ORANA
OREGON ASSOCIATION OF NURSE ANESTHETISTS

Testimony in Opposition to HB 2295

Before the House Committee on Health Care

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OREGON DOES NOT NEED ANESTHESIOLOGIST ASSISTANTS (AAs)

Certified Registered Nurse Anesthetists (CRNAs) are well-established, proven- safe and cost-effective anesthesia providers.

CRNAs have been caring for Oregonians for more than 100 years and continue to grow in number.The first school of nurse anesthesia in the *country* was established at Portland's St. Vincent Hospital more than a century ago, and Oregon still educates CRNAs today with a program at OHSU.

Anesthesiologist Assistants (AAs) are rare in the U.S. (about 1,800 nationwide compared with more than 47,000 CRNAs) and possess a limited scope of practice that would not promote access to healthcare or maintain a cost-effective anesthesia care model in Oregon.

AAs' limited scope of practice, which prohibits them from practicing without anesthesiologist supervision, would prevent them from practicing in Oregon's underserved rural areas.

ACCESS TO CARE IN OREGON

CRNAs provide anesthesia care anywhere it is needed in both rural and urban settings. CRNAs practice in every setting, including hospital surgical suites and obstetrical delivery rooms, critical access hospitals, ambulatory surgical centers; the offices of dentists, podiatrists, ophthalmologists, plastic surgeons, as well as U.S. Military and Veterans Administration healthcare facilities.

In contrast, AAs offer:

- **LIMITED UTILIZATION:** Because AAs cannot practice without anesthesiologist supervision, AAs do not practice in rural areas where CRNAs working without anesthesiologist involvement are the primary providers of anesthesia care. The AA model's focus, i.e. on only practicing where anesthesiologists practice, greatly limits their utilization. Thus, AAs cannot help solve problems of inadequate access to anesthesia care in rural and underserved communities.

- **FAILURE TO MEET DEMAND:** If for any reason an AA's supervising anesthesiologist is not available, the AA may not provide anesthesia care. The inflexible AA/anesthesiologist-driven mode of practice thus fails to adequately meet the needs of patients and healthcare providers.

- **NO PROVEN OUTCOME DATA:** There are no peer-reviewed studies published in scientific journals regarding the quality of care of AA practice or AA anesthesia outcomes. AAs are explicitly recognized in state laws or regulations in only 13 states and the District of Columbia. Louisiana actually passed legislation that has the effect of prohibiting AA practice, declaring that "CRNAs receive a much higher level of education and training than do AAs."

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EDUCATION/SCOPE OF PRACTICE

CRNAs are trained and educated to deliver anesthesia care regardless of anesthesiologist involvement. CRNAs are qualified to make independent judgments regarding all aspects of anesthesia care, based on their education, licensure, and certification. CRNAs have experience as critical care nurses and can assess and treat a broad range of health problems before even beginning anesthesia training.

In contrast, AAs offer:

• **LIMITED SCOPE OF PRACTICE:** AAs administer anesthesia solely under the medical direction of anesthesiologists. AAs thus have a much more limited scope of practice than CRNAs. AAs are NOT physician assistants (PAs).

• **NOT A FULL SERVICE ANESTHESIA PROVIDER:** The AA program curriculum trains AAs only to assist anesthesiologists in technical functions. One of the largest AA programs (at Emory University) does not even provide clinical instruction in the administration of nerve blocks and spinal/epidural anesthesia.

• **LACK HEALTH CARE EXPERIENCE:** AAs are not required to have any prior healthcare education or experience (e.g., nursing, medical, anesthesia or healthcare education, licensure, or certification) before they begin their AA educational programs.

ECONOMIC IMPACT

Independent studies have shown that CRNAs acting as the sole anesthesia provider is the most cost-effective model for anesthesia delivery. This model is used in many of our hospitals in rural communities and in our top rated critical access hospitals in Oregon. The second-most cost effective model is the CRNA/ anesthesiology care team model, which is similar to the well-established models used at Kaiser and OHSU.

In contrast, AAs offer:

• **COSTLY MODEL OF CARE:** With an AA model, two healthcare providers (a supervising anesthesiologist and an AA) must be utilized to provide anesthesia care to one patient.

• **DIFFICULTY WITH ANESTHESIOLOGIST SUPERVISON:** AAs must be supervised by anesthesiologists. The Society of Anesthesiology reports that even with an appropriate ratio of anesthesiologists to providers, lapses of supervision during critical portions of anesthetic cases would occur. In a review of one year of data from a tertiary hospital, supervision lapses occurred commonly during first-case starts even with a 1:2 supervision ratio.

OPPOSE HB 2295: Thank you

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Influence of Supervision Ratios by Anesthesiologists on First-case Starts and Critical Portions of Anesthetics

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ABSTRACT

Background: Anesthesia groups may wish to decrease the supervision ratio for nontrainee providers. Because hospitals offer many first-case starts and focus on starting these cases on time, the number of anesthesiologists needed is sensitive to this ratio. The number of operating rooms that an anesthesiologist can supervise concurrently is determined by the probability of multiple simultaneous critical portions of cases (*i.e.*, requiring presence) and the availability of cross-coverage. A simulation study showed peak occurrence of critical portions during first cases, and frequent supervision lapses. These predictions were tested using real data from an anesthesia information management system.

Methods: The timing and duration of critical portions of cases were determined from 1 yr of data at a tertiary care hospital. The percentages of days with at least one supervision lapse occurring at supervision ratios between 1:1 and 1:3 were determined.

Results: Even at a supervision ratio of 1:2, lapses occurred on 35% of days (lower 95% confidence limit = 30%). The peak incidence occurred before 8:00 AM, $P < 0.0001$ for the hypothesis that most (*i.e.*, >50%) lapses occurred before this time. The average time from operating room entry until ready for prepping and draping (*i.e.*, anesthesia release time) during first case starts was 22.2 min (95% confidence interval 21.8–22.8 min).

Conclusions: Decreasing the supervision ratio from 1:2 to 1:3 has a large effect on supervision lapses during first-case starts. To mitigate such lapses, either staggered starts or additional anesthesiologists working at the start of the day would be required.

What We Already Know about This Topic

- The most appropriate ratio of anesthesiologists to providers would avoid lapses of supervision during critical portions of anesthetic cases. A simulation study suggested this occurs most commonly with simultaneous first starts.

What This Article Tells Us That Is New

- In a review of 1 yr of data from a tertiary hospital, lapses occurred commonly during first-case starts even with a 1:2 supervision ratio.
- These data suggest that either staggered starts or additional anesthesiologists working at the start of the day would be needed to reduce lapses during critical periods.

ANESTHESIOLOGISTS often function in anesthesia care teams (*e.g.*, supervising concurrently two or more certified registered nurse anesthetists).[1–7] Many anesthesia groups perceive an incentive to decrease their supervision ratio.[8–10] Because a ratio lower than 1:2 does not satisfy accreditation requirements of the American College of Graduate Medical Education, ratios lower than 1:2 apply to nurse anesthetists, not anesthesia residents.‡ Because many hospitals focus on tardiness of first-case starts[11,12] and offer many such starts,[13–16] anesthesiologist staffing is sensitive to the supervision ratio.

The number of operating rooms (ORs) that an anesthesiologist can supervise is limited by the probability of occurrence of two or more simultaneous events (*i.e.*, critical portions) requiring either physical presence or a time-sensitive, nonpreemptive interaction. The probability of supervision lapses is also influenced by the availability of other anesthesiologists to cross-cover. The consequence might be limited to a case delay, but patient safety could be affected when there are coincident critical physiologic events.

In the United States, invoicing Medicare for professional anesthesia services requires that the anesthesiologist "personally participates in the most demanding procedures in the anesthesia plan, including induction and emergence, where indicated."§ However, to reduce the risk of substandard

◇ This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 9A.

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‡ ACGME Program Requirements for Graduate Medical Education in Anesthesiology. Available at: http://www.acgme.org/acWebsite/downloads/RRC_progReq/040_anesthesiology_07012008_u03102008.pdf. Accessed December 7, 2011.

§ CMS Manual System. Pub 100–04 Medicare Claims Processing, Transmittal 1324 Available at: https://www.cms.gov/transmittals/downloads/R1324CP.PDF. Accessed December 7, 2011.

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care,[17] many institutions do not reveal patient insurance information. Consequently, all patients are supervised in accordance with Medicare rules. Furthermore, anesthesiologists' time before induction likely will increase from implementation of the World Health Organization surgical safety checklist.[18]

Paoletti and Marty[19] used simulation to estimate the risk of a supervision lapse in surgical suites with various numbers of ORs (2–18) performing a mix of elective cases of various durations (0.8–4.5 h) and a range of anesthesiologist supervision ratios (1:1, 1:2, 1:3). Their model parameters were based on data from several French hospitals. The simulated risk of a supervision lapse peaked at the start of the day. Risks ranged from 14% to 87% for inability to supervise all critical portions of cases at a 1:2 ratio, depending on case length (higher with shorter cases) and the size of the suite (lower with more ORs). Increasing the supervision ratio to 1:3 markedly increased the risk. Providing an unassigned "floater" anesthesiologist greatly reduced the risk.

We explored predictions of the French simulation study using real data captured from an anesthesia information management system to determine the incidence and timing of simultaneous critical portions of cases.

Our first hypothesis was that, as predicted,[19] on one-third of days, there would be supervision lapses even with a supervision ratio of 1:2.

Our second hypothesis was that, as predicted,[19] the peak incidence of supervision lapses occurred at the start of the day (*e.g.*, not during lunch breaks). If true, a supervision ratio less than 1:2 would require an increase in first-case start delays; first-case starts staggered sufficiently to allow the later first case to start on schedule[20]; additional anesthesiologists available at the start of the day; or anesthesiologists not present for all critical portions of cases.

If the first and second hypotheses were true, then the mean anesthesia release time would determine the average delay when two patients, supervised by the same anesthesiologist, were simultaneously ready for induction and all other anesthesiologists were occupied. We previously published how to use such mean times for anesthesia group economic analyses of first-case starts.[12,13]

Our third hypothesis was that anesthesia release times for first-case starts would average 22 min, in the midrange of values determined at Yale-New Haven Hospital.[21]

Materials and Methods

After Thomas Jefferson University Institutional Review Board (Philadelphia, Pennsylvania) approval with waiver of informed consent, we reviewed all 15,656 records in the hospital's anesthesia information management system on nonholiday weekdays between May 3, 2010 and May 1, 2011‖ that took place in the 24 ORs comprising the two largest surgical suites. Inpatient and outpatient procedures are performed in these suites, but not cardiac surgery or diagnostic gastrointestinal procedures. The times of events and descriptive information listed in table 1 were obtained. Heart rate, oxygen saturation, and invasive and noninvasive blood pressure values were retrieved from the anesthesia information management system database, recorded at 1-min intervals. Actual room locations where procedures took place were determined as previously described.[22]

We considered the anesthesia providers (*i.e.*, those individuals delivering direct anesthesia care) to be busy during the interval from the beginning to the end of anesthesia. The duration of breaks and lunch relief was considered as the interval from the documented start of the break to the documented end of the break, or lasting the mean duration of documented breaks if only the start time of the break was recorded in the anesthesia information management system, which is typical practice (72% of cases) for our providers. Where the end time of the break was not documented, the mean lunch break duration (30 min, based on 1,998 documented breaks) was substituted (presumed for breaks occurring between 11:00 AM and 1:30 PM, which is when lunch is offered). For breaks outside this period with a missing end time, the duration was set at the mean duration of such breaks (*i.e.*, 15 min, based on 2,776 documented breaks).

Each day was divided into 1,440 1-min intervals, during each of which the total number of providers who were busy was determined. We considered anesthesiologists to be occupied in tasks that cannot be preempted (*i.e.*, unable to leave the patient being cared for) during the periods listed in table 2. For each day, the number of anesthesiologists who were occupied as specified was determined during each 1-min interval.

Table 3 lists the physiologic events (hypoxemia, hypotension, and hypertension) considered critical portions of cases. The physiologic event definitions were based on published manuscripts demonstrating adverse outcomes and represent prolonged alarm conditions, as opposed to transient or false alarms. The duration of each such event corresponded to when the threshold for the critical event occurred (*e.g.*, after 10 min with systolic blood pressure less than 70 mmHg), until when the alarm trigger no longer was in effect (*e.g.*, systolic blood pressure ≥70 mmHg). The events we included deliberately underestimated the critical portions of cases to take a conservative approach with respect to the incidence of supervision lapses, increasing the chance of rejecting Hypothesis 1 (discussed in the Statistical Methods section). For example, a blood pressure of 220/140 lasting 20 min during a case scheduled for 1 h was not classified as a critical physiologic event in our analysis, although such instances would almost certainly trigger a call to the supervising anesthesiologist. The same goes for a systolic blood pressure of 75 in a patient undergoing carotid endarterectomy, or a

‖ The data interval was selected to allow binning by 13 4-week periods and to include a representative sample of anesthesia residents at all levels of training. A year of data was required to produce a confidence interval of 1 min, making survey methods to determine the anesthesia release time impractical.

Table 1. Data Obtained from Cases

Definition	Event
Start time of continuous presence of the anesthesia care provider	Anesthesia begin
Handoff time of the patient to the recovery room or intensive care unit nurse	Anesthesia end
Time patient entered the out-of-OR location if a neuraxial or regional anesthetic was performed in this location prior to entering the OR	Enter block room
Time when the patient left the out-of-OR location, if applicable	Leave block room
Time when the patient stretcher entered the OR	Enter the OR
Time when the patient stretcher left the OR	Leave the OR
Time when the patient was turned over to the surgical team for prepping and draping	Anesthesia release
Time of insertion of the tracheal tube, laryngeal mask airway, or other airway device for patient ventilation	Intubation
Time that surgery began	Surgery begin
Time that surgery ended	Surgery end
Time when patient was turned from supine to prone, or vice versa	Position change
Time when a brief break or lunch relief started	Break/lunch start
Time when a brief break or lunch relief ended	Break/lunch end
Time when an arterial or central venous catheter was placed	Invasive line placement
Where surgery was performed	Case location
Time reserved in the OR scheduling system for the case	Scheduled case duration
Recorded in years	Patient age
Intravenous, including emergency category	ASA physical status
General, neuraxial, regional, converted to general, monitored anesthesia care	Type of anesthesia
True if the patient entered the OR prior to 8:00 AM	First-case start

ASA = American Society of Anesthesiologists; OR = operating room.

progressive drop in oxygen saturation measured by pulse oximetry from 100% to 90% in a patient undergoing robotic prostatectomy. Our approach was also conservative because there are other physiologic perturbations where the anesthesiologist would likely be notified that we did not include (*e.g.*, ST segment depression, hypercapnia not responding to an increase in minute ventilation, or runs of supraventricular tachycardia). In addition, we did not include "false alarm" conditions (*e.g.*, disconnection of an electrocardiogram electrode, kinking of the blood pressure tubing, or plugging of the capnograph sampling tubing) that may generate a call to the attending to help troubleshoot and/or resolve the problem.

For each minute of the day, we determined the total number of critical portions of cases that occurred simultaneously (fig. 1). For example, if at 8:40 AM there was a patient being extubated, a patient ready for induction of general anesthesia, and a patient with hypoxemia due to severe bronchospasm, there would be three critical portions of cases in the interval from 8:40:00 AM to 8:40:59 AM. Consequently, the total number of providers needed would equal the number of ORs with cases running plus three anesthesiologists.

Statistical Methods

Hypothesis 1. For each minute of each workday excluding Thursdays, the running minimum number of anesthesia providers during overlapping 5 min was calculated (*i.e.*, to determine the number of ORs with cases). Thursdays were excluded because the OR starts 1 h later on this day and we were assessing supervision as a function of time of day. Over the same overlapping intervals, the minimum number of simultaneous critical portions of cases was calculated (*i.e.*, to determine the number of anesthesiologists needed). For each workday, the number of ORs was calculated as the maximum of the running minimums of the number of simultaneous providers. The number of anesthesiologists needed daily was the maximum of the running minimums of simultaneous critical portions of cases. The ratio of the number of ORs to number of anesthesiologists needed was then calculated for each day. This was most commonly simply 24 ORs divided by the maximum number of anesthesiologists needed for at least 5 min. For hypothetical ratios from 1.0 to 3.0 (*i.e.*, one anesthesiologist supervising from one to three ORs), the percentage of workdays for which the daily ratio was smaller was calculated. The use of overlapping 5-min intervals deliberately resulted in underestimation of this ratio (*i.e.*, increasing the chance of rejecting Hypothesis 1). For the ratio of 2.0, the lower 95% confidence limit was calculated for the percentage of workdays for which at least one supervision lapse would have occurred. The 95% confidence interval (CI) was calculated using the method of Blyth-Still-Casella (StatXact-9, Cytel Software Corporation, Cambridge, MA).

Hypothesis 2. For each minute of each of the 202 workdays, excluding Thursdays, the total number of providers needed was calculated = provider in the operating room + anesthesiologist (if a critical portion of a case occurred) + and person on break (if applicable). Next, for each workday, the minute of the day with the largest total number of providers was calculated. That minute was then classified as "first case" if it occurred at 8:00 AM or earlier, otherwise "morning" if before 10:56 AM, otherwise "lunch" if before 1:31 PM, and otherwise "afternoon." We calculated the percentage of days for which a minute at or before 8:00 AM had the largest total number of providers for the day, along with the 95% lower confidence

Table 2. Tasks Considered as Critical Portions of the Anesthetic

Event	Start	End	Rational
Induction of GA	Enter the OR	Intubation or equivalent + 3 min	Participate in the preoperative briefing along with the surgeon, supervise induction of general anesthesia and securing of airway, check patient positioning
Postincision after regional or neuraxial block	Surgical incision	Surgical incision + 2 min	If block is inadequate, general anesthesia will be needed
Invasive line placement following induction of GA	Intubation	Until first physiologic data are recorded in the AIMS from the invasive line	Regulatory requirements related to billing for invasive lines
Turning patient between supine and prone	Position change time: 3 min	Position change time + 5 min (supine to prone) or 3 min (prone to supine)	Watch lines and airway to ensure that they do not become dislodged during the flip, ensure safe positioning following the flip. Prone positioning is more involved that returning patient to the supine position, so extra time was allocated
Neuraxial block supervision prior to entering the OR	Enter the OR– 11 min*	Enter the OR	Participate in the timeout and supervise the block
Neuraxial block after entering the OR	Enter the OR	Enter the OR + 11 min*	Participate in the timeout and supervise the block
Regional block for postoperative analgesia placed in block room	Enter the OR	Enter the OR: 24 min†	Participate in the timeout and supervise the block
Emergence from GA	Extubation time	Extubation time + 3 min	Assess readiness for extubation, assess adequate ventilation after extubation

* Mean time from entering the block room to documentation that the spinal or epidural had been placed was 11 min, SD = 9 min (n = 1,759). † Mean time from entering the block room to documentation that the regional block was placed was 23.8 min, SD = 21.8 min (n = 962).

AIMS = anesthesia information management system; GA = general anesthesia; OR = operating room.

limit. We tested whether the percentage exceeded half (*i.e.*, most) of the days. The calculations were performed twice, once with ties for the time of the day being assigned to the earlier time of day and once to the later time of day. For example, if the daily maximum of 35 anesthesia providers were needed on a day both at 7:58 AM and at 8:02 AM, then first the maximum would be attributed to the 7:58 AM "first case" and next attributed to the 8:02 AM "morning." The calculations were also repeated using anesthesiologists' critical portions instead of the total number of providers needed.

Table 3. Evidence-based Physiologic Events Considered as Critical Portions of Cases

Event	Definition	Reference
Hypoxemia	Spo_2<90% for 2 min	Ehrenfeld *et al.* 2010[29]
Tachycardia	Median HR >110 for 5 min	Reich *et al.* 2002[30]
Hypotension	Median systolic BP <70 over 10 min	Reich *et al.* 2005[31]
Hypertension	Median systolic BP >160 over 5 min and scheduled procedure length >2 h	Reich *et al.* 2002[30]

Patients younger than 18 yr were excluded in the published outcome studies for tachycardia, hypotension, and hypertension. Using the methodology described for Hypothesis 3, fewer than 20% of the minutes of critical portions (table 2 and 3) were accounted for by minutes with the above physiologic events (P < 0.0001, mean 14.7%, SE 0.5%). Excluding physiologic events occurring during critical portions (table 2) reduced the percentage to 13.8% (SE 0.4%).

BP = blood pressure; HR = heart rate; Spo_2 = oxygen saturation, measured by pulse oximetry.

Hypothesis 3. For all combinations of the 253 workdays and OR first cases of the day, the time from each OR entrance to anesthesia release was known from the anesthesia information management system data. The probability distribution of the n = 5,769 times to release were not normally distributed with or without inverse squared, inverse, inverse square root, logarithmic, square root, or squared transformations of the release time durations (all Lilliefors tests $P < 0.00001$, Systat 13, SYSTAT Software, Chicago, IL). Therefore, the mean was taken for each day. The 253 means followed a normal distribution (Lilliefors test $P = 0.42$). The means had neither statistically significant Pearson auto-correlation from 1 day to the next (Pearson r = −0.01, $P = 0.94$) nor from 1 week to the next (r = 0.11 $P = 0.08$). Therefore, the 95% two-sided CI for the mean release time was calculated using the Student t distribution, with the sample size being the 253 workdays. Similarly, the overall mean was compared

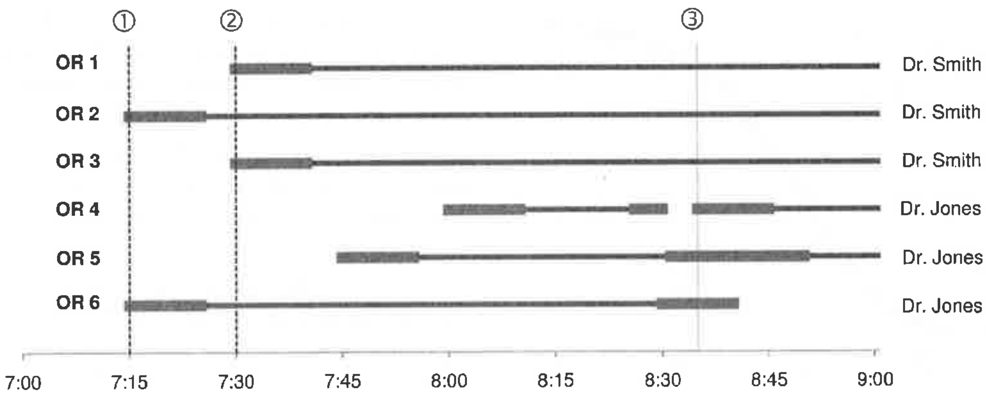

Fig. 1. Example of overlapping critical portions of cases. Critical portions of cases are noted by the *thick red lines*, and other portions by the *thin green lines*. During critical portions of cases, a supervising anesthesiologist would be expected to be present. A six operating room (OR) suite is staffed by two anesthesiologists, Drs. Smith and Jones. Dr. Smith is medically directing ORs 1 to 3 and Dr. Jones ORs 4 to 6. At time 1 (7:15), induction takes place in OR 2 and 6, staffed by the two anesthesiologists in their own rooms with no lapse in supervision. At time 2 (7:30), Dr. Smith has two cases to induce in OR 1 and 3, but Dr. Jones is available and performs the simultaneous induction in OR 3, preventing a lapse in supervision. At time 3 (8:35), Dr. Jones is helping treat a patient with hypoxemia and severe bronchospasm in OR 5, and Dr. Smith is cross-covering the extubation of the patient in OR 6. The patient in OR 4 has to wait for induction, as both anesthesiologists are busy. There has been a supervision lapse due to the occurrence of three simultaneous critical portions of cases.

with the anesthesia release time of 22 min determined at Yale-New Haven Hospital[21] using Student one group two-sided *t* test.

Results

Hypothesis 1: Staffing Lapses

The percentage of days during which there would have been at least one 5-min interval with too few anesthesiologists to supervise all critical portions of cases at varying ratios of ORs to anesthesiologists is shown in figure 2. Even at a ratio of 1:2, there would have been at least one such lapse in supervision for 35% of days (lower 95% confidence limit = 30%). At a ratio of 1:3, there would be supervision lapses on 99% of days (lower 95% confidence limit = 96%).

Extrapolating from figure 5b of the French simulation study[19] with 24 ORs, a staffing ratio of 1:2, and one additional floater anesthesiologist (*i.e.*, effective supervision ratio of 1:1.8), the expected incidence of supervision lapses is 12%. We observed a 12% incidence with a supervision ratio of 1:1.7.

The first hypothesis that supervision lapses would take place on one-third of days and that our results would be similar to the simulation study was confirmed.

Hypothesis 2: Time of Day with Largest Number of Providers Needed

The average peak activity (total providers needed) during cases occurred at the start of the workday for most days (fig. 3, table 4, $P < 0.0001$). This was especially true for critical portions of cases (*i.e.*, times that would influence anesthesiologist staffing; table 3). The second hypothesis was confirmed.

Hypothesis 3: Anesthesia Release Time

The mean number of minutes of critical portions of first-case starts was 22.2 min (95% CI 21.8–22.8 min, SD 2.8 min). This observation matched observational findings reported previously from Yale-New Haven Hospital[21] ($P = 0.29$). Thus, the third hypothesis that the mean number of critical minutes for first-case starts would match the anesthesia release time measured by observers[21] was confirmed.

Effect of Providing Higher Supervision Ratios or Staggered First-case Starts on Supervision Lapses

Because the three hypotheses were satisfied, as a sensitivity analysis, we examined the effect on supervision lapses of either lowering the supervision ratio from 1:2 at the start of the day to 1:3 after first cases had begun or supervising at a 1:3 ratio throughout the day with staggered first-case start times. The former strategy would be possible only if there were anesthesiologists with nonclinical assignments (*e.g.*, academic institutions), whereas the latter approach could be instituted anywhere. When critical portions of cases occurring at or before 8:00 AM and breaks were excluded, at least one supervision lapse would occur on 14% of days at the 1:3 supervision ratio (95% lower confidence limit = 10%). However, when breaks were included, supervision lapses increased to 62% of days (95% lower confidence limit = 56%; fig. 4). The breaks affecting the maximum supervision ratio were principally lunch reliefs (see fig. 2 and table 4). These findings indicate that at a 1:3 supervision ratio, additional providers (*e.g.*, certified registered nurse anesthetists) would be needed to provide breaks. In contrast, if supervision were maintained at 1:2 throughout the day, there would be supervision lapses on only 0% and 2% of days, excluding and including breaks, respectively. Thus, additional providers would not be necessary at a 1:2 supervision ratio. Overall, the

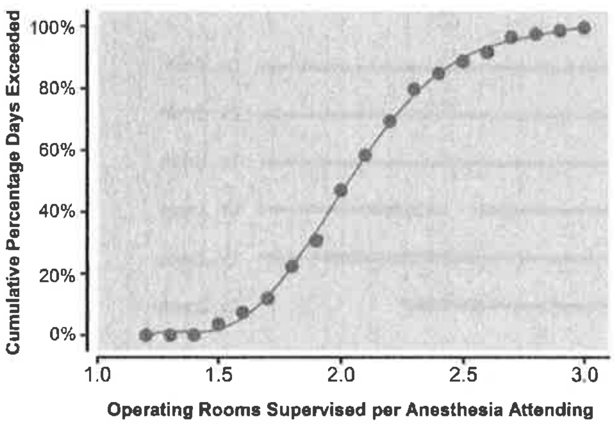

Fig. 2. Risk of supervision lapses based on number of rooms supervised by each anesthesiologist. A supervision lapse is defined as a critical portion of a case (see tables 1 and 2) where there are insufficient anesthesiologists available. For each of the 202 weekdays (excluding Thursday, when the operating room [OR] starts late) in the study interval, the minimum number of providers busy during the five previous 1-min intervals was calculated for each minute of the case. The maximum of this series equals the number of ORs that were running simultaneously at any point in the day (typically 24, but occasionally smaller if any OR were closed for the day). Similarly, the minimum number of critical portions during consecutive overlapping 5-min intervals was determined. The maximum of this series equals the number of anesthesiologists required to supervise all critical portions of cases. The ratio of maximum rooms divided by maximum anesthesiologists was then computed for each day. The value on the y-axis corresponds to the cumulative probability among the 202 days where the ratio listed on the x-axis would be exceeded for at least one interval during the day. For example, suppose each anesthesiologist is supervising two rooms, then on 35% of days, there would be at least one interval when a supervision lapse would occur.

financial benefit of decreasing the supervision ratio from 1:2 to 1:3 is offset by the need for additional nonanesthesiologist providers.

Discussion

In this study, we confirmed results of the French simulation study,[19] showing that even at a supervision ratio of one anesthesiologist for every two anesthesia providers, all simultaneous critical portions of cases could not be supervised on one-third of days without occasionally waiting for the anesthesiologist. We also confirmed that the largest number of providers is needed at the start of the day, and that is also when there was the highest incidence of critical portions of cases. The mean anesthesia release time (22 min) we measured was close to that measured at Yale-New Haven Hospital.[21] That time represents the average expected delay in starting the second case when an anesthesiologist has two patients who are ready for induction simultaneously and there is not another anesthesiologist who is available to cross-cover.

Our findings and the simulation results[19] are in contrast to the study of Wright *et al.*,[23] which found that cases with a start time after 3 PM had the highest proportion of adverse events. We obtained different results because our focus was on the time of the day with the largest total number of critical portions among all ORs. Wright *et al.* [23] considered when each individual case had the highest risk.

Administrators who want to reduce their anesthesia group's costs[24] by encouraging them to decrease their anesthesiologist supervision ratios need to consider the effect of our findings on the timeliness of first-case starts, which is often a major institutional focus.[11,12] At a ratio of one anesthesiologist to three anesthesia providers, it will not be possible to start all ORs simultaneously and have sufficient anesthesiologists to supervise all critical portions of cases on most days. Either the administrators will need to accept the fact that the additional OR often will be delayed from its scheduled start time, or agree to rearrange the OR schedule so that first cases supervised simultaneously by each anesthesiologist will have staggered start times.[20] The former approach can lead to discontent, because such delays are publicly visible.[25] The use of staggered starts has a built-in expectation that some ORs will start later than other ORs. For some organizations this may be advantageous (*e.g.*, surgeons running multiple ORs or who simply prefer to start somewhat later than the "official" start time may embrace this change). Provided the ORs selected for the staggered start times[20] are those with the most expected underutilized OR time, this has no economic disadvantage.[12,13,26,27]

Another potential approach to the problem of supervision lapses during first cases of the day is for the anesthesia group to make additional anesthesiologists available at the start of the day. Then, once the ORs have been started, some of these individuals are released to perform other duties important to the department (*e.g.*, research, informatics, and management and administrative duties). The importance of Hypothesis 2 is in knowing that lunch breaks are not the bottleneck; rather, it is the first case starts that must be considered economically.[12,24] However, the importance of our sensitivity analysis is in showing that this approach then necessitates adding additional nonanesthesiologists for breaks, which may nullify the economic benefit.

The fact that some organizations do not routinely provide breaks is not a limitation of our study to such practices, because our results of the importance of the start of the workday with respect to the peak incidence of staffing lapses would then be even *stronger*. Similarly, the fact that we studied a tertiary hospital with many long cases rather than an outpatient surgery center with short cases is not a limitation because, from the simulation study,[19] our results would be even stronger for short cases. Instead, the principal limitations of our study relate to the definitions of critical portions of anesthetics. Although we relied on process times recorded in an anesthesia information management system, such times

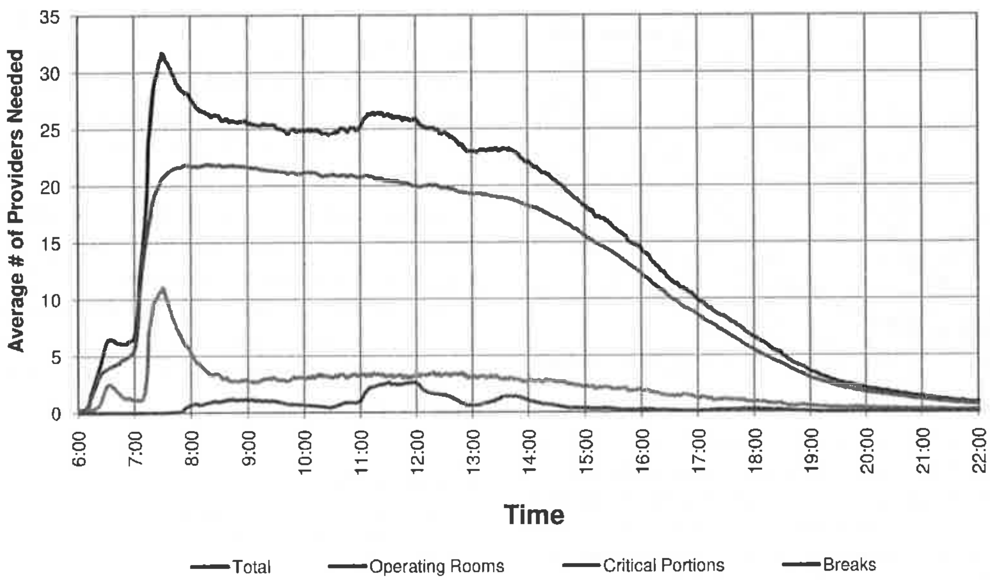

Fig. 3. Average daily workload by hours of the day. During each hour of the workday between 6:00 AM and 11:00 PM, the average numbers of staff required (providers, anesthesiologists, and break personnel) were determined. Operating rooms (*green line*) equals the number of providers, and critical portions (*red line*) are as defined in tables 1 and 2, indicating the number of supervising anesthesiologists required. Breaks (*purple line*) represent staff relieving providers for lunch and bathroom breaks. The total number of providers needed (*blue line*) is the sum of the other three quantities. The peak activity occurred at 7:30 AM, as did the number of critical portions of cases. Some operating rooms have scheduled start times of 6:30 AM and others at 7:30 AM, based on surgical specialty; this has no bearing on the results.

recorded by nurses in an operating room information system could be used equivalently, as shown by Sandberg *et al.*[28]

During our analysis, we assumed, as did Paoletti and Marty,[19] that any anesthesiologist can go into any OR when a critical portion of the case occurs and provide supervision equivalent to the anesthesiologist who is otherwise occupied and cannot be interrupted. If complex patients are involved or an extended discussion about management has taken place, such substitution may provide suboptimal patient care. To the extent that all anesthesiologists are not equivalent and thus not able to supervise every critical portion of cases (*e.g.*, a patient to receive a regional block that the available anesthesiologist does not feel qualified to perform), the percentage of days with a lapse in supervision

Table 4. Percentages of n = 202 Days for which the Time of Day Had the Largest Total Number of Providers and/or Critical Portions for Any Minute of the Day

Time of Day	First Case*	Morning†	Lunch‡	Afternoon§
% Days with ties assigned to the earliest minute of day with the maximum total number of providers for the day	78% (n = 157) $P < 0.0001$ 95% CI >73%	11% (n = 23)	10% (n = 20)	1% (n = 2)
% Days with ties assigned to the latest minute of day with the maximum total number of providers for the day	69% (n = 140) $P < 0.0001$ 95% CI >64%	11% (n = 23)	18% (n = 36)	1% (n = 3)
% Days with ties assigned to the earliest minute of day with the maximum critical portions for the day	99% (n = 199) $P < 0.0001$ 95% CI >96%	0% (n = 1)	1% (n = 2)	0% (n = 0)
% Days with ties assigned to the latest minute of day with the maximum critical portions for the day	96% (n = 193) $P < 0.0001$ 95% CI >93%	2% (n = 5)	2% (n = 4)	0% (n = 0)

The *P* value tests whether the proportion is greater than half.

* First case = in the operating room after 6:30 AM through 8:00 PM. † Morning = in the operating room after 8:00 AM through 10:55 AM. ‡ Lunch = in the operating room after 10:55 AM through 1:30 PM. § Afternoon = in the operating room after 1:30 PM.

CI = confidence interval.

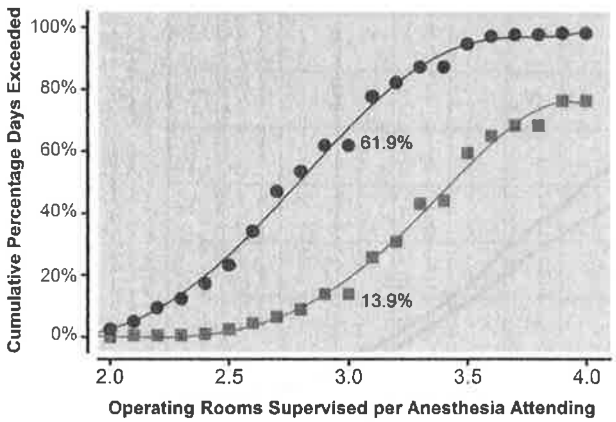

Fig. 4. Risk of supervision lapses excluding critical portions of cases on or before 8 AM. This graph was constructed as described in the legend for figure 2, with the exception that critical portions of cases occurring on or before 8 AM were excluded. Excluding supervision lapses during first-case starts represents a strategy of either staggering the start times of first cases or providing additional anesthesiologists at the start of the day. The *blue circles* and *regression line* represent the cumulative percentage of days with at least one supervision lapse when lunch reliefs and breaks after 8 AM were excluded. The *red squares* and *regression line* represent the cumulative percentage of days with at least one supervision lapse when lunch reliefs and breaks after 8 AM were included. The large increase in staffing lapses at a supervision ratio of 1:3 (13.9%–61.9%) indicates that additional staff would need to be present if lunch relief is to be provided. At a supervision ratio of 1:2, minimal additional staff would be needed, because the increase in days with staffing lapses is small (0% to 2%). Thus, the potential financial benefit of reducing the anesthesiologist staffing ratio will be offset by the need to provide additional providers for lunch relief.

with a 1:2 supervision ratio would be even larger than the observed 35%.

There are aspects of our analysis related to our definitions of critical portions of cases (tables 1 and 2) that could result in some readers viewing our conclusions as too conservative. Several of our colleagues offered feedback that they do not think that it is necessary for the supervising anesthesiologist to be physically present for induction or emergence in straightforward cases with experienced certified registered nurse anesthetists, as long as they are immediately available. The extent to which anesthesiologist presence is required during and soon after the anesthesia release time varies highly among countries because of varying regulatory requirements and within countries among institutions (*e.g.*, depending on local requirements for participation in the preoperative briefing). Because the intraoperative briefing including the surgeon and all anesthesia providers reduces mortality,[18] likely its inclusion will be increasingly prevalent.

In summary, we showed that the start of the OR day is the period of time when the anesthesiologist supervision requirement is greatest. Even with lunch breaks included, this result is so robust that changes in the anesthesiologist supervision ratio can be described to administrators simply in terms of the effect on first-case starts. This finding is useful because the psychology of first-case starts is already understood (*e.g.*, how they are interpreted economically).[11] Decreasing the supervision ratio by anesthesiologists from 1:2 to 1:3 will have a great effect on the timeliness of the start of the first cases of the day due to the high incidence of simultaneous critical portions of cases peaking at that time. As the economics of first-case starts are also fully developed, the decision to stagger first- case starts appropriately[11–13,26,27] *versus* having more anesthesiologists can be modeled for each facility.[11,12,24] Unless one of these options is chosen, the consequence will be a marked increase in the incidence of supervision lapses.

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AANA

Comparison of Certified Registered Nurse Anesthetists (CRNAs) and Anesthesiologist Assistants (AAs)

CRNAs	AAs
Definition: A CRNA is an advanced practice registered nurse specializing in nurse anesthesia. CRNAs are professional registered nurses (RNs) who have obtained, through additional education and successful completion of a national examination, certification as anesthesia nursing specialists.	**Definition:** According to the American Academy of Anesthesiologist Assistants (AAAA), the AA is an allied health professional specializing in anesthesia who works under the direction of an anesthesiologist in the anesthesia care team environment as described by the American Society of Anesthesiologists (ASA). The AA may take the National Commission for Certification of Anesthesiologist Assistants (NCCAA) examination to become an Anesthesiologist Assistant - Certified (AA-C).
Anesthesia Practice: CRNAs are qualified to make independent judgments regarding all aspects of anesthesia care, based on their education, licensure, and certification. CRNAs provide anesthetics to patients in cooperation with surgeons, anesthesiologists, dentists, podiatrists and other qualified healthcare professionals. CRNAs practice with a high degree of autonomy. The laws of every state permit CRNAs to work with physicians (such as surgeons) or other authorized healthcare professionals.	**Anesthesia Practice:** The AA develops and implements an anesthesia care plan in an assistant role/capacity. According to the Commission on Accreditation of Allied Health Education Programs (CAAHEP), the AA must work under the direction of an anesthesiologist. AAs may not work under the direction of other physicians or healthcare professionals. The anesthesiologist who is responsible for the AA is available to prescribe and direct particular therapeutic interventions in the operating room and the intensive care setting. Currently, 12 states and the District of Columbia authorize the practice of an AA through either a licensure or certification process. 1 additional state (Kentucky) authorizes the practice of an AA who is also a certified physician's assistant. In all of these states and in the District of Columbia, AAs must work under the direction or supervision of an anesthesiologist.
Practice Locations: CRNAs practice in every setting in which	**Practice Locations:** The AA most frequently practices in an

American Association of Nurse Anesthetists

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anesthesia is delivered: traditional hospital surgical suites and obstetrical delivery rooms; critical access hospitals; ambulatory surgical centers; the offices of dentists, podiatrists, ophthalmologists, plastic surgeons, and pain management specialists; and U.S. military, Public Health Services, and Department of Veterans Affairs healthcare facilities.	urban hospital setting. AAs cannot practice where anesthesiologists are unavailable or are not willing to work.
Numbers: There are approximately **45,000** nurse anesthetists. They safely administer approximately 34 million anesthetics to patients each year in the United States. CRNAs are the primary anesthesia providers in rural America. In some states, CRNAs are the sole providers in nearly 100% of rural hospitals.	**Numbers:** The ASA website states that there are **1800** working AAs.
Distribution: CRNAs practice under the laws of every state.	**Distribution:** AAs are authorized to practice through either a licensure or certification process (depending upon the state) in 12 states and the District of Columbia (Alabama, Colorado, Florida, Georgia, Missouri, New Mexico, North Carolina, Ohio, Oklahoma, South Carolina, Vermont, and Wisconsin). In Kentucky, certified physician assistants who have completed an AA program are authorized to practice through a certification process. Unlicensed AAs may be practicing in other states pursuant to laws or regulations that allow physicians to delegate certain medical acts to unlicensed individuals.
Scope of Practice: CRNAs are educated and trained to work with or without anesthesiologist supervision. CRNAs are also educated and trained to exercise independent judgment and to respond quickly to anesthetic emergencies.	**Scope of Practice:** AAs must work under the close supervision of an anesthesiologist.
History: Nurse anesthetists have been practicing for **150** years. They were the first professional group whose members specialized in anesthesia.	**History:** AAs have been practicing since the early 1970s, or approximately 40 years.
Number of Accredited Nurse Anesthesia Programs: 113 accredited programs spread throughout the country.	**Number of Accredited AA Programs: 9** (Case Western Reserve University, Cleveland, Ohio; Case Western Reserve University, Houston, Texas; Case Western Reserve University, Washington, D.C.; Emory University, Atlanta, Georgia; Nova Southeastern University, Ft Lauderdale, Florida; Nova Southeastern University, Tampa, Florida; South University, Savannah, Georgia; University of Colorado, Denver; University of Missouri-Kansas City (UMKC)).

	Quinnipiac University's AA program has not been accredited as of December 2013.
Number of Students: In 2014, approximately **2,500** students are projected to graduate from nurse anesthesia programs throughout the country.	**Number of Students:** Emory reports that the program graduates approximately 30 students each year. Case Western reports that it has 22 students in each class in both the Cleveland and Houston programs. Case Western reportedly has 18 students in its Washington, D.C. program, which commenced in May 2012. South University reportedly has approximately 24 students in each class. Nova Southeastern Ft. Lauderdale has approximately 35 students in each class. Nova Southeastern Tampa reportedly began with approximately 26 students. UMKC reports that at the start of the Spring 2010 semester, the program had a total of 16 students, and it anticipates 10-11 students for the class of 2013.
Accreditation Entity: Council on Accreditation of Nurse Anesthesia Educational Programs (COA), which is independent from the American Association of Nurse Anesthetists (AANA) and an autonomous council. The COA is recognized by the U.S. Department of Education and Council for Higher Education Accreditation (CHEA).	**Accreditation Entity:** CAAHEP, which is recognized by the CHEA. The U.S. Department of Education does not recognize CAAHEP.
Program Length: 24 to 36 months	**Program Length:** 24 to 29 months
Degree Granted: Minimum degree awarded is Master's degree. May receive doctoral degree.	**Degree Granted:** Master's degree
Admissions Requirements: COA accreditation standards require four years of professional nursing education; a baccalaureate; RN licensure; and at least one year of acute care experience as a professional RN during which the RN developed as an independent decision-maker capable of interpreting and using advanced monitoring techniques based on knowledge of physiological and pharmacological principles. Actual admission requirements of COA-accredited programs are commonly more stringent than COA standards. Emphasis is commonly placed on, for example, a history of high academic performance, completion	**Admissions Requirements:** Baccalaureate degree in the arts or sciences from an accredited institution. No nursing, medical, anesthesia or healthcare education, experience, licensure, or certification required.

of intense undergraduate science curriculum, evidence of study of statistics, proof of verbal ability and writing skills, and experience as an RN in acute care settings. Most applicants have acquired extensive clinical experience in areas such as coronary, respiratory, postanesthesia, and surgical intensive care units before they begin their nurse anesthesia programs.	
Prerequisite Coursework: Examples of courses commonly required include anatomy, physiology, microbiology, chemistry, and pharmacology; sociology and psychology; and statistics. Also baccalaureate-prepared RNs are generally well grounded in philosophy, ethics, economics, communications, telecommunications, and English composition.	**Prerequisite Coursework:** Many types of majors are acceptable for admission. Typical desirable undergraduate majors include biology, chemistry, physics, computer science, engineering, and any of the health professions.
Pre-Program Nursing Competencies: The National Council of State Boards of Nursing **NCLEX-RN Examination,** successful passage of which is a prerequisite to become licensed as an RN (a prerequisite for nurse anesthesia programs), validates the following nursing competencies: **Safe, Effective Care Environment** -- Management of Care, Safety and Infection Control; **Health Promotion and Maintenance**; **Psychosocial Integrity**; **Physiological Integrity** -- Basic Care and Comfort, Pharmacological and Parenteral Therapies, Reduction of Risk Potential, Physiological Adaptation.	**Pre-Program Health or Patient Care Education, Experience, or Credentials Required:** None.
Pre-Program Acute Care Nursing Competencies: The acute care RN has proven patient care experience with a foundation of nursing competencies. The *acute care nursing* prerequisite means that the nurse anesthesia student applicant must have competencies through experience with acutely/critically ill patients in hospitals, in the following areas: **patient assessment** (collecting relevant patient health data); **diagnoses** (analyzing assessment data in determining diagnoses); **outcome identification** (identifying individualized, expected outcomes for the critically ill patient); **planning** (developing a care plan that prescribes interventions to attain expected outcomes); **implementation** (implementing interventions identified in the care plan (e.g., delivered in a manner that minimizes complications and life-threatening situations)); **evaluation** (evaluating the patient's progress toward	**Pre-Program Acute Healthcare Competencies:** Student AAs are not required to enter their educational program with comparable credentials.

attaining expected outcomes). (American Association of Critical Care Nurses Standards of Care for Acute and Critical Care Nursing)	
Program Description: Requires successful completion of an academic program of specified didactic course work and clinical training and is a minimum of 24 months in length. COA specifies mandatory hours requirements for didactic content and a minimum number and type of anesthesia cases to be administered by nurse anesthesia students.	**Program Description:** CAAHEP guidelines for AA programs recommend, but do not appear to require, didactic and clinical content. In addition, CAAHEP guidelines for AA programs recommend, but do not appear to require, a minimum number of anesthesia cases.
Didactic Education: COA accreditation standards require at a minimum: anatomy, physiology and pathophysiology (135 hours); pharmacology of anesthetic agents and adjuvant drugs including concepts in chemistry and biochemistry (105 hours); clinical correlation conferences (45 hours); basic and advanced principles of anesthesia practice, including physics, equipment, technology and pain management (105 hours); research (30 hours); professional aspects of nurse anesthesia (45 hours).	**Didactic Education:** CAAHEP standards and guidelines do not specify minimum hours for each core course or category of core courses.
Anesthesia Clinical Education: The COA standards require that students administer a *minimum* of 550 anesthesia cases for a wide variety of procedures. Transcript data from nurse anesthesia students who completed their program in 2012 shows that the average number of anesthetics administered was **848** over an average of **1,689** hours of anesthesia and **2,559** clinical hours. Total clinical hours refers to the total number of hours the student is present in the clinical area. This may include: pre-op, post-op, patient prep, and time spent participating in clinical rounds. Total clinical hours are inclusive of total hours of anesthesia time; therefore this number must be equal to or greater than the total number of hours of anesthesia time. Nurse anesthesia programs report anesthesia seminars and conferences in didactic and not clinical hours.	**Anesthesia Clinical Education:** No minimum number of anesthesia cases required in CAAHEP accreditation criteria. Guidelines recommend 600 anesthesia cases. AA programs indicate that total clinical hours range from 2,000 to 2,747. Published descriptions of the AA programs' total clinical hours include experiences such as learning to do physicals, taking patient histories, training and certification processes for life support training, and other learning experiences that a licensed professional RN has already mastered prior to nurse anesthesia program entry.
Total Clinical Education: CRNAs receive a minimum of seven years of formal education and preparation, from the commencement of the professional education in nursing to the graduation from nurse anesthesia school, to prepare them for	**Total Clinical Education:** Total clinical education during their AA programs ranges from 2,000 to 2,747 hours.

their careers in anesthesia. During the course of their education, CRNAs will typically have acquired at least *6,000 hours* of clinical patient care experience.	
Scope of Training: CRNAs are capable of high-level independent function and receive instruction in the administration of all types of anesthesia including general and regional anesthesia, selected local and conscious sedation, monitored anesthesia care, and pain management. They are trained to provide anesthesia to patients of all ages for all types of surgery, from simple to the most complex cases. The ability to make independent judgments and provide multiple anesthetic techniques is critical to meeting an array of patient and surgical needs.	**Scope of Training:** The scope of training for AAs is severely limited. The AA curriculum is characterized by training that allows them to "assist" the anesthesiologist in technical functions.
National Certification: A nurse anesthetist must successfully pass the National Board of Certification and Recertification of Nurse Anesthetists (NBCRNA) certification examination in order to practice as a CRNA in at least 48 states and the District of Columbia. In the few states that do not explicitly require such certification, employers generally require such certification as a practical matter. Nurse anesthetists are not eligible to take their certification exam until they have successfully completed their accredited nurse anesthesia programs. (Medicare requires nurse anesthetists to be certified and recertified in order to qualify for reimbursement.)	**National Certification:** AAs are eligible to take the NCCAA examination up to 180 days before graduation. AAs may practice without certification, unless it is required by their employer or state law. (Medicare does not require that AAs must be certified or recertified in order to qualify for reimbursement.)
National Certification Prerequisites: Current, unrestricted licensure as an RN, successful completion of an accredited nurse anesthesia educational program, and successful completion of the NBCRNA exam.	**National Certification Prerequisites:** Successful completion of an accredited AA program and passage of the NCCAA certification exam.
Recertification: Every two years based on evidence of 40 continuing education credits, current and unrestricted RN or advanced practice registered nurse licensure, and verification of active practice.	**Renewal of Certification:** Every two years based on evidence of 40 continuing medical education (CME) hours. In addition, passing scores on a *Continued Demonstration of Qualifications Examination* every six years.
Standards and Ethics: AANA publishes a scope of practice statement, standards and guidelines for practice, and a code of ethics.	**Standards and Ethics:** AAAA publishes a statement on the functions and responsibilities of the AA; it also publishes guidelines for ethical standards.

Nature of Relationship with Physicians: CRNAs work cooperatively with all types of physicians.	**Nature of Relationship with Physicians:** The AA functions as an assistant to an anesthesiologist and is dependent upon the anesthesiologist's supervision and direction.
Autonomy in Practice: Practices with a significant degree of autonomy.	**Autonomy in Practice:** Works only under the close direction or supervision of an anesthesiologist.
Flexibility of Practice: Capable of working in urban and rural areas, and across all types of practice settings (e.g., ambulatory care, clinics, and hospitals).	**Flexibility of Practice:** Usually practices in hospitals that use the anesthesia care team approach, always supervised by anesthesiologists, and usually in an urban setting.
Practice in the Military: CRNAs are the predominant anesthesia provider in the armed forces and the Veterans Affairs healthcare system.	**Practice in the Military:** AAs do not practice in the military.
Medicare Reimbursement: The Medicare conditions for hospitals and ambulatory surgical centers require that a physician supervise a CRNA unless the state has "opted out" of this supervision requirement. Seventeen states have opted out of the Medicare physician supervision requirement for CRNAs. CRNAs are not required to work with anesthesiologists.	**Medicare Reimbursement:** The Medicare conditions for hospitals require that an AA be under the supervision of an anesthesiologist who is immediately available if needed; the ambulatory surgical center conditions require AAs to be under anesthesiologist supervision.
Patient Safety: Numerous studies have concluded that CRNAs are safe providers. For information about these studies, please see www.aana.com > Resources > Professional Practice > Professional Practice Manual > Quality of Care in Anesthesia.	**Patient Safety:** No credible research studies on anesthesia safety involving AAs.

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