HHS Public Access

Author manuscript

Ann Surg. Author manuscript; available in PMC 2022 December 01.

Published in final edited form as:

Ann Surg. 2021 December 01; 274(6): 1001–1008. doi:10.1097/SLA.0000000000003729.

A National Survey of Motor Vehicle Crashes Among General Surgery Residents

Cary Jo R. Schlick, MD[*], **Daniel Brock Hewitt, MD, MPH, MS**[*], **Christopher M. Quinn, MS**[*], **Ryan J. Ellis, MD, MS**[*,†], **Katherine E. Shapiro, BA**[*], **Andrew Jones, PhD**[‡], **Karl Y. Bilimoria, MD, MS**[*,†], **Anthony D. Yang, MD, MS**[*,✉]

[*]Surgical Outcomes and Quality Improvement Center, Department of Surgery, Feinberg School of Medicine, Northwestern University, Chicago, Illinois

[†]Division of Research and Optimal Patient Care, American College of Surgeons, Chicago, IL

[‡]American Board of Surgery, Philadelphia, Pennsylvania.

Abstract

Objectives: Evaluate the frequency of self-reported, post-call hazardous driving events in a national cohort of general surgery residents and determine the associations between duty hour policy violations, psychiatric well-being, and hazardous driving events.

Summary of Background Data: MVCs are a leading cause of resident mortality. Extended work shifts and poor psychiatric well-being are risk factors for MVCs, placing general surgery residents at risk.

Methods: General surgery residents from US programs were surveyed after the 2017 American Board of Surgery In-Training Examination. Outcomes included self-reported nodding off while driving, near-miss MVCs, and MVCs. Group-adjusted cluster Chi-square and hierarchical regression models with program-level intercepts measured associations between resident- and program-level factors and outcomes.

Results: Among 7391 general surgery residents from 260 programs (response rate 99.3%), 34.7% reported nodding off while driving, 26.6% a near-miss MVC, and 5.0% an MVC over the preceding 6 months. More frequent 80-hour rule violations were associated with all hazardous driving events: nodding off while driving {59.8% with ≥5 months with violations vs 27.2% with 0, adjusted odds ratio (AOR) 2.86 [95% confidence interval (CI) 2.21–3.69]}, near-miss MVCs, [53.6% vs 19.2%, AOR 3.28 (95% CI 2.53–4.24)], and MVCs [14.0% vs 3.5%, AOR 2.46 (95% CI 1.65–3.67)]. Similarly, poor psychiatric well-being was associated with all 3 outcomes [eg, 8.0% with poor psychiatric well-being reported MVCs vs 2.6% without, odds ratio 2.55 (95% CI 2.00–3.24)].

✉ anthony.yang@northwestern.edu.

These findings were presented as an oral plenary presentation at the Academic Surgical Congress; Houston Texas; February 7, 2019.

The authors report no conflicts of interest, financial or otherwise, related to this work.

Conclusions: Hazardous driving events are prevalent among general surgery residents and associated with frequent duty hour violations and poor psychiatric well-being. Greater adherence to duty hour standards and efforts to improve well-being may improve driving safety.

Keywords

ACGME duty-hour policies; emotional well-being; general surgery residents; hazardous driving events; motor vehicle crashes

Motor vehicle crashes (MVCs) are an important public health concern. The National Highway Traffic Safety Administration reported that 37,133 people died in MVCs in 2017.[1] Among resident physicians, MVCs are one of the leading causes of mortality, accounting for 2.03 deaths per 100,000 person-years in residents across all specialties.[2] Many factors are associated with MVCs, such as miles driven, driver speed, and driver fatigue.[3-5] The National Transportation Safety Board recently performed an analysis of the prevalence of fatigue as a probable cause, contributing factor, or finding in transportation accidents, and identified fatigue as a component of 40% of highway crash investigations.[6]

Residents across all specialties are subject to fatigue, which could, in part, be related to Accreditation Council on Graduate Medical Education (ACGME) duty hour policies allowing shifts of extended duration.[7] Extended shifts are associated with higher rates of MVCs in general medicine residents and interns across specialties.[4,8] Furthermore, a study of internal medicine residents found that poor psychiatric well-being, as defined by symptoms of burnout, depression, fatigue, and sleeplessness, is associated with a greater likelihood of self-reporting MVCs.[9] Several studies have evaluated wellness in general surgery residents, and have identified high rates of burnout and poor job satisfaction.[10-12] Despite evidence that surgical residents are at risk, no prior study, to our knowledge, has evaluated rates of MVCs and other hazardous driving events in general surgery residents specifically.[13]

Thus, an important knowledge gap remains concerning the incidence of MVCs and hazardous driving events in general surgery residents. Furthermore, in the current era of changing duty hour policies and increasing focus on resident wellness, it is unknown how duty hour violations and resident well-being are associated with hazardous driving events. Using a national survey of residents in all 260 ACGME-accredited general surgery programs in the United States, the objectives of this study were to (1) evaluate the frequency of 3 types of self-reported hazardous driving events after being on call: nodding off while driving, near-miss MVCs, and MVCs in a national cohort of general surgery residents, and (2) assess the association of resident and program-level factors including ACGME duty hour policy violations and resident psychiatric well-being with hazardous driving events.

METHODS

Data Source and Study Population

Residents from all 260 United States ACGME-accredited general surgery programs were offered an optional closed-ended survey after the 2017 American Board of Surgery In-Training Examination (ABSITE). Participants were excluded if they were not clinically

active (ie, residents pursuing research, advanced degrees, or who did not answer the clinically active question) or if they did not answer all 3 of the questions regarding hazardous driving events. Participants with missing data were eliminated from analyses. Resident responses and individual characteristics [eg, sex, postgraduate year (PGY), etc] were de-identified by the American Board of Surgery (ABS) before analysis. Residency program-level characteristics were provided by the ABS. The Northwestern University Institutional Review Board determined this study to be nonhuman subjects research.

Survey Instrument

The post-ABSITE survey was adapted from previously published surveys and a review of the literature. These items were pretested with general surgery residents using cognitive interviews, and were iteratively reviewed and re-tested before inclusion in the final survey.[14,15] Questions included information on safety-related events after being on call, including nodding off while driving or stopped in traffic, near-miss MVCs (defined as an incident in which property damage or bodily harm was narrowly avoided), and MVCs. Residents were specifically asked how many times (0, 1, 2, 3–5, >5 times) they had experienced each of these 3 outcomes after being on call over the past 6 months (representing the current academic year at the time of the ABSITE), with responses subsequently dichotomized for analyses as 0 times versus 1 or more times. Sensitivity analyses were performed examining different thresholds. Additional survey items included frequency of ACGME duty hour regulation violations and psychiatric well-being as measured by the general health questionnaire-12 (GHQ-12). The GHQ-12 is a validated instrumented used to evaluate psychiatric well-being and potential for psychiatric disorders.[16,17] Respondents with scores greater than or equal to 4 indicate individuals who exhibit poor psychiatric well-being, and may have, or are at greater risk of developing, psychiatric disorders including depression, anxiety, or social dysfunction in accordance with prior studies.[18,19]

Statistical Analysis

Cluster-weighted Chi-square tests accounting for resident clustering within programs were used to evaluate differences in self-reported rates of nodding off while driving, near-miss MVCs, and MVCs after being on call by resident and program characteristics. Characteristics evaluated for association with hazardous driving events included both resident- and program-level variables. Resident characteristics included PGY, sex, ACGME duty hour policy violations, and GHQ-12 score. Separate variables for ACGME duty hour policy violations in the most recent month of a general surgery rotation (worked >28 hours continuously ≥3 times or had <8 hours off between regular shifts ≥3 times) and ACGME duty hour policy violations over the academic year (number of months exceeding 80-hours per week averaged over a 4-week period) were included for analysis. GHQ-12 scores were dichotomized into low risk (score 0–3) versus high risk (score 4–12). Program characteristics included geographic region, program locale (city, suburb, or town/rural), program type (academic, community, or military hospital affiliation), and program size (number of PGY5 residents: 0–5 vs ≥6). Locale was obtained from the National Center for Education Statistics based on program ZIP code utilizing standard U.S. Census Bureau definitions.[20] For programs with ZIP codes not associated with a locale code, a search for

nearby primary or secondary schools was conducted, and the locale associated with the closest available school was used.

Separate multivariable hierarchical logistic regression models with random intercepts for residency program plus fixed effects for resident and program characteristics were estimated to examine the association between each of the pre-identified characteristics and self-reported nodding off while driving, near-miss MVCs, and MVCs after being on call. Resident and program factors were included in the models regardless of statistical significance on bivariate analysis. Based on these regression estimates, average marginal predictors of hazardous driving event rates by the number of months with 80-hour rule violations, holding all other variables as they are in the data, were computed and plotted.[21] Finally, unadjusted residency program-level trainee-reported rates of nodding off while driving, near-miss MVCs, and MVCs after being on call were calculated and plotted to evaluate for variation across training programs.

The 2-sided level of significance was set at 0.05. All analyses were performed using Stata Software, version 14 (Stata Corp, College Station, TX).

RESULTS

In total, 8227 general surgery residents took the ABSITE in 2017. There were 786 residents who were not clinically active during the administration of the ABSITE, 46 who did not answer the clinically active question, and 4 residents who did not answer all of the driving safety questions. Thus, 7391 clinically active residents from all 260 ACGME-accredited general surgery residency programs in the United States constituted the sample. The response rate was 99.3%. The sample was 61.6% male and 38.5% female. Additional demographic information and program factors are available in Table 1.

Hazardous Driving Event Rates

Of the general surgery residents included in the sample, 34.7% (n = 2565) reported nodding off while driving after being on call over the prior 6 months (current academic year), 26.6% of residents (n = 1962) reported a near-miss MVC, and 5.0% (n = 371) reported an MVC over the same interval (Table 2).

Associations Between Resident-level Characteristics and Hazardous Driving Events

Female residents were more likely to report near-miss MVCs than male residents {30.4% vs 24.1%, $P < 0.001$; Adjusted Odds Ratio 1.20 [95% confidence interval (CI) 1.07–1.35]}. PGY2, PGY3, and PGY4 residents were more likely to report all 3 hazardous driving events than PGY1 residents [eg, 38.3% of PGY2 residents reported nodding off while driving vs 30.7% of PGY1s, AOR 1.44 (95% CI 1.24–1.67); 29.6% reported near-miss MVC vs 24.9% of PGY1s, AOR 1.29 (95% CI 1.10–1.51); and 6.0% reported MVCs vs 4.2% of PGY1s, AOR 1.48 (95% CI 1.09–2.03)]. However, there were no statistically significant differences between the likelihood of self-reported hazardous driving events between PGY5 and PGY1 residents (Table 3).

Associations Between ACGME-duty Hour Violations and Hazardous Driving Events

Residents who reported working greater than 28-hours continuously ≥3 times in their most recent month on a general surgery service were more likely to report nodding off while driving [53.1% vs 31.8%, $P < 0.001$; AOR 1.63 (95% CI 1.39–1.91)] and near-miss MVCs [44.1% vs 23.7%, $P < 0.001$; AOR 1.63 (95% CI 1.39–1.93)] than residents who reported violating this duty hour regulation ≤2 times. Residents who reported having ≤8 hours off between shifts ≥3 times in their most recent month on a general surgery service were more likely to report nodding off while driving [50.8% vs 32.8%, $P < 0.001$; AOR 1.24 (95% CI 1.03–1.48)] and MVCs [11.7% vs 4.2%, $P < 0.001$; AOR 1.74 (95% CI 1.28–2.35)] than residents who reported violating this duty-hour regulation ≤2 times. Residents with more frequent 80-hour rule violations over the past 6 months were more likely to report nodding off while driving [59.8% of residents with ≥5 months with violations vs 27.2% of residents with 0, AOR 2.86 (95% CI 2.21–3.69)], near-miss MVCs [53.6% of residents with ≥5 months with violations vs 19.2% of residents with 0, AOR 3.28 (95% CI 2.53–4.24)], and MVCs [14.0% of residents with ≥5 months with violations vs 3.5% of residents with 0, AOR 2.46 (95% CI 1.65–3.67); Table 3].

Association Between Psychiatric Well-being and Hazardous Driving Events

General surgery residents with a GHQ-12 score ≥4 (indicating poor psychiatric well-being) were more likely to report nodding off while driving [42.1% vs 28.8% of residents with scores ≤3, $P < 0.001$; AOR 1.48 (95% CI 1.33–1.65)], near-miss MVCs [36.1% vs 19.0%, $P < 0.001$; AOR 1.96 (95% CI 1.75–2.20)], and MVCs [8.0% vs 2.6%, $P < 0.001$; AOR 2.55 (95% CI 2.00–3.24); Table 3].

Association Between Residency Program-level Factors and Hazardous Driving Events

Residents in programs located in suburban areas were more likely than residents in programs located in cities to report nodding off while driving [40.9% vs 33.5%, $P = 0.016$; AOR 1.38 (95% CI 1.10–1.74)], and near-miss MVCs [31.6% vs 25.7%, $P = 0.028$; AOR 1.34 (95% CI 1.06–1.70)]. There was no association between residency program geographic region, program type (academic, community, or military), or program size and resident reports of hazardous driving events.

Program-level Variation

At the program level, unadjusted rates of resident self-reported nodding off while driving ranged from 0% to 71.9% across all 260 ACGME-accredited general surgery training programs (Fig. 1). The percentage of residents reporting near-miss MVCs in residency programs ranged from 0% to 62.2%, whereas reports of MVCs ranged from 0% to 30.0%. Very few programs had 0 resident reports of nodding off while driving (n = 5) or near-miss MVCs (n = 6) over the past 6 months, whereas 95 programs had no resident reports of MVCs.

Average Marginal Predictions of Hazardous Driving Events

By holding all other covariates as they are in the dataset, the variation in the outcome contributed by 1 particular risk factor can be applied to all individuals. This describes the

magnitude of change in outcome should all individuals develop that risk factor ("average marginal prediction"). If all residents in this sample had 0 violations of the 80-hour rule over the preceding 6 months, the average marginal predicted rate of nodding off while driving would be 28.7% (95% CI 26.9%–30.5%), 21.0% (95% CI 19.4%–22.5%) for near-miss MVCs, and 4.0% (95% CI 3.3%–4.7%) for MVC (Fig. 2). In contrast, if all residents violated the 80-hour rule ≥5 overthe preceding 6 months, the average marginal predicted rates of these hazardous driving events would be 51.5% (95% CI 45.8%–57.3%) for nodding off while driving, 44.0% (95% CI 38.4%–49.5%) for near-miss MVC, and 9.0% (95% CI 6.3%–11.8%) for MVC. Thus, the average marginal predicted effect of residents violating the 80-hour rule for 5 or more months is a 22.8% absolute increase in reported rates of nodding off while driving after being on call (95% CI 16.9%–28.6%), a 23.0% absolute increase in reported rates of near-miss MVCs (95% CI 17.4%–28.7%), and a 5.0% increase in reported MVCs (95% CI 2.2%–7.9%) above those rates experienced without 80-hour policy violations. Sensitivity analyses were performed with violations of the 28-hour and 8-hour policies yielding qualitatively similar results.

DISCUSSION

Deaths among residents are relatively infrequent events, but of those deaths, MVCs are a leading cause.[2] In light of recent studies reporting that general surgery residents are at risk for poor wellness, that there is a link between wellness and fatigue, and that there is a relationship between fatigue and MVCs, we sought to examine the rates of hazardous driving events in this population of surgical trainees.[13] By surveying 7391 surgery residents from all 260 ACGME-accredited general surgery programs in the United States, with a 99.3% response rate, we were able to perform a comprehensive and detailed national evaluation of self-reported hazardous driving events among surgical residents. Overall, 34.7% of residents reported nodding off while driving, 26.6% reported a near-miss MVC, and 5.0% reported an MVC after being on call over the preceding 6 months. Self-reported event rates were more common among residents who had more ACGME duty-hour violations and those with poor psychiatric well-being.

Hazardous Driving Event Rates and Factors Associated with Hazardous Driving Events

Sleepiness and fatigue have been shown to be major contributing factors in highway crashes, with sleepiness-associated crashes having higher fatality rates than other crash types.[22-24] Greater than one-third of residents in this study reported nodding off while driving after being on call over the prior 6-month interval. A small prior survey found that 16% of professional drivers reported nodding off while driving a motor vehicle, without a specified time frame provided in the question stem.[25] Although the reported rate of nodding off while driving in general surgery residents in this study is much higher than that reported by professional drivers, it is not so divergent from other healthcare professionals. A study predominantly composed of nurses found that 27.1% of survey participants reported nodding off while driving over the past year, but this rate increased to 49.3% among those who work night shift and 51.3% in those who work a rotating schedule.[26] Similar sleepiness and fatigue issues are likely to affect both nurses and general surgery residents, particularly

because both are subject to rotating schedules and there is some evidence to suggest that exposure to night-shift work may predict adverse driving outcomes.[27]

Residents who reported repeated violations of ACGME duty hour policies, specifically those who frequently worked greater than 28 hours continuously, had fewer than 8 hours off between shifts, or exceeded 80-hours of work per week averaged over a 4-week period, had an increased likelihood of reporting hazardous driving events. These findings are similar to those of Barger et al, who reported an approximately 2.5-fold increased incidence of MVCs and 6-fold increased incidence of near-miss incidents in interns of varying specialties after extended work shifts (≥24 hours) versus shifts of a shorter length.[4] Similarly, Anderson et al, reported a 3-fold increase in self-reported adverse driving events in residents of varying specialties commuting home after extended work shifts compared with commuting to the hospital.[8] A likely explanation for this association between extended shifts and hazardous driving events is resident fatigue, making residents more susceptible to hazardous driving events.[28,29] Considering the average marginal predicted effect of a 22.8% increase in nodding off while driving, a 23.0% increase in near-miss MVCs, and a 5.0% increase in MVCs in the hypothetical situation when all residents violated the 80-hour rule monthly, compared to no residents violating the same rule, efforts to decrease duty-hour violations are warranted to promote resident safety.

Residents with poor psychiatric well-being may be more subject to feelings of fatigue, and this study found that poor psychiatric well-being was also associated with all 3 hazardous driving events. Among residents with GHQ-12 scores indicating poor psychiatric well-being, 42.1% reported nodding off while driving after call over the prior 6-month interval, 36.1% reported a near-miss MVC, and 8.0% reported an MVC. These findings are consistent with prior studies concluding that patients with psychiatric disorders have elevated rates of MVCs.[30,31] This association highlights the importance of ongoing nationwide efforts to improve both resident well-being and the training environment.

Although this study did not reveal geographic variation in self-reported hazardous driving events after call in general surgery residents, we did find that residents in suburban programs had an increased odds of reporting nodding off while driving and near-miss MVCs in comparison to residents at programs located in cities. These findings could be related to variation in the number of residents who rely on automobile transportation in these areas. Residents in urban programs may be more likely to walk or use public transportation rather than drive, thereby decreasing their likelihood of experiencing a hazardous driving event. Some residency programs provide transportation vouchers or free access to taxis and rideshare services for post-call residents, and it may be worth exploring if these or similar types of resources would be beneficial to other residency programs.

Overall, we report a 5.0% rate of self-reported MVCs in general surgery residents after being on call over a 6-month interval. To our knowledge, other studies have not specifically evaluated post-call MVCs in a resident population. However, when comparing our findings to the national population of a similar age, we find that 25–34 year-olds have a 6.3% annual rate of MVCs. Unfortunately, it is difficult to comprehensively interpret these findings in the absence of more specific comparable data regarding MVC rates in the general population

which, to our knowledge, are not readily and/or publicly available. Though it would be difficult to create a national registry, MVCs and/or hazardous driving events may be a valuable measure for individual residency programs to monitor over time.

Limitations

This study has several limitations. First, this study was survey-based and only offered to general surgery residents. Therefore, the findings can identify associations but not causation, and the results may not be generalizable to all other surgical specialties or medical specialties. Additionally, because of the survey methodology used in this study, no ideal control is available to compare resident reported hazardous driving events after call to those experienced by the general population in similar circumstances. Second, given the self-reported nature of surveys, some residents may not accurately report hazardous driving events or ACGME duty hour violations for reasons such as fear of being identified and punished for negative comments about their program. Residents may also have interpreted survey questions differently; however, the use of cognitive interviews during survey design suggested that residents tended to interpret the questions similarly, and as intended. Third, the survey design of this study subjects the responses of the residents to recall bias. We attempted to mitigate the self-reporting limitation and recall bias by asking residents about hazardous driving events that occurred over a recent, specifically defined time period (6 months, representing the current academic year at the time of survey administration) rather than over their entire training. Additionally, we asked residents to recall only hazardous driving events that occurred after being on call; therefore, this study may underestimate the true incidence of hazardous driving events. Fourth, this study only addressed violations to specific ACGME duty hour policies. Although we find that frequent violations of the 28-hour, 8-hour, and 80-hour rule are associated with hazardous driving events, we cannot infer what the effect of more stringent ACGME duty-hour policies would be based on this study. Additionally, we are unable to determine if various call patterns or utilization of a night float system impact hazardous driving events. Fifth, as noted previously, there was likely variation in residents' utilized modes of transportation. It is unclear from our study what the denominator is of residents who drive automobiles to and from work. Sixth, among those residents reporting hazardous driving events, we did not query residents as to whether they were the driver or passenger, or whether they perceived themselves to be liable for the incident. However, our cognitive testing of the survey confirmed that residents understood the questions to imply that they were the driver. Finally, some residency programs provide transportation vouchers for residents to have a compensated ride home from work after call, which could decrease the likelihood of residents experiencing a hazardous driving event. However, the prevalence of such interventions was not captured in this survey and, anecdotally, this does not currently seem to be a widespread practice.

CONCLUSIONS

In this comprehensive national survey of surgical residents, we found relatively high self-reported rates of hazardous driving events such as nodding off while driving, near-miss MVCs, and MVCs after call shifts. Residents who reported frequent ACGME duty hour policy violations and poor psychiatric well-being were more likely to report hazardous

driving events. These findings may be insightful whereas considering policy changes related to resident training and in promoting resident well-being and safety.

Acknowledgments

This study was funded by the American College of Surgeons, the American Board of Surgeons, and the Accreditation Council for Graduate Medical Education as a continuation of the FIRST trial. D.B.H. and R.J.E. are supported by postdoctoral research fellowships from the Agency for Healthcare Research and Quality (5T32HS000078). K.Y.B. is supported by the Agency for Healthcare Research and Quality (R01HS024516), A.D.Y. is supported by the National Heart, Lung, and Blood Institute (K08NIHL145139).

REFERENCES

1. Insurance Information Institute. 2018; Available at: https://www.iii.org/table-archive/20671; https://www.iii.org/table-archive/20749. Accessed August 24, 2018.
2. Yaghmour NA, Brigham TP, Richter T, et al. Causes of death of residents in ACGME-accredited programs 2000 through 2014: implications for the learning environment. Acad Med. 2017;92:976–983. [PubMed: 28514230]
3. Janke F, Dobbs B, McKay R, et al. Family medicine residents' risk of adverse motor vehicle events: a comparison between rural and urban placements. Can Med Educ. 2013;4:e28–e40.
4. Barger LK, Cade BE, Ayas NT, et al. Extended work shifts and the rise of motor vehicle crashes among interns. N Engl J Med. 2005;352:125–134. [PubMed: 15647575]
5. Tefft BC. Acute sleep deprivation and culpable motor vehicle crash involvement. Sleep. 2018;41:1–11.
6. Marcus JH, Rosenkind MR. Fatigue in transportation: NTSB investigations and safety recommendations. Inj Prev. 2017;23:232–238. [PubMed: 26929259]
7. Veasey S, Rosen R, Barzansky B, et al. Sleep loss and fatigue in residency training: a reappraisal. JAMA. 2002;288:1116–1124. [PubMed: 12204082]
8. Anderson C, Ftouni S, Ronda JM, et al. Self-reported drowsiness and safety outcomes while driving after an extended duration work shift in trainee physicians. Sleep. 2018;41:zsx195. [PubMed: 29281091]
9. West C, Tan A, Shanafelt T. Association of resident fatigue and distress with occupational blood and body fluid exposures and motor vehicle incidents. Mayo Clin Proc. 2012;87:1138–1144. [PubMed: 23218084]
10. Beierle SP, Kirkpatrick BA, Heidel RE, et al. Evaluating and exploring variations in surgical resident emotional intelligence and burnout. J Surg Educ. 2019;76:628–636. [PubMed: 30658946]
11. Elmore LC, Jeffe DB, Jin L, et al. National survey of burnout among US general surgery residents. J Am Coll Surg. 2016;223:440–451. [PubMed: 27238875]
12. Pulcrano M, Evans SR, Sosin M. Quality of life and burnout rates across surgical specialties: a systematic review. JAMA Surg. 2016;151:970–978. [PubMed: 27410167]
13. Dyrbye LN, Burke SE, Hardeman RR, et al. Association of clinical specialty with symptoms of burnout and career choice regret among US resident physicians. JAMA. 2018;320:1114–1130. [PubMed: 30422299]
14. Bilimoria KY, Chung JW, Hedges LV, et al. National cluster-randomized trial of duty-hour flexibility in surgical training. N Engl J Med. 2016;374:713–727. [PubMed: 26836220]
15. Bilimoria KY, Chung JW, Hedges LV, et al. Development of the flexibility in duty hours requirements for surgical trainees (FIRST) trial protocol: a national cluster-randomized trial of resident duty hour policies. JAMA Surg. 2016;151:273–281. [PubMed: 26720622]
16. McManus IC, Winder BC, Gordon D. The causal links between stress and burnout in a longitudinal study of UK doctors. Lancet. 2002;359:2089–2090. [PubMed: 12086767]
17. McManus IC, Keeling A, Paice D. Stress, burnout and doctors' attitudes to work are determined by personality and learning style: a twelve year longitudinal study of UK medical graudates. BMC Med. 2004;2:29. [PubMed: 15317650]

18. Goodwin L, Ben-Zion I, Fear NT, et al. Are reports of psychological stress higher in occupational studies? A systematic review across occupational and population based studies. PLoS One. 2013;8:e78693. [PubMed: 24223840]
19. Goldberg DP, Oldehinkel T, Ormel J. Why GHQ threshold varies from one place to another. Psychol Med. 1998;28:915–921. [PubMed: 9723146]
20. Geverdt D Education Demographic and Geographic Estimates (EDGE) Program. Washington DC, USA: Institute of Education Sciences, National Center for Education Statistics, U.S. Department of Education; 2017.
21. Norton EC, Dowd BE, Maciejewski ML. Marginal effects-quantifying the effect of changes in risk factors in logistic regression models. JAMA. 2019;321:1304–1305. [PubMed: 30848814]
22. Pack AI, Pack AM, Rodgman E, et al. Characteristics of crashes attributed to the driver having fallen asleep. Accid Anal Prev. 1995;27:769–775. [PubMed: 8749280]
23. Kalsi J, Tervo T, Bachour A, et al. Sleep versus non-sleep-related fatal road accidents. Sleep Med. 2018;51:148–152. [PubMed: 30179735]
24. Bioulac S, Micoulaud-Franchi JA, Arnaud M, et al. Risk of motor vehicle accidents related to sleepiness at the wheel: a systematic review and metaanalysis. Sleep. 2017;40:1–10.
25. Zwahlen D, Jackowski C, Pfaffli M. Sleepiness, driving, and motor vehicle accidents: a questionnaire-based survey. J Forensic Leg Med. 2016;44:183–187. [PubMed: 27821309]
26. Gold DR, Rogacz S, Bock N, et al. Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. Am J Public Health. 1992;82:1011–1014. [PubMed: 1609900]
27. Knott M, Classen S, Krasniuk S, et al. Insufficient sleep and fitness to drive in shift workers: a systematic literature review. Accid Anal Prev. 2020;134:105234. 10.1016/j.aap.2019.07.010. [PubMed: 31443915]
28. Lockley SW, Barger LK, Ayas NT, et al. Effects of health care provider work hours and sleep deprivation on safety and performance. Jt Comm J Qual Patient Saf. 2007;33(11 Suppl):7–18.
29. Anderson C, Sullivan JP, Flynn-Evans EE, et al. Deterioration of neuro-behavioral performance in resident physicians during repeated exposure to extended duration work shifts. Sleep. 2012;35:1137–1146. [PubMed: 22851809]
30. Raisanen T, Hakko H, Riipinen P, et al. Personality disorders of drivers killed in fatal motor vehicle accidents in Finland during 1990-2011. Acta Pschiatr Scand. 2019;140:39–49.
31. Kujansuu A, Rautianinen S, Hakko H, et al. Drivers' psychiatric disorders and fatal motor vehicle accidents in Finland. J Psychiatr Res. 2017;84:227–236. [PubMed: 27770742]

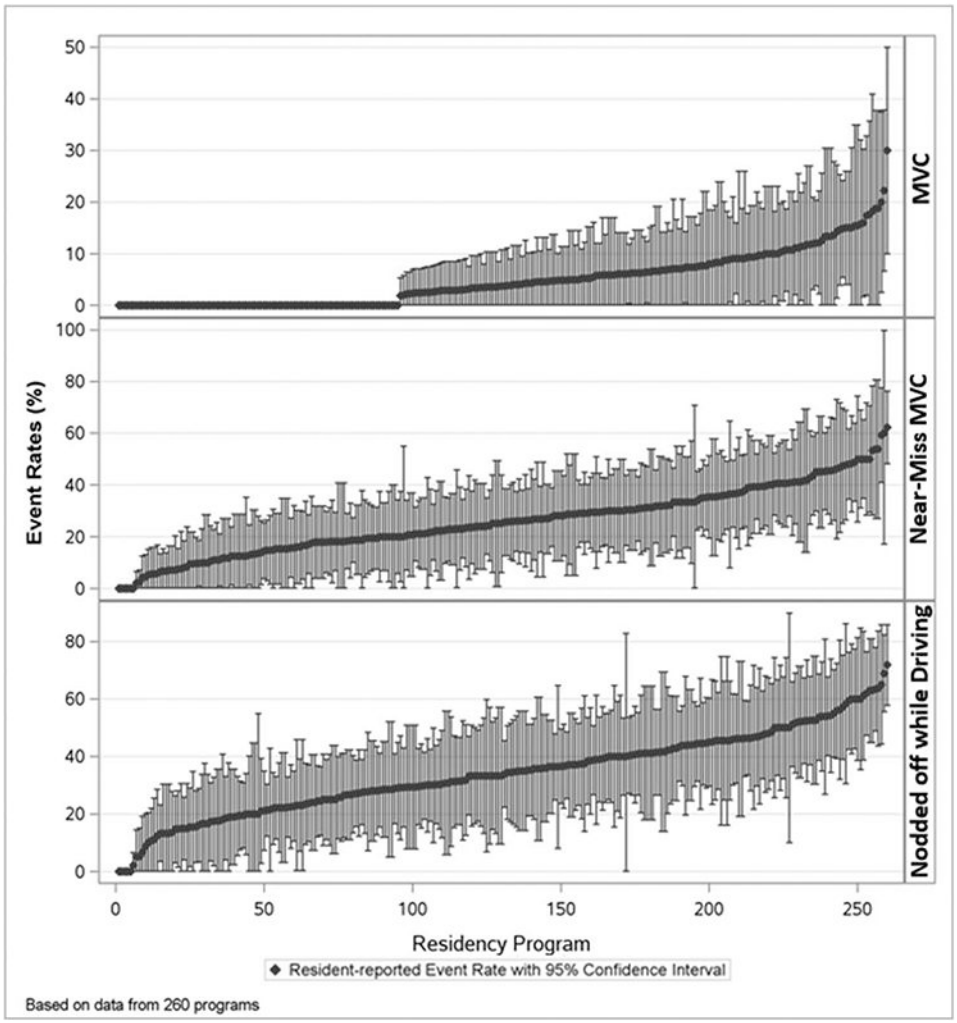

FIGURE 1.
Residency program-level rates of hazardous driving events.

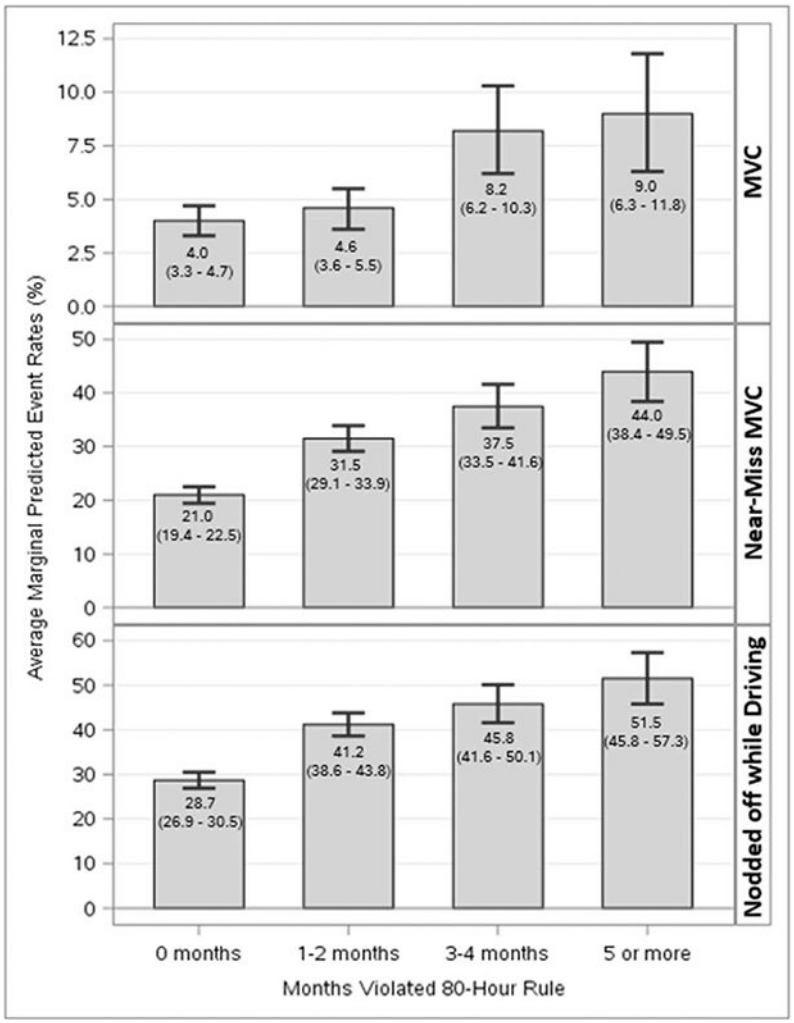

FIGURE 2.

Average marginal predictions for hazardous driving events by number of months the 80-h rule was violated. While holding all other individual covariates as they are in the dataset and calculating the risk associated with a particular factor, average marginal predicted event rates can be calculated by applying that risk to each individual in the cohort. Here, predicted event rates are shown for MVC, near-miss MVC, and nodding off while driving if each resident had 0, 1-2, 3-4, or ≥5 months with 80-hour rule violations over the preceding 6 month interval.

TABLE 1.

Resident and Program Characteristics

	Total (N = 7391) n (%)
Sex	
Male	4528 (61.6)
Female	2829 (38.5)
Postgraduate year	
1	2127 (28.8)
2	1563 (21.2)
3	1303 (17.6)
4	1224 (16.6)
5	1174 (15.9)
Worked >28 h continuously *	
0–2 times	6369 (86.2)
3 or more times	1022 (13.8)
Had <8 h off between shifts *	
0–2 times	6590 (89.2)
3 or more times	801 (10.8)
Number of months exceeded 80-h per week rule over the past 6 mo (this academic year)	
0	4573 (61.9)
1–2	1850 (25.0)
3–4	617 (8.4)
5 or more	351 (4.8)
GHQ-12 score	
0–3	4117 (55.7)
4–12	3270 (44.3)
Program geographic region	
Northeast	2473 (33.5)
Southeast	1425 (19.3)
Midwest	1597 (21.6)
Southwest	852 (11.5)
West	1044 (14.1)
Primary program locale †	
City	5877 (79.5)
Suburb	1079 (14.6)
Town or rural	435 (5.9)
Program type	
Academic	4448 (60.2)
Community	2727 (36.9)
Military	216 (2.9)
Number of PGY5 slots in program	

	Total (N = 7391) n (%)
0–5	4010 (54.3)
6 or more	3381 (45.7)

*In the most recent month of a general surgery rotation.

†Primary program locale designated by National Center for Education Statistics locale type for nearby primary or secondary school.

GHQ indicates general health questionnaire.

TABLE 2.

Characteristics Associated With Surgical Residents Experiencing Hazardous Driving Events*

Characteristic	Nodded Off While Driving or Stopped in Traffic – n (%)	*P*-value‡	Near-miss Motor Vehicle Crash† – n (%)	*P*-value‡	Motor Vehicle Crash – n (%)	*P*-value‡
All Residents	2565 (34.7)		1962 (26.6)		371 (5.0)	
Sex		0.018		<0.001		0.007
Male	1495 (33.0)		1093 (24.1)		197 (4.4)	
Female	1059 (37.4)		861 (30.4)		172 (6.1)	
Postgraduate year		0.001		0.016		0.045
1	653 (30.7)		529 (24.9)		90 (4.2)	
2	599 (38.3)		463 (29.6)		94 (6.0)	
3	486 (37.3)		379 (29.1)		78 (6.0)	
4	474 (38.7)		335 (27.4)		67 (5.5)	
5	353 (30.1)		256 (21.8)		42 (3.6)	
Worked >28 h continuously§		<0.001		<0.001		<0.001
0–2 times	2022 (31.8)		1511 (23.7)		277 (4.4)	
3 or more times	543 (53.1)		451 (44.1)		94 (9.2)	
Had <8 h off between shifts§		<0.001		<0.001		<0.001
0–2 times	2158 (32.8)		1619 (24.6)		277 (4.2)	
3 or more times	407 (50.8)		343 (42.8)		94 (11.7)	
Number of months exceeded 80-h per week rule over the past 6 mo (this academic year)		<0.001		<0.001		<0.001
0	1244 (27.2)		880 (19.2)		158 (3.5)	
1–2	799 (43.2)		625 (33.8)		96 (5.2)	
3–4	312 (50.6)		269 (43.6)		68 (11.0)	
5 or more	210 (59.8)		188 (53.6)		49 (14.0)	
GHQ-12 score		<0.001		<0.001		<0.001
0–3	1186 (28.8)		783 (19.0)		108 (2.6)	
4–12	1377 (42.1)		1179 (36.1)		263 (8.0)	
Program Geographic Region		0.494		0.192		0.458
Northeast	851 (34.4)		662 (26.8)		142 (5.7)	

Characteristic	Nodded Off While Driving or Stopped in Traffic – n (%)	*P*-value‡	Near-miss Motor Vehicle Crash† – n (%)	*P*-value‡	Motor Vehicle Crash – n (%)	*P*-value‡
Southeast	476 (33.4)		346 (24.3)		59 (4.1)	
Midwest	566 (35.4)		415 (26.0)		79 (5.0)	
Southwest	274 (32.2)		217 (25.5)		41 (4.8)	
West	398 (38.1)		322 (30.8)		50 (4.8)	
Primary Program Locale¶		0.016		0.028		0.549
City	1971 (33.5)		1511 (25.7)		292 (5.0)	
Suburb	441 (40.9)		341 (31.6)		61 (5.7)	
Town or Rural	153 (35.2)		110 (25.3)		18 (4.1)	
Program Type		0.887		0.866		0.103
Academic	1550 (34.9)		1195 (26.9)		229 (5.2)	
Community	936 (34.3)		712 (26.1)		139 (5.1)	
Military	79 (36.6)		55 (25.5)		3 (1.4)	
Number of PGY5 slots in program		0.645		0.328		0.520
0–5	1407 (35.1)		1036 (25.8)		194 (4.8)	
6 or more	1158 (34.3)		926 (27.4)		177 (5.2)	

*Within the last 6 mo (current academic year), after being on call.

†Defined as an event in which property damage or bodily harm was narrowly avoided.

‡*P*-values based on group-adjusted clustered Chi-squared tests.

§In the most recent month of a general surgery rotation.

¶Primary program locale designated by the National Center for Education Statistics locale type for nearby primary or secondary school.

GHQ indicates general health questionnaire.

TABLE 3.

Adjusted Associations Between Resident and Program Characteristics and Hazardous Driving Events[§]

	Adjusted[‖] Odds Ratios (95% Confidence Interval)		
Characteristic	**Nodded Off While Driving or Stopped in Traffic**	**Near-miss Motor Vehicle Crash[¶]**	**Motor Vehicle Crash**
Sex			
Male	1.00 (REF)	1.00 (REF)	1.00 (REF)
Female	1.08 (0.97–1.20)	1.20 (1.07–1.35)[†]	1.21 (0.97–1.50)
Postgraduate year			
1	1.00 (REF)	1.00 (REF)	1.00 (REF)
2	1.44 (1.24–1.67)[‡]	1.29 (1.10–1.51)[†]	1.48 (1.09–2.03)[*]
3	1.41 (1.20–1.64)[‡]	1.29 (1.09–1.52)[†]	1.53 (1.10–2.11)[*]
4	1.61 (1.38–1.89)[‡]	1.28 (1.08–1.52)[†]	1.48 (1.06–2.08)[*]
5	1.17 (0.99–1.39)	1.03 (0.86–1.24)	1.03 (0.70–1.52)
Worked >28 h continuously[#]			
0–2 times	1.00 (REF)	1.00 (REF)	1.00 (REF)
3 or more times	1.63 (1.39–1.91)[‡]	1.63 (1.39–1.93)[‡]	1.15 (0.86–1.54)
Had <8 h off between shifts[#]			
0–2 times	1.00 (REF)	1.00 (REF)	1.00 (REF)
3 or more times	1.24 (1.03–1.48)[*]	1.20 (1.00–1.44)	1.74 (1.28–2.35)[‡]
Number of months exceeded 80-h per week rule over the past 6 mo (this academic year)			
0	1.00 (REF)	1.00 (REF)	1.00 (REF)
1–2	1.82 (1.61–2.06)[‡]	1.82 (1.59–2.08)[‡]	1.15 (0.87–1.52)
3–4	2.23 (1.84–2.71)[‡]	2.44 (2.00–2.98)[‡]	2.21 (1.58–3.11)[‡]
5 or more	2.86 (2.21–3.69)[‡]	3.28 (2.53–4.24)[‡]	2.46 (1.65–3.67)[‡]
GHQ-12 score			
0–3	1.00 (REF)	1.00 (REF)	1.00 (REF)
4–12	1.48 (1.33–1.65)[‡]	1.96 (1.75–2.20)[‡]	2.55 (2.00–3.24)[‡]

Characteristic	Adjusted[//] Odds Ratios (95% Confidence Interval)		
	Nodded Off While Driving or Stopped in Traffic	Near-miss Motor Vehicle Crash[¶]	Motor Vehicle Crash
Program geographic region			
Northeast	1.00 (REF)	1.00 (REF)	1.00 (REF)
Southeast	1.05 (0.83–1.32)	0.98 (0.77–1.24)	0.80 (0.55–1.16)
Midwest	1.11 (0.89–1.38)	1.04 (0.83–1.31)	0.93 (0.66–1.31)
Southwest	1.00 (0.75–1.33)	1.06 (0.79–1.42)	0.91 (0.59–1.42)
West	1.23 (0.95–1.59)	1.26 (0.96–1.64)	0.82 (0.55–1.24)
Primary program locale[**]			
City	1.00 (REF)	1.00 (REF)	1.00 (REF)
Suburb	1.38 (1.10–1.74)[†]	1.34 (1.06–1.70)[*]	1.03 (0.72–1.46)
Town or rural	0.92 (0.66–1.27)	0.88 (0.62–1.24)	0.77 (0.43–1.37)
Program type			
Academic	1.00 (REF)	1.00 (REF)	1.00 (REF)
Community	0.96 (0.79–1.16)	1.02 (0.84–1.24)	1.11 (0.82–1.50)
Military	1.13 (0.71–1.81)	1.09 (0.66–1.79)	0.34 (0.10–1.16)
Number of PGY5 slots in program			
0–5	1.00 (REF)	1.00 (REF)	1.00 (REF)
6 or more	0.91 (0.75–1.11)	1.03 (0.84–1.25)	1.05 (0.78–1.42)

Based on 7353 observations with nonmissing data on all covariates.

Statistical significance denoted as follows:

[*] $P < 0.05$.

[†] $P < 0.01$.

[‡] $P < 0.001$.

[§] Within the last 6 months (current academic year), after being on call.

[//] Effects mutually adjusted for all variables displayed.

[¶] Defined as an event in which property damage or bodily harm was narrowly avoided.

[#] In the most recent month of a general surgery rotation.

** Primary program locale designated by National Center for Education Statistics locale type for nearby primary or secondary school.

GHQ indicates general health questionnaire.