare data from the Multicenter Perioperative Outcomes Group

Provider sign-in/sign-out data accurately captured due to billing and compliance reqs

Inclusion criteria:

- Elective procedures
- Adult patients (≥ 18 years of age)
- Jan 1, 2010 - Oct 31, 2017
- Surgical types: General, Gynecologic, Neurological, ENT, Orthopedic, Urology, Vascular

Exclusion criteria:

- Procedures with a “fixed staffing ratio”: cardiac, liver transplants, cataract removal, and obstetrics
- >25% resident involvement
- Missing anesthesia CPT
- Overnight, weekend, holiday cases

Methods

Propensity score matching methods were applied to create four balanced sample groups with respect to patient, procedure, and hospital level factors:

- Single case (SR = 1)
- 1-2 overlapping cases ($1 < SR \leq 2$)
- 2-3 overlapping cases ($2 < SR \leq 3$)
- 3-4 overlapping cases ($3 < SR \leq 4$)

Variables included in the propensity score derivation model and used to calculate the likelihood of being in a particular staffing ratio group included age, sex, type of operation, surgical service, anesthesia duration, and institution.

Three models were sequentially fit to obtain propensity scores corresponding to each paired group, using $1 < SR \leq 2$ as the reference.

3624399 Operations

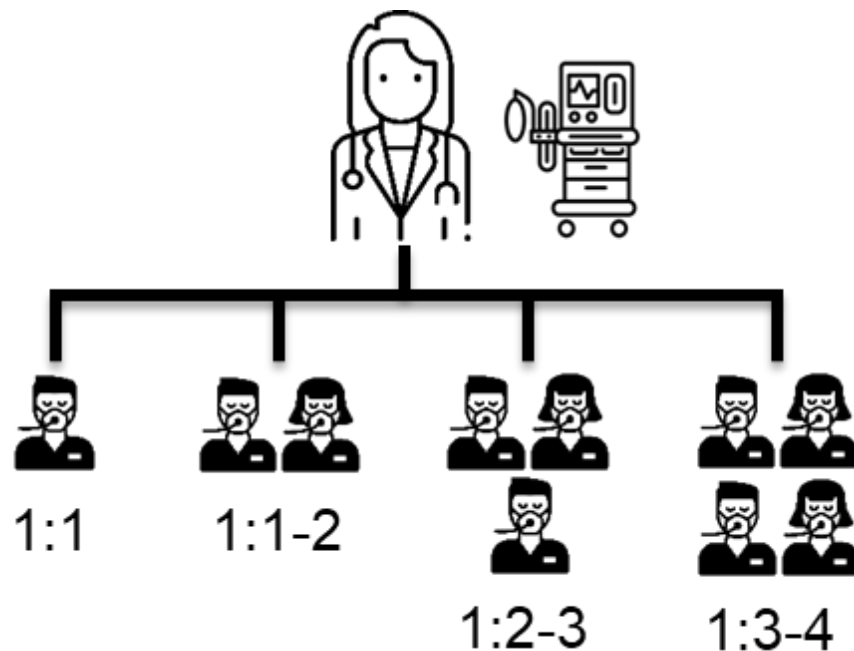
2757946 Excluded

- 14349 Any flag for invalid sign-in data
- 253674 Fixed staffing ratio operations
- 8625 Moribund patient or deceased organ donor
- 155672 Weekend or holiday operation
- 101391 Overnight operation
- 208256 Missing anesthesia CPT code
- 184 Missing staffing ratio
- 651177 Resident involvement for >25% of operation
- 230752 Staffing ratio 1:0 (personally performed)
- 3810 Staffing ratio >1:4
- 1548 Excluded sites
- 1091374 Excluded surgical categories
- 37134 Age <18 y

866453 Operations after exclusions

578815 Matched

- 48555 Staffing ratio group 1
- 247057 Staffing ratio group 1-2
- 216193 Staffing ratio group 2-3
- 67010 Staffing ratio group 3-4



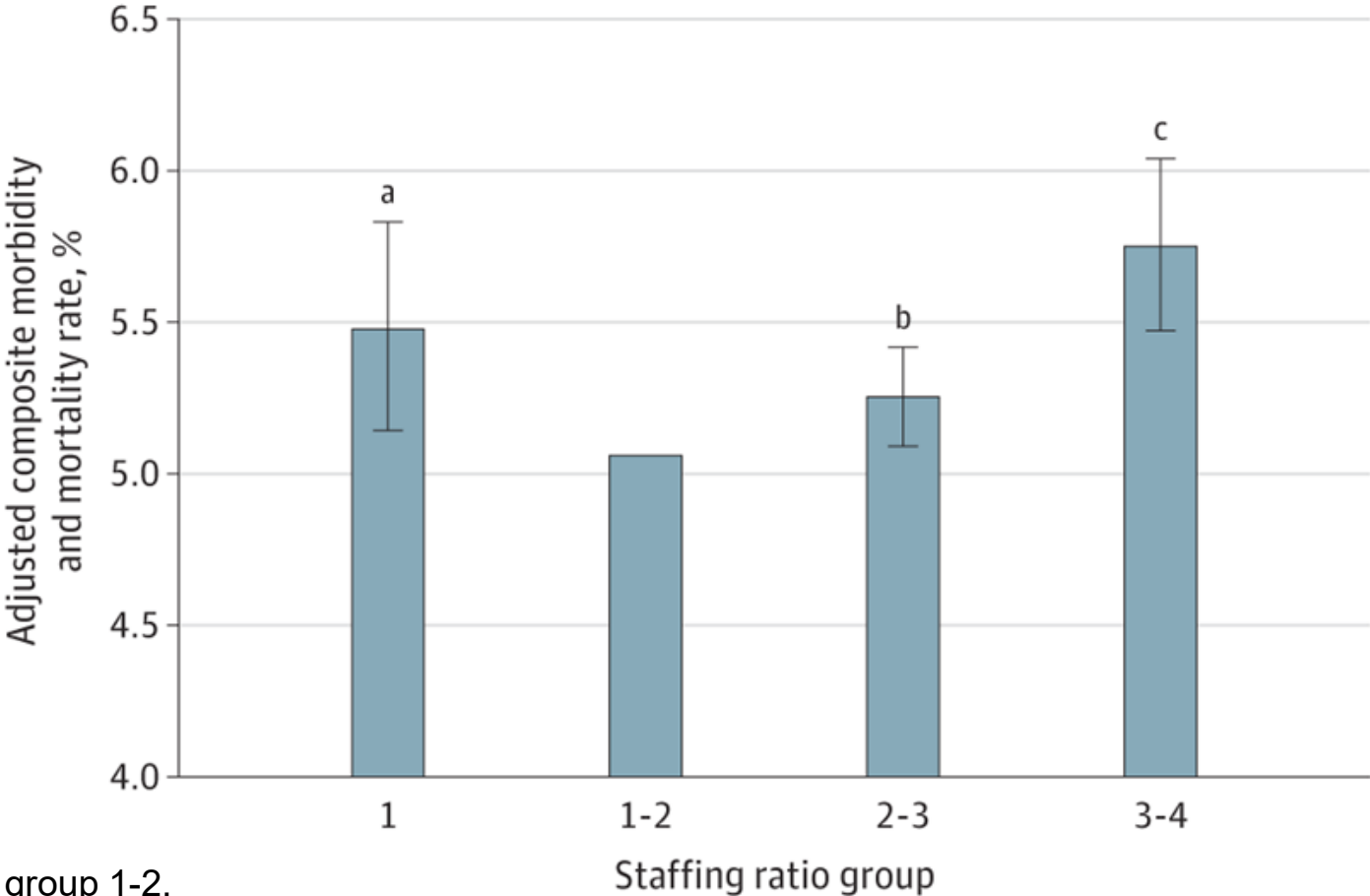
Characteristic	No. (%)	Time-weighted average staffing ratio group				Staffing ratio group comparison, absolute standardized difference ^c		
	All matched (N = 578 815) ^b	1	1-2	2-3	3-4	1 vs 2-3 vs	3-4 vs 1-2	
At teaching institution	301 687 (52.1)	At Teaching Institution, 3-4 vs 1-2 = 0.26					0.26	
Surgical service category								
General	227 811 (39.4)	17 704 (36.5)	96 410 (39)	87 602 (40.5)	26 095 (38.9)	0.05	0.03	0
Gynecology	34 641 (6.0)	2299 (4.7)	13 850 (5.6)	13 470 (6.2)	5022 (7.5)	0.04	0.03	0.08
Neurology	30 355 (5.2)	2689 (5.5)	12 945 (5.2)	11 585 (5.4)	3136 (4.7)	0.01	0.01	0.03
Otolaryngology	22 827 (3.9)	3929 (8.1)	10 470 (4.2)	3591 (1.7)	4837 (7.2)	0.16	0.15	0.13
Orthopedic	170 759 (29.5)	12 038 (24.8)	73 882 (29.9)	68 012 (31.5)	16827 (25.1)	0.11	0.03	0.11
Urology	74 804 (12.9)	7726 (15.9)	31 653 (12.8)	25 481 (11.8)	9944 (14.8)	0.09	0.03	0.06
Vascular	1					0.07	0.01	0.09
Anesthesia duration, median (IQR), min	1	Anesthesia Duration, 1 vs 1-2 = 0.34				0.34	0.02	0.16
Operative year								
2010	21 467 (3.7)	2365 (4.9)	10 890 (4.4)	6760 (3.1)	1452 (2.2)			
2011	21 943 (3.8)	2253 (4.6)	10 998 (4.5)	6939 (3.2)	1753 (2.6)			
2012	27 349 (4.7)	3007 (6.2)	12 763 (5.2)	9163 (4.2)	2416 (3.6)			
2013	35 434 (6.1)							
2014	69 909 (12.1)	Operative Year, 3-4 vs 1-2 = 0.25					0.25	
2015	131 109 (22.7)	9165 (16.9)	52 465 (21.2)	51 925 (21.6)	17 588 (26.2)			
2016	148 118 (25.6)	12 240 (25.2)	61 595 (24.9)	56 205 (26.0)	18 078 (27.0)			
2017	123 486 (21.3)	9977 (20.6)	50 745 (20.5)	46 770 (21.6)	15 994 (23.9)			

Results

Table 3. Staffing Ratio Association With Primary Outcome-Adjusted Odds Ratio

Staffing ratio group comparison ^a	Adjusted odds ratio (95% CI) ^b	<i>P</i> value
1 vs 1-2	1.09 (1.02-1.16)	.01
2-3 vs 1-2	1.04 (1.01-1.08)	.02
3-4 vs 1-2	1.15 (1.09-1.21)	<.001
1 vs 2-3	1.05 (0.98-1.12)	.20
1 vs 3-4	0.95 (0.88-1.03)	.20
3-4 vs 2-3	1.10 (1.04-1.16)	.001

Results



(a) $P = .01$ for group 1 vs group 1-2.
(b) $P = .02$ for group 2-3 vs group 1-2.
(c) $P < .001$ for group 3-4 vs group 1-2.

Limitations

1. 23 U.S. institutions
2. Relatively limited operative set
3. Challenging to address unmeasured confounders
4. Staffing ratios were limited to between 1:1 and 1:4
5. Limited to physician-led anesthesiologist care teams
6. Limited resident involvement to less than 25% in each operation
7. Unable to classify outcome severity

Manuscript Interpretations

- This was a care-team workload study, a topic of importance in every clinical field.
- Given anesthesiologist and CRNA shortages, understanding any potential impact of workload on patient outcomes is essential to deliver quality care to our patients but should be weighed against access benefits.
- We are not comparing individual providers, for example CRNAs vs anesthesiologists.
- These national data affirm our current approach to team-based care.

Conclusions

Compared to patients receiving care from an anesthesiologist covering between 1-2 operations, 2-3 and 3-4 overlapping operations demonstrated a higher risk of mortality/morbidity.

These findings highlight potential effects of anesthesiologist responsibilities in perioperative team models and should be considered in clinical coverage efforts.

It is important to balance potential efficiency with access benefits to assess how much overlap may be appropriate.

Thank you!

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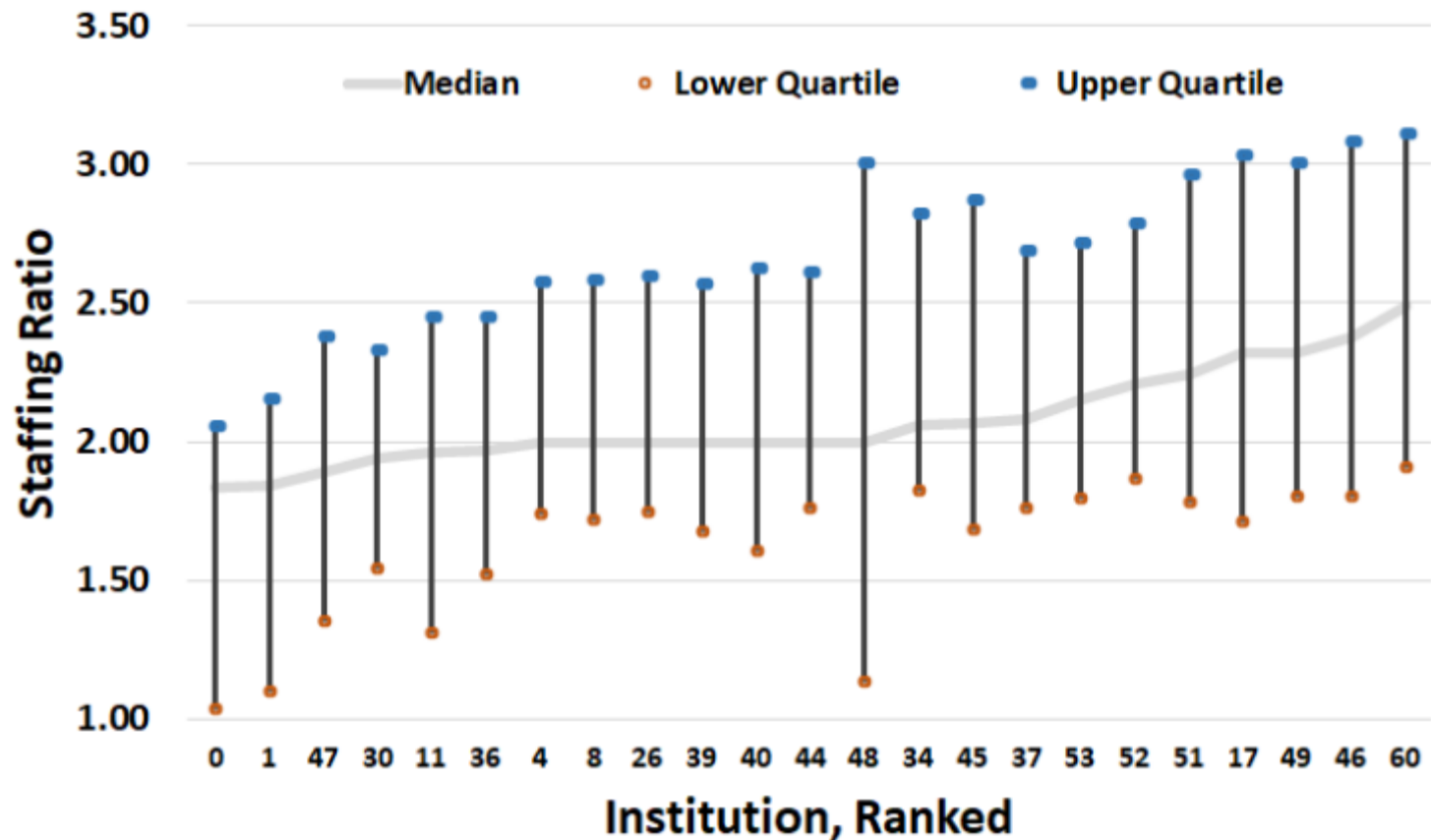
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Potential Next Steps

Quality of care exploration into staffing ratio to investigate the results we have found in this study.

Investigate anesthesia team models compared to 1:0 (anesthesiologist sitting their own cases).

Analyzing anesthesiology operation handovers.



Median time-weighted average staffing ratio (y-axis) by institution (each vertical line represents a single institution). Error bars represent the interquartile range of values for each institution. Institutions are ordered by increasing average staffing ratios.

eTable 2. Composite morbidity/mortality outcome and its components

Outcome	Total N	%	Time Weighted Average Staffing Ratio			
			Staffing Ratio =1	1< Staffing Ratio <=2	2< < Staffing Ratio <=3	3< < Staffing Ratio <=4
Cardiac	5,133	0.89	0.65	0.93	0.9	0.84
Respiratory	6,645	1.15	1.21	1.11	1.14	1.26
Gastrointestinal	6,694	1.16	1.06	1.1	1.19	1.3
Urinary	5,093	0.88	0.77	0.84	0.9	1.06
Bleeding	4,457	0.77	0.74	0.75	0.77	0.88
Infectious	4,963	0.86	0.95	0.81	0.81	1.14
Mortality	2,607	0.45	0.53	0.43	0.43	0.52
Composite Morbidity / Mortality	30,026	5.19	4.88	5.06	5.23	5.74

The unadjusted number of operations (Total N) and percentage (%) of operations with the composite morbidity/mortality outcome and each individual component (Mortality and the following perioperative comorbidities: Cardiac, Respiratory, Gastrointestinal, Urinary, Bleeding, Infection). Some operations contain greater than one individual outcome component. Percentage of operations is shown as total and within each Time Weighted Average Staffing Ratio group.