

Supplementary Online Content

King CR, Gregory S, Fritz BA, et al; ACTFAST Study Group. Impact of an intraoperative telemedicine program on perioperative quality measures: the ACTFAST-3 randomized clinical trial. *JAMA Netw Open*. 2023;6(9):e2332517. doi:10.1001/jamanetworkopen.2023.32517

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

eTable 1. Outcome Definitions

| Hypotension | Duration of time with MAP < 60 mmHg | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|------|------------------|------------|---|-----------|---|-----------|---|----------|---|-----------|---|-------------|----|---------------|---|-------------|---|-----------|----|------------|---|-----------|----|-----------|---|---------------|---|--------------|---|------------|----|
| Temperature monitoring | At least 1 documented intraop temperature (among cases > 1 hour) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Antibiotic redosing | <p>All antibiotic doses followed by a redose within recommended intervals while patient is intraoperative (max 3 doses, excluding administrations with the same drug administered pre-procedure > 1 doses):</p> <table border="1"> <thead> <tr> <th>Drug</th> <th>Interval (hours)</th> </tr> </thead> <tbody> <tr><td>ampicillin</td><td>2</td></tr> <tr><td>aztreonam</td><td>4</td></tr> <tr><td>cefazolin</td><td>4</td></tr> <tr><td>cefepime</td><td>4</td></tr> <tr><td>cefoxitin</td><td>2</td></tr> <tr><td>ceftriaxone</td><td>12</td></tr> <tr><td>ciprofloxacin</td><td>8</td></tr> <tr><td>clindamycin</td><td>6</td></tr> <tr><td>ertapenem</td><td>24</td></tr> <tr><td>gentamycin</td><td>8</td></tr> <tr><td>linezolid</td><td>10</td></tr> <tr><td>meropenem</td><td>2</td></tr> <tr><td>metronidazole</td><td>8</td></tr> <tr><td>piperacillin</td><td>2</td></tr> <tr><td>vancomycin</td><td>12</td></tr> </tbody> </table> | Drug | Interval (hours) | ampicillin | 2 | aztreonam | 4 | cefazolin | 4 | cefepime | 4 | cefoxitin | 2 | ceftriaxone | 12 | ciprofloxacin | 8 | clindamycin | 6 | ertapenem | 24 | gentamycin | 8 | linezolid | 10 | meropenem | 2 | metronidazole | 8 | piperacillin | 2 | vancomycin | 12 |
| Drug | Interval (hours) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ampicillin | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| aztreonam | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| cefazolin | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| cefepime | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| cefoxitin | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ceftriaxone | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ciprofloxacin | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| clindamycin | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ertapenem | 24 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| gentamycin | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| linezolid | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| meropenem | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| metronidazole | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| piperacillin | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| vancomycin | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Intraoperative blood glucose management | Failure = no insulin administered for blood glucose greater than 180 mg/dL OR no intraoperative measurement of blood glucose in patients with type 1 diabetes undergoing cases \geq 1 hour OR no intraoperative measurement of blood glucose in patients with type 2 diabetes undergoing cases > 2 hours | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Neuromuscular monitoring documentation | Proportion of cases with a train of four documented prior to extubation if a nondepolarizing neuromuscular blocking agent was administered | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ventilator management | Among cases with mechanical ventilation, failure = median tidal volume more than 10 mL/kg ideal body mass | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Volatile anesthetic utilization | Mean fresh gas flow rates for cases with volatile anesthetic use > 80% of case duration | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | |
|-----------------------------------|--|
| Postoperative acute renal failure | In first 7 postoperative days, KDIGO stage of AKI. Where baseline creatinine unavailable, age, sex, height, race, and weight normed value imputed. |
| Postoperative atrial fibrillation | Flowsheet records of incident atrial fibrillation in first 7 postop days, atrial fibrillation billing diagnosis not present on admission |
| Postoperative respiratory failure | Any mechanical ventilation in first 7 postoperative days, excluding patients with preoperative ventilation (Epic era only) |
| Postoperative delirium | Any positive CAM-ICU score in first 7 postoperative days, excluding patients with preoperative positive CAM-ICU in the prior 7 days. |
| Intraoperative awareness | Removed from analysis plan – not consistently evaluated |
| Surgical site infection | Removed from analysis plan due to low data quality. Defined as billing ICD10-CM codes T81.4, K68.11, O86.0, T8[34].5, T8[23].6, T8[245].7 excluding “D” and “S” codes (subsequent encounter and sequelae) as well as present-on-admission. |
| 30-day readmission | Admission to any BJC facility in 30 days after discharge from index procedure |
| 30-day mortality | Death recorded in first 30 postoperative days |

eTable 2. ACT Contact Activity

| Group | Intervention | Control | Intervention | Control |
|----------------------------------|--------------|----------|--------------|---------|
| Period | Pre-Epic | Pre-Epic | Epic | Epic |
| Number of Cases | 5808 | 6065 | 7172 | 7209 |
| Number of Alerts | 9281 | 9488 | 53644 | 53732 |
| Fraction w alert | 0.65 | 0.65 | 0.97 | 0.97 |
| Num w contact | 877 | 40 | 759 | 59 |
| Num w alert contact | 877 | 40 | 521 | 34 |
| Num w review contact | 0 | 0 | 367 | 31 |
| Num contact w significant issue | 367 | 20 | 370 | 34 |
| Num contact affecting management | 387 | 20 | 216 | 11 |

eTable 3. Common Alerts

| MESSAGE | N | PRE-EPIC | EPIC |
|---|------|----------|------|
| MAP TRENDING DOWN. POTENTIAL HYPOTENSION. | 9100 | 0 | 9100 |
| HIGH CUMULATIVE VASOPRESSOR BOLUS DOSE. | 8599 | 4330 | 4269 |
| TACHYCARDIA. HR = | 7121 | 3209 | 3912 |
| PONV RISK. CONSIDER TWO OR MORE ANTIEMETICS. | 6609 | 0 | 6609 |
| NO BP MEASURED | 6574 | 0 | 6574 |
| PONV RISK. [A] ADMINISTERED. CONSIDER ADDITIONAL | 6396 | 0 | 6396 |
| HYPOTENSION: MAP = | 5899 | 0 | 5899 |
| TIDAL VOLUME = [A] ([B] CC/KILO OF IDEAL BODY WEI | 5803 | 1398 | 4405 |
| LOW TEMPERATURE = | 5358 | 0 | 5358 |
| CONSIDER DOCUMENTING TRAIN OF FOUR. | 4747 | 3587 | 1160 |
| TACHYCARDIA. HR = | 4444 | 1950 | 2494 |
| HYPERTENSION. MAP = | 3968 | 0 | 3968 |
| HIGH MAC = | 3776 | 0 | 3776 |
| LOW MAC = | 3056 | 0 | 3056 |
| ANTIBIOTIC HAS NOT BEEN DOCUMENTED PRIOR TO... | 2741 | 0 | 2741 |
| CUMULATIVE TIME FOR MAP < [A] = [B] MINUTES. | 2718 | 623 | 2095 |
| LOW CO2 = | 2696 | 0 | 2696 |
| LOW MAC = | 2517 | 0 | 2517 |
| HYPOTENSION: MAP = | 2449 | 0 | 2449 |
| LOW PEEP = | 2446 | 0 | 2446 |

eTable 4. Descriptive Statistics Excluding Surgeries Within 30 Days of an Index Operation

Stratified by intervention. P-values for quantitative variables by Mann-Whitney U, factor variables by Fisher's exact test.

| | Control | Intervention |
|-----------------------------------|-------------|--------------|
| N | 12457 | 12179 |
| Age (median [IQR]) | 60 [47, 69] | 60 [47, 69] |
| Body Mass Index (median [IQR]) | 29 [24, 34] | 29 [24, 34] |
| Sex n (%) | | |
| Female | 6387 (51.3) | 6361 (52.2) |
| Male | 6066 (48.7) | 5813 (47.7) |
| Other | 4 (0.0) | 5 (0.0) |
| Race n (%) | | |
| White | 9585 (76.9) | 9371 (76.9) |
| Black | 2516 (20.2) | 2438 (20.0) |
| Other | 210 (1.7) | 226 (1.9) |
| Asian | 146 (1.2) | 144 (1.2) |
| Surgery Type n (%) | | |
| Other | 2072 (16.6) | 2038 (16.7) |
| Orthopedics | 1429 (11.5) | 1386 (11.4) |
| Cardiac and Thoracic | 1295 (10.4) | 1195 (9.8) |
| Gynecology | 1379 (11.1) | 1376 (11.3) |
| Urology | 1330 (10.7) | 1235 (10.1) |
| General | 852 (6.8) | 875 (7.2) |
| Neurology | 852 (6.8) | 849 (7.0) |
| Otolaryngology | 838 (6.7) | 773 (6.3) |
| Vascular | 741 (5.9) | 748 (6.1) |
| Gastroenterology | 390 (3.1) | 439 (3.6) |
| Colorectal | 423 (3.4) | 414 (3.4) |
| Transplant | 376 (3.0) | 354 (2.9) |
| Hepatobiliary | 336 (2.7) | 370 (3.0) |
| Plastics | 144 (1.2) | 127 (1.0) |
| ASA n (%) | | |
| 1 | 542 (4.9) | 548 (5.0) |
| 2 | 4491 (40.2) | 4370 (39.9) |
| 3 | 4984 (44.6) | 4975 (45.4) |
| 4 | 1130 (10.1) | 1035 (9.4) |
| 5 | 27 (0.2) | 26 (0.2) |
| Barthel index < 100 n (%) | 1350 (10.8) | 1406 (11.5) |
| Coronary Artery Disease n (%) | 1525 (13.4) | 1464 (13.1) |
| Congestive Heart Failure n (%) | 1158 (10.2) | 1117 (10.0) |
| Atrial Fibrillation n (%) | 1024 (9.0) | 984 (8.8) |
| Peripheral Arterial Disease n (%) | 911 (8.0) | 860 (7.7) |

| | | |
|------------------------------------|-------------|-------------|
| Diabetes Mellitus n (%) | 2667 (27.6) | 2614 (27.6) |
| Cirrhosis = 1 (%) | 232 (2.0) | 229 (2.1) |
| Functional Capacity < 4 METs n (%) | 3078 (30.7) | 3128 (31.5) |
| Hypertension n (%) | 5960 (52.3) | 5824 (52.2) |
| COPD or Asthma n (%) | 2253 (19.8) | 2176 (19.5) |
| End Stage Renal Disease n (%) | 516 (4.4) | 528 (4.6) |
| Cerebrovascular Disease n (%) | 808 (7.1) | 693 (6.2) |
| Current Cancer n (%) | 2508 (22.0) | 2477 (22.2) |

eTable 5. Treatment Effects Excluding Surgeries Within 30 Days of an Index Operation

Coef = rate ratio for binary (n %) and ordinal (median IQR) outcomes, regression coefficient for continuous (mean SD) outcomes. CI = 95% confidence interval by GEE clustered on OR and day. AKI, delirium, respiratory failure, atrial fibrillation exclude patients with those characteristics preoperatively. AKI= acute kidney injury (KDIGO stage), TV = tidal volume. See supplemental table 1 for definitions. P-values Holm corrected in each group of outcomes (2 primary, 8 secondary, 6 clinical tests).

| Outcome | Intervention | Control | coef (CI) | p |
|--|-------------------|-------------------|---------------------|-------|
| Primary outcomes | | | | |
| Not postop hypothermic, n (%) | 7109/10796 (66) | 7261/11009 (66) | 1.00 (0.98, 1.02) | 1 |
| Not postop hyperglycemic, n (%) | 6923/8069 (86) | 6989/8169 (86) | 1.00 (0.99, 1.02) | 1 |
| Secondary outcomes | | | | |
| Glucose measurement done, n (%) | 1258/1833 (69) | 1189/1853 (64) | 1.07 (1.02, 1.12) | 0.04 |
| Intra low map minutes, mean (SD) | 7 (17) | 7 (18) | -0.22 (-0.67, 0.23) | 1 |
| Temperature monitoring, n (%) | 8185/8731 (94) | 8336/8943 (93) | 1.01 (1.00, 1.01) | 1 |
| No missed antibiotics, n (%) | 11971/12179 (98) | 12237/12457 (98) | 1.00 (1.00, 1.00) | 1 |
| Insulin per clinical guidelines, n (%) | 609/947 (64) | 680/1015 (67) | 0.96 (0.90, 1.02) | 1 |
| Neuromuscular monitoring documented, n (%) | 4471/6263 (71) | 4420/6318 (70) | 1.02 (1.00, 1.04) | 0.665 |
| Appropriate TV, n (%) | 4632/4955 (93) | 4650/4994 (93) | 1.00 (0.99, 1.01) | 1 |
| Fresh gas flow L/min, mean (SD) | 3 (1) | 3 (1) | -0.00 (-0.05, 0.04) | 1 |
| Clinical outcomes | | | | |
| AKI stage | | | 0.98 (0.88, 1.10) | 1 |
| = 0, n (%) | 10780/11479 (94%) | 11012/11738 (94%) | | |
| = 1, n (%) | 531/11479 (5%) | 553/11738 (5%) | | |
| = 2, n (%) | 75/11479 (1%) | 70/11738 (1%) | | |
| = 3, n (%) | 93/11479 (1%) | 103/11738 (1%) | | |
| 30-day mortality, n (%) | 168/12179 (1) | 194/12457 (2) | 0.89 (0.72, 1.09) | 0.996 |
| 30-day readmission, n (%) | 499/12179 (4) | 441/12457 (4) | 1.16 (1.02, 1.32) | 0.156 |
| Delirium, n (%) | 195/546 (36) | 187/543 (34) | 1.04 (0.88, 1.22) | 1 |
| Respiratory failure, n (%) | 204/10781 (2) | 204/10946 (2) | 1.02 (0.83, 1.24) | 1 |
| Incident atrial fibrillation, n (%) | 268/11053 (2) | 307/11291 (3) | 0.89 (0.76, 1.05) | 0.85 |
| SSI, n/total (%) | 284/12179 (2) | 306/12457 (2) | 0.95 (0.81, 1.12) | 0.531 |
| multipleCases, n/total (%) | 2336/12179 (19) | 2410/12457 (19) | 0.99 (0.94, 1.05) | 0.752 |

eTable 6. Descriptive Statistics Stratified by Intervention, Ignoring Prior Treatment Assignments in Subsequent Surgeries

P-values for quantitative variables by Mann-Whitney U, factor variables by Fisher's exact test.

| | Control | Intervention |
|-----------------------------------|--------------|--------------|
| N | 13289 | 12965 |
| Age (median [IQR]) | 60 [47, 69] | 60 [47, 69] |
| Body Mass Index (median [IQR]) | 28 [24, 34] | 29 [24, 34] |
| Sex n (%) | | |
| Female | 6706 (50.5) | 6687 (51.6) |
| Male | 6579 (49.5) | 6273 (48.4) |
| Other | 4 (0.0) | 5 (0.0) |
| Race n (%) | | |
| White | 10204 (76.8) | 9965 (76.9) |
| Black | 2714 (20.4) | 2613 (20.2) |
| Other | 222 (1.7) | 239 (1.8) |
| Asian | 149 (1.1) | 148 (1.1) |
| Surgery Type n (%) | | |
| Other | 2146 (16.1) | 2104 (16.2) |
| Orthopedics | 1520 (11.4) | 1467 (11.3) |
| Cardiac and Thoracic | 1465 (11.0) | 1359 (10.5) |
| Gynecology | 1391 (10.5) | 1396 (10.8) |
| Urology | 1397 (10.5) | 1292 (10.0) |
| General | 985 (7.4) | 985 (7.6) |
| Neurology | 894 (6.7) | 907 (7.0) |
| Otolaryngology | 893 (6.7) | 814 (6.3) |
| Vascular | 795 (6.0) | 800 (6.2) |
| Gastroenterology | 455 (3.4) | 517 (4.0) |
| Colorectal | 440 (3.3) | 426 (3.3) |
| Transplant | 392 (2.9) | 364 (2.8) |
| Hepatobiliary | 342 (2.6) | 379 (2.9) |
| Plastics | 174 (1.3) | 155 (1.2) |
| ASA n (%) | | |
| 1 | 552 (4.6) | 556 (4.8) |
| 2 | 4685 (39.2) | 4522 (38.7) |
| 3 | 5380 (45.0) | 5377 (46.0) |
| 4 | 1303 (10.9) | 1197 (10.2) |
| 5 | 33 (0.3) | 30 (0.3) |
| Barthel index < 100 n (%) | 1417 (10.7) | 1476 (11.4) |
| Coronary Artery Disease n (%) | 1652 (13.6) | 1595 (13.4) |
| Congestive Heart Failure n (%) | 1301 (10.7) | 1244 (10.5) |
| Atrial Fibrillation n (%) | 1143 (9.4) | 1109 (9.3) |
| Peripheral Arterial Disease n (%) | 1021 (8.4) | 962 (8.1) |

| | | |
|------------------------------------|-------------|-------------|
| Diabetes Mellitus n (%) | 2889 (28.0) | 2844 (28.2) |
| Cirrhosis (%) | 267 (2.2) | 251 (2.1) |
| Functional Capacity < 4 METs n (%) | 3247 (30.3) | 3308 (31.3) |
| Hypertension n (%) | 6413 (52.7) | 6244 (52.5) |
| COPD or Asthma n (%) | 2456 (20.2) | 2353 (19.8) |
| End Stage Renal Disease n (%) | 569 (4.5) | 571 (4.7) |
| Cerebrovascular Disease n (%) | 885 (7.3) | 763 (6.4) |
| Current Cancer n (%) | 2627 (21.6) | 2597 (21.8) |

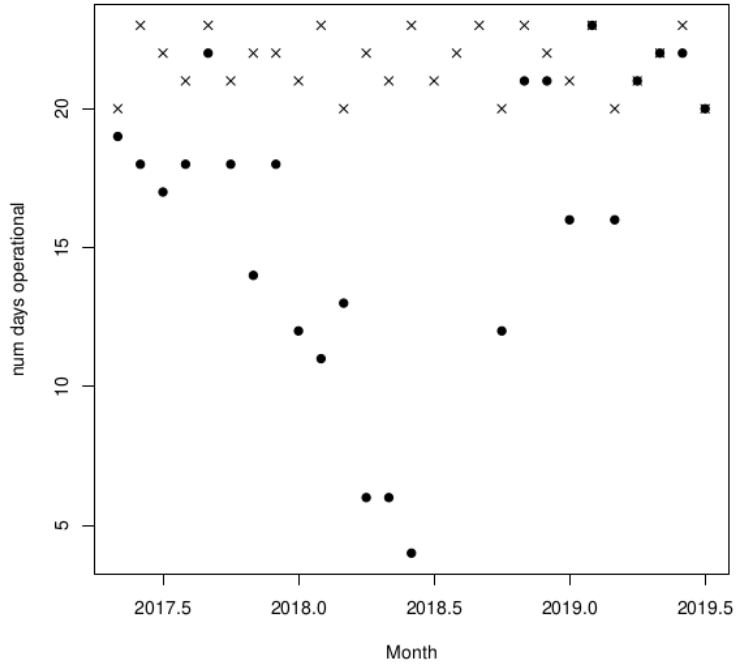
eTable 7. Treatment Effects, Ignoring Prior Treatment Assignments in Subsequent Surgeries

Coef = rate ratio for binary (n %) and ordinal (median IQR) outcomes, regression coefficient for continuous (mean SD) outcomes. CI = 95% confidence interval by GEE clustered on OR and day. AKI, delirium, respiratory failure, atrial fibrillation exclude patients with those characteristics preoperatively. AKI= acute kidney injury (KDIGO stage), TV = tidal volume. See supplemental table 1 for definitions. P-values Holm corrected in each group of outcomes.

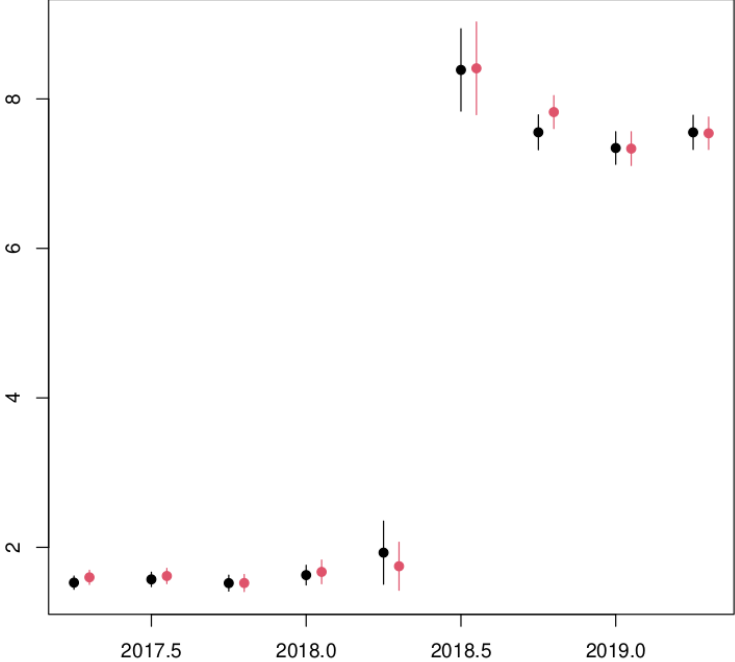
| Outcome | Intervention | Control | coef (CI) | p |
|--|-------------------|-------------------|---------------------|-------|
| Primary outcomes | | | | |
| Not postop hypothermic, n (%) | 7600/11433 (66) | 7785/11686 (67) | 1.00 (0.98, 1.02) | 1 |
| Not postop hyperglycemic, n (%) | 7469/8693 (86) | 7535/8798 (86) | 1.00 (0.99, 1.02) | 1 |
| Secondary outcomes | | | | |
| Glucose measurement done, n (%) | 1355/1977 (69) | 1265/1981 (64) | 1.07 (1.03, 1.12) | 0.016 |
| Intra low map minutes, mean (SD) | 7 (17) | 7 (18) | -0.22 (-0.66, 0.21) | 1 |
| Temperature monitoring, n (%) | 8637/9219 (94) | 8792/9452 (93) | 1.01 (1.00, 1.02) | 0.833 |
| No missed antibiotics, n (%) | 12738/12965 (98) | 13036/13289 (98) | 1.00 (1.00, 1.00) | 1 |
| Insulin per clinical guidelines, n (%) | 648/1013 (64) | 717/1073 (67) | 0.96 (0.90, 1.02) | 1 |
| Neuromuscular monitoring documented, n (%) | 4621/6577 (70) | 4609/6670 (69) | 1.02 (0.99, 1.04) | 1 |
| Appropriate TV, n (%) | 5036/5388 (93) | 5083/5452 (93) | 1.00 (0.99, 1.01) | 1 |
| Fresh gas flow L/min, mean (SD) | 3 (1) | 3 (1) | -0.01 (-0.05, 0.03) | 1 |
| Clinical outcomes | | | | |
| AKI stage | | | 0.99 (0.89, 1.10) | 1 |
| = 0, n (%) | 11438/12177 (94%) | 11685/12448 (94%) | | |
| = 1, n (%) | 561/12177 (5%) | 575/12448 (5%) | | |
| = 2, n (%) | 77/12177 (1%) | 74/12448 (1%) | | |
| = 3, n (%) | 101/12177 (1%) | 114/12448 (1%) | | |
| 30-day mortality, n (%) | 206/12965 (2) | 232/13289 (2) | 0.91 (0.76, 1.10) | 1 |
| 30-day readmission, n (%) | 568/12965 (4) | 526/13289 (4) | 1.11 (0.98, 1.25) | 0.576 |
| Delirium, n (%) | 224/637 (35) | 210/622 (34) | 1.04 (0.89, 1.22) | 1 |
| Respiratory failure, n (%) | 236/11289 (2) | 234/11493 (2) | 1.03 (0.85, 1.23) | 1 |
| Incident atrial fibrillation, n (%) | 306/11673 (3) | 340/11968 (3) | 0.92 (0.79, 1.08) | 1 |

eFigure 1A. Number of Days per Month With Included Cases (ACT Staffed, Randomization Operational, Outcomes Measured)

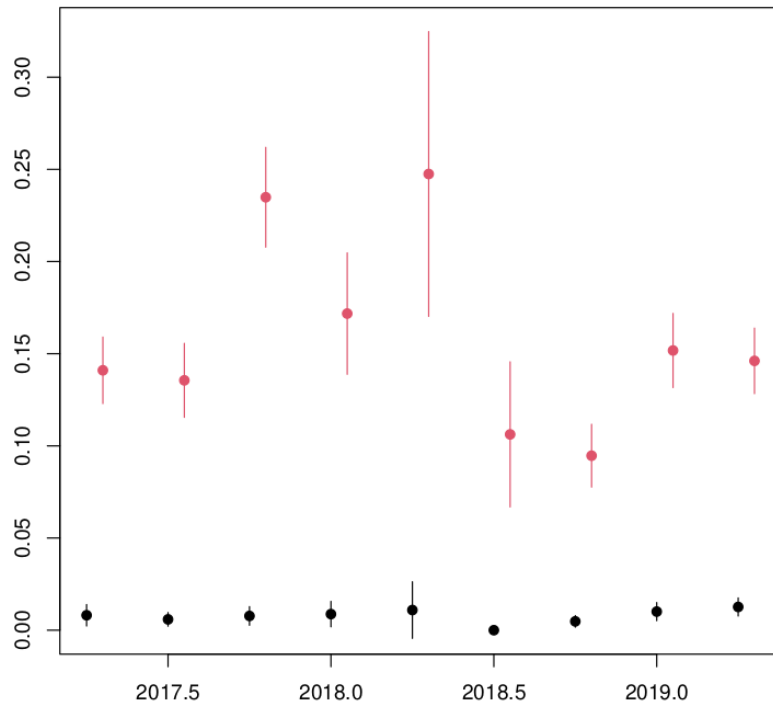
Circle = actual value, x = number of weekdays. No adjustment for holidays.



eFigure 1B. Mean Number of Alerts per Case Over Time



eFigure 1C. Number of Contacts per Case Over Time



eFigure 2. Secondary and Clinical Outcomes Over Time

Dotted line = EHR transition. AKI_st2 = KDIGO grade 2 or higher AKI, outcomes defined in Sup Table 1. Confidence intervals by clustered GEE with linear response on proportion or outcome.

