Call-Shift Fatigue and Use of Countermeasures and Avoidance Strategies by Certified Registered Nurse Anesthetists: A National Survey

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This study surveyed Certified Registered Nurse Anesthetist (CRNA) members of the American Association of Nurse Anesthetists (AANA) on their frequency of call-shift fatigue, fatigue symptoms, medical errors associated with fatigue, and use of fatigue countermeasures and avoidance strategies. A secondary aim was to identify predictors of call-shift fatigue. An invitation to complete an anonymous electronic survey was sent to 2,500 randomly selected AANA members. Data were collected on CRNAs' fatigue experience, call-shift length and frequency, errors in patient care, and use of fatigue countermeasures and avoidance strategies. Analysis included descriptive and inferential statistics. Logistic regression was used to identify predictors of call-shift fatigue.

Of 325 CRNAs who provided data, 82% reported experiencing call-shift fatigue, 87% used fatigue countermeasures, 77% used fatigue-avoidance strategies, and 28% reported committing a medical error because of fatigue. Predictors included hours to recovery from a call shift (odds ratio [OR] = 1.08, 95% confidence interval [CI] = 1.04-1.12), working 5 to 6 calls per month (OR = 3.78, CI = 1.17-12.23), working 7 or more calls per month (OR = 4.87, CI = 1.93-12.33), use of fatigue countermeasures (OR = 5.44, CI = 2.15-13.77), and fatigue symptoms (OR = 2.19, CI = 1.03-4.67). Call-shift fatigue is a common problem among CRNAs and is associated with medical errors and negative health consequences.

Keywords: Anesthesia, call shift, countermeasures, fatigue, nurse anesthetists.

Workplace fatigue for anesthesia providers poses public health and safety concerns.[1] More than 40 million anesthetics are administered each year for diagnostic, interventional, obstetric, and surgical procedures, with Certified Registered Nurse Anesthetists (CRNAs) serving as the hands-on provider in more than 34 million of these procedures in the United States. Shortages in anesthesia providers, combined with increasing number and complexity of procedures requiring anesthesia support throughout the day and night, have put ever-increasing demands on CRNAs to provide safe anesthesia care.[2] These demands pose both a public health and safety concern because they may lead to sleep deprivation and fatigue.[1-3]

A large body of research has identified the negative consequences of sleep-related fatigue on performance and patient outcomes.[4-12] Rogers et al[11] found that nurses who worked shifts longer than 12.5 hours were 3 times more likely to make a patient error. Lapses in concentration and fatigue due to working extended shifts were identified to be common factors for needlestick injuries in medical interns.[12] Needlestick rates are higher in nurses who work long shifts (> 13 hours), work more weekends, and work shifts other than the day shift.[10]

The impact of sleep-related fatigue can also have negative consequences on the health and safety of CRNAs. Negative consequences include increased risk of obesity and associated complications such as diabetes, hypertension, and cardiovascular disease, and higher rates of motor vehicle accidents.[13] Biddle and Aker[1] in 2011 reported the results of a large national survey of CRNAs (N = 1,284). They found that 25% of CRNAs reported fragmented sleep, and 68% are excessively tired during the day; 16% of them reported experiencing sleep-related behaviors during a case, and alarmingly, 49% have witnessed a colleague asleep during a surgical case.

• ***Definition.*** *Fatigue* is a common symptom of normal physiologic and psychological response to exertion or stress that is associated with a lessened capacity or motivation for work or efficiency; it is usually accompanied by weariness, irritability, and sleepiness.[4,14] It may arise unexpectedly from any cause when energy expenditure exceeds a person's capability. Acute fatigue, characterized as occurring over a short period, is protective for the individual, is experienced in healthy persons, and

is relieved by rest.[15] In contrast, chronic fatigue does not have a known purpose, can have multiple causes, is frequently related to an illness (not exertion or sleep deprivation), persists over time, and may not be relieved by rest. Chronic fatigue is typically more problematic when pathologic conditions arise from constant fatigue; however, even acute fatigue can become problematic if situational demands require higher level cognitive functioning and complex psychomotor skills.[16]

Partial chronic sleep deprivation occurs when an individual receives less sleep per night than his or her optimal time and accumulates a sleep "debt." Over time, a sleep debt can manifest as declines in attention and cognitive performance.[17] Unlike chronic fatigue, a sleep debt is typically relieved by sleep. Fatigue experts have presented evidence that extended shift length (working shifts longer than 12 hours) is related to poor performance and decreased vigilance in medical personnel[8,10,12,18] and anesthesia providers.[6,7]

• ***Fatigue-Avoidance Strategies and Fatigue Countermeasures.*** Experts in healthcare worker and aviation fatigue support the use of fatigue-avoidance strategies and fatigue countermeasures, as well as policies that limit consecutive calls and require time off between shifts.[2,19-24] *Fatigue-avoidance strategies* are practices to prevent fatigue, whereas a *countermeasure* describes practices to counteract fatigue. Examples of fatigue-avoidance strategy include healthy sleep practices, avoidance of stimulants before bed, going to sleep and awakening at the same time each day, and taking a nap before a long shift. *Fatigue countermeasure* examples include tactics such as taking naps, activity breaks (to include mild physical activity such as walking and increased social interaction), increasing lighting intensity, and use of stimulants, such as drinking caffeinated products.[25]

Multiple research studies have demonstrated the effectiveness of fatigue-avoidance strategies and countermeasures. Hayashi et al[21] examined combinations of fatigue-avoidance strategies and countermeasures and found improved performance on computer tasks and decreased daytime sleepiness when a person combined a short nap with ingestion of caffeine, exposure to light, or face washing. Schweitzer et al[23] reported an evening nap on the first 2 of 4 consecutive night shifts plus caffeine improved performance on the Psychomotor Vigilance Test and decreased subjective sleepiness in subjects working the night shift. Other investigators have found that drinking coffee or napping at night significantly reduced driving impairment without altering sleep; however, these effects may vary from person to person.[22] Scott et al[26] developed a fatigue-countermeasure program for nurses based on strategies used in other high-risk industries, which included strategic naps and breaks; they found significant improvements in nurses' sleep duration, sleep quality, alertness, and error prevention. Caldwell et al,[27] in their review, suggest that when sleep opportunities are temporarily inadequate (eg, those that occur when providing on-call anesthesia services), a person should limit time on each task, strategically nap, and use alertness-enhancing compounds such as caffeine. They also noted that some individuals might be more prone to effects of chronic sleep debt than others. Biddle and Aker[1] reported that CRNAs use a variety of fatigue countermeasures such as standing and walking around during a case, interacting socially with the surgical team, reading lay literature, and asking for a break from clinical care.

• ***Study Purpose.*** The results of the national survey by Biddle and Aker[1] highlight the problem of CRNA fatigue and the need for further research. Given that many CRNAs work extended call shifts (eg, 24-hour call)[2] and serve as the sole anesthesia provider on call in many rural and small military hospitals, it is critical that we examine the problem of "on-call" fatigue. Therefore, the purpose of this study was to survey CRNA members of the American Association of Nurse Anesthetist (AANA) on their frequency of call-shift fatigue, fatigue symptoms, medical errors associated with fatigue, and use of fatigue countermeasures and avoidance strategies. A secondary aim was to identify predictors of call-shift fatigue.

Methods

A nationally representative random sample of AANA members were asked to complete an electronic survey about call-shift fatigue countermeasures and strategies in Fall 2010. The study was approved by the institutional review board at the University of San Diego and was distributed by the AANA. Potential participants (N = 2,500) were recruited via an email invitation generated by a paid web survey company contracted by the AANA. Two weeks after the initial invitation, a second email reminder was sent to potential participants. The invitation stated that a completed and returned survey would serve as implied consent. Inclusion criteria were male and female members in active practice with previously completed AANA demographic questionnaires and report of taking call (on-demand anesthesia services provided after hours).

• ***Survey Description.*** The lead author of this article developed a 26-item survey, derived from the literature and clinical practice. The survey included rated responses and open-ended questions to elicit data on CRNAs' fatigue experience, use of fatigue countermeasures, and fatigue-avoidance strategies. The survey contained multiple questions related to the following: (1) call-shift length and frequency, (2) strategies used to prevent fatigue before call (fatigue-avoidance strategies), (3) use of fatigue countermeasures during call, (4) error in patient care because of fatigue, (5) experience of health symptoms while fatigued, and (6) questions related to fatigue experience during military deployment if applicable (Table 1). A panel composed of a fatigue expert

1. Do you participate in "call" services at your workplace (on-demand services provided after hours)? Yes, No
2. What is the *scheduled duration* of your weekday call? < 15 h, 16 h, 17-23 h, 24 h, > 25 h
3. What is the *scheduled duration* of your weekend/holiday call? < 15 h, 16 h, 17-23 h, 24 h, >25 h
4. In an average *month*, how many calls do you have? < 2, 3-4, 5-6, 7-8, > 9
5. In an average *week*, how many days do you provide anesthesia including call? (Include OR time, OB and out-of-OR anesthesia duties)? < 3, 4, 5, 6, 7
6. Do you experience fatigue *during* call? Rarely (once/y), Occasionally (4 times/y), Frequently (once per month), Often (nearly every call), Do not work call
7. What *fatigue-avoidance* strategies do you use prior to call to avert fatigue? In order of frequency, list the fatigue-avoidance strategies. Describe and quantify what you do.
8. Which strategy do you think is most effective?
9. When you experience fatigue, what *fatigue countermeasures* do you use to minimize the effects? In order of frequency, list the fatigue countermeasure(s) you use. Describe and quantify what you do.
10. Which countermeasure do you think is most effective?
11. How many fatigue-avoidance strategies do you use prior to call? 0, 1, 2, 3, > 4
12. How many fatigue countermeasures do you use during call? 0, 1, 2, 3, > 4
13. Prior to call, what is the average number of consecutive hours you are awake?
14. What is the average number of consecutive hours you are awake *after* starting a call shift?
15. During call if you need to prepare for a case or procedure and feel fatigued, do you perform a fatigue countermeasure? Yes, No
    List countermeasures performed.
16. Have you *ever* committed an error in patient care while doing anesthesia because you were fatigued? Yes, No
    Please explain the number of occasions and what you did during the situation, if anything.
17. Do you feel fatigue is a common problem CRNAs experience? Yes, No, Do not know
18. How long does it take you to "recover" from a call shift? List number of hours.
19. When you experience fatigue, do you experience physical or psychological symptoms? Yes, No
    If yes, please explain.

Questions 20-23 answered by military CRNAs

20. How many days were you deployed? < 30 d, 31-90 d, 91-180 d, 181-210 d, > 210 d
21. Do you feel you had adequate time for sleep in order to perform your anesthesia duties safely while deployed? Yes, No, Sometimes
22. Have you *ever* committed an error in patient care, while doing anesthesia because you were fatigued while deployed? Yes, No
    Please explain the number of occasions and what you did during the situation, if anything.
23. Do you feel *fatigue* is a common problem military CRNAs experience during deployment? Yes, No, Do not know
24. What is your gender? Female, Male
25. Please list your age:
26. Is there anything you would like to add regarding CRNA or job-related fatigue?

Table 1. Survey Questions
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; OB, obstetrics; OR, operating room.

and 3 doctoral-prepared nurse scientists were consulted to establish content validity of survey items. The survey was pilot tested with 6 CRNAs before distribution.

Fatigue is a common symptom of normal physiologic and psychological response to exertion or stress. For this survey, *fatigue* was defined as "a feeling of mental or physical exhaustion, beyond being tired as a result of continued stimulation." *Fatigue-avoidance* strategies were defined as "an action that would prevent the individual from becoming fatigued." *Fatigue-avoidance strategy* examples include healthy sleep practices, avoidance of stimulants before bedtime, going to sleep and awakening at the same time each day, and taking a nap before a long shift.[25] *Fatigue countermeasures* were defined as "actions used to oppose the effects of fatigue." Examples include tactics such as taking naps, activity breaks (to include mild physical activity such as walking and increased social interaction), increasing lighting intensity, and use of stimulants.[25] The survey questions and response choices are listed in Table 1.

• ***Data Analysis.*** Data were analyzed using a statistical analysis software program (SPSS 21.0, IBM). Descriptive characteristics of the sample were compared using *t* tests for continuous variables and χ^2 tests for categorical variables. The experience of call-shift fatigue in question 6 was dichotomized (yes = occasionally [4 times per year], frequently [once per month], or often [nearly every call] vs no = rarely [once per year]). It was then tested for

Variable	No.[a] (%) or mean ± SD (range)
Gender	
Female	179 (55.2)
Male	145 (44.8)
Age, y	47.9 ± 10.3 (range, 29-73)
Call-shift length, h	
Weekday ≤ 16	174 (53.8)
Weekday 17-24	122 (37.2)
Weekday ≥ 25	26 (8.0)
Weekend ≤ 16	80 (24.7)
Weekend 17-24	123 (38.0)
Weekend ≥ 25	118 (36.5)
Number of anesthesia days in workweek (including call)	
≤ 3	55 (17.1)
4	91 (28.3)
5	139 (43.2)
6	24 (7.5)
7	13 (4.0)
Number of call shifts per month	
≤ 4	167 (51.4)
5-6	66 (20.3)
≥7	92 (28.3)
Experience fatigue during call	
Rarely (once per year)	58 (18.0)
Occasionally (4 times per year)	126 (39.0)
Frequently (once per month)	104 (32.2)
Often (nearly every call)	35 (10.8)
Do you think CRNA fatigue is common?	
No	32 (9.9)
Yes	236 (73.1)
Do not know	55 (17.0)
Physical or psychological symptoms when fatigued?	
No	64 (19.8)
Yes	215 (66.5)
No response	44 (13.6)
Committed an error in patient care because of fatigue?	
No	222 (68.7)
Yes	91 (28.2)
Not sure/refuse to answer	10 (3.1)
Fatigue-avoidance strategies	
Number who use a fatigue-avoidance strategy	249 (77.0)
Average number used prior to call	1.30 ± 0.958 (range, 0-4)
Fatigue countermeasures	
Number who use a fatigue countermeasure	281 (87.0)
Average number used during call	1.65 ± 1.02 (range, 0-4)

Table 2. Demographic and Call-Shift Characteristics of Survey Respondents (N = 325)
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; SD, standard deviation.
[a] Some do not total to 325 because some respondents did not answer that

an association with categorical variables using a χ^2 test. These categorical variables were collapsed into smaller categories for analysis and were postulated to be related to call-shift fatigue (Table 2). Next, all variables with a $P < .1$ were entered as a block into a logistic regression model to identify potential predictors of the outcome of call-shift fatigue. All categorical variables were collapsed into dichotomous variables (yes or no). Only variables with a $P < .2$ were retained in the final model. Odds ratios (ORs) with 95% confidence intervals (CIs) were

calculated. Open-ended questions that inquired about associated factors of fatigue were coded using the constant comparison method. A $P < .05$ was considered significant. Using a 10% response rate, we calculated that we would need to send out 2,500 email invitations to receive 250 completed surveys.

Results

A total of 388 participants opened the survey, 347 provided usable data, and of those, 325 met the criterion of taking call and were included in the analysis (response rate, 13%). Descriptive characteristics of the sample overall and by fatigue experience are presented in Table 2. The sample was nearly evenly distributed by gender, with slightly more female respondents (55%, n = 179). Ages ranged from 29 to 73 years old (mean ± SD, 47.9 ± 10.2). Slightly more than half worked a weekday call shift of 16 hours or less (53.8%, n = 173 of 322 CRNAs responding to this question), and 146 (45.2%) reported 17-hour weekday call shifts and longer. For weekend call, 74.5% (241/321) reported call shifts of at least 17 hours. In an average week including call, 45.3% (n = 146) worked 4 days or less, 43.2% (n = 139) worked 5 days a week, and 11.4% (n = 37) worked 6 or 7 days per week. Approximately half of the respondents (51.4%; n = 167) reported working 4 or fewer call shifts per month.

When asked about the experience of fatigue during call, 82.0% (265/323) reported experiencing fatigue during call occasionally, frequently, or often; only 18% (n = 58) reported it rarely. Almost three-fourths of CRNAs (73.1%, 236 of 323) believed that fatigue was a common problem. Approximately two-thirds (66.5%, n = 215) experienced physical or psychological symptoms with fatigue. Fatigue-avoidance strategies were used by 77% of the respondents (n = 249), and fatigue countermeasures by 87% (n = 281). Roughly one-third of respondents (28.2%, n = 91) reported they had committed a patient care error because of fatigue.

Of the 325 who responded to the survey, 33 (10.2%) were military CRNAs. More than one-third (39.4%, n = 13) reported being deployed for 90 days or less, 15.2% (n = 5) for 91 to 180 days, and 45.4% (n = 15) for 181 days or more. When asked "Do you feel you had adequate time for sleep in order to perform your anesthesia duties safely while deployed?", 54.5% (n = 18) reported yes, 12.1% (n = 4) reported no, and 33% (n = 11) reported sometimes. Only 3 (9.1%) reported ever committing an error in patient care while administering anesthesia because they were fatigued while deployed. Of 36 respondents, 16 (47.2%) reported they believed fatigue was a common problem that military CRNAs experience during deployment, 4 (11.1%) said no, and n = 15 (41.7%) said they do not know.

Results of the analysis of associations between CRNA experience of call-shift fatigue and potential predictors are listed in Table 3. The CRNAs who reported experiencing call-shift fatigue were approximately 3 years older compared with those not reporting fatigue ($P = .045$). The number of consecutive hours awake during call was similar between these 2 groups ($P = .065$). The number of hours reported to recover from call was significantly higher in CRNAs who reported experiencing fatigue during call ($P < .0001$). The CRNAs who worked 5 or more calls per month or 17-hour weekend call shifts or longer, respectively, had higher rates of self-reported call-shift fatigue ($P < .05$). The percentage of CRNAs who used fatigue-avoidance strategies, fatigue countermeasures, and reported physical or psychological symptoms with fatigue were all significantly higher in those who reported experiencing call-shift fatigue ($P < .05$).

Variables from Table 3 with a $P < .1$ were entered into a logistic regression model to identify potential predictors of CRNA self-reported fatigue during call (Table 4). Five independent predictors were identified: hours to recovery from a call shift, working 5 to 6 calls per month, working 7 or more calls per month, use of fatigue countermeasures, and fatigue symptoms ($P < .05$). All predictor ORs were greater than 1, indicating that as the predictor increased, the odds of experiencing call-shift fatigue increased. For every 1-hour increase in recovery time from call the odds of reporting fatigue during call increased 1.08 times ($P < .0001$). The CRNAs who worked 5 to 6 calls per month were almost 4 times more likely ($P = .03$), and those who worked 7 or more calls per month were almost 5 times more likely ($P = .001$) to report experiencing call-shift fatigue compared with those who worked fewer than 5 calls per month ($P < .05$). If CRNAs reported using fatigue countermeasures during call, they were 5.4 times more likely to report experiencing call-shift fatigue ($P < .0001$). Likewise, those who reported physical or psychological symptoms when fatigued were 2 times more likely to report experiencing call-shift fatigue ($P = .043$).

Our study was modeled after the theory of unpleasant symptoms.[28] The middle-range theory of unpleasant symptoms is a conceptual framework that includes three major factors: (1) influencing factors (physiologic, psychologic, and situational) which lead to or affect (2) symptom experience, that in turn influence or impact (3) performance. Performance can then have a reciprocal influence on symptom experience and the influencing factors. Seven themes emerged and were categorized into the 3 fatigue-associated factor groups: physiologic, psychological, and situational; 1 symptom group; and performance. For the physiologic factors, 3 themes emerged: (1) fatigue prevention activities, such as sleeping longer the day of call and napping before call; (2) nutritional influences were dietary interventions, including eating small meals or drinking caffeine; and (3) exercise. The psychological factors had a single theme labeled stress reduction, using tactics of

Potential predictors	Fatigue during call[a]		*P* value
	Yes (n = 267)	No (n = 58)	
Age, y, mean ± SD	48.43 ± 10.10	45.45 ± 10.64	.045
Gender, %			.77
Male	82.8	81.4	
Female	17.2	18.6	
Hours awake during call shift,[b] mean ± SD	13.3 ± 6.83	11.45 ± 6.32	.065
No. of hours needed to recover from call shift, mean ± SD	23.79 ± 15.27	11.42 ± 10.84	< .0001
No. of anesthesia days per workweek, %			.001
≤ 3 d	65.5	34.5	
4-5 d	84.8	15.2	
≥ 6 d	89.7	10.3	
Calls per month, %			.001
≤ 4 calls	74.3	25.7	
5-6 calls	90.9	9.1	
≥ 7 calls	90.2	9.8	
Weekday call duration, %			.080
≤ 16 h	86.5	13.5	
≥ 17 h	78.5	21.5	
Weekend call duration, %			
≤ 16 h	73.5	26.5	.020
≥ 17 h	85.1	14.9	
Fatigue-avoidance strategies, yes	85	15	.02
Fatigue countermeasures, yes	85.6	14.4	< .0001
Fatigue symptoms, yes[c]	87.2	12.8	< .0001

Table 3. Analysis of Potential Predictors of Call Fatigue

Abbreviation: SD, standard deviation.

[a]Reported experiencing call-shift fatigue (yes = occasionally, frequently, or often vs no = rarely).

[b]Hours awake during call shift = number of consecutive hours awake after starting call.

[c]Fatigue symptoms = experience physical or psychological symptoms experienced with fatigue.

Predictor	Mean	SEM	Wald χ^2	*df*	*P* value	Odds ratio (95% CI)
No. of hours to recover from call shift	0.08	0.018	17.88	1	< .0001	1.08 (1.04-1.12)
Work 5-6 calls per month	1.33	0.60	4.9	1	.03	3.78 (1.17-12.23)
Work ≥ 7 calls per month	1.58	0.47	11.18	1	.001	4.87 (1.93-12.33)
Fatigue countermeasures	1.69	0.47	12.76	1	< .0001	5.44 (2.15-13.77)
Fatigue symptoms[b]	0.78	0.39	4.09	1	.043	2.19 (1.03-4.67)
Constant	−2.27	0.58	15.45	1	< .0001	0.10

Table 4. Logistic Regression Analysis of Predictors of Fatigue During Call[a]

Abbreviations: CI, confidence interval; *df*, degrees of freedom; SEM, standard error of the mean.

[a] Outcome is the experience of call-shift fatigue (yes = occasionally, frequently, or often vs no = rarely).

[b] Fatigue symptoms = physical or psychological symptoms experienced with fatigue.

deep breathing and finding a place to relax. The situational factors had 2 themes: (1) decrease the occurrence of fatigue, such as delegating work and taking a break and (2) actions to keep busy such as reading, talking, or calling someone on the telephone. For the symptom group, the theme was fatigue symptoms, and performance was "reporting committing error when fatigued." Two topics emerged from answers of (1) not applicable or does not apply (as respondents agreed they were not called in often or did not experience fatigue during call); (2) others commented "nothing works" and were not grouped based on the model.

This model of unpleasant symptoms[28] provided a framework for respondents' answers and highlighted the interrelationship of physiologic, psychological, and situational factors, which could ultimately affect fatigue-related symptoms and performance. Notably, more than two-thirds of CRNAs who used a fatigue-avoidance strat-

egy used fatigue prevention (physiologic theme) as their chief strategy (67%, n = 217). Reported psychological factors that may influence CRNA fatigue are stress associated with work demands, patient acuity, and a CRNA's coping mechanisms. Interestingly, only a small proportion of respondents used psychological fatigue-avoidance strategies or countermeasures as a primary tactic (2% and 1%, respectively). The third factor of the model were situational factors, such as demands of the call shift (eg, "long or multiple cases" or "ability to take a break"), and professional obligations ("having to work the next day" and "shift length"). Situational countermeasures (24%, n = 78), were the second largest domain listed after nutrition countermeasures (46%). The framework suggests a preceding health symptom (eg, headache), may result in the onset of other symptoms, as expressed in a few descriptions: "mentally drained and physically tired" and "headache, muscle tightness, and [having] less patience". Two-thirds (66.5%) of CRNAs expressed experiencing physiologic or psychological symptoms when fatigued, and 28% conveyed they committed an error in patient care because of being fatigued. Taken together, these findings are consistent with the framework that indicates physiologic, psychological, and situational factors interact and influence unpleasant symptoms (eg, fatigue symptoms) and that these symptoms interact and ultimately influence performance (eg, committing an error because of fatigue).

Discussion

Our results demonstrate that call-shift fatigue is a common problem among practicing CRNAs. More than 80% of the sample reported experiencing call-shift fatigue, with most (73%) of the respondents reporting that call-shift fatigue was common. More than two-thirds reported experiencing physical or psychological symptoms when fatigued. Alarmingly, almost one-third reported committing an error in patient care because of fatigue. These results support the findings of Biddle and Aker[1] that CRNA work fatigue is a concern for our profession and is a patient safety issue. We believe that administrators and leaders in the anesthesia community should consider our results, along with those of Biddle and Aker,[1] and the AANA position statement[2] when developing policies and guidelines for CRNA call-shift duration and frequency.

This is one of the first studies to identify predictors of CRNA call-shift fatigue. We identified 5 independent predictors of call-shift fatigue: (1) hours to recovery from a call shift, (2) working 5 to 6 calls per month, (3) working 7 or more calls per month, (4) use of fatigue countermeasures, and (5) fatigue symptoms. These results are not surprising; CRNAs who work more call (≥5 calls per month) experience more call-shift fatigue, tend to experience more physical and psychological symptoms, and when fatigued during call are more likely to use fatigue countermeasures (eg, taking a nap, drinking caffeinated products). The detrimental effect is evident, as those who reported call-shift fatigue also reported a longer time to recover from their call-shift.

The use of fatigue-avoidance strategies and countermeasures support the theoretical framework that indicates physiologic, psychological, and situational factors interrelate to produce health symptoms (in this case, fatigue-related) and together can ultimately influence performance (eg, committing an error because of fatigue). Anesthetists working long call-shifts use fatigue interventions (avoidance strategies and countermeasures) to counteract the overwhelming influence of the need for sleep. The problem with working extended call shifts (≥ 17 hours) is that it may interfere with an individual's sleep-wake cycle, natural circadian rhythm, and need for sleep.[29] Extended wakefulness leads to subjective sleepiness and decreases in neurobehavioral performance and alertness.[17] Dawson and Reid[30] in 1997 demonstrated that 17 or more hours and 24 hours of wakefulness was equivalent to a blood alcohol concentration of 0.05% and 0.10%, respectively. (In California a driving under the influence offense is a blood alcohol level of 0.08%.) Alarmingly, with increasing sleep deprivation, cognitive deficiencies can accumulate without recognition by the individual.[12,31] It may be that use of avoidance strategies and countermeasures are effective only to a certain extent in minimizing but not completely preventing call-shift fatigue. Working fewer call shifts and having healthy sleep habits are more likely to have a stronger effect on preventing call-shift fatigue.[2] Readers are referred to the AANA position statement on fatigue[2] and the Joint Commission Sentinel Alert on Health Care Worker Fatigue and Patient Safety.[20]

Weekend call-shift duration of 17 hours or longer was identified in our univariate analysis as being associated with call-shift fatigue; however, it was not identified as an independent predictor in our logistic regression model. In contrast, weekday call-shift duration was not associated with call-shift fatigue. Our results suggest that during the week CRNAs tend to work shorter call shifts, but on weekends they work longer call shifts. In some facilities on-call CRNAs may come in later in the day during the week (eg, 4 PM), and thus may have the ability to take a nap before (or during) the call shift. Longer weekend call-shift duration is not uncommon because less staffing is necessary to cover the weekend duration. Additionally, the workload in some institutions may be less intense on weekends. Reduced weekend workload may allow CRNAs to use fatigue countermeasures such as taking a nap. On the other hand, in some smaller facilities a CRNA may not have another staff anesthesia provider available to relieve him or her for a break or nap. Future studies may wish to explore whether CRNAs who work extended call shifts (≥ 17 hours) and take frequent call (≥

5 calls per month) experience more call-shift fatigue. We speculate that this combination may be associated with higher rates of fatigue and fatigue symptoms.

Professional organizations have placed limits on trainees' (medical residents' and student registered nurse anesthetists') work hours and call-shift hours.[32,33] However, no such limits exist for staff CRNAs. CRNAs who are scheduled for call do not have federal work-hour restrictions despite anesthesia's label of a "safety-sensitive" profession. Other professions have work-hour restrictions: truck drivers (who can drive continuously for only 11 hours), nuclear plant workers and train engineers (maximum 12-hour shifts), and airline pilots on domestic routes (restricted to fly not more than 8 in 24 hours). The AANA has recommended that CRNAs should not provide anesthesia patient care for more than 12 to 16 consecutive work hours within a 24-hour work period (scheduled on duty or on call), and they must have opportunities for breaks and rests.[2] We agree that, ideally, CRNAs should not work more than 12 to 16 consecutive hours. In reality, smaller facilities with fewer staff members (eg, solo practice) might not be able to comply with this recommendation. Our univariate results support the argument that extended call shifts are associated with greater fatigue; additionally 28% of respondents reported they committed an error in patient care while administering anesthesia because they were fatigued. However, in our multiple logistic regression analysis, one of the strongest predictors of fatigue was working more than 5 calls per month. Limiting CRNA call-shift duration may increase CRNA call frequency, which in turn may worsen call-shift fatigue and potentially have an impact on patient safety. Ultimately, it is the CRNA's personal and professional responsibility to ensure he or she is well rested and fit for duty. Organizations should always put patient safety first and should balance call-shift duration and frequency with staff desires and abilities.[2]

• ***Limitations.*** There are several limitations to this study. Our survey response rate, 13%, was low compared with previous published surveys in the *AANA Journal*. Chipas and McKenna,[34] in a survey on stress and burnout, had a response rate of 26.9% in an electronic survey of approximately 28,000 AANA members. Biddle and Aker had a 40.5% (1,284 of 3,170) response rate to mailed surveys. However, our target sample size was 10% (250 of 2,500); therefore, we exceeded our sample size goal.

Additionally, it is possible that CRNAs who have experienced fatigue or who experience it more often may have been more likely to respond to this survey, given our high rate of call-shift fatigue (82%). This may limit the generalizability of our results. Our definition of call-shift fatigue may have contributed to the high rate. In this study, experience of call-shift fatigue was defined as experiencing fatigue "occasionally," "frequently," or "often," and no call-shift fatigue was defined as "rarely." We acknowledge this potential bias; however, this was the first study examining call-shift fatigue in CRNAs, and thus there was limited evidence to base the survey design on. Future surveys of call-shift fatigue should include a response "never" when asking about frequency of call-shift fatigue.

Despite these limitations, we believe these results are important because they provide some preliminary evidence on the prevalence of call-shift fatigue, the associated negative health consequences, and frequency of self-reported patient care errors due to call-shift fatigue.

Conclusion

Our results demonstrate that call-shift fatigue is a common problem among practicing CRNAs and is associated with decreased patient safety (as evidenced by the 28% rate of fatigue-related medical errors) and negative health consequences. Administrators and leaders in the anesthesia community should consider these results when developing policies and guidelines for CRNA call-shift duration and frequency. Our results build off the work by Biddle and Aker[1] and support the AANA position statement[2] on fatigue. Administrators and leaders in the anesthesia community should consider our results and those of Biddle and Aker[1] and the AANA[2] when developing policies and guidelines for CRNA call-shift duration and frequency. Future research should explore the association between CRNA call-shift fatigue and CRNA injury (eg, needlesticks, motor vehicle accidents), types of fatigue-related medical errors and near misses (eg, closed claims database), biological markers of fatigue, and efficacy of interventions to reduce call-shift fatigue.

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