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ABSTRACT

BACKGROUND AND PURPOSE: High call frequency can lead to inadequate sleep, fatigue, and burnout, resulting in detrimental effects on physicians and patients. We aimed to assess the correlation between the frequency and burden of neurointerventional surgery calls and sleep deprivation with physician burnout, physical and driving safety, and fatigue-related medical errors.

MATERIALS AND METHODS: We sent an online questionnaire to the members of the 2 neurointerventional surgery societies comprising 50 questions and spanning 3 main topics: 1) overnight/weekend call burden, 2) sleeping patterns, and 3) Copenhagen Burnout Inventory.

RESULTS: One hundred sixty-four surveys were completed. Most (54%) neurointerventional surgeons reported burnout. Call burden of ≥1 every 3 days and being in practice >10 years were independent predictors of burnout. Thirty-nine percent reported falling asleep at the wheel, 23% reported a motor vehicle crash/near-crash, and 34% reported medical errors they considered related to call/work fatigue. On multivariate logistic regression, high call burden (called-in >3 times/week) was an independent predictor of sleeping at the wheel and motor vehicle crashes. Reporting <4 hours of uninterrupted sleep was an independent predictor of motor vehicle crashes and medical errors. Most neurointerventional surgeons recommended a maximum call frequency of once every 3 days.

CONCLUSIONS: Call frequency and burden, number of years in practice, and sleep deprivation are associated with burnout of neurointerventional surgeons, sleeping at the wheel, motor vehicle crashes, and fatigue-related medical errors. These findings contribute to the increasing literature on physician burnout and may guide future societal recommendations related to call burden in neurointerventional surgery.

ABBREVIATIONS: CBI = Copenhagen Burnout Inventory; NIS = neurointerventional surgeons; RVU = Relative Value Unit; SNIS = Society of Neurointerventional Surgery; SVIN = Society of Vascular and Interventional Neurology

Physician burnout is a major health care concern and is very common among health care workers compared with the general population.[1] More than 45% of US physicians reported at least 1 symptom of burnout with a prevalence approaching 50%.[2,3] Work-related burnout has been defined as a combination of emotional exhaustion, depersonalization, and job dissatisfaction.[4]

Physicians experiencing burnout syndrome feel emotional exhaustion with a loss of enthusiasm for work, depersonalization and cynicism, and a low sense of personal accomplishment.[5,6] Burnout is associated with alcohol and substance abuse, broken relationships, early retirement, and suicidal ideation in cross-sectional studies.[7-10] Not only does burnout correlate with adverse personal effects, but it is also associated with professionalism, quality of patient care, and increased medical errors.[11,12] Variable rates of physician burnout are noted among different subspecialties but range from approximately 40% to 75% in certain specialties such as emergency medicine. Nearly 60% of radiologists and neurologists as well as 50% of neurosurgeons have reported burnout.[13]

Neurointerventional surgeons (NIS) may be at high risk for burnout given the call frequency, overnight calls, the relatively high proportion of urgent/emergent cases, and, in particular, the

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considerable increase since 2015 in the number of acute stroke thrombectomy cases, frequently occurring outside regular hours. NIS often commute emergently from home with interrupted sleep, raising their risk of sleeping at the wheel, being involved in motor vehicle crashes, and committing fatigue-related medical errors. Work-related interruption of sleep has been strongly correlated with physician burnout.[14,15]

The American College of Graduate Medical Education has recently increased its focus on promoting well-being and avoiding burnout in trainees by increasing education on wellness, exercise, healthy diet, sleeping habits, and work-life balance, in addition to setting limits on weekly and individual shift work hours. However, attending physicians are not subject to these guidelines on call frequency or work hours. Our study aimed to establish more accurate and robust rates of burnout among NIS by using the Copenhagen Burnout Inventory (CBI) survey and to specifically assess the association of call frequency and coverage to rates of burnout, inadequate sleep, daytime fatigue, medical errors, and vehicular crashes/near-crashes. Finally, we polled the NIS community for recommendations on optimum call frequency, organization, and compensation.

MATERIALS AND METHODS

The study protocol was reviewed by Northwestern University, Feinberg School of Medicine institutional review board, which exempted the study as a nonhuman subject design. The study survey was designed by 5 experienced NIS and 1 sleep medicine physician. The study used a 3-part survey (a detailed 3-part questionnaire that can be found in the Online Supplemental Data) and was designed to be completed in 5 minutes. The survey was initially developed in the REDCap electronic data capture tool (https://catalyst.harvard.edu/redcap/) and distributed via e-mail to the Society of Neurointerventional Surgery (SNIS) and Society of Vascular and Interventional Neurology (SVIN) boards as a single-click link to be distributed to their membership. In addition, it was then posted to SNIS members using the society's "SNIS Connect" platform, and the remainder was sent by direct e-mail. A reminder e-mail was sent 10–15 days later during the period of the study, which extended from March 1 to May 31, 2018. Because responses were anonymous, REDCap recorded the Internet Protocol addresses of respondents to avoid duplicates.

The study questionnaire comprised 3 parts:

Part 1, Overnight and weekend call: 15 questions that surveyed the existing frequency and model of call, including backup call, number of hospitals covered, following-day adjustment in response to being late on call, division of weeknight and weekend calls, call-compensation systems, and their recommendations on optimal call frequency, model, and compensation.

Part 2, Sleep: surveyed the association of work and call coverage with sleep, daytime fatigue, history of previous call-related motor vehicle crashes/near-crashes, history of previous work-related errors, and the existing prevalence of sleep disorders. We categorized sleeping hours into 3 categories: <4 hours, 4–6 hours, and 6–8 hours.

Part 3, Burnout: CBI used 3 domains: personal burnout (6 questions), work-related burnout (7 questions), and patient-related burnout (6 questions).

There were 5 possible answers to each question, and those answers were converted to a scoring system from 0 to 100 and subcategorized as follows: always, 100; often, 75; sometimes, 50; seldom, 25; and never/almost never, 0. A mean score of >50 points in any domain was positive for burnout.[16,17] We also collected the demographics of survey respondents, including age, sex, years of practice, practice setting, and location.

Statistical Analysis

All analysis was conducted using SPSS (Version 24.0; IBM) and R statistical and computing software (http://www.r-project.org/). Descriptive statistics were reported in percentages, means, medians, and range. Factors affecting our dependent variables (burnout, motor vehicle crashes/near-crashes, sleeping at the wheel, and fatigue-related medical errors) were evaluated in a univariate analysis using the Fisher exact and χ^2 tests. Multivariate logistic regression analysis was performed to evaluate independent predictors of those dependent variables. A P value $< .05$ was considered statistically significant. The Cronbach α coefficient testing was used to assess the reliability of the CBI Likert scale, with values ≥.9 considered excellent, .7 to <.9 good, .6 to <.7 acceptable, .5 to <.6 poor, and <.5 unacceptable.

RESULTS

Sample and Demographics

Based on a previously published study in 2019, the number of US NIS in 2 of the largest neurointerventional societies in the United States, SNIS and SVIN, was 898 and 496, respectively with many of those physician-surgeons having dual membership in >1 society. The study estimated the total number of US NIS at that time to be approximately 1200 physicians. After sending surveys to the members of SNIS and SVIN, we had 164 respondents, most of whom were between 40 and 49 years of age (50%), with approximately 20% of respondents between 30 and 39 years, 20% between 50 and 59 years, and 10% between 60 and 69 years of age. Only 1 respondent was older than 69 years of age, and 2 respondents were younger than 30 years of age. Seventy-eight percent of respondents had been in practice for >5 years, with approximately 18% practicing for >20 years. Most respondents practiced in large urban cities with populations of >500,000, with only 11.5% of respondents practicing in small or rural cities. There was a homogeneous distribution among respondents in terms of their practice settings with 41.5% in academic, 33.5% in private practice, and 25% in a mixed practice. The male/female ratio among respondents was approximately 9:1.

Call Burden

Regarding call frequency, 48% of respondents were on call more than once every 3 days; 32%, once every 3 days; 15%, once every 4 days; 4%, once every 5 days; and only 1%, less than once every 5 days. Most respondents (59%) use a one week at a time call coverage model, whereas 28% had fixed weekdays with a rotating weekend, and 13% used miscellaneous arrangements including a night float, sole operator call, or alternating calls on a biweekly or monthly basis. When it came to being "called-in" during nights and weekends, 33% of respondents reported an average ≥4 times during a week of calls; 26%, 3 times; 29%, twice; and 12%, once,

Table 1: Baseline characteristic (in scores) of CBI questionnaires

CBI Dimension	Cronbach α	Mean (SD)	Median	Min/Max	% Mean Score >50
Personal burnout	0.9	49.4 (19.9)	45.8	8.3–100	48.8
Work-related burnout	0.8	47.4 (15.9)	46.4	3.6–92.9	44.5
Patient-related burnout	0.9	29.9 (20.4)	29.2	0–100	16.5

Note:—Min indicates minimum; Max, maximum.

resulting in approximately 60% of respondents being called-in ≥3 times during weekends and after-hours. Nearly all (98%) respondents had no built-in mechanism for taking the next day off if they were called-in or worked past midnight, and 86% responded "never or rarely" to how often they rescheduled next-day patients under these circumstances. A third (35%) of respondents covered >1 hospital when on-call, but only 6% were responsible for >3 hospitals. Only 34% of respondents reported having >1 person on call (eg, backup or call tree), while 48% of respondents who covered call at >1 hospital did not have a built-in system for a backup call person. When asked what would constitute optimal call frequency, most NIS recommended once every 3–4 days (39% once every 4 days and 37% once every 3 days) with only 7% suggesting a call frequency greater than every 3 days.

Increased call-in frequency ≥3 times a week was significantly associated with falling asleep at the wheel (47.9% versus 26.5%, $P = .006$), and in multivariate logistic regression, it was an independent predictor of falling asleep at the wheel (OR, 3.36; 95% CI, 1.51–7.86; $P = .004$). Even though increased call-in frequency showed a trend only toward motor vehicle crashes/near-crashes in univariate analysis (28.1% versus 16.2%, $P = .09$), when controlling for other variables in a multivariate logistic regression analysis, increased call-in frequency was an independent predictor of motor vehicle crashes/near-crashes (OR, 3.07; 95% CI, 1.17–8.80; $P = .03$).

Call Compensation

When looking at different compensation models, 84% of respondents were salary-based versus only 8% reporting a compensation model that was purely based on Relative Value Units (RVUs) or 9% with alternative compensation models. Greater than half of respondents received bonuses based on RVUs alone (18%) or RVUs combined with other productivity factors (35%), but only 8% of respondents had their RVUs in after-hours multiplied by a factor because most (92%) had fixed RVUs regardless of the day and time of the week. Only half of respondents (51%) received extra compensation for overnight/weekend calls, with 22% having call compensation built into their base salary and the rest having a certain number of calls included in their baseline salary. Only 61 physicians (37%) responded to the question about the number of calls included in the baseline salary, and the mean/median and mode of answers were 10 calls per month, with a range between 1 and 31. When we looked at the monetary value for weeknight call compensation, 50% of respondents were compensated at $1000–$2000, 30% were compensated <$1000, and 20% were compensated at >$2000. Call compensation was overall slightly greater on the weekends, with 21% being compensated <$1000% and 28% compensated >$2000.

Physician Burnout

Table 1 demonstrates the mean, SD, median, and range of the CBI scales. The results showed good-to-excellent internal consistency with a Cronbach α coefficient of ≥ 0.8. The Cronbach α was .91 for personal burnout, .79 for work-related burnout, and .91 for patient-related burnout. More than half of respondents (54%) reported burnout in at least 1 of the domains: 12.2% in a single domain, 28.7% in 2 domains, and 13.4% in all domains. The highest burnout perceived was in the personal burnout domain with almost half of respondents (48.8%) reporting burnout in this domain and a nearly equivalent number (44.5%) of respondents reporting work-related burnout, but only 16.5% perceived patient-related burnout (for which the cutoff point of CBI scale score was 50 points).

The Online Supplemental Data demonstrate a univariate correlation of potential independent factors for burnout. There was a trend toward increased burnout in respondents who covered calls a week at a time compared with using a split weekday/weekend model (60.4% versus 43.5%; $P = .07$) after removing other less common models. There was a trend toward increased burnout with decreased sleep (61.4% versus 48.9%, $P = .12$, for <4 hours of uninterrupted sleep and 75% versus 51.4%, $P = .06$, for <6 total hours of sleep), but this did not reach statistical significance. Even though call frequency did not correlate with burnout in univariate analysis, a call frequency of ≥3 times a week was an independent predictor of burnout (OR, 3.24; 95% CI, 1.22–9.19; $P = .02$) when accounting for various factors in a multivariate logistic regression model (Online Supplemental Data). NIS with >10 years of practice showed a trend toward an increased likelihood of experiencing burnout (59.3% versus 47.9%, $P = .16$), and practicing for >10 years was an independent predictor of burnout in multivariate logistic regression analysis (OR, 2.78; 95% CI, 1.11–7.69; $P = .03$). However, physicians reporting burnout did not have a statistically increased risk of motor vehicle crashes/near-crashes (28.1% versus 17.3%; $P = .14$), sleeping at the wheel (39.3% versus 38.7%; $P = .99$), and/or reporting fatigue-related medical errors (31.5% versus 37.3%; $P = .51$).

Sleep and Fatigue

The total and uninterrupted hours of sleep while on call and not on call are demonstrated in Table 2. Regarding on-call days and total sleep hours, 65% slept between 4 and 6 hours versus 23% who had 6–8 hours of sleep, but there was also less uninterrupted sleep, with 43% reporting <4 hours and only 10% achieving 6–8 hours. When off-call, no respondent slept <4 hours, and 89% reported 6–8 hours of sleep per day, most of which was uninterrupted (80%). When asked to rate the quality of sleep during a call night, only 9% of respondents thought it was average/same as a noncall night, 57% believed they had fair sleep quality, and 34% reported poor sleep quality. Sleep disorders were identified in 16% of respondents, with 9% reporting sleep apnea. Sleep deprivation and call-/work-related fatigue resulted in 39% falling asleep at the wheel at least once, 23% experiencing motor vehicle crashes/near-crashes, and 34% reporting medical errors. Most (75%) respondents related that they needed a daytime nap due to call-related

Table 2: Total and uninterrupted sleep hours—on call versus not on call

	Total Sleep Hours/Call	Total Sleep Hours/ Not on Call	Uninterrupted Sleep Hours/Call	Uninterrupted Sleep Hours/Not on Call
Less than 4	20 (12.2%)	0	70 (42.7%)	2 (1.2%)
4–6	106 (64.6%)	19 (11.6%)	77 (47%)	31 (18.9%)
6–8	38 (23.2%)	145 (88.4%)	17 (10.4%)	131 (79.9%)
P value	.01		.05	

fatigue, yet only 42% would have the ability/chance to sleep during work hours.

The Online Supplemental Data demonstrate a univariate correlation between multiple independent factors and burnout, sleeping at the wheel, having motor vehicle crashes/near-crashes, and fatigue-related medical errors. Less than 4 hours of total sleep and <4 hours of uninterrupted sleep demonstrated a trend toward burnout (75% versus 51.4%, $P = .06$, and 61.4% versus 48.9%, $P = .12$, respectively). There was a statistically significant association of sleeping <6 hours with falling asleep at the wheel (43.7% versus 23.7%, $P = .04$) and fatigue-related medical errors (38.9% versus 18.4%, $P = .02$). The risk of medical errors showed an even stronger association in respondents reporting <4 hours of uninterrupted sleep (45.7% versus 25.5%, $P = .008$), as well as a significantly increased risk for motor vehicle crashes/near-crashes (34.3% versus 14.9%, $P = .005$). Uninterrupted sleep of <4 hours was an independent predictor of motor vehicle crashes/near-crashes (OR, 3.11; 95% CI, 1.28–7.92; $P = .01$) and medical errors (OR, 2.60; 95% CI, 1.21–5.68; $P = .01$). In terms of demographics, men were more likely to fall asleep at the wheel (OR, 10.90; 95% CI, 1.83–210.90; $P = .0.03$), and women were more likely to report fatigue-related medical errors (OR, 4.17; 95% CI, 1.10–18.52; $P = .04$).

DISCUSSION

NIS may be at high risk of burnout, in large part due to the high proportion of emergency procedures and the frequency of on-call coverage.[18,19] Among those who participated in our study, we found that increased years of practice and a call frequency greater than or equal to once every 3 days (increased call frequency) were independently associated with burnout. In addition, an increased call frequency was associated with an increased risk of falling asleep at the wheel, motor vehicle crashes/near-crashes, and medical errors. In addition, sleeping <4 hours, which was more commonly encountered during call days, was an independent predictor of motor vehicle crashes and medical errors. To date, there are no standards for call frequency for NIS; when asked about optimal call frequency, most responding physicians selected a maximum of once every 3 days.

In our survey, 54% of respondents reported burnout in at least 1 domain of the CBI survey, with 13.4% reporting burnout in all domains. We used the CBI survey rather than the more commonly used Maslach Burnout Inventory for several reasons. The validity of the CBI has been supported by prior studies and has been used in multiple health care studies.[17,20,21] When they are compared directly, the CBI and Maslach Burnout Inventory showed very similar results, but unlike the Maslach Burnout Inventory, the CBI can measure personal burnout as a total score with better psychomotor properties, allowing it to measure the degree of burnout change across time (rather than assuming a stable individual trait).[22,23] The CBI is also nonproprietary and open access.

In a previous study of burnout, physician well-being, and the correlation to medical errors in 6695 physicians across different medical specialties, 54.3% of physicians reported burnout; 32.8%, excessive fatigue; and 10.5%, a major medical error within the prior 3 months. The study found that burnout and fatigue were independently associated with medical errors.[24] Risks for burnout included long working hours, frequent overnight call duties, sleep deprivation and sleep disturbances, high work intensity, and suboptimal compensation among other factors.[19] In our study, call burden (being on call once or more every 3 days) was an independent predictor of burnout. This finding aligns with prior studies showing a 3% increased risk for burnout with every extra hour of work per week and a 3%–9% increased risk of burnout for additional nights and weekend call.[25]

As per the American Heart Association/American Stroke Association guidelines, mechanical thrombectomy is standard-of-care treatment for large-vessel-occlusion acute ischemic strokes with salvageable brain tissue up to 24 hours from symptom onset or time last known well.[26,27] Stroke call is inherently stressful due to the challenging, emergent nature of the interventions and the often high morbidity of the disease, with increased burnout also demonstrated among noninterventional stroke neurologists.[28] Wilson et al[29] demonstrated that almost 60% of stroke consults in a 24-hour shift occurred during nonworking hours. The same study showed increasing stroke thrombectomy rates from once every 5 days to once every 3 days,[29] which are expected to further increase with expanding indications and place NIS at an even higher risk of burnout. When asked about the optimal maximal neurointerventional call burden in our survey, approximately 80% of respondents selected a call frequency not to exceed once every 3 days, with 39% selecting once every 4 days as the ideal call frequency, yet nearly half (48%) reported a current call frequency of greater than once every 3 days.

Our finding that >10 years of neurointerventional practice experience independently predicts burnout is contrary to prior studies that showed early-to-middle career physicians work more hours and have lower career satisfaction, less work-life balance, and more burnout and are more likely to quit the practice of medicine.[30] The discrepancy may be related to the steep learning curve and time required for proficiency as well as the novel, challenging nature of neurointervention being strong motivators in the early years, whereas senior practitioners are liable to experience greater monotony, frustration, and less opportunity for advancement.

As a direct consequence of call burden, sleep deprivation, and burnout, it is important to consider the physical well-being of physicians and the risk of medical errors, patient harm, and litigation. Most studies find that a majority of emergent stroke

thrombectomy calls occur outside standard daytime work hours. Combined with stricter guidelines for earlier access and reperfusion times, this timing means that the NIS will often transition from sleeping to driving within minutes, potentially putting them at risk for motor vehicle crashes. Although the frequency of call coverage did not directly correlate with sleeping at the wheel or motor vehicle crashes, increased call-in frequency or being called-in >3 times per week was an independent predictor of sleeping at the wheel or being involved in motor vehicle crashes/near-crashes. This finding is alarming and raises an important question of who should be responsible for ensuring good backup coverage from partners when the interventionalist has been up all night treating patients. Should there be a societal guideline by the SNIS/SVIN to restrict the number of call days per week, number of call days taken back-to-back, and the number of hours worked continuously? Does the frequency of call coverage need to be tailored to practice volumes, the number of hospitals covered on call, and the likelihood of being called-in multiple times during call periods?

The relationship between sleep and cognitive and psychomotor function has been well-established, as well as the impact on medical errors, motor vehicle crashes, and health, such as obesity and heart disease. Sleep is a very complex process and varies significantly from one night to another. Frequent call coverage is likely to cause disturbed sleep. In our survey, 65% of respondents reported <6 hours of total sleep when on call, and 43% reported <4 hours of uninterrupted sleep. While the American College of Graduate Medical Education has regulated minimum hours of protected sleep among trainees, no such rules exist for attending physicians.[31,32] The American Academy of Sleep Medicine recently published a position statement on sleep, fatigue, and burnout, estimating that maladaptive sleep techniques led to a burnout prevalence of 50%, with sleep deprivation being one of the main culprits.[32] A previous study demonstrated that the risk of procedural complication rates significantly increased if physicians experienced <6 hours of sleep (3.4% versus 6.2% with an OR of 1.72).[33] In our study, having <4 hours of uninterrupted sleep while on call was an independent predictor of motor vehicle crashes/near-crashes and medical errors, whereas we found a nonsignificant trend toward increased burnout.

Again, this sounds an alarm on what needs to be done to provide call coverage for emergency stroke cases, without affecting the patients' outcomes or putting the providers at considerable risk. Should we train more neurointerventionalists to have adequate coverage, and if so, how would that affect the volume for other neurovascular pathologies treated by those physicians and would that eventually reduce individual expertise for treating those pathologies? On the other hand, should there be an alternative training pathway in which physicians are given the opportunity to do either 1 year of training to only perform stroke thrombectomies versus 2 years of training for all neurovascular pathologies, to ensure adequate stroke coverage without affecting the expertise in treatment of other neurovascular pathologies? Should there be a minimum number of emergent large-vessel occlusions in a hospital to allow the hospital to offer stroke thrombectomy service while having enough physicians to cover/backup the call? Should there be a minimum number of neurointerventionalists/stroke interventionalists employed by the hospital to provide thrombectomy service?

With regard to compensation models that use productivity/RVU as a basis, other specialties such as Emergency Medicine have developed formulas that assign a positive multiplication factor to RVUs generated during evening/night shifts. Should this model be applied to NIS as well? Given the tremendous societal burden of stroke, should productivity models be used at all for NIS compensation? These are all important questions that need to be addressed on a societal level to ensure continued provision of thrombectomy coverage without putting physicians at significant life-threatening risk or increasing medical errors that would affect patients' outcomes.

Our study has several limitations. First, the survey results may be distorted by recall and selection bias in that a physician experiencing burnout may be more inclined to respond and lead to an overestimation of the burnout problem. However, the rates of burnout in our survey aligned with previously published data in the neurointerventional surgery field[18] and other studies analyzing burnout in radiology, neurology, and neurosurgery.[13] Second, the small proportion of responses limited the power of our study to find statistically significant associations. Due to the relatively small number of NIS compared with other specialties, we suggest conducting a repeat survey designed by a collaboration of the major neurointerventional societies, distributed more efficiently through conferences and e-mail lists, with emphasis on specific issues identified in these previous studies. Finally, we assessed burnout, accidents, and medical errors as a function of call burden, compensation, and sleep deprivation but did not include other, more difficult-to-categorize personal factors. Controlling for this myriad of influences will always pose a challenge to surveys addressing the complex causes of burnout, fatigue, and sleep disturbances.

CONCLUSIONS

Call frequency/burden, the number of years in practice, and sleep deprivation are associated with NIS burnout, falling asleep at the wheel, motor vehicle crashes/near-crashes, and fatigue-related medical errors. Our findings add to the increasing literature on physician burnout and point out the increased risk of medical errors in patient care and significant life-threatening risks for physicians, and hopefully, they will guide future society-led surveys and practice-improvement guidelines related to call burden for NIS.

Disclosure forms provided by the authors are available with the full text and PDF of this article at www.ajnr.org.

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