



Original Investigation | Anesthesiology

Extended Work Periods Among Anesthesiologists and Postoperative Patient Outcomes

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Abstract

IMPORTANCE Attending anesthesiologists are not subject to work hour restrictions. Fatigue from long shifts may plausibly contribute to patient harm.

OBJECTIVE To examine the association between anesthesiologist extended work periods and patient outcomes.

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional study used data from the Multicenter Perioperative Outcomes Group registry from January 1, 2010, to August 30, 2020, representing all surgical procedures in patients 18 years or older from more than 50 hospitals across 18 US states. Data analyses were conducted from July 1 through November 30, 2025.

EXPOSURE Anesthesiologist extended work periods, defined as 16 hours or more of continuous intraoperative work.

MAIN OUTCOMES AND MEASURES The primary outcome was a composite of in-hospital mortality or major complication. Secondary outcomes were individual components of the composite. A within-anesthesiologist approach was used to compare outcomes for patients treated by each anesthesiologist when in an extended work period vs not, adjusting for patient demographics, comorbidities, American Society of Anesthesiologists classification, emergency status, hour of surgery start, and surgery type.

RESULTS The study cohort comprised 1 648 720 surgical procedures involving 1711 unique anesthesiologists across 36 institutions (patient mean [SD] age, 51.7 [17.8] years; 982 020 [59.6%] female). A total of 11 556 procedures (0.7%) involved anesthesiologists in an extended work period. Unadjusted incidence of the composite outcome was 12.3% (95% CI, 11.7%-12.9%) for extended work periods vs 12.0% (95% CI, 12.0%-12.1%) for standard work periods. Adjusted absolute risk difference in the composite outcome was 0.1% (95% CI, -0.4% to 0.5%; $P = .82$). Multiple sensitivity analyses resulted in statistical significance with point estimates of similar direction and magnitude. In-hospital mortality was higher for extended (1.3%; 95% CI, 1.1%-1.6%) vs standard (1.0%; 95% CI, 1.0%-1.0%) work periods, with a risk difference of 0.3 (95% CI, 0.1%-0.5%; $P = .009$). Other secondary outcomes had risk increases of similar magnitude.

CONCLUSIONS AND RELEVANCE In this cross-sectional study, the primary analysis did not identify a statistically significant difference in composite outcome, although the magnitude and precision of risk estimates across multiple sensitivity analyses suggested a small (<1.0%) increase in risk. Secondary analyses also suggested small absolute increases in outcomes, including in-hospital

(continued)

Key Points

Question Are extended work periods for anesthesiologists associated with worse postoperative patient outcomes?

Findings In this cross-sectional study of 1 648 720 surgical procedures involving 1711 anesthesiologists across 36 institutions, the primary adjusted analysis did not demonstrate a statistically significant difference in a composite of in-hospital major morbidity or mortality between extended and standard work periods; however, point estimates suggested small increases in risk, with sensitivity analyses yielding directionally consistent estimates. In-hospital mortality was also higher in extended work periods.

Meaning These findings suggest that patients cared for by anesthesiologists who have been working continuously for 16 hours or longer and who may be fatigued may be at slightly higher risk for adverse outcomes.

+ Supplemental content

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Abstract (continued)

mortality. These findings raise the possibility that fatigue related to prolonged anesthesiologist work periods may have implications for patient safety.

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Introduction

Work hour restrictions are implemented in many industries.¹ In health care, concerns about fatal fatigue-related medical errors² have led to changes in work hour restrictions for physician trainees.³ However, attending physicians are not subject to duty hour restrictions. In anesthesiology, attending physicians' shifts can last 24 consecutive hours or more and involve cognitive, physical, and emotional strains that may plausibly result in exhaustion and medical errors, given the high-stakes nature of their work. Understanding whether longer shifts are associated with adverse patient outcomes is important and could prompt systemic policy-level changes.

Whether extended shifts for attending physicians may impact patient outcomes is not yet understood. Although a prior investigation⁴ found no difference in perioperative outcomes according to whether the attending surgeon had performed an operation the night before, findings from that study are specific to surgeon work schedules. Studies^{5,6} on physician trainees in internal medicine and general surgery have not found significant differences in mortality or other measures of patient safety, although longer shift length is associated with higher risk of physician motor vehicle crash and well-being.⁷ Within anesthesiology, residents who have worked long or overnight shifts underestimate their level of sleepiness and have worse response times and executive functioning,⁸⁻¹⁰ and self-reports from resident and attending anesthesiologists in other countries have suggested that longer work shifts lead to higher levels of fatigue and medical errors.¹¹ However, the association of these measures with patient outcomes has not been tested.

We examined the association between extended intraoperative work periods for attending anesthesiologists and perioperative outcomes using data from the Multicenter Perioperative Outcomes Group (MPOG), a large, multicenter registry of surgical procedures performed in the US.¹² We hypothesized that patients cared for by attending anesthesiologists during extended work periods would be more likely to experience adverse perioperative outcomes, including mortality and major complications. Given that the registry contained information on all patients undergoing surgery cared for by a given anesthesiologist at each institution, we addressed confounding by comparing outcomes for a given anesthesiologist when they were in an extended work period vs not: a within-anesthesiologist approach.

Methods

Study Design

We conducted a cross-sectional study using data from MPOG, a registry of all procedures requiring anesthesia care from more than 50 hospitals across 18 US states. The registry includes detailed clinical information, such as anesthesia start and stop times (corresponding to initiation of anesthesiologist preoperative evaluation immediately before surgery and postanesthesia care unit handoff, respectively), the *Current Procedural Terminology (CPT)* code for the procedure, and an encrypted anesthesiologist identifier. MPOG also reports in-hospital mortality and provides *International Classification of Diseases, Ninth Revision (ICD-9)* and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* diagnosis codes from the hospital discharge. This study was deemed exempt from institutional review board review and informed consent requirements by Stanford University because patient identifiers were removed

and the dataset was considered limited. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies.¹³

Sample

The initial sample consisted of 4 617 416 surgical procedures performed between January 1, 2010, and August 30, 2020, excluding cases from institution-years missing a large proportion of data and low-risk procedures generally performed outside the operating room: ophthalmologic operations (CPT codes 65091-68899), upper and lower endoscopy (CPT codes 43180-43278 and 45300-45393), and central venous access (CPT codes 36555-36598). Given that anesthesiologists work in shifts, patient care may be handed off from one anesthesiologist to another intraoperatively; for cases with more than one anesthesiologist, we assigned a primary anesthesiologist by identifying the one who was signed in to the case the longest. We next implemented multiple exclusion criteria to account for data quality and our analytic approach (eMethods 1 and eTable 1 in [Supplement 1](#)).

Exposure

For each procedure, the binary exposure variable was whether the attending anesthesiologist had been working continuously for 16 hours or more at the start of the case (ie, an extended work period) or not (ie, a standard work period). We chose this definition given the use of a 16-hour threshold implemented in the past by the American College of Graduate Medical Education for trainee physicians and because this definition encompasses the varied types of shifts that anesthesiologists undertake, including daytime, nighttime, swing, and 24-hour in-house or home-call shifts. Additional information on construction of the exposure variable is provided in eMethods 2 in [Supplement 1](#). We prespecified sensitivity analyses centered around alternative definitions of this variable.

Outcomes

The primary outcome was a binary composite variable that equaled 1 if the patient died or experienced a major complication during the inpatient stay and 0 if not. MPOG provided in-hospital mortality data, and major complications were identified using ICD-9 and ICD-10 codes from the discharge summary. Major complications (myocardial infarction, stroke, thromboembolic event, acute kidney injury, major respiratory complications, mesenteric ischemia, or anesthesia-related complications) were chosen based on the plausible association between an error related to an anesthesiologist's decision-making and potential clinical effects (see eTable 2 in [Supplement 1](#) for list of codes). Secondary outcomes were in-hospital mortality and disaggregated major complications. Additional variables to adjust for potential confounding were patient age, sex, Elixhauser comorbidities identified using discharge diagnosis codes, American Society of Anesthesiologists physical status classification and emergency status as reported by the attending anesthesiologist, hour of surgical case start, and surgical procedure type.

Statistical Analysis

For each outcome, we estimated a linear probability model. The independent variable was whether the anesthesiologist had been working continuously for 16 hours or longer. We estimated linear probability models to generate interpretable estimates of risk difference and because the inclusion of a large number of fixed effects can lead to biased estimates in models such as logistic regression and can create issues with complete separation leading to failed model convergence.¹⁴⁻¹⁶ To account for potential unobservable confounders due to differences in anesthesiologist practice style, the models included anesthesiologist fixed effects. This within-anesthesiologist approach compares a given anesthesiologist's outcomes when in an extended work period or not and implicitly adjusts for unobservable factors across institutions (eg, differences in operating room staffing, medications, and patient acuity) that might confound our results. This approach requires that each included fixed effect (ie, each anesthesiologist) have at least one instance in the dataset with each possible exposure (ie, extended or normal work period). If the anesthesiologist never met criteria for an

extended shift, the exposure would be perfectly collinear with that anesthesiologist's data, meaning that it would not influence the estimate of the association between exposure and outcome. We therefore excluded anesthesiologists who never met criteria for an extended work period from our study cohort. Additionally, we included fixed effects for operation type (surgical CPT code), patient characteristics (ie, age, sex, comorbidities), and fixed effects for the hour of day or night when the procedure started. Thus, this model compared outcomes for patients with similar risk factors undergoing similar procedures, at the same time of day or night, when their anesthesiologist had been continuously working for at least 16 hours vs when they had not.

A prespecified analysis plan was registered with the MPOG Perioperative Clinical Research Committee before data analysis. All analyses were performed using Stata software, version 17.0 (StataCorp LLC). Data analyses were conducted from July 1 through November 30, 2025. We clustered SEs at the anesthesiologist level and used a 2-sided $P < .05$ to indicate statistical significance.

We conducted prespecified exploratory analyses on the following subgroups: (1) high-risk patients, defined as those in the top quartile of predicted probability for the composite outcome, as derived from a multivariable logistic regression fit to estimate risk of the composite outcome based on age, sex, American Society of Anesthesiologists physical status score, surgical procedure, and Elixhauser comorbidities; (2) surgical subspecialties (ie, cardiovascular surgery [CPT codes 33016-37799], orthopedic surgery [CPT codes 20100-29999], urology [CPT codes 50010-55899], and neurosurgery [CPT codes 61000-64999]); and (3) cases with or without a resident or fellow physician, certified registered nurse anesthetists, and/or anesthesiology assistant also signed in to the case.

We performed prespecified sensitivity analyses to test the robustness of our definition of anesthesiologist extended work periods: (1) modeling work periods as a continuous variable and using 2 alternate thresholds for a binary variable representing extended work (12 and 20 hours) and (2) modeling hours worked as an ordinal variable (≥ 16 and < 18 hours, ≥ 18 and < 20 hours, ≥ 22 and < 24 hours, and ≥ 24 hours compared with < 16 hours as the reference). We conducted the following additional sensitivity analyses that respecified our statistical approach: (1) excluding anesthesiologist fixed effects from our model, (2) excluding fixed effects for the hour of the start time of the case, (3) clustering SEs at the level of the institution rather than the anesthesiologist, and (4) applying a multivariable logistic regression using the same set of explanatory variables, with robust SEs clustered by anesthesiologist. Finally, we respecified our outcome to include surgical site infections as part of the composite outcome.

Results

We analyzed 1 648 720 surgical procedures involving 1711 unique anesthesiologists across 36 institutions (patient mean [SD] age, 51.7 [17.8] years; 982 020 [59.6%] female and 666 700 [40.4%] male). Of these, 11 556 procedures (0.7%) involved primary anesthesiologists who had worked 16 hours or more at the start of the case. A list of the 50 most common CPT codes is provided in eTable 3 in Supplement 1. Operations performed when the attending anesthesiologist had worked 16 hours or longer were more likely to be emergency procedures (2667 [23.1%] vs 103 638 [6.3%]; standardized mean difference, 0.487) and less likely to involve higher-risk patients, defined as patients in the upper quartile of estimated risk of the composite outcome (2293 [19.8%] vs 409 887 [25.0%]; standardized mean difference, 0.125) (Table 1). Of 16 670 patients who died, 13 075 (78.4%) had a diagnosis code for one of the morbidity-related complications included in the composite outcome. The unadjusted incidence of the composite outcome was 12.3% (95% CI, 11.7%-12.9%) in procedures when the attending anesthesiologist had worked 16 hours or longer and 12.0% (95% CI, 12.0%-12.1%) in procedures when the attending anesthesiologist had not (risk difference, 0.3%; 95% CI, -0.3% to 0.9%; $P = .38$;) (Table 2). After adjustment, the risk difference was 0.1% (95% CI, -0.4% to 0.5%; $P = .82$; extended: 12.1%; 95% CI, 11.6%-12.5%; standard: 12.0%; 95% CI,

12.0%-12.0%). The adjusted risk difference for in-hospital mortality was 0.3% (95% CI, 0.1%-0.5%; $P = .009$); extended: 1.3%; 95% CI, 1.1%-1.6%; standard: 1.0%; 95% CI, 1.0%-1.0%). This adjusted risk difference translated to a relative increase in in-hospital mortality of approximately 30%. There were also increases in risk difference in myocardial infarction, acute kidney injury, major respiratory complication, and mesenteric ischemia and a decrease in other thromboembolic events, although none reached the prespecified level of statistical significance (**Figure** and Table 2). There were no significant differences in the composite outcome for patients who were considered in the highest quartile of risk of the composite outcome, for attending anesthesiologists who worked with or without a trainee, or for specific surgical subspecialties (ie, neurosurgery, cardiovascular surgery,

Table 1. Characteristics of the Study Sample

Characteristic	No. (%) of patients ^a		Standardized mean difference
	≥16 Hours worked (n = 11 556)	<16 Hours worked (n = 1 637 164)	
Age, mean (SD), y	42.01 (16.64)	51.80 (17.75)	0.569
Sex			
Female	8638 (74.7)	973 382 (59.5)	0.330
Male	2918 (25.3)	663 782 (40.5)	0.330
Comorbidities			
HIV or AIDS	27 (0.2)	5618 (0.3)	0.020
Alcohol abuse	239 (2.1)	39 404 (2.4)	0.023
Blood loss anemia	135 (1.2)	24 086 (1.5)	0.027
Cardiac arrhythmias	1645 (14.2)	304 571 (18.6)	0.118
Chronic pulmonary disease	1513 (13.1)	253 960 (15.5)	0.069
Coagulopathy	958 (8.3)	122 552 (7.5)	0.030
Congestive heart failure	617 (5.3)	136 658 (8.3)	0.119
Deficiency anemia	545 (4.7)	69 169 (4.2)	0.024
Depression	1300 (11.2)	214 143 (13.1)	0.056
Diabetes (complicated)	684 (5.9)	148 089 (9.0)	0.119
Diabetes (uncomplicated)	808 (7.0)	192 467 (11.8)	0.164
Drug abuse	437 (3.8)	53 523 (3.3)	0.028
Fluid and electrolyte disorder	1536 (13.3)	246 037 (15.0)	0.050
Hypertension (complicated)	880 (7.6)	179 574 (11.0)	0.116
Hypertension (uncomplicated)	2082 (18.0)	541 341 (33.1)	0.350
Hypothyroidism	875 (7.6)	162 961 (10.0)	0.084
Liver disease	540 (4.7)	98 589 (6.0)	0.060
Lymphoma	66 (0.6)	16 477 (1.0)	0.049
Metastatic cancer	236 (2.0)	99 922 (6.1)	0.207
Obesity	2004 (17.3)	340 300 (20.8)	0.088
Other neurologic disease	532 (4.6)	106 025 (6.5)	0.082
Paralysis	174 (1.5)	25 933 (1.6)	0.006
Peptic ulcer disease	85 (0.7)	16 568 (1.0)	0.030
Peripheral vascular disease	664 (5.7)	134 815 (8.2)	0.098
Psychosis	80 (0.7)	11 260 (0.7)	0.001
Pulmonary or circulatory disorder	299 (2.6)	60 666 (3.7)	0.064
Kidney failure	832 (7.2)	161 257 (9.8)	0.095
Rheumatoid arthritis	211 (1.8)	48 932 (3.0)	0.076
Solid tumor without metastases	686 (5.9)	282 587 (17.3)	0.359
Valvular disease	527 (4.6)	120 989 (7.4)	0.120
Weight loss	630 (5.5)	95 936 (5.9)	0.018
ASA physical status classification, mean (SD)	2.36 (0.76)	2.50 (0.75)	0.177
Emergency case	2667 (23.1)	103 638 (6.3)	0.487
High-risk patient ^b	2293 (19.8)	409 887 (25.0)	0.125

Abbreviation: ASA, American Society of Anesthesiologists.

^a Unless otherwise indicated.

^b Defined as a patient in the top 25th percentile of risk of the composite outcome, as estimated using a multivariable logistic regression adjusted for age, sex, Elixhauser comorbidities, and ASA physical classification and emergency status.

orthopedic surgery, or urologic surgery), although all point estimates for surgical specialties were greater than zero (Table 3).

Prespecified sensitivity analyses that redefined the exposure, outcome, or model found increases in risk of the composite outcome that were in line with direction and magnitude of the primary analysis, with point estimates generally ranging from greater than 0.1% to less than 1.0%

Table 2. Unadjusted and Adjusted Estimates of Primary and Secondary Outcomes^a

Outcome	Incidence (95% CI), %		Risk difference (95% CI), % ^b	P value
	Anesthesiologist worked ≥16 h	Anesthesiologist worked <16 h		
Composite outcome ^c				
Unadjusted	12.3 (11.7-12.9)	12.0 (12.0-12.1)	0.3 (−0.3 to 0.9)	.38
Adjusted	12.1 (11.6-12.5)	12.0 (12.0-12.0)	0.1 (−0.4 to 0.5)	.82
Secondary outcomes				
In-hospital death				
Unadjusted	1.7 (1.6-1.9)	1.0 (1.0-1.0)	0.7 (0.6-0.9)	<.001
Adjusted	1.3 (1.1-1.6)	1.0 (1.0-1.0)	0.3 (0.1-0.5)	.009
Myocardial infarction				
Unadjusted	0.8 (0.6-1.0)	1.1 (1.1-1.1)	−0.3 (−0.5 to −0.1)	.002
Adjusted	1.2 (1.0-1.3)	1.1 (1.1-1.1)	0.1 (−0.1 to 0.2)	.37
Stroke				
Unadjusted	0 (0-0)	0 (0-0)	0 (0-0)	.18
Adjusted	0 (0-0)	0 (0-0)	0 (0-0)	.02
Other thromboembolic event ^d				
Unadjusted	2.3 (2.0-2.5)	2.1 (2.1-2.2)	0.1 (−0.1 to 0.4)	.30
Adjusted	1.9 (1.7-2.2)	2.1 (2.1-2.1)	−0.2 (−0.4 to 0.1)	.16
Acute kidney injury				
Unadjusted	7.4 (6.9-7.8)	6.7 (6.6-6.7)	0.7 (0.2-1.1)	.004
Adjusted	7.1 (6.6-7.5)	6.7 (6.7-6.7)	0.4 (−0.1 to 0.8)	.08
Anesthesia-related complications				
Unadjusted	0.2 (0.1-0.3)	0.2 (0.2-0.2)	0 (−0.1 to 0.1)	.90
Adjusted	0.2 (0.1-0.3)	0.2 (0.2-0.2)	0 (−0.1 to 0.1)	.67
Major respiratory complication ^e				
Unadjusted	6.1 (5.7-6.6)	5.7 (5.7-5.7)	0.4 (0.0-0.8)	.07
Adjusted	6.0 (5.6-6.3)	5.7 (5.7-5.7)	0.3 (−0.1 to 0.6)	.15
Mesenteric ischemia				
Unadjusted	1.5 (1.4-1.7)	1.0 (1.0-1.0)	0.5 (0.4-0.7)	<.001
Adjusted	1.0 (0.8-1.2)	1.0 (1.0-1.0)	0.1 (−0.1 to 0.3)	.58

^a Adjusted estimates were estimated using linear probability models adjusted for age, sex, Elixhauser comorbidities, American Society of Anesthesiologist physical status classification and emergency status, and fixed effects for anesthesiologist, surgical procedure type, and hour of case start.

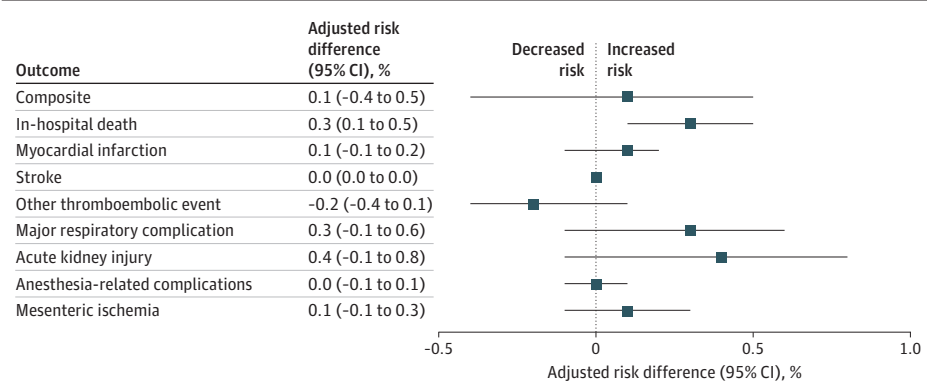
^b Represents the increase or decrease in incidence of the outcome associated with anesthesiologist extended work shift (≥16 hours of continuous intraoperative work).

^c The primary composite outcome represented in-hospital death or occurrence of any of the other listed complications.

^d Pulmonary embolism, deep vein thrombosis, or venous thromboembolism.

^e Aspiration pneumonitis and/or postoperative respiratory failure.

Figure. Forest Plot Showing Adjusted Estimates of Primary and Secondary Outcomes



The primary composite outcome represented in-hospital death or occurrence of any of the other listed complications. Estimates were adjusted for age, sex, Elixhauser comorbidities, American Society of Anesthesiologist physical status classification and emergency status, and fixed effects for anesthesiologist, surgical procedure type, and hour of case start.

(Table 4). Of note, defining fatigue as a binary exposure using a threshold of working 12 hours or longer revealed a 1.1% higher risk of the composite outcome (95% CI, 0.8%-1.5%; $P < .001$), and modeling the exposure as an ordinal outcome revealed a 2.2% higher risk of the composite outcome (95% CI, 1.2%-3.1%; $P < .001$) and a 1.1% higher risk (95% CI, 0.0%-2.1%; $P < .001$) in patients treated by anesthesiologists who had worked 16 hours or longer to less than 18 hours or 18 hours or longer to less than 20 hours, respectively.

Table 3. Adjusted Estimates of Primary Outcome in Select Subgroups

Subgroup	Incidence (95% CI), %		Risk difference (95% CI), %	P value
	Anesthesiologist worked ≥ 16 h	Anesthesiologist worked < 16 h		
High-risk patients ^a (n = 412 179)	42.0 (40.2-43.9)	40.6 (40.6-40.6)	1.4 (-0.4 to 3.3)	.13
Trainee, nurse anesthetist, or anesthesia assistant involvement ^b				
No involvement (n = 203 488)	7.3 (6.4-8.2)	7.9 (7.9-7.9)	-0.5 (-1.4 to 0.4)	.26
With involvement (n = 1 445 227)	12.7 (12.2-13.2)	12.6 (12.6-12.6)	0.1 (-0.4 to 0.6)	.73
Surgical subgroups ^c				
Cardiovascular (n = 142 163)	45.9 (42.6-49.3)	44.6 (44.6-44.6)	1.3 (-2.0 to 4.9)	.43
Orthopedic (n = 362 133)	9.7 (8.1-11.4)	9.2 (9.2-9.2)	0.6 (-1.1 to 2.2)	.50
Urologic (n = 86 063)	13.5 (9.6-17.4)	10.0 (10.0-10.0)	3.5 (-0.4 to 7.4)	.08
Neurosurgical (n = 145 799)	16.0 (13.0-19.0)	14.3 (14.3-14.3)	1.7 (-1.3 to 4.7)	.27

^a Defined as those in the top 25th percentile of risk of the composite outcome, as estimated using a multivariable logistic regression adjusted for age, sex, Elixhauser comorbidities, and American Society of Anesthesiologists physical classification and emergency status.

^b Defined as the involvement of any trainee (resident or fellow physician), nurse anesthetist, or anesthesia assistant at any point during the case.

^c Defined using *Current Procedural Terminology* codes (cardiovascular surgery: 33016-37799; orthopedic surgery: 20100-29999; urologic surgery: 50010-55899; and neurosurgery: 61000-64999).

Table 4. Sensitivity Analyses

	Incidence (95% CI), %		Risk difference (95% CI), %	P value
Variable	Anesthesiologist worked ≥16 h	Anesthesiologist worked <16 h		
Respecified statistical approach				
Without fixed effects for hour of case start	12.9 (12.4-13.3)	12.0 (12.0-12.0)	0.8 (0.4-1.3)	<.001
Without fixed effects for anesthesiologist	12.9 (12.5-13.4)	12.0 (11.9-12.2)	0.9 (0.5-1.4)	<.001
SEs clustered at level of institution rather than anesthesiologist	12.9 (12.3-13.4)	12.0 (12.0-12.0)	0.8 (0.3-1.4)	.002
Logistic regression	13.0 (12.4-13.5)	12.1 (12.1-12.1)	0.9 (0.4-1.4)	.001
Respecified definition of exposure				
Extended work defined as working ≥12 h	13.1 (13.0-13.5)	12.0 (12.0-12.0)	1.1 (0.8-1.5)	<.001
Extended work defined as working ≥20 h	12.0 (11.5-12.5)	12.0 (12.0-12.0)	0 (−0.6 to 0.5)	.92
Hours worked modeled as ordinal variable				
≥0 to <16 (reference)	12.0 (12.0-12.0)	NA	1.0 [Reference]	NA
≥16 to <18 (n = 3395)	14.2 (13.3-15.2)	NA	2.2 (1.2-3.1)	<.001
≥18 to <20 (n = 2093)	13.1 (12.1-14.1)	NA	1.1 (0.0-2.1)	<.001
≥20 to <22 (n = 1419)	12.6 (11.4-13.8)	NA	0.6 (−0.6 to 1.8)	.33
≥22 to <24 (n = 1105)	12.2 (11.1-13.4)	NA	0.2 (−1.0 to 1.3)	.74
≥24 (n = 3544)	11.7 (11.1-12.4)	NA	−0.3 (−1.0 to 0.3)	.35
Respecified definition of outcome				
Included surgical site infections as part of composite outcome	13.2 (12.7-13.7)	12.4 (12.4-12.4)	0.8 (0.4-1.3)	.001

Abbreviation: NA, not applicable.

Discussion

Understanding the effects of extended work hours is crucial given the potential impact on patient outcomes and implications for physician well-being. Given the high-stakes nature of anesthesiologists' work and their need for rapid decision-making and sustained vigilance, fatigue from extended work hours may plausibly result in serious errors and impact patient safety. Thus, in this large, multicenter, cross-sectional study, we examined the association between anesthesiologist extended work periods (defined as being signed in to a surgical case for ≥ 16 continuous hours) and patient outcomes. Our approach yielded estimates that represent the difference in incidence of patient outcomes for the same anesthesiologist when in an extended work period vs not, assuming the same surgical procedure and same start time of the surgery.

Although the primary analysis found no statistically significant association between 16-hour or longer work periods and combined mortality and morbidity complications, the primary and multiple sensitivity analyses found small increases in point estimates for risk of this composite outcome ranging from 0.1% or more to 1.0% or less. The primary analysis, specified as a linear probability model, allowed estimation of absolute risk differences and inclusion of a large number of fixed effects representing individual anesthesiologists; the point estimates and 95% CIs from sensitivity analyses replicate and lend credence to the general direction and magnitude of findings from the primary analysis.^{17,18} Similarly, focusing on the prespecified secondary outcome of in-hospital mortality, we found an absolute increase of 0.3% in incidence (relative increase of 30.0%) for patients treated by anesthesiologists who had worked 16 hours or more compared with those who had not, along with small absolute increases in multiple other secondary outcomes that did not reach statistical significance. Together these findings were directionally consistent and imply that there may be a small increase in severe morbidity and mortality in patients treated by anesthesiologists in extended work shifts.

This study advances understanding of attending anesthesiologist extended work periods and patient outcomes by providing estimates from a large, multicenter registry. Our findings are consistent with those for other specialties that have demonstrated variable associations between physician work shift length and outcomes. Randomized trials^{5,19} comparing first-year residents who were exposed or unexposed to 16-hour shift limits have found no difference in patient outcomes, such as mortality, although medical errors may have been reduced by the team-based nature of hospital-based internal medicine and surgical practice. A prior MPOG analysis⁴ similarly found no association between patient outcomes and attending surgeon fatigue, defined as surgeons who performed operations on both the day and night before. In contrast, studies²⁰⁻²² using polysomnography and performance testing in emergency physicians demonstrated slower reaction times, poorer cognition and procedural skills, and more triage errors as night shifts progressed. Survey data across multiple specialties, including anesthesiology, found that physicians with severe sleep impairment also reported higher rates of significant medical errors.²² This study furthers our understanding of the magnitude of effect of fatigue on anesthesiologists' patient outcomes, showing slight (generally $<1.0\%$) absolute increases in major morbidity and mortality. Although these absolute risks are small, they are not inconsequential because (1) the overall incidence of in-hospital perioperative major morbidity and mortality is also low at approximately 2.5% to 3.0% for noncardiac surgery,²³ meaning that even a 0.1% increase attributable to physician fatigue is meaningful, particularly in the context of the more than 30 million noncardiac and 250 000 cardiac operations performed in the US annually, and (2) any death or major organ injury associated with physician fatigue is potentially preventable.

Our study has implications for anesthesiologist staffing and patient safety. US anesthesiologist shortages, related to increasing surgical volumes and declining workforce,²⁴ may lead to more prolonged shifts. Appropriate anesthesiologist coverage must be weighed against fatigue and risk of medical errors causing patient harm.

Limitations

This study has important limitations. First, our analysis focused on comparing outcomes from cases performed by anesthesiologists who had worked at least once for 16 hours or longer, meaning that findings selectively represent patient outcomes for anesthesiologists who either chose to work 16 hours or longer at a time or who were part of a practice model that required prolonged shifts. Second, many of the included centers were academic institutions, and our results may not apply to nonacademic centers with different patient populations, staffing models, or policies regarding work shifts. Third, because this was a retrospective cross-sectional study, we were unable to account for characteristics between groups that were unobservable. We considered that patients cared for by anesthesiologists on extended work shifts may be at higher risk at baseline, but the opposite was true: these patients were in fact less likely to be at high risk, making their increased mortality rates even more notable. Fourth, the MPOG dataset is limited to in-hospital, predischARGE outcomes defined using diagnosis codes; therefore, we were unable to estimate longer-term outcomes. Furthermore, because administrative claims generally ascertain in-hospital death more reliably than secondary diagnosis codes for complications, estimates for mortality may be more robust than estimates for complications occurring proximate to death, which are more susceptible to misclassification and timing ambiguity.^{25,26} Fifth, our dataset did not include additional information about anesthesiologists (eg, age, sex, years in practice), and we therefore were unable to perform subgroup analyses based on these characteristics. Sixth, our approach to defining anesthesiologist extended work periods was based on surgical case sign-ins; however, we were unable to capture additional time spent on other tasks, such as managing difficult airways or labor epidurals in other parts of the hospital, extended preoperative or postoperative management of patients, or setting up medications or equipment for complex cases. Seventh, we were unable to study physician-specific outcomes related to fatigue, such as impacts on wellness, burnout, or major incidents, such as motor vehicle crashes, that did not directly contribute to patient harm.

Conclusions

In this cross-sectional study of patients treated by anesthesiologists who had or had not worked for an extended duration, primary and sensitivity analyses found small but meaningful (<1.0%) increases in combined morbidity and mortality, along with small increases in some secondary outcomes (eg, 0.3% absolute increase and 30.0% relative increase in in-hospital mortality). These results suggest that policies limiting anesthesiologist work hours may be important in promoting patient safety. Future analyses may evaluate what specific errors or other root causes may explain the increased incidence of adverse outcomes in patients treated by anesthesiologists who have worked for extended periods and may identify qualitative, physician-informed methods to define fatigue.

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REFERENCES

1. Caldwell JA, Mallis MM, Caldwell JL, Paul MA, Miller JC, Neri DF; Aerospace Medical Association Fatigue Countermeasures Subcommittee of the Aerospace Human Factors Committee. Fatigue countermeasures in aviation. *Aviat Space Environ Med*. 2009;80(1):29-59. doi:10.3357/ASEM.2435.2009
2. Lerner BH. A life-changing case for doctors in training. *New York Times*. March 3, 2009. Accessed January 19, 2023. <https://www.nytimes.com/2009/03/03/health/03zion.html>
3. Accreditation Council for Graduate Medical Education. Summary of proposed changes to ACGME common program requirements section VI. Accessed January 19, 2023. <https://www.acgme.org/What-We-Do/Accreditation/Common-Program-Requirements/Summary-of-Proposed-Changes-to-ACGME-Common-Program-Requirements-Section-VI>
4. Sun EC, Mello MM, Vaughn MT, et al. Assessment of perioperative outcomes among surgeons who operated the night before. *JAMA Intern Med*. 2022;182(7):720-728. doi:10.1001/jamainternmed.2022.1563
5. Silber JH, Bellini LM, Shea JA, et al; iCOMPARE Research Group. Patient safety outcomes under flexible and standard resident duty-hour rules. *N Engl J Med*. 2019;380(10):905-914. doi:10.1056/NEJMoat1810642
6. Rajaram R, Chung JW, Jones AT, et al. Association of the 2011 ACGME resident duty hour reform with general surgery patient outcomes and with resident examination performance. *JAMA*. 2014;312(22):2374-2384. doi:10.1001/jama.2014.15277
7. Schlick CJR, Hewitt DB, Quinn CM, et al. A national survey of motor vehicle crashes among general surgery residents. *Ann Surg*. 2021;274(6):1001-1008. doi:10.1097/SLA.0000000000003729
8. Williams GW, Shankar B, Klier EM, et al. Sensorimotor and executive function slowing in anesthesiology residents after overnight shifts. *J Clin Anesth*. 2017;40:110-116. doi:10.1016/j.jclinane.2017.04.002
9. Howard SK, Gaba DM, Rosekind MR, Zarcone VP. The risks and implications of excessive daytime sleepiness in resident physicians. *Acad Med*. 2002;77(10):1019-1025. doi:10.1097/00001888-200210000-00015

10. Howard SK, Rosekind MR, Katz JD, Berry AJ. Fatigue in anesthesia: implications and strategies for patient and provider safety. *Anesthesiology*. 2002;97(5):1281-1294. doi:10.1097/00000542-200211000-00035
11. Stuetzle KV, Pavlin BI, Smith NA, Weston KM. Survey of occupational fatigue in anaesthetists in Australia and New Zealand. *Anaesth Intensive Care*. 2018;46(4):414-423. doi:10.1177/0310057X1804600411
12. Multicenter Perioperative Outcomes Group. Home page. Accessed January 19, 2023. <https://mpog.org/>
13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Epidemiology*. 2007;18(6):800-804. doi:10.1097/EDE.0b013e3181577654
14. Greene W. The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. *Econom J*. 2004;7(1):98-119. doi:10.1111/j.1368-423X.2004.00123.x
15. Hellevik O. Linear versus logistic regression when the dependent variable is a dichotomy. *Qual Quant*. 2009;43(1):59-74. doi:10.1007/s11135-007-9077-3
16. Wooldridge JM. *Econometric Analysis of Cross Section and Panel Data*. MIT Press; 2010.
17. Wasserstein RLLN. The ASA's statement on P values: context, process, and purpose. *Am Stat*. 2016;70(2):129-133. doi:10.1080/00031305.2016.1154108
18. Thomas LE, Pencina MJ. Do not over (P) value your research article. *JAMA Cardiol*. 2016;1(9):1055. doi:10.1001/jamacardio.2016.3827
19. Bilimoria KY, Chung JW, Hedges LV, et al. National cluster-randomized trial of duty-hour flexibility in surgical training. *N Engl J Med*. 2016;374(8):713-727. doi:10.1056/NEJMoa1515724
20. Smith-Coggins R, Rosekind MR, Buccino KR, Dinges DF, Moser RP. Rotating shiftwork schedules: can we enhance physician adaptation to night shifts? *Acad Emerg Med*. 1997;4(10):951-961. doi:10.1111/j.1553-2712.1997.tb03658.x
21. Smith-Coggins R, Rosekind MR, Hurd S, Buccino KR. Relationship of day versus night sleep to physician performance and mood. *Ann Emerg Med*. 1994;24(5):928-934. doi:10.1016/S0196-0644(94)70209-8
22. Dula DJ, Dula NL, Hamrick C, Wood GC. The effect of working serial night shifts on the cognitive functioning of emergency physicians. *Ann Emerg Med*. 2001;38(2):152-155. doi:10.1067/mem.2001.116024
23. Smilowitz NR, Gupta N, Ramakrishna H, Guo Y, Berger JS, Bangalore S. Perioperative major adverse cardiovascular and cerebrovascular events associated with noncardiac surgery. *JAMA Cardiol*. 2017;2(2):181-187. doi:10.1001/jamacardio.2016.4792
24. Menezes J, Zahalka C. Anesthesiologist shortage in the United States: a call for action. *J Med Surg Public Health*. 2024;2:100048. doi:10.1016/j.glmedi.2024.100048
25. Zeltzer D, Balicer RD, Shir T, Flaks-Manov N, Einav L, Shadmi E. Prediction accuracy with electronic medical records versus administrative claims. *Med Care*. 2019;57(7):551-559. doi:10.1097/MLR.0000000000001135
26. Quan H, Parsons GA, Ghali WA. Assessing accuracy of diagnosis-type indicators for flagging complications in administrative data. *J Clin Epidemiol*. 2004;57(4):366-372. doi:10.1016/j.jclinepi.2003.01.002

SUPPLEMENT 1.

eMethods 1. Additional Information on Cohort Construction

eTable 1. Steps in Cohort Construction

eMethods 2. Additional Information on Construction of the Exposure Variable

eTable 2. Codes Used to Define Primary and Secondary Outcomes

eTable 3. Top 50 CPTs Represented in Study Sample, by Total and Exposure-Specific Frequency

eReferences

SUPPLEMENT 2.

Data Sharing Statement