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Extended Work Shifts and the Risk of Motor Vehicle Crashes among Interns

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ABSTRACT

BACKGROUND

Long work hours and work shifts of an extended duration (≥24 hours) remain a hallmark of medical education in the United States. Yet their effect on health and safety has not been evaluated with the use of validated measures.

METHODS

We conducted a prospective nationwide, Web-based survey in which 2737 residents in their first postgraduate year (interns) completed 17,003 monthly reports that provided detailed information about work hours, work shifts of an extended duration, documented motor vehicle crashes, near-miss incidents, and incidents involving involuntary sleeping.

RESULTS

The odds ratios for reporting a motor vehicle crash and for reporting a near-miss incident after an extended work shift, as compared with a shift that was not of extended duration, were 2.3 (95 percent confidence interval, 1.6 to 3.3) and 5.9 (95 percent confidence interval, 5.4 to 6.3), respectively. In a prospective analysis, every extended work shift that was scheduled in a month increased the monthly risk of a motor vehicle crash by 9.1 percent (95 percent confidence interval, 3.4 to 14.7 percent) and increased the monthly risk of a crash during the commute from work by 16.2 percent (95 percent confidence interval, 7.8 to 24.7 percent). In months in which interns worked five or more extended shifts, the risk that they would fall asleep while driving or while stopped in traffic was significantly increased (odds ratios, 2.39 [95 percent confidence interval, 2.31 to 2.46] and 3.69 [95 percent confidence interval, 3.60 to 3.77], respectively).

CONCLUSIONS

Extended-duration work shifts, which are currently sanctioned by the Accreditation Council for Graduate Medical Education, pose safety hazards for interns. These results have implications for medical residency programs, which routinely schedule physicians to work more than 24 consecutive hours.

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Residents in their first postgraduate year (interns) in the United States frequently work shifts of an extended duration (≥24 hours), a practice that results in long workweeks.[1,2] Both the number and the distribution of work hours can affect sleep, productivity, and safety.[3] The risk of fatigue-related crashes, a leading cause of truck crashes that have been fatal to the driver in the United States,[4,5] increases markedly as a function of truckers' consecutive driving hours.[6] Despite long-standing concerns regarding the effects of work hours on performance and safety among postgraduate physicians,[7-10] prior studies have not directly associated safety outcomes with such a specific characteristic of their work schedule.

To address this issue, we administered a monthly Web-based questionnaire to interns nationwide to investigate the association between validated work hours, extended work shifts, and driving safety. Assessment of driving safely included documented motor vehicle crashes, near-miss incidents, incidents involving falling asleep while driving, and incidents involving falling asleep while stopped in traffic.

METHODS

DATA COLLECTION

In April 2002, advertisements announcing the Harvard Work Hours, Health, and Safety study and offering the chance of a monetary incentive for participation were sent by e-mail to people who were matched to a residency by the National Resident Matching Program and to graduates of U.S. medical schools. The advertisement that was used is contained in the Supplementary Appendix (available with the full text of this article at www.nejm.org). Thereafter, responses to detailed questions regarding work hours, shifts of extended duration (≥24 hours), motor vehicle crashes, near-miss incidents (near-miss motor vehicle crashes in which property damage or bodily harm was narrowly avoided), and incidents of involuntary sleeping were collected monthly through May 2003, when responses regarding the overall first postgraduate year were also collected. Although this report addresses only data regarding extended shifts, motor vehicle crashes, and near-miss incidents, the questions regarding these exposure and outcome variables were distributed among 60 other questions on the monthly surveys. The Human Research Committee of Brigham and Women's Hospital and Partners HealthCare approved all the study procedures, and all the participants provided electronic written informed consent.

VALIDATION OF WORK HOURS

A random subgroup of participants (7 percent) completed daily work diaries. We validated these diaries in a separate study in which direct observation was used for continuous monitoring of work hours. A very high correlation was found between work hours ($r=0.98$) and shifts of extended duration ($r=1.0$) as reported by observers and as recorded in the diaries.[11] This work-diary subgroup recorded their work hours for at least 21 out of 28 days and completed the corresponding monthly survey. Pearson's product-moment correlation was used to determine the association between the daily average number of work hours and the number of extended-duration work shifts that were reported in the diary and in the monthly survey.

DOCUMENTATION PROCESS FOR CRASHES

Participants who reported a motor vehicle crash were requested to provide documentation of the crash. A police report, an insurance claim, an auto-repair record, a medical record, a photograph of the damaged vehicle, or a written description of the crash was accepted as documentation. For participants who did not complete the year-end survey, no additional crashes were identified, either through a search of the Social Security Death Index or through inquiries to the interns' designated emergency contacts.

STATISTICAL ANALYSIS

We used two independent techniques to quantify exposure and to assess relative risk. First, the subgroup of crashes and near-miss incidents that occurred on the commute from work was analyzed with the use of a within-person case-crossover design. For each participant, we assessed the number and proportion of crashes and near-miss incidents that had occurred after an extended work shift, as compared with a shift that was not extended. The Mantel–Haenszel test (with each subject as a separate stratum) was used to calculate the odds ratio for crashes and near-miss incidents that occurred after an extended work shift as compared with a nonextended shift.[12] Second, to address potential reporting bias (because both the crashes and the number of extended shifts were reported in each monthly survey), we also prospectively assessed whether the mean monthly number of scheduled

extended shifts (collected on the baseline survey) was associated with the subsequent occurrence of motor vehicle crashes as reported on the monthly surveys. We then used Poisson regression analysis that was adjusted for age and sex to determine whether the mean monthly number of scheduled extended shifts was associated with the occurrence of crashes. For each participant, the time at risk for the Poisson regression was considered to be the number of monthly surveys that each participant completed.

A case-crossover analysis was used to determine whether the number of extended shifts that interns worked per month was associated with incidents of falling asleep while driving or while stopped in traffic. The Mantel–Haenszel test was used to calculate odds ratios. The case-crossover study design eliminated the need to account for potential confounders, such as differences in age, sex, commuting time or distance, or medical specialty, since participants served as their own controls.[13] All data are reported as means ±SD. All odds ratios are reported with 95 percent confidence intervals; all P values are two-sided. Additional information about the methods used is provided in the Supplementary Appendix.

RESULTS

A total of 3429 interns volunteered to participate in the study. Of those, 2737 (80 percent) completed the baseline survey and were thus deemed the study cohort. Each month, an average of 1548±376 surveys were completed. Ninety-three percent of the study cohort completed at least one monthly survey and were eligible for the analysis of crashes and near-miss incidents; 82 percent completed at least two monthly surveys and were thus eligible to be included in all analyses (Fig. 1). We collected a total of 19,740 surveys, including 2737 baseline surveys and 17,003 monthly surveys.

DEMOGRAPHIC DATA

The demographic characteristics of the study participants were similar to those of all interns matched through the National Resident Matching Program in 2002. Of the participants, 53 percent were female, with a mean age of 28.0±3.9 years; 79 percent were in medical specialties, 11 percent in surgical specialties, and 10 percent in other or nonspecified specialties; and 85 percent were graduates of U.S. medical schools. Among all interns in 2002, 41 percent were female, with a mean age of 30.2 years; 88 percent were in medical specialties and 12 percent in surgical specialties; and 74 percent were graduates of U.S. medical schools. Sixty-nine percent of the study participants commuted by car, and their average weekly commute was 91.6±96.2 miles, with 4.4±3.4 hours spent each week commuting.

VALIDATION

Pearson's correlation coefficient for the number of hours reported on the monthly surveys (249.8±75.3 hours) versus the actual number of hours worked, as indicated by daily work diaries completed by a subgroup of 192 participants (244.0±69.3 hours), was 0.76 (P<0.001). Likewise, the number of extended work shifts reported on the monthly surveys (3.6±3.3) was highly correlated with the number of extended work shifts reported in the daily diaries completed by 40 participants (3.5±2.8; r=0.94, P<0.001) (Fig. 1).

WORK HOURS

Interns averaged 70.7±26.0 hours in the hospital weekly; they were awake 67.4±24.4 of those hours and asleep 3.2±4.2 hours (Fig. 2). They reported that they spent an additional 3.9±5.0 hours per week working or studying outside the hospital, classroom, or workplace related to their program and that they spent 0.1±1.6 hours per week working at a job outside their program. Interns averaged 6.5±4.0 days off per month, including weekends, holidays, and allocated time off.

EXTENDED WORK SHIFTS

The mean monthly number of extended work shifts that were reported was 3.9±3.4, with an average duration of 32.0±3.7 hours. The mean number of scheduled monthly shifts of extended duration correlated significantly with the mean number of extended shifts reported on the monthly surveys for participants who completed all 12 surveys (r=0.71, P<0.001). On 86 percent of monthly surveys, participants reported having worked extended shifts without any night-float coverage (the assignment of another physician to take calls for the on-call participant during an overnight shift for a period of time so that the participant could rest). On only 7 percent of the surveys did they report having had night-float coverage on all extended shifts, and on another 7 percent of the surveys, they reported having had some night-float coverage. Of those report-

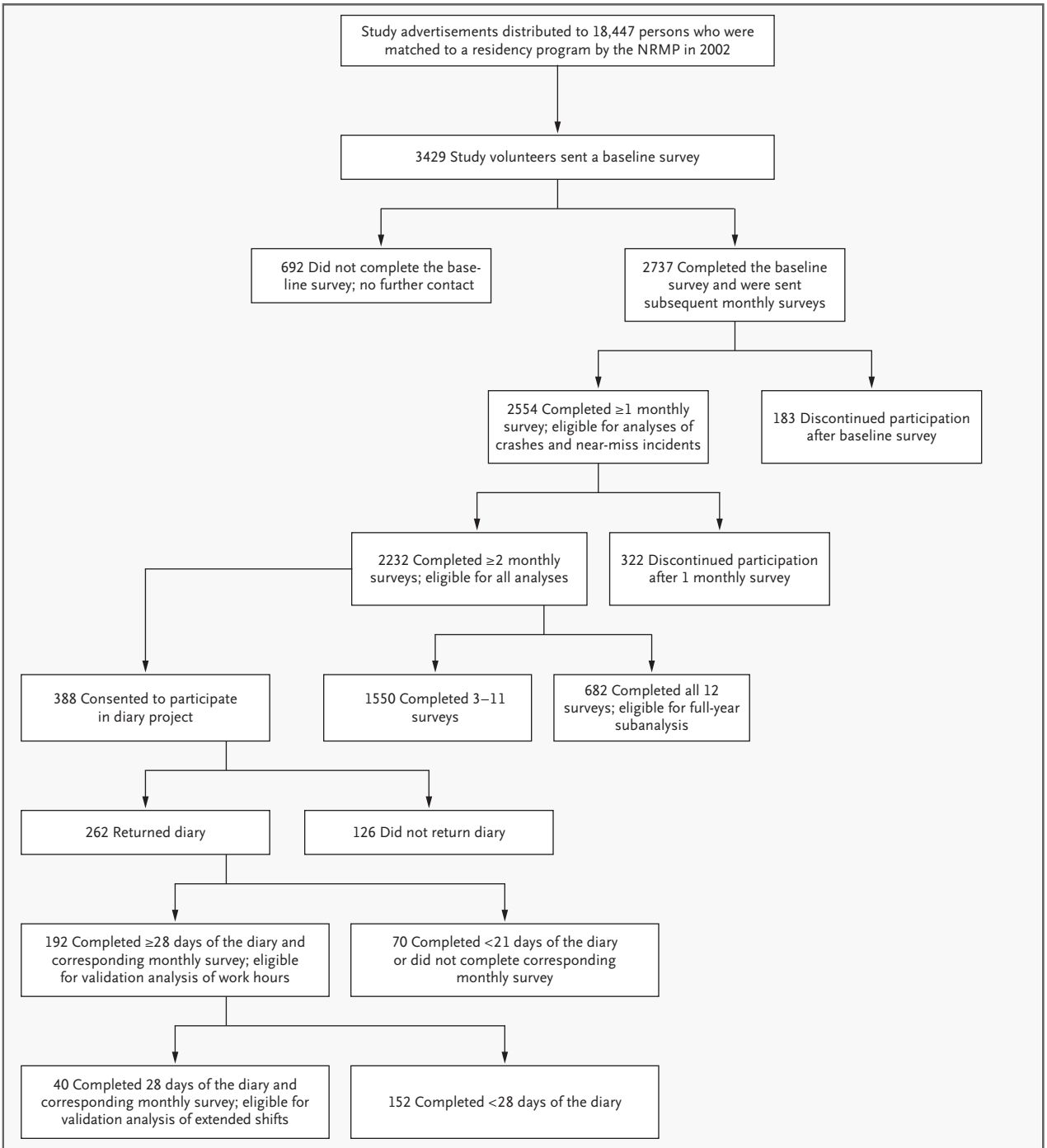

Figure 1. Flow Chart of Participation in the Study.

Although the primary means of advertisement and entrance into the study was through the National Resident Matching Program (NRMP), advertisements were also sent out to U.S. medical school graduates. Therefore, participants in the survey may have included those who arranged their internships outside of the NRMP.

ing night-float coverage, the average number of hours of night-float coverage per extended shift was 7.3±3.3 hours. The average number of sleep hours per extended shift for those with night-float coverage was significantly greater than the number for those without night-float coverage (3.2±1.6 hours vs. 2.6±1.7 hours; t=21.3; P<0.001). The number of sleep hours during extended shifts is shown in Figure 3.

The largest number of continuous hours that interns reported that they were physically at work averaged 27.6±10.5 hours (Fig. 4A). Although a quarter of the interns reported that their longest shift did not exceed 16 hours, the modal length of the longest shift worked for the remaining three quarters of the interns was 33 to 36 hours. The largest number of hours that interns remained continuously awake averaged 25.3±8.3 hours, with a subgroup remaining continuously awake much longer (Fig. 4D), indicating that extended work shifts of 48 to 84 hours still occurred in some residency programs, presumably on weekends.

MOTOR VEHICLE CRASHES

A total of 320 motor vehicle crashes were reported, including 133 that were consequential (i.e., crashes leading to treatment in an emergency department, property damage of $1,000 or greater, the filing of a police report, or a combination of these factors); 131 of the 320 crashes occurred on the commute from work. Documentation was obtained for 82 percent of all crashes. The risk of either a crash or a near-miss incident was significantly greater if the intern was commuting from work after an extended shift than it was after a nonextended shift. The Mantel–Haenszel odds ratio was 2.3 (95 percent confidence interval, 1.6 to 3.3) for motor vehicle crashes (χ^2=21.4, with 1 df; P<0.001) and 5.9 (95 percent confidence interval, 5.4 to 6.3) for near-miss incidents (χ^2=2419.5, with 1 df; P<0.001) (Table 1). To address possible reporting bias, we calculated these ratios for the 682 interns who completed all 12 monthly surveys, and the results were similar: 44 crashes during the commute from work (odds ratio, 2.5; 95 percent confidence interval, 1.4 to 4.7) and 663 near-miss incidents (odds ratio, 5.5; 95 percent confidence interval, 4.8 to 6.3). Crashes that occurred after extended shifts and those that occurred after nonextended shifts followed similar temporal patterns for both the time of day and the day of the week (Fig. 1 of the Supplementary Appendix).

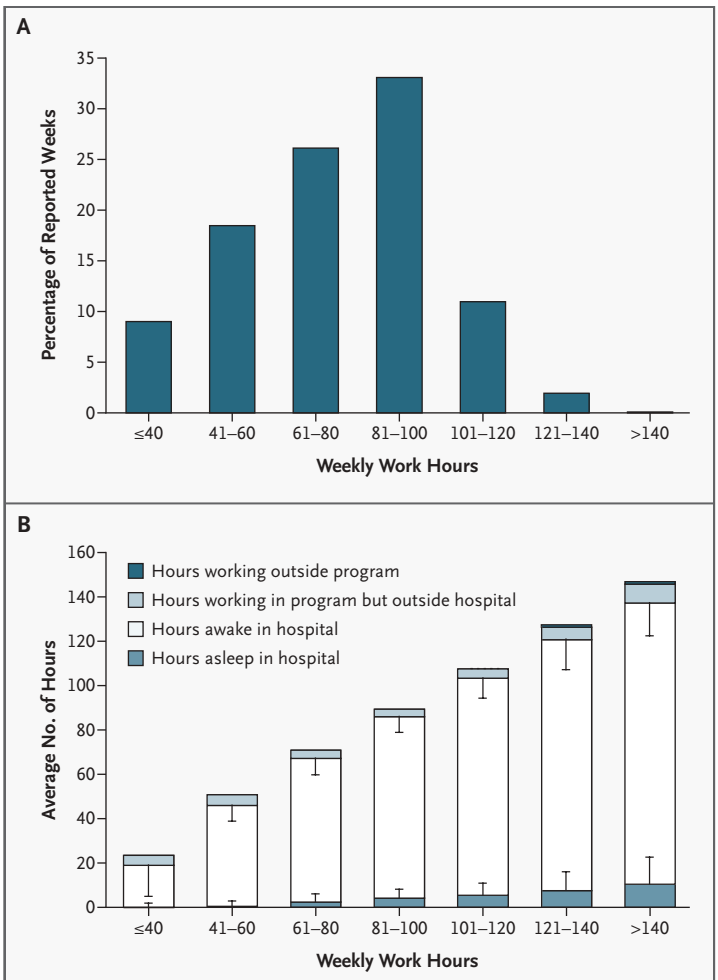

Figure 2. Weekly Hours That Interns Worked as a Percentage of Reported Weeks.

A total of 17,003 person-months of data were collected from a nationwide sample during 2002–2003. The distribution of the percentages of reported weeks with a given range of work hours is shown in Panel A. Panel B shows the average number of hours that interns spent asleep in the hospital, awake in the hospital, studying or working in relation to their program but outside the hospital, and working outside of the program. T bars indicate standard deviations. Interns reported spending an average of 193.4±88.8 of their waking hours in the hospital each month participating in direct patient care (e.g., examining patients; writing progress notes; interpreting diagnostic tests, radiographic studies, and pathological specimens; and consulting with other physicians), 43.3±47.0 hours in duties not directly related to patient care (e.g., completing other paperwork and scheduling tests), 23.5±20.1 hours in structured learning sessions (including classes, laboratories, and grand rounds), and 7.3±16.4 hours teaching students or house staff.

Every extended shift that was scheduled per month increased the monthly rate of any motor vehicle crash by 9.1 percent (95 percent confidence interval, 3.4 to 14.7 percent) and increased the monthly rate of a crash on the commute from work by 16.2 percent (95 percent confidence interval, 7.8 to 24.7

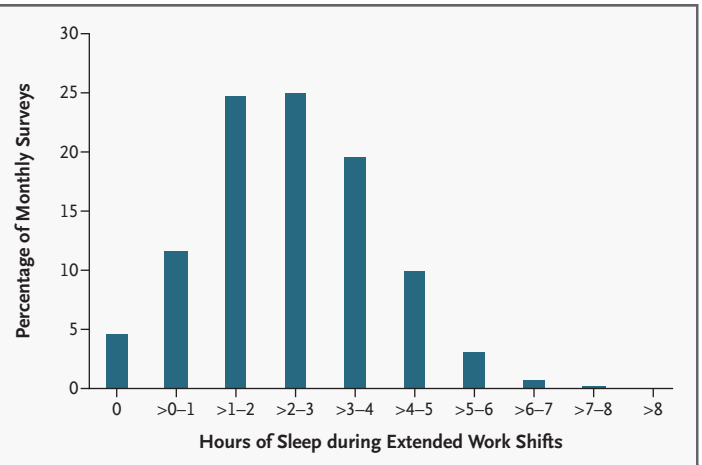

Figure 3. Hours That Interns Slept during Extended Shifts as a Percentage of Monthly Surveys.

percent). The odds ratios for falling asleep while driving or while stopped in traffic increased significantly as the number of extended shifts worked per month increased (Table 2).

DISCUSSION

We found that the odds that interns will have a documented motor vehicle crash on the commute after an extended work shift were more than double the odds after a nonextended shift. Near-miss incidents were more than five times as likely to occur after an extended work shift as they were after a nonextended shift. These findings, which are of particular concern because motor vehicle crashes are the leading cause of death in this age group,[14] are consistent with the findings that sleep deprivation degrades performance[5,15,16] and that the number of fatigue-related crashes increases in proportion to the time spent on task.[6] Given the percentage of interns in our study who commuted by car (69 percent), these data suggest that implementation of a work schedule for interns without any extended shifts[11] could prevent a substantial number of crashes.

We also found, with the use of a validated survey instrument, that in the 2002–2003 academic year, 46.2 percent of the weeks that interns worked averaged more than 80 work hours, and 11.0 percent of the weeks they worked averaged more than 100 work hours. These findings are consistent with earlier studies of self-reported work hours.[1] Overall, interns reported that they were awake during 96.1 percent of their hours in the hospital. Contrary to conventional wisdom, interns whose weekly work hours exceeded the equivalent of three full-time jobs (i.e., >120 hours per week) slept just as small a percentage of their time in the hospital as did interns working the most common weekly work hours (81 to 100 hours per week).

These findings reveal that the schedule of present-day resident physicians in the United States is far different from that of resident physicians 60 years ago who lived, worked, and slept in the hospital in order to follow the evolution of the illnesses of patients who were hospitalized for extended periods.[17] Currently, interns work extended shifts with minimal sleep in the hospital while caring for patients who are hospitalized during the most acute phase of their illness. Yet interns are still anachronistically described as being "on call" during these extended shifts, even though they are working 96 percent of the time. In today's climate of pressure to reduce the length of patients' hospital stays, 85.6 percent of monthly surveys indicated that interns slept four hours or less while working on extended shifts.

Given that there are 168 hours in a week, the opportunity for sleep is severely limited among interns who are working more than 100 hours per week. Their ability to sleep for the recommended eight hours per night becomes physically impossible and inevitably leads to progressively more severe chronic sleep restriction, with its attendant consequences.[15-18]

Most interns in our study routinely worked more than 30 consecutive hours, a schedule that involved at least one night of acute sleep deprivation. It is remarkable that there were 275 reports from interns who worked more than 40 continuous hours, a shift that necessarily involved the intrusion of acute sleep deprivation into a second consecutive night. Given the 1400 person-years of data collected, extrapolation of these results to the wider population of 102,577 person-years worked by residents in U.S. hospitals in 2002–2003[19] suggests that physicians in training worked approximately 20,000 extended shifts that exceeded 40 consecutive hours while caring for patients. Of note, extrapolation from our data suggests that 10 percent of these shifts may have exceeded 64 continuous hours in duration, indicating potential intrusion of acute sleep deprivation into a third consecutive night on a single work shift.

Our study has a number of limitations. First, even

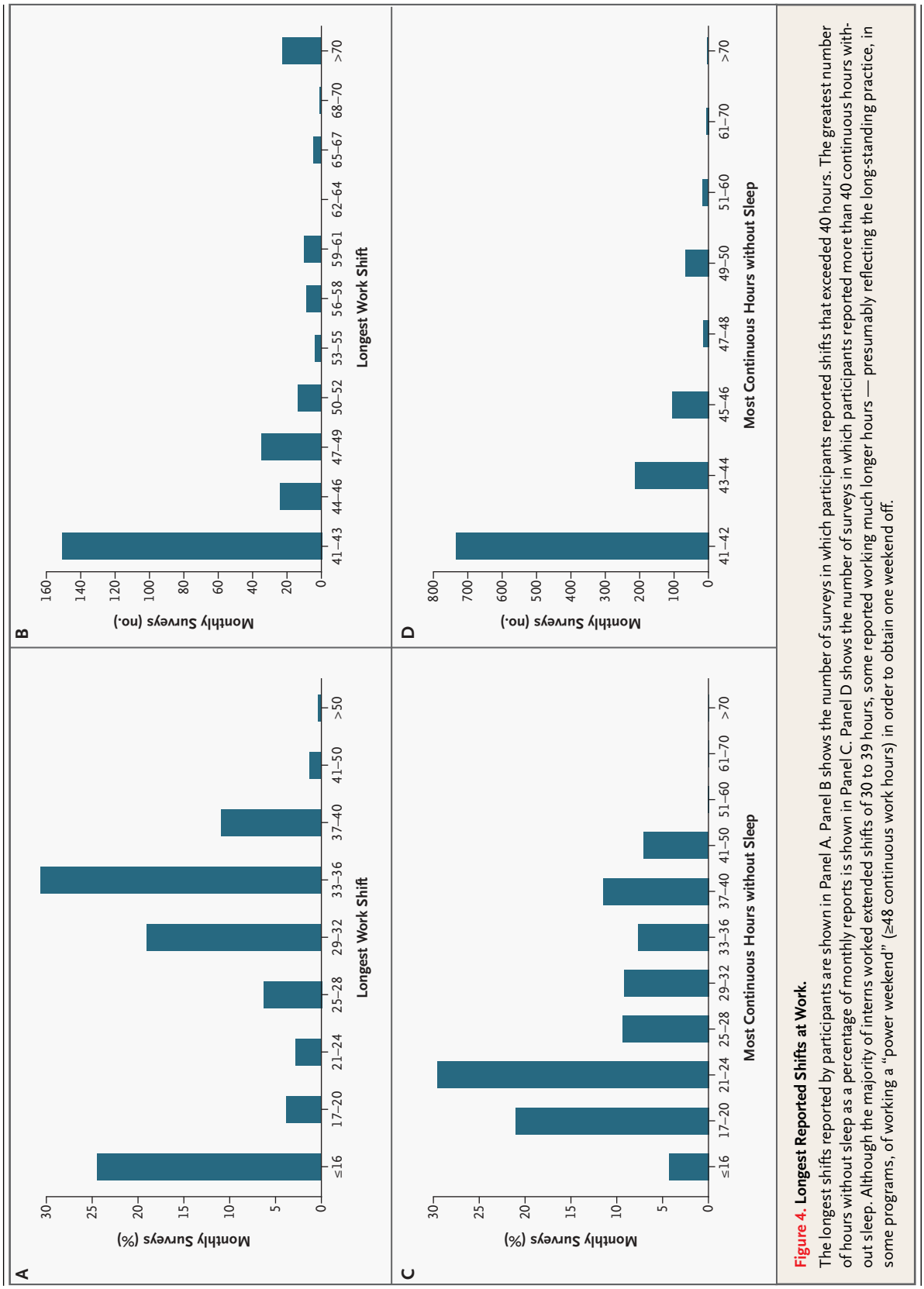

Figure 4. Longest Reported Shifts at Work.

The longest shifts reported by participants are shown in Panel A. Panel B shows the number of surveys in which participants reported shifts that exceeded 40 hours. The greatest number of hours without sleep as a percentage of monthly reports is shown in Panel C. Panel D shows the number of surveys in which participants reported more than 40 continuous hours without sleep. Although the majority of interns worked extended shifts of 30 to 39 hours, some reported working much longer hours — presumably reflecting the long-standing practice, in some programs, of working a "power weekend" (≥48 continuous work hours) in order to obtain one weekend off.

Table 1. Risk of Motor Vehicle Crashes and Near-Miss Incidents after Extended Shifts.*

Variable	Extended Work Shifts (≥24 hr)	Nonextended Work Shifts (<24 hr)
Crashes		
No. reported	58	73
No. of commutes	54,121	180,289
Rate (per 1000 commutes)	1.07	0.40
Odds ratio (95% CI)	2.3 (1.6–3.3)	1.0
Near-miss incidents		
No. reported	1,971	1,156
No. of commutes	54,121	180,289
Rate (per 1000 commutes)	36.42	6.41
Odds ratio (95% CI)	5.9 (5.4–6.3)	1.0

* A within-person case-crossover analysis was used to assess the risks of motor vehicle crashes and near-miss incidents among interns during commutes after extended shifts as compared with nonextended shifts. A two-by-two table was constructed for each intern who reported either a crash or a near-miss incident, consisting of the number of crashes or near-miss incidents after an extended shift, the number of crashes or near-miss incidents after a nonextended shift, the number of extended shifts that did not precede a crash or a near-miss incident, and the number of nonextended shifts that did not precede a crash or a near-miss incident. CI denotes confidence interval.

though we had a response rate of 80 percent from interns who volunteered to participate, those who did may not be representative. However, the distributions of age and residency-program type of our participants were comparable to those in the entire National Resident Matching Program. Notably, participants were not apprised of the study hypotheses, and the questions regarding our primary variables of exposure (work shifts of extended duration) and outcome (motor vehicle crashes) were validated and documented, respectively, and distributed among numerous other questions. As such, we believe that it is highly improbable that the participants — even those with a specific interest in the work hours of residents — could have deliberately affected the specific data regarding crash and near-miss rates that we report here. Second, the case-crossover analysis cannot account for the contribution of within-person factors that may have been covariates with exposure status. For example, interns probably had higher average blood levels of caffeine during their commutes after extended shifts as compared with commutes after nonextended shifts — a factor that may have had an effect on our results.[20] However, even if extended shifts were to elicit behavior that affected risk, this elicited behavior would not obviate the potential causal relationship between exposure to extended shifts and motor vehicle crashes. Third, our prospective analysis may have been confounded by uncontrolled covariates, although the results of that analysis were consistent with the results of our case-crossover analysis, which was free of such confounders because each participant served as his or her own control. Fourth, by collecting data on a monthly basis, we attempted to reduce, but could not eliminate, the effect of recall bias. Fifth, reporting bias could have confounded the results of our case-crossover analysis if participants preferentially completed monthly surveys after having had a motor vehicle crash. However, the prospective analysis, which was relatively free of this type of reporting bias, yielded similar results. Furthermore, case-crossover analysis of the subgroup of participants who completed all the surveys yielded an odds ratio of 2.5 (95 percent confidence interval, 1.4 to 4.7) for having a motor vehicle crash after working an extended shift (as compared with a nonextended shift) that was similar to that of the entire study population (odds ratio, 2.3; 95 percent confidence interval, 1.6 to 3.3). Overall, the convergence of our crash results with the use of two independent methods of exposure-data collection strongly supports our conclusion that an increased risk of crashes and near-miss incidents is associated with working extended shifts.

The increased rate of actual motor vehicle crashes and near-miss incidents during interns' commutes after extended work shifts that we have documented has legal implications, since drivers in both the United States[21,22] and Great Britain[23] have already been convicted of vehicular homicide for driving when impaired by sleepiness. Furthermore, the state of New Jersey has recently amended its vehicular-homicide statute to add to the definition of reckless driving "driving after having been without sleep for a period in excess of 24 consecutive hours," a revision that explicitly subjects drivers in that state to a conviction of criminal homicide under such circumstances.[24] Similar legislation is pending in New York, Massachusetts, and Michigan. Moreover, appeals courts in two states have ruled that an employer's responsibility for fatigue-related crashes can continue even after an employee has left work, similar in concept to the liability incurred by people who serve alcohol to drivers who are subsequently involved in alcohol-related mo-

Table 2. Odds Ratios for Falling Asleep while Driving or while Stopped in Traffic, According to the Monthly Number of Extended Work Shifts.*

Question	0 Extended Work Shifts				1–4 Extended Work Shifts				≥5 Extended Work Shifts			
	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio (95% CI)	No. of Person-Months	No. of Person-Months with Positive Response	Rate of Positive Response	Odds Ratio (95% CI)
Did you nod off or fall asleep while driving?	3035	199	0.066	1.00	3068	286	0.093	1.82 (1.73–1.93)	6933	872	0.126	2.39 (2.31–2.46)
Did you nod off or fall asleep while stopped in traffic?	3039	311	0.102	1.00	3078	508	0.165	1.74 (1.68–1.81)	6944	1608	0.232	3.69 (3.60–3.77)

* Data are from interns' monthly reports on extended shifts. The number of person-months varies because nonresponses were eliminated from the analysis. Rates represent the proportion of months in which participants reported one or more incidents of nodding off or falling asleep, regardless of how many incidents were reported. CI denotes confidence interval.

tor vehicle crashes.[25,26] The Department of Surgery at the University of Michigan has taken the initiative to address this concern by offering round-trip taxicab vouchers to surgical residents on request (Mulholland M: personal communication). However, the impairment of judgment about one's own ability to perform after sleep deprivation[15] could limit the use of such transportation vouchers by residents, even when they are available.

In 2005, the current work-hour guidelines of the Accreditation Council for Graduate Medical Education still allow interns in the United States to work 30 consecutive hours every other shift. This practice has recently been prohibited by the European Union, which stipulates a "minimum daily rest period of 11 consecutive hours per 24-hour period" (thereby limiting the duration of shifts for all physicians to 13 hours), although the regulation includes some exceptions and a controversial opt-out provision.[27] Our data indicate that scheduling physicians to work such extended shifts, which our group has recently shown to increase the risk of failures of attention[11] and serious medical errors,[28] poses a serious and preventable safety hazard for them and other motorists. These results have important implications for scheduling practices in medical-residency programs.

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