Interns' Compliance With Accreditation Council for Graduate Medical Education Work-Hour Limits

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Context Sleep deprivation is associated with increased risk of serious medical errors and motor vehicle crashes among interns. The Accreditation Council for Graduate Medical Education (ACGME) introduced duty-hour standards in 2003 to reduce work hours.

Objective To estimate compliance with the ACGME duty-hour standards among interns.

Design, Setting, and Participants National prospective cohort study with monthly Web-based survey assessment of intern work and sleep hours using a validated instrument, conducted preimplementation (July 2002 through May 2003) and postimplementation (July 2003 through May 2004) of ACGME standards. Participants were 4015 of the approximately 37 253 interns in US residency programs in all specialties during this time; they completed 29 477 reports of their work and sleep hours.

Main Outcome Measure Overall and monthly rates of compliance with the ACGME standards.

Results Postimplementation, 1068 (83.6%; 95% confidence interval [CI], 81.4%-85.5%) of 1278 of interns reported work hours in violation of the standards during 1 or more months. Working shifts greater than 30 consecutive hours was reported by 67.4% (95% CI, 64.8%-70.0%). Averaged over 4 weeks, 43.0% (95% CI, 40.3%-45.7%) reported working more than 80 hours weekly, and 43.7% (95% CI, 41.0%-46.5%) reported not having 1 day in 7 off work duties. Violations were reported during 3765 (44.0%; 95% CI, 43.0%-45.1%) of the 8553 intern-months assessed postimplementation (including vacation and ambulatory rotations), and during 2660 (61.5%; 95% CI, 60.0%-62.9%) of 4327 intern-months during which interns worked exclusively in inpatient settings. Postimplementation, 29.0% (95% CI, 28.7%-29.7%) of reported work weeks were more than 80 hours per week, 12.1% (95% CI, 11.8%-12.6%) were 90 or more hours per week, and 3.9% (95% CI, 3.7%-4.2%) were 100 or more hours per week. Comparing preimplementation to postimplementation responses, reported mean work duration decreased 5.8% from 70.7 (95% CI, 70.5-70.9) hours to 66.6 (95% CI, 66.3-66.9) hours per week ($P<.001$), and reported mean sleep duration increased 6.1% (22 minutes) from 5.91 (95% CI, 5.88-5.94) hours to 6.27 (95% CI, 6.23-6.31) hours per night ($P<.001$). However, reported mean sleep during extended shifts decreased 4.5%, from 2.69 (95% CI, 2.66-2.73) hours to 2.57 (95% CI, 2.52-2.62) hours ($P<.001$).

Conclusion In the first year following implementation of the ACGME duty-hour standards, interns commonly reported noncompliance with these requirements.

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In 2003, the Accreditation Council for Graduate Medical Education (ACGME) implemented work-hour limits for all physicians-in-training (residents) in the United States. Each trainee is limited to a maximum of 30 consecutive work hours, including the time used for sign-out, didactic teaching, and continuity of patient care (30-hour rule), and a maximum of 80 weekly work hours, averaged over 4 weeks (80-hour rule). In addition, 1 day in 7 (averaged over 4 weeks) must be free of all duties (7-day rule).[1] These limits were developed in response to national concern with the long work hours of residents, manifest by initiatives to limit the work hours of medical trainees through both federal regulation and legislation.[2-5] In deferring federal action, both the executive and legislative branches chose to rely instead on the internal professional regulation being developed and implemented as the new ACGME work-hour limits.[6,7]

Data reported by the ACGME suggest that these limits succeeded in eliminating nearly all work weeks greater than 80 hours and shifts greater than 30 consecutive hours. Based largely on mandatory reports submitted to the ACGME by residency programs, the ACGME reported that only 5.0% of residency training programs were noncompliant with the standards in the year after their release, and that only 3.3% of surveyed residents reported violations of the 80-hour rule.[8] The reliability of these data

See also pp 1049, 1055, 1071, and 1132.

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is unclear, however, because the resident survey instrument used by the ACGME has not been validated and the manner in which residency programs collect work hours data is not standardized.[9] Moreover, the ACGME has the authority to withdraw the accreditation of noncompliant programs,[10] which could lead to inaccurate reporting by institutions. Preliminary cross-sectional surveys have suggested that house officers' work hours may be higher than those reported to the ACGME,[11-14] but prospective, longitudinal studies using validated measures of work hours have not been conducted.

Since July 2002, we have been prospectively collecting independent data on the work and sleep of medical trainees through the Harvard Work Hours, Health and Safety (HWHHS) program. The primary purpose of this study was to estimate the frequency with which interns (first-year residents) were compliant with the ACGME duty-hour standards; as a secondary aim, we evaluated the degree to which reported work hours and sleep changed after implementation of the standards.

METHODS

In April of 2002 and 2003, the Association of American Medical Colleges attempted on our behalf to email advertisements about the HWHHS study to a cohort of 18 447 medical students in 2002 and 18 806 in 2003. The students had been matched by the National Residency Matching Program to approximately 3200 programs for trainees in their first postgraduate year in 1100 teaching hospitals nationwide.[15,16] In addition, in the spring of 2002, we sent email advertisements to all known email addresses of 4th year medical students graduating from US programs. It is not known how many reached the intended recipients. The mailing informed students of our intent to conduct a longitudinal study of work hours, health, and safety. Potential participants were directed to a secure Web site that gave detailed information about the study and enabled them to provide electronically written informed consent. Participants were entered into a cash lottery.

Those who consented to participate were asked to provide data on a monthly basis from July through May of their intern year, such that monthly data were collected from a national sample of interns in 2002-2003 and 2003-2004. In June of each year, interns who consented to participate used a password-protected secure Web site to enter baseline demographic, health, and safety information; data on work hours were not collected in the baseline survey. Interns who completed the baseline survey comprised the study cohort.

From July through May, on the 28th of each month, emails were sent to all participants in the study cohort, requesting detailed data on their work hours and sleep during the first, second, third, and fourth week of that month. These questions were administered alongside many others regarding monthly activities and work experiences that served as distractors, including use of caffeinated beverages and alcohol, motor vehicle crashes, needlestick injuries, and job performance. Key items analyzed for this study were "Hours spent physically awake in the hospital, classes, or workplace"; "Hours spent working or studying outside of the hospital, classroom, or workplace (eg, at home or at the library) related to your program"; "Hours of sleep at school, the workplace, or hospital"; "Hours of sleep outside of school, the workplace, or hospital"; "Number of days off (ie, a full 24-hour period)"; "Number of extended shifts" ($\geq$24 hours continuous at work); "Average length of extended shift"; "Average hours of sleep during these extended shifts"; "In the month of [insert month], what was the longest number of continuous hours you were actually physically at work? Include protected time for sleep provided during an extended shift"; and "In the month of [insert month], what was the longest number of continuous hours you went without sleep?" No mention was made in the survey of the ACGME duty-hour standards or compliance with work-hour rules. Participants had the opportunity to provide monthly data from the time of the initial email through the 27th of the following month.

Participants completed data forms on Web sites hosted and maintained by Pearson NCS, Inc (Eagen, Minn). Pearson NCS securely transmitted all data on a weekly basis to Brigham and Women's Hospital; data were coded and participants were assigned a study identification number. Potentially identifiable data were stored in a secure location separate from the main database. The Centers for Disease Control and Prevention issued a certificate of confidentiality for this study. In addition, because the Agency for Healthcare Research and Quality supported this research, the data confidentiality is protected by federal statute (Public Health Service Act 42 USC). The HWHHS study was approved by the Brigham and Women's Hospital Human Research Committee. Further details regarding HWHHS recruitment and study methods have been published previously.[17]

Validation

As previously described,[17] to validate hours reported using our monthly instrument, we had a 7% random sample of participants in 2002-2003 (year 1) complete daily work diaries. Total work hours and number of extended work shifts reported via the surveys and diaries were well correlated (Pearson coefficients, 0.76 and 0.94, respectively; $P<.001$ for both). We further validated daily diary data against directly observed work hours ($r=0.98$; $P<.001$) and polysomnographically recorded sleep ($r=0.94$; $P<.001$) in 20 interns in another study.[18]

Statistical Analyses

Descriptive statistics were used to estimate compliance with each of the ACGME duty-hour standards in the year after their implementation, as well as interns' work and sleep hours before and after implementation of the standards. The HWHHS compliance data were compared with the ACGME's published compliance data[8] using Fisher exact tests. Mean work and sleep hours in the year before and after implementation of the standards were compared using nonparametric Wilcoxon rank sum tests. Trends over time in

rates of compliance were analyzed using the Cochran-Armitage test for trend. SAS version 9.1 (SAS Institute Inc, Cary, NC) was used for statistical comparisons. Significance level was set at .05; all reported *P* values are 2-sided.

RESULTS

The Association of American Medical Colleges attempted to send advertisements to 18 447 medical students in 2002 and 18 806 medical students in 2003. Of these, 2737 (14.8%) in 2002 (preimplementation) and 1278 (6.8%) in 2003 (postimplementation) volunteered to participate and completed baseline surveys, for a total cohort of 4015 participants. As interns, they completed a total of 29 477 baseline plus monthly reports of their work and sleep hours (mean [SD] 7.3 [4.0] out of 12 possible). Of the participants, 60.1% (17.1%) responded to each wave of the survey in year 1, and 63.5% (17.5%) responded to each wave of the survey in year 2. Compared with all applicants in the Electronic Residency Application Service database, there was a greater percentage of female residents in our study cohort (53% vs 41%) in 2002, and the mean age of our interns was lower (28.0 years vs 30.2 years) (data from the Electronic Residency Application Service; personal communication, Paul Jolly, PhD, Senior Associate Vice President, AAMC, July 19, 2006). The study cohort consisted of 79% medical specialties, 11% surgical specialties, and 10% other/not specified, compared with 88% medical specialties and 12% surgical specialties in the National Residency Matching Program cohort.[19] Most hospitals in the study sample were represented by several interns, well-distributed geographically and across program types. There was a mean of 3.7 interns and 23.1 intern-months per represented hospital; 420 hospitals were represented in year 1 and 346 in year 2 of the approximately 1100 teaching hospitals nationwide.

Compliance With ACGME Duty Hour Standards

In the year following implementation, 1068 (83.6%; 95% confidence interval [CI], 81.4%-85.5%) of 1278 participating interns reported work hours that were noncompliant with the ACGME standards during at least 1 month (TABLE 1). Hours in violation of the duty-hour standards were reported during 3765 (44.0%; 95% CI, 43.0%-45.1%) of the 8553 monthly reports received postimplementation; 2660 (61.5%; 95% CI, 60.0%-62.9%) of the 4327 months during which interns worked exclusively in hospital settings contained reported hours in violation of the standards. Over the year, monthly rates of noncompliance decreased from 48.8% (95% CI, 46.0%-51.6%) in July 2003 to 38.0% (95% CI, 34.4%-41.2%) in May 2004 ($P<.001$) (FIGURE).

Violations were reported from 604 (85.4%; 95% CI, 82.6%-87.8%) of the 707 represented residency programs (TABLE 2) and from interns in 314 (90.8%; 95% CI, 87.2%-93.3%) of the 346 represented hospitals (TABLE 3). Fewer reports were submitted from hospitals without any reported violations than from hospitals with violations (mean 6.0 [95% CI, 4.4-7.6] vs 24.8 [95% CI, 22.2-27.4]; $P<.001$). Violations were reported from a smaller proportion of hospitals in New York and Puerto Rico (the only 2 states or commonwealths with governments that currently have laws enforcing resident work limits[20]) than from hospitals in all other states, where no such laws are in effect (78.1% [95% CI, 61.1%-88.9%] vs 92.0% [95% CI, 88.5%-94.5%]; $P=.02$); 30-hour violations were reported in less than half as many New York and Puerto Rican hospitals (37.5% [95% CI, 22.9%-54.9%] vs 84.1% [95% CI, 79.6-87.7]; $P<.001$).

Table 1. Proportion of Hospitals, Residency Programs, Interns, Intern-Months, and Inpatient Intern-Months With Reported Hours in Violation of the ACGME Work Hour Rules, 2003-2004

	No.	Percent With Reported Violations (95% CI)
No. of hospitals	346	
Any rule violation	314	90.8 (87.2-93.3)
30-h Rule violation	276	79.8 (75.2-83.7)
80-h Rule violation	283	81.8 (77.4-85.5)
7-d Rule violation	220	63.6 (58.4-68.5)
No. of residency programs	707	
Any rule violation	604	85.4 (82.6-87.8)
30-h Rule violation	496	70.2 (66.7-73.4)
80-h Rule violation	493	69.7 (66.2-73.0)
7-d Rule violation	360	50.9 (47.2-54.6)
No. of interns	1278	
Any rule violation	1068	83.6 (81.4-85.5)
30-h Rule violation	862	67.4 (64.8-70.0)
80-h Rule violation	549	43.0 (40.3-45.7)
7-d Rule violation	559	43.7 (41.0-46.5)
No. of intern-months	8553	
Any rule violation	3765	44.0 (43.0-45.1)
30-h Rule violation	2719	31.8 (30.9-32.8)
80-h Rule violation	1865	21.8 (20.9-22.7)
7-d Rule violation	850	9.9 (9.3-10.6)
No. of inpatient intern-months*	4327	
Any rule violation	2660	61.5 (60.0-62.9)
30-h Rule violation	1925	44.5 (43.0-46.0)
80-h Rule violation	1674	38.7 (37.2-40.1)
7-d Rule violation	561	13.0 (12.0-14.0)

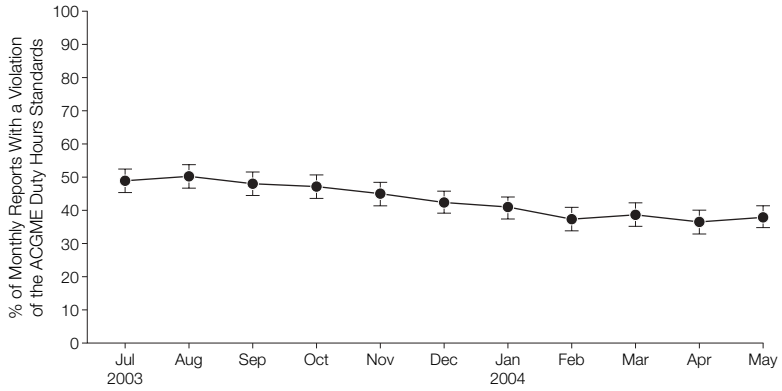
Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; CI, confidence interval.
*Inpatient intern-months is defined as months during which interns' primary activity for the entire month was working in hospital settings, including hospital wards, hospital consult services, or intensive care units; excludes months that contained vacation, electives, ambulatory rotations, and other nonhospital rotations.

Interns' Sleep and Work, Pre- vs Post-ACGME Duty-Hour Standards

Interns' reported mean weekly work hours (excluding vacation time and extended leave) decreased 5.8% following implementation of the ACGME standards from 70.7 hours (95% CI, 70.5-70.9) to 66.6 hours (95% CI, 66.3-66.9) ($P<.001$) (TABLE 4). Of the 63 455 reported work weeks of interns in the preimplementation group, 25 313 (40.0%; 95% CI, 39.5%-40.3%) were more than 80 hours per week; 15 509 (24.4%; 95% CI, 24.1%-24.8%) were 90 or more hours per week, and 7098 (11.2%; 95% CI, 10.9%-11.4%) were 100 or more hours per week. In comparison, of the 31 256 reported work weeks of interns in the postimplemenation group, 9141 (29.0%; 95% CI, 28.7%-29.7%) were more than 80 hours per week, 3815 (12.1%; 95% CI, 11.8%-12.6%) were 90 or more hours per week, and 1235 (3.9%; 95% CI, 3.7%-4.2%) were 100 or more hours per week ($P<.001$ for each category).

Following implementation, the mean reported duration of extended work shifts decreased 6.9% from 32.1 (95% CI, 32.0-32.2) hours to 29.9 (95% CI, 29.8-30.0) hours ($P<.001$) (Table 4). In weeks with extended duration work shifts, the weekly mean length of extended duration work shifts was reported to exceed 30 hours on 56.1% of weeks before and 22.5% of weeks after implementation of the 30-hour rule ($P<.001$). The longest number of hours in a month that interns reported remaining continuously awake was not significantly changed (25.3 [95% CI, 25.1-25.4] vs 24.9 [95% CI, 24.7-25.0] hours; $P=.25$). Postimplementation, reported mean nightly sleep increased 6.1% (22 minutes) from 5.91 (95% CI, 5.88-5.94) hours to 6.27 (95% CI, 6.23-6.31) hours per night ($P<.001$); reported sleep during extended shifts, however, decreased 4.5%, from 2.69 (95% CI, 2.66-2.73) hours to 2.57 (95% CI, 2.52-2.62) hours ($P<.001$).

Figure. Trend in Monthly Rates of Noncompliance With the ACGME Duty-Hour Standards, July 2003-May 2004



Error bars indicate 95% confidence intervals. A mean (SD) of 778 (199) reports of work hours were submitted each month (range, 491-1212). There is a significant decrease in the percentage of months with any violation ($P<.001$, Cochran-Armitage test for trend). ACGME indicates Accreditation Council for Graduate Medical Education.

COMMENT

In this cohort study, 83.6% of participating interns reported working hours that were noncompliant with the ACGME duty-hour standards during at least 1 month in the year following their introduction. Violations were reported during 44.0% of intern-months, including inpatient months as well as months with vacations, electives, and ambulatory rotations; violations were reported during 61.5% of all intern-months worked exclusively in inpatient settings.

Violations of the 30-hour rule remained common following implementation of the standards, despite the mean decrease of 6.9% in the length of extended duration work shifts. The weekly mean

Table 2. Proportion of Residency Programs With Interns Reporting Violations of the ACGME Work Hour Rules by Program Type, 2003-2004

Program Type	No. of Programs	No. (%; 95% CI) of Programs With Any ACGME Violations	No. (%; 95% CI) of Programs With 30-Hour Violations	No. (%; 95% CI) of Programs With 80-Hour Violations	No. (%;95% CI) of Programs With 7-Day Violations
Family medicine	76	66 (86.8; 77.4-92.6)	58 (76.3; 65.6-84.4)	53 (69.7; 58.6-78.9)	41 (53.9; 42.8-64.7)
Internal medicine	105	99 (94.3; 88.1-97.3)	89 (84.8; 76.6-90.4)	90 (85.7; 77.7-91.1)	53 (50.5; 41.0-59.9)
Preliminary medicine year	64	54 (84.4; 73.5-91.2)	45 (70.3; 58.2-80.1)	46 (71.9; 59.8-81.4)	29 (45.3; 33.7-57.5)
Medicine-pediatrics	19	18 (94.7; 75.1-98.8)	17 (89.5; 68.3-96.8)	14 (73.7; 50.9-88.1)	12 (63.2; 40.8-80.9)
Pediatrics	81	74 (91.4; 83.2-95.7)	62 (76.5; 66.2-84.4)	64 (79.0; 68.9-86.4)	44 (54.3; 43.5-64.7)
Emergency medicine	44	40 (90.9; 78.8-96.2)	35 (79.5; 65.4-88.8)	32 (72.7; 58.1-83.6)	23 (52.3; 37.9-66.3)
Transitional year	54	48 (88.9; 77.8-94.7)	42 (77.8; 65.0-86.8)	36 (66.7; 53.3-77.8)	20 (37.0; 25.4-50.4)
Obstetrics/gynecology	47	33 (70.2; 55.9-81.3)	22 (46.8; 33.3-60.8)	27 (57.4; 43.2-70.5)	22 (46.8; 33.3-60.8)
Pathology	20	10 (50.0; 29.8-70.2)	1 (5.0; 1.2-23.8)	3 (15.0; 5.4-36.3)	8 (40.0; 21.8-61.6)
Psychiatry	36	31 (86.1; 71.2-93.8)	25 (69.4; 53.0-82.0)	18 (50.0; 34.4-65.6)	21 (58.3; 42.1-72.9)
General surgery	64	51 (79.7; 68.2-88.0)	39 (60.9; 48.6-72.0)	43 (67.2; 54.9-77.4)	40 (62.5; 50.2-73.3)
Preliminary surgery year	35	32 (91.4; 77.5-96.9)	22 (62.9; 46.2-76.9)	27 (77.1; 60.8-87.9)	23 (65.7; 49.0-79.2)
Other residency	62	48 (77.4; 65.5-86.0)	39 (62.9; 50.4-73.9)	40 (64.5; 52.0-75.3)	24 (38.7; 27.6-51.2)
Total	**707**	**604 (85.4; 82.6-87.8)**	**496 (70.2; 66.7-73.4)**	**493 (69.7; 66.2-73.0)**	**360 (50.9; 47.2-54.6)**

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; CI, confidence interval.

Table 3. Number of Hospitals With Interns Reporting Violations of the ACGME Work Hour Rules by State/Commonwealth, 2003-2004

State/Commonwealth	No. of Represented Hospitals	No. (%)			
		Hospitals With Any ACGME Violations	Hospitals With 30-Hour Violations	Hospitals With 80-Hour Violations	Hospitals With 7-Day Violations
Alabama	5	4 (80.0)	4 (80.0)	4 (80.0)	2 (40.0)
Arizona	7	7 (100.0)	7 (100.0)	7 (100.0)	5 (71.4)
Arkansas	3	3 (100.0)	3 (100.0)	2 (66.7)	0 (0.0)
California (Northern)	20	18 (90.0)	18 (90.0)	17 (85.0)	12 (60.0)
California (Southern)	24	24 (100.0)	24 (100.0)	22 (91.7)	14 (58.3)
Colorado	5	5 (100.0)	5 (100.0)	4 (80.0)	5 (100.0)
Connecticut	6	5 (83.3)	5 (83.3)	3 (50.0)	3 (50.0)
Delaware	2	2 (100.0)	2 (100.0)	2 (100.0)	2 (100.0)
District of Columbia	3	3 (100.0)	3 (100.0)	3 (100.0)	3 (100.0)
Florida	10	9 (90.0)	7 (70.0)	7 (70.0)	6 (60.0)
Georgia	6	6 (100.0)	6 (100.0)	6 (100.0)	4 (66.7)
Hawaii	3	1 (33.3)	1 (33.3)	1 (33.3)	1 (33.3)
Idaho	1	1 (100.0)	1 (100.0)	0 (0.0)	0 (0.0)
Illinois	16	13 (81.3)	12 (75.0)	11 (68.8)	9 (56.3)
Indiana	4	4 (100.0)	4 (100.0)	4 (100.0)	3 (75.0)
Iowa	3	3 (100.0)	2 (66.7)	2 (66.7)	3 (100.0)
Kansas	3	2 (66.7)	2 (66.7)	1 (33.3)	2 (66.7)
Kentucky	3	3 (100.0)	3 (100.0)	3 (100.0)	2 (66.7)
Louisiana	7	7 (100.0)	6 (85.7)	7 (100.0)	3 (42.9)
Maine	1	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
Maryland	11	11 (100.0)	10 (90.9)	11 (100.0)	7 (63.6)
Massachusetts	16	15 (93.8)	14 (87.5)	15 (93.8)	13 (81.3)
Michigan	14	12 (85.7)	11 (78.6)	10 (71.4)	7 (50.0)
Minnesota	8	6 (75.0)	6 (75.0)	5 (62.5)	5 (62.5)
Mississippi	2	2 (100.0)	2 (100.0)	2 (100.0)	2 (100.0)
Missouri	5	5 (100.0)	5 (100.0)	3 (60.0)	4 (80.0)
Nebraska	1	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
Nevada	1	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
New Hampshire	1	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
New Jersey	5	5 (100.0)	5 (100.0)	5 (100.0)	2 (40.0)
New Mexico	1	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)
North Carolina	9	9 (100.0)	9 (100.0)	9 (100.0)	5 (55.6)
Ohio	12	11 (91.7)	11 (91.7)	10 (83.3)	9 (75.0)
Oklahoma	3	3 (100.0)	3 (100.0)	3 (100.0)	3 (100.0)
Oregon	3	3 (100.0)	2 (66.7)	3 (100.0)	1 (33.3)
Pennsylvania	20	20 (100.0)	15 (75.0)	18 (90.0)	15 (75.0)
Rhode Island	5	4 (80.0)	4 (80.0)	4 (80.0)	4 (80.0)
South Carolina	6	6 (100.0)	3 (50.0)	5 (83.3)	3 (50.0)
Tennessee	10	9 (90.0)	6 (60.0)	8 (80.0)	5 (50.0)
Texas	21	18 (85.7)	17 (81.0)	17 (81.0)	13 (61.9)
Utah	3	3 (100.0)	3 (100.0)	2 (66.7)	3 (100.0)
Vermont	1	1 (100.0)	1 (100.0)	0 (0.0)	1 (100.0)
Virginia	6	6 (100.0)	5 (83.3)	6 (100.0)	4 (66.7)
Washington	9	8 (88.9)	6 (66.7)	6 (66.7)	6 (66.7)
West Virginia	2	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Wisconsin	7	7 (100.0)	6 (85.7)	7 (100.0)	5 (71.4)
Subtotal (percent with violations; 95% CI)	314	289 (92.0; 88.5-94.5)	264 (84.1; 79.6-87.7)	260 (82.8; 78.2-86.5)	201 (64.0; 58.6-69.1)
New York*	29	23 (79.3)	12 (41.4)	22 (75.9)	17 (58.6)
Puerto Rico*	3	2 (66.7)	0	1 (33.3)	2 (66.7)
New York and Puerto Rico* (percent with violations; 95% CI)	32	25 (78.1; 61.1-88.9)†	12 (37.5; 22.9-54.9)‡	23 (71.9; 54.4-84.4)	19 (59.4; 42.1-74.5)
Total (percent with violations; 95% CI)	**346**	**314 (90.8; 87.2-93.3)**	**276 (79.8; 75.2-83.7)**	**283 (81.8; 77.4-85.5)**	**220 (63.6; 58.4-68.5)**

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; CI, confidence interval.
*New York and Puerto Rico are the only 2 state /commonwealth governments in the US that currently have laws enforcing work-hour limits (80 h maximum per week, averaged over 4 weeks, and no more than 24 consecutive hours). Violating hospitals in New York are subject to civil penalties; violating hospitals and residents in Puerto Rico are subject to civil penalties.[20]
†$P = .02$, New York and Puerto Rico hospitals vs subtotal for hospitals in all other states.
‡$P < .001$, New York and Puerto Rico hospitals vs subtotal for hospitals in all other states.

Table 4. Duration of Interns' Reported Work and Sleep, Preimplementation vs Postimplementation of the ACGME Duty Hour Standards

	Preimplementation (95% CI)	Postimplementation (95% CI)	Change, %	*P* Value
Mean No. of weekly work hours*	70.7 (70.5-70.9)	66.6 (66.3-66.9)	−5.8	<.001
Mean duration of extended work shifts, h	32.1 (32.0-32.2)	29.9 (29.8-30.0)	−6.9	<.001
Mean longest period with no sleep, h	25.3 (25.1-25.4)	24.9 (24.7-25.0)	−1.6	.25
Mean nightly sleep duration, h	5.91 (5.88-5.94)	6.27 (6.23-6.31)	+6.1	<.001
Mean nightly sleep during extended shifts, h	2.69 (2.66-2.73)	2.57 (2.52-2.62)	−4.5	<.001

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; CI, confidence interval.
*Excludes vacation weeks and leaves of absence.

length of reported extended duration shifts postimplementation exceeded 30 hours during 22.5% of all intern-weeks. Reports of working patterns that violated the 80-hour rule likewise remained common, even though having up to 3 weeks in a row that each exceed 80 hours is permissible under current ACGME standards and was not counted as a violation. Because interns are considered to be in violation of the 80-hour and 7-day rules only if work hours exceed these limits averaged over 4 weeks, there was by definition only 1 opportunity per 4 weeks per intern for such violations to occur. Therefore, the reported rates of 80-hour and 7-day violations per intern-month (21.8% and 9.9%, respectively) and per inpatient intern-month (38.7% and 13.0%, respectively) represent not only the total percentage of months during which interns were in violation of these rules but also the absolute rate of violations per opportunity.

There are limitations that need to be considered in interpreting this study. First, although the number of interns (4015) who enrolled was large, they represented only a small percentage (10.8%) of all potential interns. Our method of recruitment is similar to that of large epidemiological studies, such as the Nurses Health Study II,[21] in which advertisements were sent to a large number of potential participants nationwide, in the expectation that only a small percentage would enroll. Although selection bias may have occurred, we believe that the study design reduced that possibility and that these data are likely to be informative regarding compliance with ACGME standards. Interns were recruited prospectively before commencing their internships and therefore as a group should not have been biased by dissatisfaction with their residency program. During recruitment and after entering the study cohort, they were not made aware of our study aim to measure compliance, and they were administered many distractor questions alongside key questions. Although not all questions regarding work and sleep patterns were validated, the measures of total work hours and number of extended work shifts underwent a 2-step validation process that provides supporting evidence for the accuracy of the reported work hours.

Second, because not all monthly surveys were completed, reporting bias may have occurred. Several participants reported that they could not complete work-hour reports during their busiest months, indicating that our data may underestimate the actual rate of violations. Furthermore, although we were able to provide assurances of data confidentiality, some interns may have been reluctant to report violations since data collection was not anonymous.

Third, we did not have access to the identities of the few programs granted exceptions to the 80-hour rule by the ACGME, which allows residents to work up to 88 hours.[1] Because only 75 (0.9%) of 7973 of accredited programs were granted exceptions in 2003-2004,[8] this information would be unlikely to alter our calculated rates of violations substantially. Fourth, while the diversity and large total number of interns in the study allow us to present state and specialty-specific data, our program-level and hospital-level analyses were not adequately powered to provide reliable data on individual programs.

Finally, our data reflect the effects of the ACGME duty-hour standards in their first year only. Compliance may increase over time as programs learn to adapt to these regulations; indeed, we found a trend toward decreasing noncompliance, although the monthly rates of noncompliance at the end of the academic year remained high. Further studies of the longer-term effects of the ACGME duty-hour standards using a validated instrument are warranted.

Our results are notably different from those of the ACGME, which found in its national survey of residents that only 3.3% were noncompliant with the 80-hour rule. Similarly, in full reviews of 2027 residency programs nationwide, the ACGME cited only 2.6% of residency programs for noncompliance with the 80-hour rule, 1.3% of programs for noncompliance with the 30-hour rule, and 1.4% of programs for noncompliance with the 7-day rule.[8]

Much of the difference in our results is likely explained by differences in survey method. We estimated violations using open-ended questions principally directed toward accurately measuring work and sleep hours. The questions in the ACGME survey directly assessed noncompliance: "[During the previous 4 week rotation], on average, excluding call from home, how many hours were you on duty per week?"; "How many times did you work more than 30 continuous hours?"; and "How many days (24-hour periods) did you have completely free from all educational and clinical responsibilities?"[22] Such closed-ended inquiries may have limited the accuracy of responses, and framing the questions about noncompliance may have altered reporting. In addition, our study investigated interns only, whereas the ACGME evaluated the work hours of residents at all postgraduate levels.

Although by mandating participation, the ACGME achieved a very high response rate (89%),[23] residency programs and residents themselves face a

direct conflict of interest in acknowledging violations to the ACGME,[14] because the identities of those reporting violations have not been adequately protected in the past.[24] Because disclosure of violations to the ACGME could lead to loss of program accreditation, disclosure could threaten residents' own careers.

The ACGME asked residents to report violations during the prior 4 weeks, whereas we captured work hours longitudinally over a year. Consequently, we had many more opportunities to capture reports of violations. However, this cannot explain all of the discrepancy in rates, because even on a per 4-week basis, we found more than 10 times as many interns to be in violation than did the ACGME. Finally, vacation is not included by the ACGME in its counting of duty-hour compliance. Although inclusion of vacation has the effect of lowering rates of noncompliance, this difference in methods would tend to narrow differences in results. Moreover, we found markedly higher rates even when excluding vacation months.

Several studies have reported work hours and noncompliance rates exceeding those reported by the ACGME, but most have been limited to single medical centers or specialties and have not used validated instruments. Studies of pediatric, neurology, and otolaryngology residents have found 10% to 39.5% reported noncompliance with the 80-hour rule, and 22% to 50% noncompliance with the 30-hour rule.[11-13] In a cross-sectional study, the American Medical Association found that 11% of 1010 residents reported working more than 80 hours per week during their most recent rotation.[14] Our study adds to this literature by providing prospective, longitudinal data on the work hours and compliance rates of a national multispecialty cohort of interns, both before and after the implementation of the ACGME duty-hour standards, using self-reports that have had objective validation.

The ACGME developed the duty hour standards out of concern for the effects of excessive resident work hours on patient and resident safety.[25] Staying awake for 24 consecutive hours induces decrements in human performance similar to a blood alcohol level of 0.10%[26]; despite often obtaining some sleep while on call, residents working 24-hour overnight shifts in the hospital every 4th to 5th night perform similarly to those with a blood alcohol level of 0.04% to 0.05%.[27] Interns working traditional 24-hour to 30-hour shifts make significantly more serious medical errors than those whose consecutive work is limited to 16 scheduled hours,[28] and they have more than twice the odds of having a motor vehicle crash on the drive home from work.[17] A recent meta-analysis of studies investigating the effects of sleep loss on performance found that 24 hours of consecutive sleep loss reduced physicians' clinical performance to the 7th percentile of their performance when rested.[29] In light of these studies, further reductions in current limits on consecutive duty hours appear to be needed.

There are several reasons why rates of noncompliance may be high. First, the ACGME duty-hour standards were unaccompanied by financial and technical support. Programs may not have the resources or expertise to redesign their schedules to the extent required. In addition, house officers are typically unwilling to depart precipitously at the scheduled change of shift when an emergent patient care situation demands their continued presence.[18] Such situations are common in high intensity settings, yet most scheduling systems do not account for these commonplace emergencies. Rather, house officers are routinely scheduled to be working up until the minute of their sign out, a situation that could predictably lead to overstaying work limits. Multicenter studies of the changes implemented at various medical centers are needed to better understand program-level successes and reasons for noncompliance.

Noncompliance also might be due to attitudes within an institution's medical culture. Some senior physicians have expressed disapproval of work-hour limits,[30,31] and there exists a widespread perception among many physicians that fatigue is not a problem[14,25] despite the accumulation of considerable evidence to the contrary. Concerns about continuity of care and sign out[32] may slow adoption of reduced-hour work schedules, particularly in settings in which robust sign-out tools[33] have not been implemented, and in which teamwork training and functioning is limited.

In the United Kingdom, physicians' work was limited recently to 13 consecutive hours and 58 hours per week by law.[34,35] By contrast, the ACGME duty-hour standards continue to permit 30 consecutive hours of work and 80 hours per week, yet even these relatively mild limits have not been consistently achieved. Even though the downward trend in noncompliance during the first year following implementation of the standards is encouraging, the decrease has been modest, and noncompliance remains common. To achieve further reductions in work hours consistent with current best evidence, additional efforts to implement safe schedules are needed, as is research into reasons for noncompliance.

Author Contributions: Dr Landrigan had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Landrigan, Barger, Cade, Ayas, Czeisler.
Acquisition of data: Landrigan, Barger, Cade.
Analysis and interpretation of data: Landrigan, Barger, Czeisler.
Drafting of the manuscript: Landrigan.
Critical revision of the manuscript for important intellectual content: Landrigan, Barger, Cade, Ayas, Czeisler.
Statistical analysis: Landrigan, Barger, Cade.
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Study supervision: Barger, Czeisler.
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ciety (for which Dr Czeisler served as president); Respironics Inc; Takeda Pharmaceuticals Inc; Unilever; Vanda Pharmaceuticals Inc and Warburg-Pincus. He owns an equity interest in Hypnion Inc and Vanda Pharmaceuticals Inc. He has received lecture fees from the ACGME, Cephalon Inc, MPM Capital, Philips Lighting, Sanofi-Aventis, Takada, and multiple academic institutions and organizations. Dr Czeisler holds a number of process patents in the field of sleep/circadian rhythms (eg, photic resetting of the human circadian pacemaker), all of which are assigned to the Brigham and Women's Hospital per institutional policy. He has also received research prizes with monetary awards from the American Academy of Sleep Medicine; American Clinical and Climatological Association; Association for Patient-Oriented Research; National Institute for Occupational Safety and Health and National Sleep Foundation; clinical trial research contracts from Cephalon Inc and Pfizer Inc; an investigator-initiated research grant from Cephalon Inc; and unrestricted research and education funds from Cephalon Inc, Philips Lighting, and the Brigham and Women's Hospital. Dr Czeisler is the incumbent of an endowed professorship provided to Harvard University by Cephalon Inc. Since 1985, Dr Czeisler has served as an expert witness on various legal cases related to sleep and/or circadian rhythms. Dr Czeisler has never served as an expert witness for a commercial research sponsor. Dr Landrigan is a paid employee of Brigham and Women's Hospital and Children's Hospital Boston, both of which employ interns and residents. He has served as a paid consultant to the District Health Boards of New Zealand, performing an assessment of current working conditions for junior physicians in New Zealand, and providing recommendations on how to improve the safety of scheduling practices. Dr Landrigan has received research prizes with monetary awards from the National Sleep Foundation, the Sleep Research Society, the Society of Hospital Medicine, and the Mount Sinai School of Medicine. Dr Landrigan has received honoraria for delivering lectures on sleep and safety for multiple academic institutions and organizations.

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