The 80 Hour Workweek

Internal Medicine Grand Rounds
University of Texas Southwestern Medical Center
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This is to acknowledge that Brett Moran has disclosed no financial interests or other relationships with commercial concerns directly or indirectly with this program.

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Areas of interest: Preventive health
Community-acquired pneumonia
Hypertension
Resident education

Part I: The Past

Introduction

The world is changing: there has been massive improvement and changes in technology, increasing longevity of life, disseminated worldwide information, increasing complexity of medical disease, diagnosis, and treatment. It has been estimated that there will be more technological advancements in the 1st 10 years of the 21st Century than in the last 100 years altogether, and yet the current residency training program is essentially unchanged from the late 19th century.

As Paul Betalden stated, "The health care system is broken and residents live in the cracks of the broken system. They are the glue that holds it together."[1]

The 80-hour workweek has become a flashpoint topic in medicine with varying opinions from the Accreditation Council for Graduate Medical Education (ACGME), medical training programs, faculty, housestaff, and the public. It was enacted by the ACGME in response to widespread criticism of residency work hours and increasing public demand for reform, including threats of governmental regulation. It has become a fulcrum point in graduate medical education, raising questions about the current medical training model.

Those in favor of it note that it allows better sharing of workload, and consistent schedule with a regular time out of the hospital. Those against it state that it enhances a lack of teaching responsibility, lack of follow-though on patient issues, encourages assembly-line mentality, and does not emulate the "real world".

Patients are frustrated over seeing fatigued doctors and are afraid of highly publicized errors purported due to fatigue. While at the same time, they do not wish to have multiple caregivers. The end results of these changes have not been well documented are many are still being studied. Training programs nationwide are scrambling to cover for the work deficit created by complying with these regulations, and some feel that as a result, services are now trying to either find funds to hire ancillary personnel or push patient care responsibility to another as a way to reduce resident work hours. Physicians are looking more closely at admissions and quarrelling more as to service placement. The following pages hope to shed more light on the impact and effects of the residency work hour reduction, both good and bad.

A. The History of Residency Reform

From the earliest days through times of Hippocrates until the early 19th century, internal medicine training was done essentially by apprenticeship. Eventually, formal education through collegiate instruction was added as a requirement prior to apprenticing with a physician. Surgery, in contrast, arose from barbershop apprenticeships before joining medicine in the rigor of formal basic scientific study.

Originally, the apprenticeships were poorly organized or structured. Students would follow a specific surgeon for an unspecified period of time. They would then leave to practice on their own when the surgeon released them or they felt like leaving, hopefully competent in their new profession.

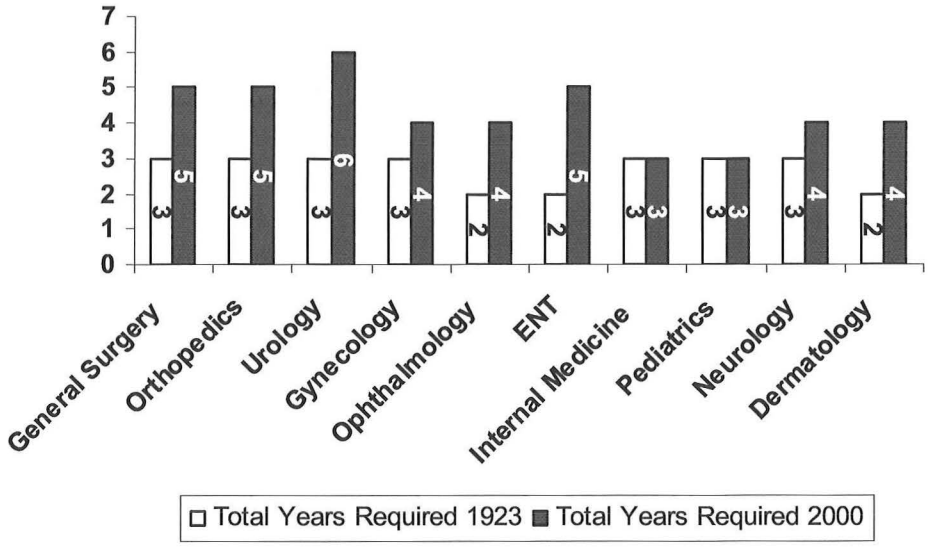
Before World War I, medical and surgical education encompassed 4 years of fairly formalized medical school training, after which the students were considered full-fledged physicians, ready for practice. After World War I, medicine advanced by leaps and bounds with new medications, treatment techniques, and knowledge. If was felt there was too much to teach, even with 4 years of medical school training. Thus, post-graduate medical training was introduced to offer a period of hospital education to solidify the clinical experience prior to entering private practice. This "internship" became standard for all medical training programs. The "graduate medical education" was based upon two principles: 1) that the housestaff would assume full responsibility for patient management, and 2) that the education would be an "intensive and thorough study of relatively few patients".[2] Furthermore, with advancing medical knowledge, specialists, sub-specialists and researchers became necessary and thus, further hospital training was required, giving birth to the era of the residency.

William Halstead, chairman of Johns Hopkins University department of surgery in the end of the 19th Century introduced residency conceptually as we know it today based on a model conceived at the University of Leiden in the Netherlands during the 18th century. The esteemed Herman Boerhaave (1668-1738) was the first in Europe to emphasize the importance of the natural sciences for the study of medicine. This model emphasized a long, varied training with pyramidal promotion, and a restrictive lifestyle. The students lived in the hospital, worked long hours for little pay, and were strongly discouraged from other endeavors, including marriage.[3] The word "resident" became apropos. This system was introduced by Halstead in his lecture "The Training of the Surgeon" given at Yale University in 1904. With minor changes, such as eradication of the pyramidal promotion style, and permission to live outside the hospital and marry, this residency model has remained intact to this day.

This duality of education and service; however that became problematic for the residency programs throughout the years. One could not determine how much service was required to train housestaff without interfering with or displacing the educational aspect. The residents were required to demonstrate utmost dedication to their profession and competence to care for all of the patients' issues, thus further exacerbating their service hours. Additionally, due to the long hours and low pay given to residents, they became an easily abused commodity by the hospitals. A "tradition of economic exploitation" was documented as early as the 1920's, and some think, continues today.[2]

In June 1923, the American Medical Association (AMA) House of Delegates adopted the "Principles Regarding Graduate or Postgraduate Medical Schools" which was viewed as a precursor to the ACGME program requirements. In an attempt to standardize training and enforce adequate physician preparation, these principles mandated minimum years required to achieve competence in internal medicine was 3 years. During this time, diseases have been conquered and replaced by more complicated entities, technology has increased, over 10,000 clinical trials are performed now per year, specialists have doubled, and yet residency remains essentially unchanged. Over the years, all of these specialties have expanded their programs, requiring more training years before completion, save Internal Medicine and Pediatrics.[4]

In 1925 the Council on Medical Education and Hospitals published principles and began implementing review of processes of education among training hospitals. By 1927, the AMA had published its first list of hospitals approved for residencies in specialties in the US.[4] At some point in the coming decades, the workload at the hospitals exceeded the residency programs' abilities to maintain adequate work hours, education, and quality of patient care. The hospitals were and have remained reticent to supplement the services with additional support.



Even as early as 1940, comments on residency reform began, with the 1st report on Graduate Medical Education in the United States, which wrote, hospitals "must work out plans to relieve the intern [and resident] from many routine procedures which he is now performing but which have relatively little educational value." It was suggested that the hospitals hire salaried physicians if necessary to ensure appropriate education of the housestaff. These suggestions went unheeded. Further recommendations were issued by other organizations including the Millis report (AMA sponsored), the Coggeshall report (Association of American Medical Colleges sponsored) calling for enhancement of the educational experience of housestaff. With progressive housestaff dissatisfaction and increasing burdens of work through hours and sheer numbers of patients, decreasing length of stay, increasing medical technology, and increasing average severity of illness, residents even looked unsuccessfully towards unionization in the 1970's. [2] The National Labor Relations Board denied them the opportunity to form a union and bargain collectively, ruling that they were students.

In 1981 the ACGME was formed and replaced the AMA's Liaison Committee on Graduate Medical Education, taking on the duties of accrediting, regulating, and monitoring residency programs and ensuring quality and standards.[4]

The shot heard round the world

On March 4, 1984, an 18-year-old female college student was admitted to a New York Hospital with fever, dehydration and otalgia. Little did she or her doctors know the impact her course would have on the future of medicine. She was diagnosed as having a viral syndrome by the intern and junior resident, and, after conferring with the attending by phone, admitted for observation to the regular floor. Her father was told she would be well cared for and that he could pick her up in the morning. It was 11:30 pm. She would be pronounced dead by 6:30 am, less than 8 hours later.

Through the night, Ms. Libby Zion became more agitated and febrile. The intern, who had been awake for more than 18 hours and who was covering for 40 patients, gave verbal orders for haloperidol and meperidine (which she also wrote in the admission orders). The patient clinically deteriorated throughout the night and by 4:30 am the floor nurse called the intern asking her to

come see the patient, as she was thrashing in the bed. The intern refused but ordered restraints, diagnosing the patient as having "hysterical symptoms". The patient clinically worsened, with temperatures reaching 108° Celsius. By 6:30 am the patient had arrested and was pronounced dead. Autopsy would later conclude the cause of death as bilateral bronchopneumonia but also would comment on a sudden febrile event and cardiovascular collapse.

It would later be found that the intern had prescribed over the phone some meperidine for fever and anxiety in this patient on phenelzine, an MAO inhibitor, which is an absolute contraindication. The patient had developed classic serotonin syndrome with hypyrexia, central nervous system overstimulation, and presumed eventual fatal cardiac instability. Controversy arose over whether the patient had informed the physicians of her prescription medications as well as the fact that she had taken cocaine in the recent past.

The father, Sydney Zion, was distraught and enraged. He blamed the hospital and doctors for letting this happen. He felt her death was a result of negligence in her care by the doctors on call, as well as the hospital itself for enforcing the training system where an inexperienced physician is left alone to care for 40 patients, under sleep deprived circumstances, without supervision. Mr. Zion was a formidable opponent with a resume of experience including former Federal prosecutor, author, former reporter for *The New York Times* and *The New York Post*, and an ongoing job as columnist at *The Daily News*. He was able to generate intense publicity and garner public support for hospital reform.

He filed a civil suit against the intern, resident, attending, and hospital which took 11 years to conclude. The trial was held on Court TV and received significant public attention. On February 6, 1995, the jury found that three of the doctors were negligent in giving meperidine to Libby Zion, but that Libby Zion was also 50% responsible for her own death because she did not tell the doctors that she had taken cocaine and other prescription drugs. No punitive damages were awarded, but the doctors were ordered to pay $375,000 for pain and suffering.

More importantly, the hospital was cleared of any wrongdoing, stating that its practices were non-differing from all teaching hospitals in the state. However, before this trial even began, the Libby Zion case had impacted residency education irreversibly.

The 405 regulations in New York State

Not only did Sidney Zion file civil suit against the hospital, he also persuaded a colleague, Robert Morganthau, then Manhattan District Attorney, to investigate for possible criminal activity on part of the hospital and doctors. Thus, a grand jury was convened for this purpose. The grand jury, meeting in December 1986, declined to indict the doctors or hospital for criminal activity but castigated the hospital in its training practices, leaving interns and residents overworked and undersupervised, which they described as counterproductive to providing quality medical care. They released five recommendations based on their investigation. Those pertaining to medical education included better upper level supervision of residents and limitation in housestaff hours of consecutive duty.

As a result of the grand jury recommendations as well as widespread and vociferous public outcry for reform, New York State Health Commissioner, Dr. David Axelrod formed an Ad Hoc Advisory Committee on Emergency Services to investigate this. He appointed Dr. Bertrand Bell, Professor of Medicine at Albert Einstein College of Medicine, to chair the committee. "The most important thing in being a doctor is not the hours, but responsibility," Bell said. In March of

1987, the committee met and made specific recommendations that became known as the "Bell Regulations". These recommendations included:

- 24 hour supervision of acute care inpatient units by experienced attending physicians
- Improved working conditions and greater ancillary support for residents
- Twelve hour work limits for emergency department physicians (attending and resident alike)
- 24 hour work hour restriction for any other area of the hospital besides the ER
- Limiting resident workweeks to no more than 80 hours when averaged over a 4 week period of time
- At least 24 consecutive hours off per week[5]

After hearing testimony on the proposals, including evidence that their changes would cost an estimated amount of more than $200 million to cover ancillary personnel, the recommendations were enacted as part of the New York State Health Code, as a revision to section 405, on July 1, 1989. As over 15% of resident physicians are trained in New York, national attention followed.

Initially there was a problem with lack of enforcement of the Bell regulations as they became known, but with strict Department of Health enforcement, program fines and public embarrassment, it became archetypal of all New York State residency programs.

About this same time, there were several articles that emphasized preventable errors in medicine and the high cost to society by them.[6-8] These articles fueled the fire of public distrust of medical care and led to further calls for reform in hospitals, both academic and private. Some residency committees chose to create standards of work hours at this time, including Emergency Medicine, but other areas remained without limits.[9]

In an interview with Bertrand Bell some years after the 405 Regulations, he admitted that the inciting event for residency reform was probably the Libby Zion case, and that despite all the attention to long resident hours and sleep deprivation, he felt the paramount cause of her death was lack of supervision, rather than exhaustion or overwork.[10] The civil trial jury, on the other hand, cited too-great a workload for the intern, but similarly did not feel sleep deprivation played a role.

The development of national residency regulations

In November, 1999 the Institute of Medicine (IOM) released a report, "To Err is human", which brought criticism and further public attention to the issue of medical errors. In it, they cited two studies looking at adverse hospital events that estimated incidences of 2.9%-3.7% of hospitalizations. They went on to cite 6.6%-13.3% of these events lead to patient death, and that over half of these events were preventable. These estimates led them to conclude that as many as 98,000 patients die annually because of preventable adverse events, making adverse medical events more fatal than even breast cancer, AIDS, or automobile accidents, essentially comparable to the 8th leading cause of death in the nation.[11] Looking at just adverse drug events, they calculated that increased hospital costs due to these errors could cause a $2 billion impact on the nation annually.

While there have been criticisms of the two studies upon which the IOM based its assumptions,[12] the fact remains that adverse medical errors were more common than the public had expected. And although the IOM report did not mention or address residency duty hours, nor attribute adverse medical errors to problems with residency, the publication drew national attention to the issues of errors in medicine.[13] Following this report, proponents of work hour reform began to link errors to resident fatigue, and from there, residency programs were put under the microscope even more.[14] It was this extreme attention to residency work hours and sleep deprivation that sparked public outcry in bordering states and led to attempts of reform at a national level.

The AMA House of Delegates adopted a resolution calling for evaluation of fatigue and sleep deprivation on medical education and physician performance the next year. In November of 2001, Representative John Conyers of Michigan introduced The Patient and Physician Safety and Protection Act of 2001 (which now has 71 co-sponsors), establishing limitation on resident work hours. Senator Jon Corzine of New Jersey introduced companion legislation on June 12, 2002, and in the case of the senate bill, linked regulation of work hours to Medicare participation. With these pending bills and ongoing public interest, the ACGME released its report on residency duty hours. Though the ACGME had previously suggested restrictions to resident hours, this time, they inserted these regulations into the common program requirements for all core and subspecialty programs, mandating compliance with their directives in order to maintain certification. All programs were told to begin enforcing the ACGME residency duty restrictions as of July 1, 2003. These requirements included the following points:

- Continuous supervision of the residents by faculty
- No more than 80 hours of work per week (averaged over 4 weeks), inclusive of all in-house call activities
- Residents must be given one day per 7 off from all educational and clinical duties, averaged over a 4 week period
- There should be adequate time to rest after in-house call, no less than 10 hours
- In-house call can occur no more frequently than every 3rd night, averaged over a 4 week period
- Continuous duty cannot exceed 24 consecutive hours, with the exception of 6 hours additionally for didactic activities, transfer of care, outpatient clinics, and providing continuity of care
- No new patients can be accepted after 24 hours of continuous duty
- An RRC may grant exceptions for up to 10% extension on the 80-hour workweek based on sound educational rationale and permission from the GMEC is obtained.

Interestingly, it was with the release of these new program requirements that the ACGME eliminated a tenet that had been in their program requirements for years: "Physicians must have a keen sense of personal responsibility for maintaining patient care, and must recognize that their obligation to patients is not automatically discharged at any given hour of any particular day of the week. In no case should the resident go off duty until the proper care and welfare of the patients is ensured."[15]

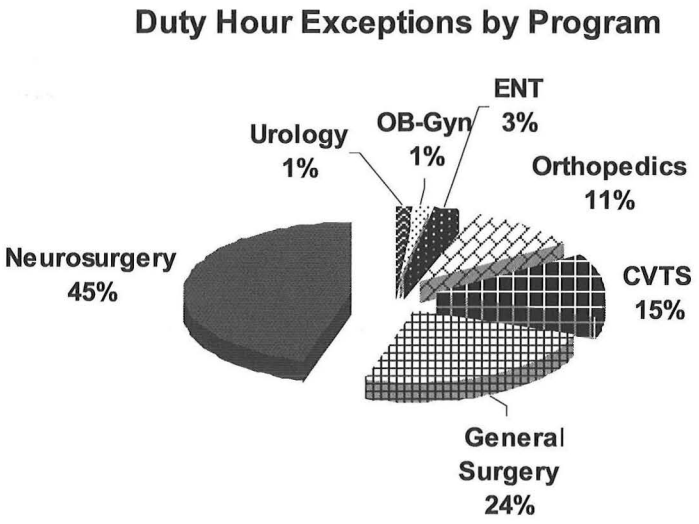
Initial dissatisfaction of the regulation by programs, individual residents and faculty alike were widespread. The executive director of the American College of Surgeons was quoted as saying: "constrained work hours do not prepare residents for the real world of surgical specialty…it seems illogical to make specific time-work recommendations without considering the effect on the educational opportunity and experience for those in the residency phase of their career".

The ACGME regulations, like the Bell regulations, were initially tested by several programs, but after the revoking of accreditations for the Yale surgery program in February 2002, and the Johns Hopkins internal medicine program in August 2003, programs began to take them very seriously.

Though the House and Senate bills failed to pass, other attempts at governmental regulation of housestaff were made. On April 30, 2001, the Committee of Interns and Residents, Public Citizen, American Medical Student Association, and the Service Employees International Union filed a petition to the Occupational Safety and Health Administration (OSHA) requesting that OSHA incorporate similar residency restrictions as those of the 405 regulations in New York due to health risks on the housestaff with long working hours and sleep deprivation. This request was denied in 2002 partially because the organization felt this was already being addressed adequately by the ACGME.

On June 20, 2002, the American Medical Association approved a work hours policy that emulated the ACGME regulations, and similarly other organizations have banded together supporting the ACGME policy, and generally opposing governmental regulation, including the AAMC, American College of Physicians (ACP), and American College of Surgeons (ACS). Joining New York, Puerto Rico has also established legal mandates on residency work hours. Others states are or have considered legislation for reform, including California, Delaware, Massachusetts, New Jersey, and Pennsylvania.

During the 2003-2004 academic year, the ACGME granted program exceptions to only 75 of 89 requests out of the over 8,192 residency programs, allowing those few programs to work 88 hour workweeks. None included internal medicine programs.[16]



The debate for governmental legislation of GME is ongoing, with the "Patient and Physician Safety and Protection Act of 2005" introduced by Representative John Conyers and Senator Jon Corzine in a reattempt of passing their initial bills from 2001 and 2002. Differences between the ACGME regulations and those proposed by congress include that the proposed legislation would mandate 80 workweeks without averaging, no possibility for extensions by anyone, afford whistleblower protection, fines for noncompliance of up to $100,000, and a mandated one weekend off per month.[17] The time allowed for handoffs would be reduced as well. The most important benefit offered, however, would be funding for these changes, though the details of

how much money would be provided, where it would come from, and what if any strings would be attached are unclear.

Interestingly, much of the attention on resident reform at this time and henceforth focused on long work hours and lack of sleep, rather than lack of senior supervision. It should also be noted that these regulations were created without any studies or scientific evidence that these problems led to hospital errors or that fixing them would effect change for improved hospital performance. These regulations were instead created based on surveys, one particular in which the residents replied that they felt that they made more mistakes when sleep deprived and that they had made life threatening mistakes due to fatigue. The survey went on to state that 41% of the residents identified fatigue as the cause of their most serious mistake, in which reportedly a third of the patients died as a result of this mistake.[18]

Residency hours in other countries

Residency work hour reform is not new overseas. There, programs have been grappling with this issue for the last few decades, with mixed success. One can learn from the experiences of them, however, and take home some important points.

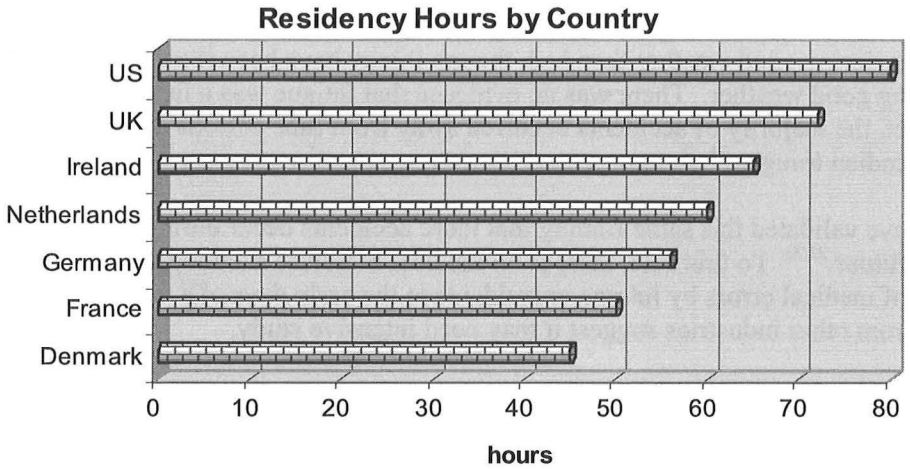
The impetus for reform in countries overseas has come from a variety of sources, many of which were the physicians themselves. Reform has been enacted through national legislation, collective agreement, or Ministerial dictate. They have discovered that typical on-call schedules result in prolonged and unexpected lengthening of the workweek. Shift-work rosters lead to more predictable hours and shorter workweeks on average, and programs that have enacted the shift-work pattern have been able to reduce hours of duty of housestaff. It has been historically known that interns and residents bear the brunt of duty hours at night and on the weekends, and any country which has enacted duty hour reforms has had to employ more senior doctors to fill the void left by the reduced hours. This has resulted in the favorable outcome of an increase of the senior to junior physician ratio, but the unfavorable outcome of senior faculty working less desirable hours and shifts.

Unfortunately, experience in the European Union (EU) and in the National Health Services have shown a large decrease in case experiences due to shortened work hours.[19] Despite this, and the fact that work hour reform has been shown to reduce housestaff training hours by 25%, there have been no core changes to the training program's schedules to compensate for this, specifically in terms of ratio of service to education. Most importantly, there are yet no studies showing that the changes nationally or even locally have effect a mortality or even morbidity effect in a well done research trial.

Non-resident physician workweek restrictions have been enforced since November 1993 when the European Union Working Time Directive stipulated a 48 hour week. This legislation also demanded a 4 week paid vacation annually and a minimum of 11 hours between duty shifts.

In the United Kingdom (UK) resident duty hour restrictions were enacted through Ministerial agreement with backing from the British Medical Association (BMA). Governmental funding was required to compensate programs and hospitals for loss of labor. The UK current workweek limit is 56 hours for "actual work" and a maximum of 72 hours total. They are limited to 32 hours of work during the weekdays and from 16-24 hours of shift duty call. On the other hand, the training of "full" doctors takes longer in the UK. Upon completion of medical school, an applicant enters their "clinical" years in which they work at a teaching hospital for 2 or 3 years.

After this is completed, they are awarded a Bachelor of Medicine (BM) or Bachelor of Surgery (BCh or BS). Doctors then enter a 2 year "Foundation Programme" in which they train in a variety of different specialties. Following completion of the program, a doctor can choose to specialize in a particular field or proceed into the community as a General Practitioner (GP).[9]



In the Netherlands, reform was initiated by the salaried physicians. In 1993, national legislation was enacted, and more senior doctors were utilized for covering the duty hours, which resulted in reduced unemployment in the country as well as a lower realized cost to the country than expected. Governmental subsidization was required, however, to assist with the transition. It was achieved by paying for expansion of residency program size, something limited by the Balanced Budget Act here in the US.

It has been estimated that the economic impact of workweek restrictions would be highest in those countries in which the housestaff are paid the least for long hours or overtime, such as France and Ireland.

In France, there is no current regulation of duty hours; however, the average workweek is usually around 50 hours. This limit in duty hour is partially enforced by the fact that duty hours beyond the maximal pay limit are unpaid. Ireland, likewise, has no specific legislation or agreement for duty hour regulation. Their average workweek for housestaff is around 65 hours but continuous duty shift can extend up to 72 hours. They also control economic costs by reimbursing physicians' overtime hours at only 50% of the standard rate.[20]

B. A Review of Sleep

Physiologically, humans are diurnal with circadian rhythms that are regulated by a circadian pacemaker located in the suprachiasmatic nucleus within the brain. External clues also play a role. These timegivers or "Zeitgebers" promote sleep at night and wakefulness during the day. Zeitgebers include light, external noise, food, temperature changes, and social factors. Some studies have shown women to be less adaptive to shift work than men, felt due in part to more domestic challenges.

Sleep regulations in other industries

In other industries the literature is quite robust in sleep studies, while studies of sleep deprivation in the medical field are just starting to catch up. A study of offshore workers and accidents found that the majority of accidents occurred between 9 AM and 4 PM, independent of whether they were on or off duty. The frequency of incidents was greatest during the 1st four hours of the shift, raising speculation of sleep inertia, though sleep pattern evaluation was not available for this study. Accidents occurred more during the beginning of the tour rather than later on. Accidents occurred more often during good weather than bad, though it may have been that they were more likely to work during good weather. There was no evidence that fatigue was a factor in the accidents and in fact, the majority of accidents occurred away from time periods usually associated with circadian troughs.[21]

Other researches have validated this same finding that more accidents occur during the first several days of shift/tour.[22,23] To this date, there is no medical literature showing similar increased patterns of medical errors by interns or residents in the early days of a new rotation, though indicators from other industries suggest it may need intensive study.

The history of duty hour regulation in the trucking industry is eerily similar to the ongoing medical residency saga. In 1935, Congress directed the Interstate Commerce Commission to establish duty hour rules for truckers. In 1938, despite finding that no scientific basis had been provided, the commission established rules that limited driving to 10 hours in a 24 hour period and required a minimum of 8 consecutive off duty hours within 24 hours. Driving weekly was limited to 60 hours per week. The agency also commissioned the 1st study of fatigue which in 1941 found that there was a decline in performance on a battery of psychomotor tests during a period of 10 hours. However, there was no link to this and motor vehicle accidents. Further studies showed decreased performance on several tests, including driving simulators, but none found a link to risk of accidents.

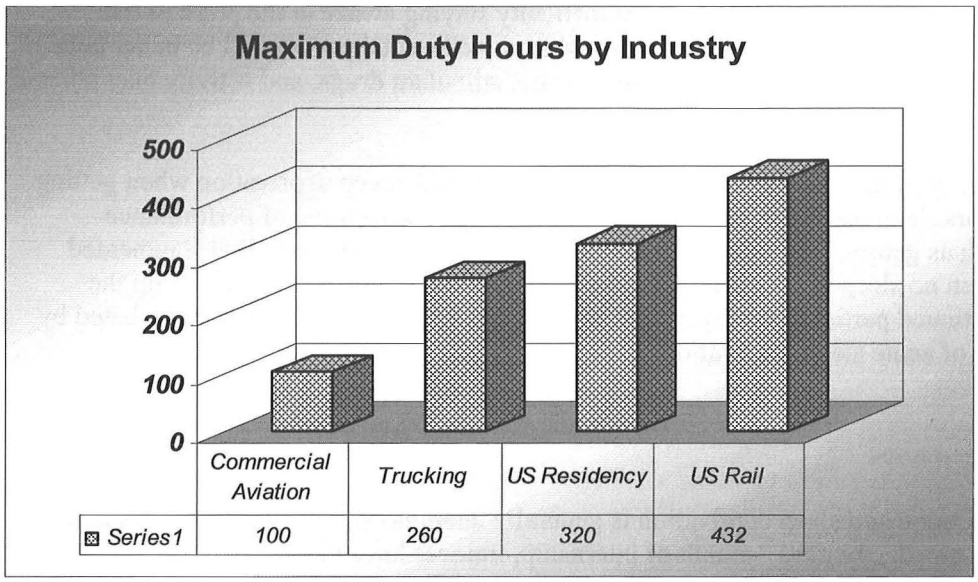
Sleep deprivation effects are well known in truck drivers. A study done by Mitler in 1997 performed continuous electrophysiologic and performance monitoring of 80 truck drivers and found that the drivers averaged only 4.78 hours sleep per day, and while there was evidence of fatigue by EEG monitoring and video analysis, there were no accidents or other vehicle mishaps. Despite the finding of no increased accidents or even near-misses, the Department of Transportation in 2003 increased the required off-duty time to 10 hours every 24 hours.[24]

In contrast to the transportation industry, the aviation industry duty hour restrictions arose from negotiations between trade unions and airlines, originally in the 1930's. Current regulations limit pilots to no more than 30 hours flying per week, 100 hours per month, and 1000 hours per year. They are guaranteed a minimum of 24 hours off per week and 8-11 hours rest preceding scheduled flight time.[9]

It is interesting that there has been so much attention to those areas that have been fairly safe, such as the trucking and aviation industries. In trucking, it is estimated that there is an accident every 1.2 million miles driven.[24] In commercial aviation, it was 58.03 accidents per million flight hours.[25]

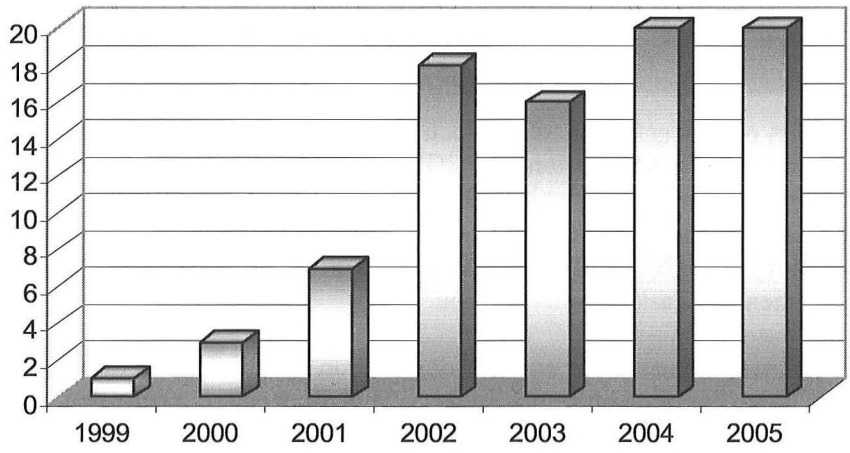
Scientists have learned from studies of sleep and performance in underground mine shift-workers that humans, when working shift work, better tolerate a clockwise forward rotating schedule, with longer periods of time between shift rotations.[26]

The allowable total weekly hours of duty for residents surpass those of many other industries, including commercial aviation, commercial trucking, and the nuclear power industry. It is only surpassed by few, such as the rail workers.



Sleep studies in medicine

Sleep literature investigating effects of deprivation on medical housestaff were scarce prior to initiation of the ACGME regulations. After being encouraged by the AMA and Congress to further study this, the number of articles began to expand.



In general, sleep deprivation has been associated with increased depression and hostile symptoms. It also has previously been shown to affect mood, creativity, vigilance, and other cognitive tasks.[27] Factual knowledge has been shown to be relatively insensitive to the effects of sleep deprivation. Studies have shown that exercise is not adversely affected by sleep deprivation, and others that muscle strength and reaction time are not affected but that time to exhaustion is

shortened in the sleep deprived individual of up to 72 hours.[28] Nearly a quarter of the population has been shown to be extremely susceptible to sleep loss.

A person who is sleep deprived will have more difficulty staying awake at the point of the circadian cycle where sleep is normally induced, while a well-rested person will be better able to fight the urge. Bright light, noise, temperature, posture, stimulant drugs, and activity may reverse sleep loss decrements temporarily.

Though the majority of articles show most severe problems with sleep deprivation when getting five or fewer hours sleep per night, others have shown a steady worsening of performance beginning as high as getting less than seven hours sleep per night, and others that fragmented sleep is worse than no sleep at all. As deficits build up over days, a person may develop the syndrome of continued partial sleep deprivation, which can then be even further exacerbated by transient periods of acute sleep deprivation.

Mood and Performance

The literature on mood and sleep deprivation is generally unanimous in that deprived housestaff have a worsened mood. By the 5th month of internship, trainees have demonstrated significantly increased levels of depression-dejection, anger-hostility, and fatigue-inertia. An estimated 30% were clinically depressed.[29] Surveys of residents in multiple specialties have shown a linear relationship between sleep deprivation and medical errors (subjective), adverse patient outcomes, conflicts with others, use of medications to stay awake, use of alcohol, feeling belittled or humiliated, and being overall less satisfied.[30]

Performance, on the other hand, has had conflicting results. Some fault the studies for not accounting for chronic sleep deprivation playing a role and others for not distinguishing the control group with more hours sleep.

Sleep deprivation was shown to affect 3 of 4 cognitive function tests in internal medicine housestaff after overnight call. The 4th function test that was not affected was mathematical problem solving.[31]

There have been two studies of concentration using electroencephalography (EEG). A prospective cohort study looked at concentration by EEG in regular call vs. night-float coverage, where interns were allowed 4 hours to sleep while a float covered their patients. This study was problematic in that the interns did not use the time to sleep and instead used it to catch up on incomplete work. Interesting, though, was the fact that neither group of interns showed any deterioration in Divided Attention Task in concentration.[32]

One of the more recent and well done studies on sleep deprivation and clinical performance was done as part of the Intern Sleep and Patient Safety Study. This prospective, controlled, within-subject study showed that with ICU shift changes to 4 interns covering rather than 3, there was a decrease in work hours, increased sleep, and fewer attentional failures per hour at night by continuous electrooculography (EOG). The control interns had 50% more attentional failures and committed 22% more serious errors on critical care units. They went further and analyzed the time of most attentional failures and found they occurred 2 times more often between 11PM and 7AM, and 1.5 times as often from 7AM to 10 PM. It should be noted that despite all the attentional failures and increased serious errors, there were no differences in preventable adverse events.

Interns on the study schedule slept 0.83 hours more per day than the controls and worked nearly 3 hours less per day (84.9 hour workweek vs. 65.4 for the study group).[33] This suggests that the interns used less than one third of their new free time to sleep.

A meta-analysis looked at mood and performance in sleep deprivation and noted that mood was the area most affected by sleep deprivation, then performance, followed by motor function. Also of interest was that partial sleep deprivation, defined as less than 5 hours of sleep in a 24 hour period, was found to have a significantly greater overall effect on subjects' tests more so than short-term deprivation (<45 hours) or long-term deprivation (>45 hours). This partial-sleep-deprived group performed at a level two standard deviations below the non-sleep-deprived controls. Performance was found to be worse on complex tasks and long tasks. Overall performance in the sleep deprived group was comparable to only the 9th percentile of the non-sleep-deprived controls.[28]

There is some evidence to suggest that the effects of sleep deprivation may not be generalized to attendings. A prospective double-blind placebo-controlled trial found sleep deprived emergency room attendings had a decline in psychomotor vigilance task and mood impairment but no differences in performance on a test of electrocardiogram (ECG) analysis and interpretation[21] in contrast to a similar study done on housestaff.[34]

Fatigue=Alcohol?

Two compelling studies have been widely quoted in arguing for resident work hour reform. The first study was published in *Science* and found impairment on a tracking task after 17 hours of sleep deprivation to be equivalent to a blood alcohol concentration of 0.05 g% (3-4 standard drinks) in nonresidents.[35]

The second study looked at performance measures of vigilance, simulated driving, and sustained attention on residents during the final week of light and heavy call rotations. The light call group was further subdivided into placebo and those given alcohol to achieve a blood alcohol concentration of 0.04-0.05 g%. There were statistically significant differences compared with light call "control" group and light call with alcohol and heavy call on tests of Stanford sleepiness scale, visual analog scale, psychomotor vigilance tasks, and simulated driving. The heavy call group actually was even more impaired than the alcohol group for errors of commission on the continuous performance tests and in speed variability on the driving simulator. It should be pointed out that response times, vigilance, and simulated driving performance are not measures of clinical efficacy or patient safety (nor are they intermediate markers), though the indirect implication is that sleep deprived residents are equal to or worse than an intoxicated, well-rested resident.[36]

Patient Mortality

Research on sleep deprivation and physicians has involved limited assessments of functionality and neurocognitive functioning and has only looked at patient outcome in an inadequate manner.

In one of the most widely publicized surveys, 45% of internal medicine residents admitted to making mistakes when on the wards. This survey of 254 residents showed that 41% claimed

fatigue as a cause of their most serious mistake, and 31% reported that the mistakes resulted in fatalities.[18]

To study this, Hillson and colleagues found an increased mortality rate associated with nighttime admission to the medical floor at a teaching hospital. There was a nonlinear relationship between the number of admissions and length of stay. It was speculated that the residents were more sleep deprived and had less supervision at night.[37]

This was disputed by a study out of the Division of Pulmonary and Critical Care Medicine at the Mayo who found an actual statistical decrease in the mortality rate of patients admitted to the MICU at night, even on days of heavy admissions (13.9% vs. 17.2%, $p<0.0001$). There was also a significant reduction in length of stay (11.0 days vs. 12.7 days, $p<0.0001$).

Sleep deprivation has been shown to impair the dexterity of surgeons in vitro, but no in vivo. Several studies have looked at skills on the simulated laparoscope and all consistently show them to be less efficient, slower to complete the task, and to commit more errors than when well rested.[38-40] Despite these findings, studies of post-operative complication rates have failed to show any correlation with fatigue.[41]

Housestaff Mortality

Neurocognitive deficits seem to predominate between 8-10 AM after a night without sleep. Similarly, the peak time of auto accidents when fatigue was thought to play a role is 8 AM.[42] There is significant observational data that indicates prolonged work hours to be associated with increased housestaff automobile accidents or near-accidents. Whether these findings are linked or a mere bystander effect has not been rigorously studied to date. An observational survey study queried emergency medicine interns nationwide. Though this survey was biased in several aspects, it did find the odds ratio (OR) for having an accident or near-miss accident to be 2.3 for extended shifts as opposed to regular shifts. Per the interns' reports, the OR of falling asleep while driving after an extended shift was 2.39 and of falling asleep at a stop light were 3.69.[43] An accompanying editorial suggested reforming emergency room extended duty shifts.[24] Other articles have found an association with emergency medicine residents being involved in higher numbers of motor vehicle accidents and near-crashes after working night shifts compared with other shifts.[6]

Emergency room housestaff are not the only ones affected. Pediatrics residents reported falling asleep behind the wheel and having motor vehicle accidents significantly more than faculty members (49% vs. 13% and 20% vs. 11% respectively).[44]

Female residents have been shown to have higher rates of preterm labor (11% vs. 6%), preeclampsia or eclampsia (8.8 vs. 3.5%) compared with male residents' wives.[45] They have also been shown to have higher instances of spontaneous or induced abortions compared with non-resident females.[46]

In summary, sleep deprivation has been attributed as the Achilles' heel of the medical profession. Over the past 30 years, studies have shown that sleep deprivation increases scores on measures of depression, anxiety, confusion, anger, psychomotor performance, tracking skills. While it has been fairly easy to prove that sleep deprivation impairs global performance in an individual compared with their well-rested state, it has been more difficult to prove that sleep deprivation impaired *clinical* performance. Many of the early sleep studies were flawed either in

methodology or through use of unvalidated measures. They were small in size and limited in design.[9] And although there were surveys which found residents attributing their medical errors to fatigue, it has been difficult to prove this is the case. What we do know is that housestaff have disproportional more automobile accidents and near-accidents than their non-physician cohorts or faculty; that their overall mood is worsened and their cognitive function based on tests is worsened to the point of equal scores with a person imbibing alcohol.

Rote knowledge seems unaffected and tasks requiring attention for 3 minutes or less are likewise preserved. There is a suggestion that experience, either from a knowledge base or a tolerance base to sleep deprivation, lends some resistance to ill effects in performance. Concentration problems based on cognitive testing seems to occur primarily between the hours 8AM and 10AM but can occur throughout the day. So it seems obvious that with the 80 hour workweek housestaff will be better rested, experience better moods, score better on neurocognitive tests, and have fewer accidents.

Unfortunately, it appears the residents are not using their newfound spare time to sleep as much as predicted. A survey of over 3000 residents from a wide sampling of specialties showed that the correlation between work hours and sleep hours was less robust than previously thought ($r = -0.39$, a value of -1.0 would imply perfect inverse linear correlation between work and sleep, whereas a value of 0 would imply a lack of correlation). Some speculate that the resident physicians are not using their free time to repair their sleep debt and are perpetuating a culture of chronic sleep deprivation.[30]

Others suggest new responsibilities need to be given to housestaff: preparing for work by getting sufficient sleep and delegating high intensity activities currently performed at night to well-rested physicians in the morning whenever possible.[9] It may become an obligation of residency to ensure program mandated adequate sleep nightly.

Part II: The Present

The 80 hour workweek: models for complying

There have been four proposed models for helping programs meet the 80 hour obligation:

The stretch model: the most traditional model of coverage. The resident takes call as usual (every 4th night) but leaves early the post-call morning, sending the resident home after 24 hours. This preserves the team concept, but creates more strain on teams covering for each other, creating unreasonable workloads, and increasing cross-coverage by physicians not familiar with the team.[47] Under most circumstances, this model will create an 86 hour workweek.

The night float model: partitions off a fraction of the residents to work night duty and assist with admissions and cross-cover during the nighttime hours. A typical resident would work a 76 hour workweek using this model. Drawbacks of the program are that the night float residents get little education or supervision, and the patients get less continuity. The upside of this model is that the housestaff are allowed more rest and the traditional resident team remains intact.

The apprentice model: residents work exclusively with one or two faculty members for a period of time, following them and being directly involved with whatever activities the attendings are performing. Average hours per week would be about 60-70. It harkens back to the older days of

training. Negatives include the individual variability of teaching from the attendings, potential lack of variety of patient exposure, and total disruption of the traditional resident team concept. Positives of it are that the residents would get direct individual supervision with faculty, mimicking the real life of the physician, allowing them to experience the professionalism directly. Learning could be tailored to the residents' particular needs and advance at their individual pace.

The mastery or competency model: residents are required to master particular knowledge bases prior to being allowed to advance in their teaching. For example, a surgeon would be required to master the intricacies of herniorrhaphy prior to being allowed to participate in open cholecystectomies. Similarly, internists would be required to master particular disease states, perhaps organized by organ, prior to advancing in their training. The average workweek could easily be limited to 60-70 hours. Negatives of this model include the incredibly complicated scheduling required to allow residents to experience only those areas they are required to study. Communication between housestaff and attendings would be severely impaired, and the residency team concept would be destroyed, creating a vacuum for inpatient care.

Whang looked at how surgery programs handled the Bell regulations in 1998 and found:

- 50% of the programs increased resident cross-coverage
- 42% instituted a night float system
- 35% transferred work from junior residents to senior residents
- 14% recruited new residents or reassigned existing ones
- 14% allowed nonteaching patients
- 54% increased mid-level providers roles in the hospital
- 11% increased lower-level providers' roles[48]

Monetary effects on programs

Another factor to consider when implementing the ACGME regulations was cost. Expenses in complying with the ACGME provisions will come not only from loss of manpower as residents are 10-25% less available, but also from costs of monitoring to ensure compliance (including creation of a compliance officer), and loss of productivity as residents are asked to somehow track of their hours via simple time cards (a time consuming activity) or by elaborate computer programs or websites (quicker but more costly). If the programs use programs to monitor hours, those too will add to expenses. If the programs chose to merely create a night-float system, there may be added expenses as length of patient stay may be prolonged and there may be increased tests ordered.[49] Unfortunately, the ACGME provisions come without funding. The only other option is governmental regulation with funding but then loss of control of medical education by the programs and ACGME. The worst case scenario would be both ACGME regulations and governmental law as programs would have to scramble to comply with both likely differing regulations.

Niederee found in a survey of residents and faculty that only 14% of respondents thought the benefits of a reduction in duty hours would outweigh the costs.[50] It had been estimated in 1994 that it would cost $1.4-1.8 billion dollars to cover the transition of labor from residents to others.[9] A similar study in 2002 from the New England Journal predicted a cost of over $1.5 billion nationally to cover the expenses of conforming to the ACGME requirements.[13]

Since the requirements have been mandated, programs across the country have been experiencing significant expenses covering the loss of manpower. Both The Brigham and Women's Hospital

in Boston and the University of Michigan have estimated the changes will cost their programs $1 million per year. The Los Angeles County hospital system spent $7.4 million, and the University of Pennsylvania hospital system spent $6.5 million to comply with the ACGME guidelines.[14]

In order for graduate medical education programs to survive, they will need to find a way to compensate for the lost resident time. There are only a few options: 1) find cheaper labor, which is very unlikely, 2) create a system which is more efficient allowing the same work to be done in a shorter amount of time, or 3) reduce in-hospital expenses such that the losses with ACGME regulations are negated.

A well thought out study from the UCLA General Internal Medicine department looked to evaluate the cost in 2001 dollars the effects of the ACGME mandates and to calculate the reduction of preventable adverse events needed to make these changes cost neutral. They used some fairly favorable estimates towards ACGME compliance costs, such as that the changeover would not cost programs, and that the new system would have the same length of stay and test ordering, and enforcement of compliance would be negligible.

They then estimated the costs of covering for the reduced resident hours by 4 models: to attending physicians, to mid-level providers, to task-tailored substitutes (the lowest-level providers appropriate for a noneducational task), or among existing residents. As one would expect, the resident group was the cheapest at $0 and the attending group was the most expensive at $2.24 billion annually in the US. Replacing resident with mid-level substitutes would cost $1.19 billion, with task-tailored substitutes costing $673 million annually. In order to "break even" from a teaching hospital perspective, the preventable adverse event rates would need to be improved by an absolute reduction of 18.5% for task-tailored substitutes, 30.9% for mid-level providers, and an enormous 61.9% to cover attendings. To put it another way, if using attendings as substitutes resulted in even an absolute 10% decline in preventable adverse events, it would still cost society $452,978 per life saved.[17]

How has it been accepted by programs?

The overall responses of residents and faculty to the 80 hour workweek restrictions are mixed. By and large, the residents like certain aspects, specifically the reduction in fatigue, but they have concerns about whether their training and experiences as well as patient care will decline. Faculty, for the most part, are not happy with the restrictions and subsequent increased job demands. Feelings of the work being merely pushed "up the ladder" to them are common.

After the 405 regulations, residents indicated less fatigue and more personal time as benefits of the restrictions.[28] Trontell showed that 81% of program directors felt that program morale was improved with initiation of the float system.[51]

Diversity of faculty comments can be seen in the following 3 quotes.

"The 3 years of residency training mark the most important period in the professional development of an internist. The learning curve is at its steepest; professionalism evolves; and it is a time when physicians develop habits, both good and bad...The new system rewards them for nonprofessional behavior, admonishes them to leave on time, and criticizes them if they want to stay to help their sickest patients in an acute crisis. We are enforcing the idea that (it) is perfectly acceptable to leave a sick patient in the midst of a medical emergency."[52]

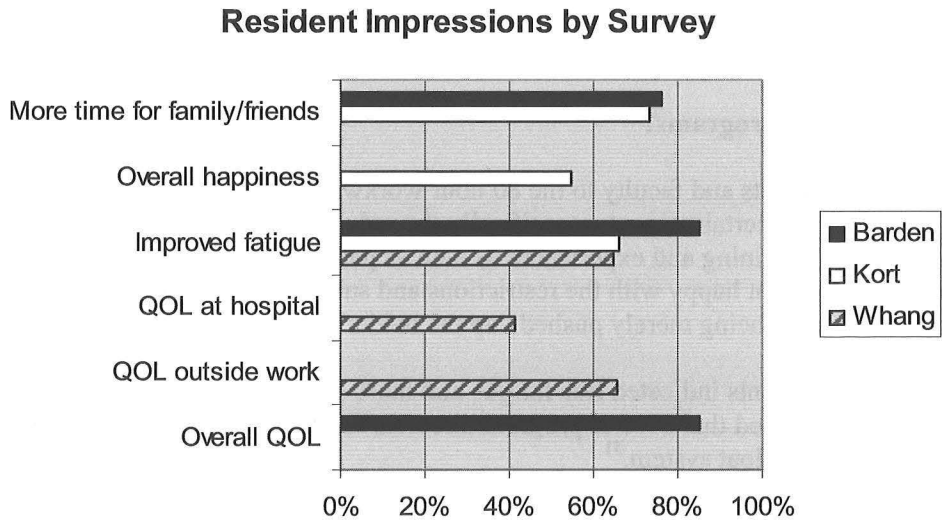
"I believe that the proper response to these challenges is creative and long-overdue change in the way we educate medical residents, not a retreat to a blatantly broken status quo. Since more reasonable work hours and shared patient responsibilities are common facts of life after residency and themselves risk reduced continuity of care, we must do a better job of teaching our residents how to relay information about shared patients."[53]

"Currently well-prepared internists can graduate in 3 years in the United States compared with 5 or 6 years in Europe, thanks only to long hours and intense case exposure. Graduates of the new system will probably be unfit to assume the responsibilities, stress, and multi-tasking of an attending physician, who has no limits on hours, census, and length of shift. Therefore, it will be necessary to make changes similar to those made in Europe..." [54]

A. Resident satisfaction

When it comes to resident satisfaction with the ACGME or 405 Regulations, the results are almost unanimously favorable (the majority of surveys coming from the 405 Regulations). Nearly two-thirds of housestaff report experiencing improved quality of life, both in activities outside the job as well as in the hospital.[48] Some suggest that they will have more personal time, more balanced a lifestyle, enhancing their gratification outside of their professional role and leading to even greater satisfaction as physicians.[55]

It has been shown that emphasizing intensive training can create personal stress and burnout for professionals and suboptimal care for patients.[56] And while the subjective and objective effects of reduced hours have not yet shown improved patient care, they have consistently reflected reduced stress and increased happiness in the housestaff by most surveys.[57]



A small survey of residents done at the UC Irvine Department of Surgery performed the Maslach Burnout Inventory Human Services Survey before and after duty hour restrictions. They found no statistical differences in number of spare hours after work, and no differences in scores of resident emotional exhaustion, depersonalization, and personal accomplishment between the two periods of time.[58]

Despite the above study, the majority of residents felt they had more free time to spend with family, friends, or activities outside the hospital. There was a trend towards improved job satisfaction, especially among the more junior residents.[57]

While resident safety is one of the reasons for duty hour reform, there have been no published studies looking at automobile accidents or near-crashes, nor pregnancy complication surveys. One looks forward to more objective studies of resident well-being.

B. Patient safety

Medical errors/Quality of patient care

One of the major reasons given for the push for residency duty hour reform has been patient safety. Surprisingly, however, there has been little research done to assess this area. Of the available literature, only one randomized, controlled trial has been done. The remaining other few studies are of retrospective or nonrandomized variety.

To date, no study has shown a reduction in preventable adverse events inhouse as a result of the ACGME regulations. The studies otherwise conflict on whether in-hospital complications (not leading to adverse events to the patients) are increased with increasing cross coverage for the patients or reduced with less sleep-deprived residents. Below is a brief discussion of the most notable of the studies.

Surveys, the least strenuous of research modalities, have shown consistent feelings among housestaff that the new work hour changes seem to impede their ability to care for the patients. In what has been described as the most comprehensive study on the effect of work hour restrictions, Whang and colleagues performed a statewide survey to assess the impact of the 405 Regulations in anticipation of national ACGME enforcement of similar restrictions. The majority of residents found no change in quality of care, and 35% reported worse care since work hour reform.

Less than one third of residents felt that their quality of work had improved since initiation of work hour limitations and more than a quarter felt it had actually worsened. Similarly, only 21% felt that the quality of care for their patients had improved while 34.9% felt it had worsened.[48] Another survey found similar results in that the majority of residents felt that patient care was negatively impacted (62%) compared with only 9% who felt it was improved with work hour reform. Within that group, 47.9% felt that despite improved fatigue, the rate of medical errors was unchanged, while only 20.5% felt it was better. When asked about patient safety, 36.2% felt that it had worsened.[57]

Several studies evaluated the effects of night float systems and patient quality of care and medical errors[59-61]. A retrospective cohort study of general internal medicine patients looked at post-call transfer of responsibility. This study followed patients admitted to the regular service or to a service with a night float system. There was found to be no difference in mortality, resource utilization, length of stay, orders for consultations, procedures, or radiographs between the two groups. There was, however, an increase in the number of laboratory tests ordered and in the total inpatient days in the night float group felt due to transferring to a different medical resident from the admitting resident the next day.[59]

Another retrospective study done out of the same hospital in which Libby Zion was admitted just 9 years earlier looked at the impact of patient care of New York State regulations. Again, there was found to be no difference in mortality, length of stay, or procedure delays after the intervention. They did, however, find a statistically significant increase in patients suffering at least one medical complication (22% vs. 35%), specifically electrolyte abnormalities; and at least one diagnostic test delay (1.9% vs. 17%). These differences persisted even after multivariate analysis.[60]

Outcome	1988 Cohort	%	1989 Cohort	%
In-hospital mortality	25	9.5	25	9.5
CPR performed	4	1.5	5	1.9
ICU/telemetry transfer	16	6.1	19	7.2
Discharge to another inpatient setting	19	7.2	17	6.5
In-hospital complications	59	22.0	91	35.0
Delays in tests/procedures	9	1.9	53	17.0

The last night float study was a prospective, case-control study done out of Brigham and Women's Hospital in 1994. This study asked the question, "Who is better equipped to take care of a patient, a fatigued primary team member or a well rested, but less informed cross coverage intern or float?" Patients were admitted to one of three coverage systems: regular call coverage, intern cross-coverage, or night-float coverage. They identified 124 adverse events, 44% of which were deemed preventable. These patients were more than twice as likely to be covered by either an intern from another team or the night-float resident at the time of the event (26% vs. 12%, $p<0.05$), and preventable adverse events climbed nearly 500% on days that interns were cross-covering.[61]

Two other studies looked at medical errors, but they looked at them after initiation of more novel changes in resource utilization, rather than mere night float.[49,62] While neither of these showed reduced preventable adverse events, they did show some promise.

A prospective, prepost design out of Minnesota looked at changes in patient care after initiation of a night-float system as well as a change in the call regimen such that the teams pulled long-call only every 7 days and spent the night in the hospital only once in 7 weeks. Using this unique call schedule, the program was able to alter patient admissions such that whereas previously 25% of patients were admitted to the night float and 80% of admissions were taken by the "long-call" team, now only 10% of patients are admitted to the night float and only 40% of admissions are taken by the "long-call" team. After this intervention, they found significant reductions in length of stay (10.9 days vs. 9.3 days), number of laboratory tests ordered per patients (24 vs. 19), and fewer medication errors (16.9 vs. 12 per 100 patients discharged). The authors concluded that efficiency of care increased while rates of errors among housestaff decreased.[49]

The most recent, and best structured study was done out of Brigham and Women's Hospital in 2004. This prospective, randomized crossover trial looked at "serious" medical errors made by interns while working in the MICU and CCU areas. The intervention rotated 4 interns instead of the usual 3, allowing maximum work shifts to be only 16 hours. Resident schedules were unchanged from usual. Procedural, medication, diagnostic and "other" errors were closely followed by several avenues including "continuous" observation (though not completely continuous as only one of 2 working interns could be followed at a time if both were working in

the afternoon). Overall, there was no significant difference in preventable adverse events between the two groups. There were, however, significant differences in errors between the two groups.

Interns in the control group were found to make 35.9% more serious combined medical errors (136.0 vs. 100.1 per 1000 patient-days). Both intercepted errors and non-intercepted errors were increased. When breaking down the error types, medication errors were also increased in the traditional group by 20.8% (99.7 vs. 82.5 per 1000 patient-days). Diagnostic errors occurred 5.6 times more often with 18.6 vs. 3.3 per 1000 patient-days ($p<0.001$). Procedural and "other" errors did not differ between the two groups. Interestingly, when looking at the resident and intern as a group and comparing the traditional and intervention groups, the differences remained, suggesting that either the intern intervention group residents were somehow less prone to mistakes, or that the interns were making most all of the diagnostic and medication decisions without supervision in the ICU's.[62] One limitation of this study was that it did not evaluate the intern mistakes as to time of day or amount of sleep deprivation to see if more errors were attributed to acute sleep deprivation or more to chronic fatigue.

These studies lead one to conclude that currently there is no evidence to support the claim that the 80 hour workweek reduces preventable adverse events in the hospital. There also appears to be evidence that the use of a mere night float does not help and may in fact lead to increased adverse patient events if not merely increased ordering of tests, length of stay, delays in ordering tests, and electrolyte complications. There is some hope, though, that more innovative changes as listed in the latter two studies may create an environment where there can be fewer medical and diagnostic errors, reduced length of stay and less laboratory ordering.

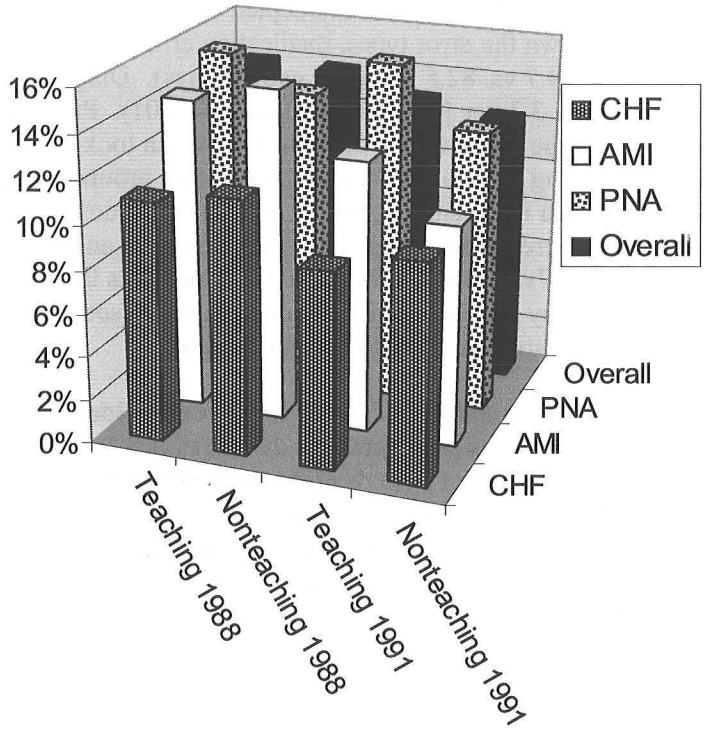
In-house mortality

Similar to morbidity and safety, there have been very few studies on the overall impact of the residency reform changes on patient mortality. As the reform has already occurred and is likely here to stay, the ability to perform prospective, randomized, controlled trials is negated. Thus, only studies done looking at "before and after" data or those performed before nationwide regulations went into effect can help shed light on this facet.

One of the 1st groups to study mortality came out of the Brody School of Medicine, who prospectively collected data 11 months before and 11 months after the initiation of ACGME new regulations. They evaluated whether the planned residency regulations resulted in improved patient safety and mortality benefit as speculated by the ACGME, reviewing indicators such as mortality, length of hospital stay, length of ICU stay, ventilator days, Injury Severity Score (ISS) and complication data. They found no significant differences in any of these parameters between the two periods of time.[63]

A well-done, retrospective study looked at inpatient discharge files through a statewide database to evaluate the effects of the 405 Regulations on mortality. They looked at outcomes in three common diseases: congestive heart failure (CHF), acute myocardial infarction (AMI), or pneumonia (PNA) for the year 1988 and 1991 to assess inpatient mortality at all hospitals in the state of New York before and after enactment of the work hour restrictions. They found that combined unadjusted mortality for CHF, AMI, and PNA patients declined between 1988 and 1991 in both the teaching hospitals (14.1% to 13.0%; $P=0.0001$) as well as those that were nonteaching hospitals (14.0% to 12.5%; $P=0.0001$). The adjusted mortality rates also showed a

similar decline in both groups (OR 0.868 vs. 0.853). Looking at each diagnosis individually likewise showed no differences between the two years. The authors suggested that the duty hour regulations could not be responsible for the decrease in mortality because of the similar reductions at nonteaching facilities. They conclude that there is no clear evidence of improved patient outcome by reducing the work hours of internal medicine or family practice residents.



A retrospective cohort study from the Mayo Division of Pulmonary and Critical Care Medicine sought to evaluate whether mortality rates were affected by the time one was admitted to the MICU. Patients were separated into "daytime" admissions or "nighttime" admissions and those admitted at night were further subdivided into "regular" and "heavy workload" (shifts when 3 or more patients were admitted) groups. They found that nighttime admissions actually had a lower mortality rate (13.9% vs. 17.2%, $p<0.0001$) and shorter length of stay (11.0 days vs. 12.7 days; $p<0.0001$) than the dayshift admissions. When looking at the subdivided night admissions, there was no difference in mortality rates between "regular" and "heavy workload" nights. The authors suggest that the staffing services made up for any potential adverse outcomes from sleep deprivation.[64]

A recent systemic review of the effects of resident work hours on patient safety sought to critically evaluate whether adhering to the ACGME standards has been shown to improve patient safety, a cornerstone of the reasons for the ACGME gave for mandating its duty hour restrictions. They looked at over 300 papers before narrowing down the list to include seven that met their strict criteria. These were rigorously analyzed and the authors concluded that there was insufficient evidence to prove or disprove any mortality benefit with the residency changes.[65]

In summary, to date, there are no studies showing an improvement in inpatient mortality with reduction in resident work hours. Though this was the sentinel reason for the 405 Regulations and subsequent ACGME changes, it has yet to be proven. One can look at it the other way, though, and state that with changes to allow residents to be more rested and less overworked, patient mortality has not suffered, either.

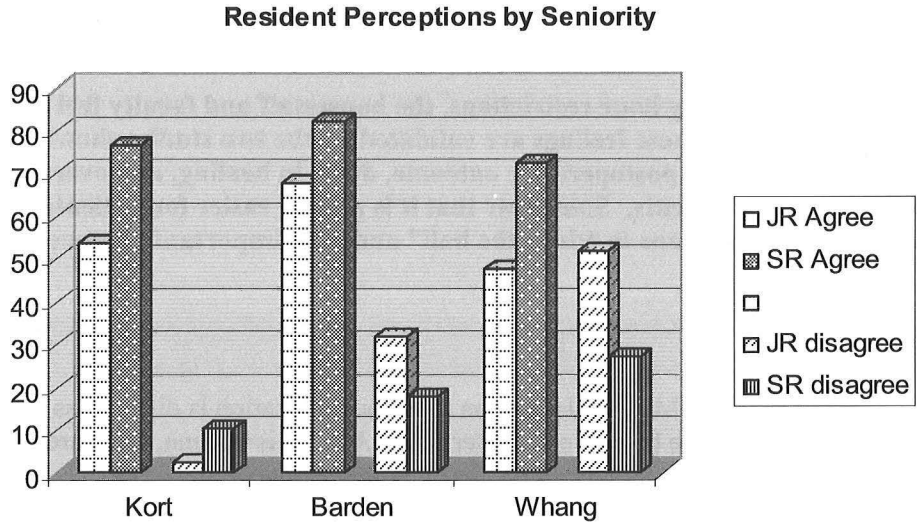
Continuity

When it comes to continuity of patient care, the residents and faculty feel overwhelmingly that duty hour restrictions are having a negative impact.

Do you feel that continuity has been negatively impacted by duty hour restrictions?

	Agree	Disagree
Kort[57]	61.8%	9.3%
Barden[66]	76%	12%
Whang[48]	60.4%	6.2%

In one study, over 75% of the residents in the program felt that patient continuity was worse after initiation of restrictions on work hours.[66] This impression is agreed upon by residents and faculty alike, though the faculty and upper level residents seem to feel this more so than junior residents or interns.[48,57,66]



Petersen, in a case control study described above in the medical errors section, found that there was a statistically significant increase in preventable adverse events when patients were cross-covered by someone not on their primary team. It was suggested that the lack of patient continuity accounted for the increased adverse events, especially by the interns, where the chances of preventable adverse events doubled compared with controlled patients in matched beds.

In multivariate analysis, the study found three risk factors which were statistically significant and associated with preventable adverse events: cross-coverage by an intern or night-float not associated with the team (odds ratio 6.1), Acute Physiology and Chronic Health Evaluation II score (APACHE-II) (odds ratio 1.2), and history of gastrointestinal bleed (odds ratio 4.7). When looking at *unpreventable* adverse events with logistic regression modeling, only APACHE-II score was found to be statistically significant.[61]

A study out of Germany sought to evaluate if a decrement in continuity affected patient outcome. In a prospective, multicenter study of 6 surgical intensive care units (SICU), they looked at

patient outcomes as they complied with mandated physician hour restrictions. On January 1, 1996, the German working-time regulations went into effect restricting physicians work to 8 consecutive hours, from a previous limit of 12. They evaluated 347 patients, in a 2:1 randomization to either the three-shift model (3-SM) vs. the standard two-shift-model (2-SM) of physician care. In univariate analyses, they found trends towards increased lengths of stay in the SICU (1.6 days longer), overall hospital stay (2.3 days longer), as well as increased readmissions to the SICU, reinterventions, and frequency of complications. There was a statistically significant finding in that APACHE-II scores decreased more quickly in the 12 hour shifts ($P<0.05$).

With multivariate analysis, there were statically significant differences in percentage of patients in the ICU less than 24 hours, total days in the ICU, patients with good postoperative course outcome, and slopes in the APACHE-II score in the ICU.[67]

	2-SM	3-SM	Significance
<24 hours in ICU	59%	42%	P<0.05
Days on ICU	5.6	7.2	P<0.01
Good postoperative course "outcome"	79.9%	70.1%	P<0.01
Slope of APACHE-II score in ICU	-4.6	-2.1	P<0.01

It seems that after initiation of duty hour restrictions, the housestaff and faculty feel that patient continuity has suffered. These feelings are validated by the two studies showing increased length of stay, worsened postoperative outcome, delay in healing, and overall increase in preventable adverse events. Some fear that it is getting easier for patients to fall through the cracks and for physicians to "drop the ball" and miss important diagnoses.[52,68]

C. Resident education

Evaluation of the impact of the ACGME regulations on residency education is difficult as the only available studies have been done by survey or interview. As of this writing, there are no objective studies of the work hour regulations on residency board scores or any other standardized evaluation method, nor will there ever be as there cannot be a control group anymore.

Are well rested physicians better learners, or is the push to leave the hospital within the allotted time impeding education? There is concern that residents, faced with limited hours, will reduce participation in teaching conferences and other didactics so that they may care for their patients or obtain more experience in procedures or surgeries. Attendance at continuity clinics may be further affected as well.

Lefrak studied the effects of the night float system on resident education at the University of Virginia Department of Surgery after the initiation of the ACGME work-hour restrictions. They sought to evaluate whether the night float residents would find the experience beneficial (enhance their diagnostic and decision-making skills) or detrimental (less didactic teaching, attending interaction, and overall decreased quality of training) compared with their colleagues on regular rotation. This study was done by survey and thus had significant limitations. The results revealed post-graduate year one (PGY1) night floats to have less satisfaction with conference attendance, operative experience, and attending teaching interactions compared with their daytime colleagues. In fact, 89% reported NO attending teaching interaction compared with 60%

in the daytime. The PGY3 residents reported better attending teaching but less operative experience. Despite changes made in the program as a result of the July results, the operative experience remained less for the night floats compared with their peers.[69]

Data from the statewide survey of New York State residents found that 47% felt that they had increased time for studying or reading, but only 22% felt that their quality of training had improved compared to 35% who felt it had worsened.[48]

Restricted hours did not appear to change education, specifically unchanged were resident perceptions of ability to attend teaching conferences, study outside work, or pursue clinical or basic research. Likewise, relationships with other residents and with ancillary health care staff were unchanged. Almost a third of residents felt, however, that their relationships with attendings were worsened with the restricted hours. Similarly, more than half of surgeons surveyed felt that there was a decline in operative case experiences and that the work hour restrictions had a negative impact on their technical abilities.[57]

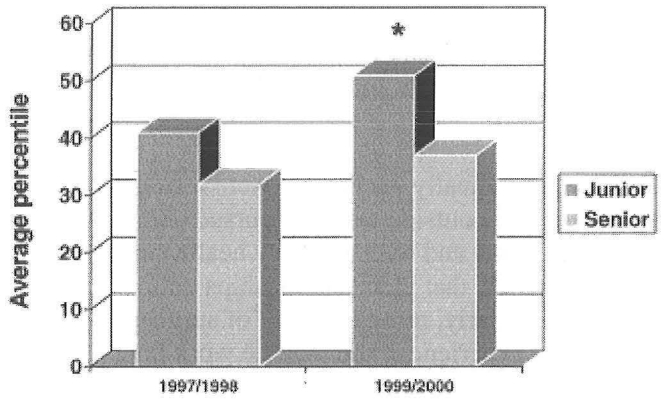
Survey results of the effects of work hour restrictions on education[48,57,66]

Quality	Improved	Unchanged	Worsened
Time to study	47%	n/a	n/a
Learning opportunities	20%	29%	51%
Ability to attend teaching conferences	21.6%	68.0%	10.3%
Ability to study and read outside work	35.4%	58.3%	6.3%
Ability to pursue research	29.8%	66.0%	4.3%
Quality of training	22%	43%	35%
Quality of surgical training	12.9%	48.4%	38.7%
Operating room time	8.3%	34.4%	57.3%
Relationship with attending	14.6%	56.3%	29.2%
Overall resident education	6%	73%	21%
Faculty teaching	6%	62%	29%
Knowledge of basic science	24%	58%	18%

An interesting survey out of New York compared resident and attending perceptions of the impact of the 405 Regulations on resident training. While residents felt that the regulations generally allowed them to read more, the faculty disagreed and felt the residents were reading less. Both groups agreed that the regulations were creating a shift-work mentality. Residents and faculty were fairly neutral on questions of providing better patient care or being more intellectually interested in challenging clinical problems. They were both uncertain as well about the educational value of the float rotatation.[70] Other surveys have reinforced that the residents feel they are maintaining their sense of responsibility for their patients.[71]

Another survey done to evaluate the effects of the 405 Regulations looked at the American Board of Surgery In-Training Examination (ABSITE) scores before and after the initiation of duty hour restrictions. The percentile scores averaged for the two years before and after the changes showed significant improvement after the changes. Furthermore, the number of surgical cases performed by chief residents actually increased slightly (though not statistically significant) despite perceptions of the residents on surveys that the case load was lower. The authors speculated that the increased board scores may be a reflection of the increased time for residents to read and attend conferences.[66] Another study, however, showed no improvement in Council on

Resident Education in Obstetrics and Gynecology (CREOG) In-Training Examination scores despite subjective increased time for outside reading.[72]



* p<0.05

Internal medicine residents sitting for The American Board of Internal Medicine (ABIM) Certification Examination have been consistent in their passing rates for the years 2003 through 2005 at 92%. A request for further breakdown as to the absolute scores was declined by the ABIM.

Thus, the effects of duty hour restrictions are unclear. Certainly by survey, the housestaff seem dissatisfied with some of the perceived negative impacts. Very few objective evaluations have been made to assess the housestaff learning, and the two studies that have looked at in-service examination scores found conflicting results. The attitude of surgeons that they are suffering from reduced OR time (at least in chief residents) has been validated by experience from the European Union. Only with further objective data can the ACGME truly assess the educational impact of their changes.

Part III: The Future

First and foremost, the future needs to include well-done, large studies looking at hard outcomes in residency reform. These studies need to ultimately determine what the major cause of preventable adverse events is. Studies need to be performed looking at objective measures evaluating the effectiveness of the ACGME regulations, and the public and professional bodies need to be open enough to change those areas that require it.

It seems fait accompli that resident workweek regulations are here to stay. What is left for the programs to determine is how best to continue the GME directives of service and education. Perhaps they need to create a distinct division between patient care and graduate medical educational activities. The current plan encourages light-switch mentality to training—when at the hospital, learn; when home, sleep or play, but do no supplemental learning. Whatever the outcome, the academic medical community needs to advocate for adequate public funding and payer support for GME and teaching hospitals.[73] Similarly, hospitals will have to re-develop their systems of care, relying less on residents for the brunt of the labor.

Some feel the skill of *how* to learn rather than *what* to learn needs to be stressed. More focus needs to be placed on the mechanics of diagnosing a problem and researching its treatment, rather than memorizing therapeutic regimens that may be outdated before the residents even graduate.

Many of the treatments taught to residents today may well be obsolete within 5-10 years, so the rote knowledge may not serve them as well as the skill to know *how* to find the current treatment modalities within the current information technology age. Emphasis on pimping housestaff on rare diseases or syndrome names that they may never see should be replaced with that of the education of critical analysis and problem solving through broad general means, which can be applied to any situation.

During the last 15 years, there has been a major change in the face of medicine, due in part to managed care, and part to the growth of the biotechnology industry. While hospitals and residencies are striving to endow their housestaff with the latest scientific breakthroughs, they have by and large abrogated the duty to prepare their graduates for changes in the practice environment. Consideration of changing the curriculum has been suggested to reflect changes in the health care environment and organization of medical services. More focus needs to be made on quality of care and costs of test and procedures ordered. Better teaching of information technology is a must.

Suggested curricula categories are very different from classic days, more adapted to reflect pertinent issues in the new medical environment:[74]

Health care system overview	Population-based care
Quality measurement and improvement	Medical management
Preventive care	Physician-patient communication
Ethics	Teamwork and collaboration
Information management and technology	Practice management

Work on the "handoff"

If residencies are to move towards a flexible or even shift-work model, guaranteeing appropriate checking out to cross-coverage becomes paramount. Residents need to be taught and then evaluated on these skills.

Investigation into different modalities of the "handoff" should be implemented. From items as simple as a preprinted checkout card, to complex computer programs with capabilities to draw recent labs and vital signs. Several studies have shown computerized sign-out systems to improve patient continuity and be a deterrent to preventable adverse events.[75]

The University of Washington created a computer program which had a centralized database that automatically downloaded patient vitals, labs, and printed them out in a progress note, rounding sheet, or sign out template. Performing a cross-over prospective study they found that the use of this program virtually cut in half the number of patients missed on resident rounds in a month of following data. Subjectively by survey, the residents (medicine and surgery) felt the program allowed better sign-out quality and improved continuity of care (66.1% agreed). The residents were able to spend 40% more of their prerounding time seeing patients and halved the amount of time spent on prerounds accruing data and hand copying vitals and laboratory results. Rounds were shortened by 1.5 minutes per patient. In their pilot, it decreased time spent by residents rounding by up to 3 hours per week. An unanticipated effect of the program was that the residents, particularly in internal medicine, did not actually shorten their prerounding time, but instead utilized the extra time to spend more time at the bedside, directly interacting with the patients.[76]

Address deficiencies of the 80 hour workweek

As mentioned above during the discussion on residency reform in other countries, as of yet, no changes have been made to the core residency training model despite drastic reduction in time on campus for the housestaff. Programs will need to start being more creative in their curricula, utilizing off-duty time more for educational activities. Lectures can be taped for archiving on a website for later streaming for the residents' convenience. Faculty will have to improve their mentorship skills and use educational time more effectively. There may also be a shift to more computer-based learning.[14] This interactive, computer-based teaching (which can be done at the residents' leisure) can incorporate modules for learning while allowing program directors to monitor progress and proficiency of housestaff on core subjects.

Fine-tune resident duties: eliminate resident activities found nonproductive in an educational/clinical manner

A systemic review done in 2001 sought to look at housestaff duties and assess the educational value of their work. They found that residents spend as much as 35% of their time performing activities of marginal or no educational value (29.5 hours out of an 84.5 hour week). This time on marginal activities was statistically significantly greater than time spent on teaching and learning or on other activities and was essentially equal to the time spent on patient care activities.[77] Residency programs will need to look closely at this and enact changes to delegate these duties to ancillary staff, or even delegate them to other services where appropriate.

A retrospective study from the Department of Surgery at the University of Vermont College of Medicine looked at workload redistribution as a way to reduce resident work hours. They began a policy of direct admission to the surgical subspecialty service those cases with single-system injuries. This policy of "share the wealth" allowed the trauma service to reduce admissions by 15% without any changes in overall mortality, complications, missed or delayed diagnoses. Resident work hours were reduced by 9.7% on the trauma service with a 14% reduction in intern duty hours.[78]

Proponents have argued that hospitalists can improve efficiency and quality of inpatient care as well as serve as a new resource for educating the residents and medical students. They can admit those diagnoses that are overrepresented in teaching services, allowing them more time to focus on interesting cases. A study done out of the Brigham and Women's Hospital and Harvard Medical School looked at the financial aspects of a hospitalists system in a teaching hospital. They created a "short stay unit" (SSU) which was manned by hospitalists with the goal of reducing volume to the teaching services. They found a reduction in LOS (18%) for the SSU patients and a 24% reduction in hospital charges with an estimated savings to the hospital of $700,000 per year. They also estimated that the SSU saved the training physicians 6 admissions per day.[73]

Sleep hygiene

Housestaff need to be educated about sleep hygiene. They need to understand that as part of their residency duties, they must ensure adequate sleep each night. If they are to be awake for prolonged periods, they need to understand strategic use of stimulants (coffee, soft drinks, etc…if

used), rather than counterproductive use. Hospitals should consider results of studies showing ambient light of specific intensity and wavelengths that may mitigate the deterioration in performance resulting from circadian misalignment,[33] and use bright lights strategically.[79] Residents should consider prophylactic napping, try to work on limiting consecutive duty hours, and ensure protected "recovery" sleep.

Think outside the box

Programs need to become creative in finding solutions to the housestaff hour restrictions. Any modality that can make ward duties easier or more time-efficient should be considered. The century-old practice of writing daily progress notes needs to be reviewed. Progress notes now are often utilized more for auditing by payers or inhouse credentialing rather than providing information to doctors about a patient's care. New, computerized systems using a problem-based outline should be considered, allowing information on problems to be updated by the minute rather than once a day. Prerounds could become obsolete if electronic charting allowed instant downloading of vital signs and current labs to the doctor's computer stations or personal data assistants.

Information technology, long known to increase productivity in other professions, has only recently been explored as an option to reducing resident work load. By survey, medicine residents reported spending 13.1 hours work per day, 5.5 (42%) of which were spent on data management while only 1.9 (14%) were spent performing direct patient care. On average, the residents reported spending 3.5 hours daily searching for and gathering patient data (laboratory and radiology results, medication profiles, etc…), and an additional 2 hours moving that data onto another "more useable" format (paper, computer, personal note cards, etc…). Over 51.7% of those surveyed would like a PDA type device to allow access to patient data from the hospital information system.

This survey report estimated that if new information technology such as PDA productivity could be effected and reduce the time needed to collect and abstract data by even 30 minutes each day (of the 5.5 hours daily on average searching for and abstracting data currently), the programs would save 3 hours per week per resident. Extrapolated to the UT Southwestern Department of Internal Medicine residency program, this would save 483 resident work hours per week, and 25,116 hours per year. This is the equivalent of 6 full time residents working 80 hour weeks, or roughly $300,000.[80] If this work was instead to be performed by extenders such as physician assistants or nurse practitioners, assuming a workweek of 40 hours, the cost to the program would be estimated at $675,468-$807,600 annually.[81,82]

Are we done yet? Do we need to cut back further on the workweek?

A survey of 1126 medical students and 1011 residents by the AMA's Member Connect program found that 29% of residents and 26% of medical students felt that sleep deprivation or fatigue still put them at risk and the majority had been in a car crash or near miss because of fatigue. Eleven percent of residents and 12% of medical students still worked more than 80 hours, and unfortunately, program directors have no way of enforcing sleep mandates when physicians are away from the hospital. It thus appears that fatigue and its inherent risks persist. At what level of fatigue do the national governing bodies, as well as the programs themselves, feel comfortable? Where is the cost-effectiveness break-even point? At what point do the duty hour limitations affect the overall education?

It has been suggested that if work hours are to be appropriately addressed, patients will also need to alter their expectations. They will not always be able to be seen or cared for by the same physician. Procedures or operations may need to be rescheduled if the team has worked too many hours that particular day. If the overseas experience is any indicator, duty hour reform will continue and the workweek will continue to shorten. This will be guided; it is hoped, by stringently performed studies looking at hard outcomes with sleep deprivation, and resurgence in attention to the "E" in GME.

CONCLUSIONS:

The 80-hour workweek was a reflex response to public outcry over the concern that sleep deprivation may be the primary cause of preventable errors in hospitals. The facts have yet to prove this point. Residency reform was needed. The days of spending the night in the hospital and slowly, methodically reviewing a patient, her labs, radiographs, and manually reviewing the smears are long gone. The complexity of medicine has been surpassed only by the sheer enormity of numbers of patients now being admitted to teaching hospitals. Residents are faced with more acutely ill patients with more complicated medical issues, and are forced to deal with them in a shorter amount of time, all the while maintaining standards of care and excellence of treatment. Change was bound to occur; unfortunately, it was forced upon programs rather than allowing them to participate in creating the new system.

The 80-hour workweek does not answer all the problems with GME, and in many instances, exacerbates them. Institutions of medical training still have a long way to go in developing the ideal mixture of exposure of residents to service and education, professionalism and pragmatism. We know that sleep deprivation causes significant disturbances in mood of housestaff, that it affects performance on certain lab-based tests, is associated with attentional failures, and is linked to interns making more serious errors. Less definitive data links it to housestaff mortality with automobile accidents and pregnancy complications. No studies have shown reduction in these risks since institution of the ACGME regulations.

We know that housestaff are happier and more rested now, but that there are concerns of worsened continuity and patient care. Studies have even shown increased errors and preventable adverse events with duty hour changes. And healthcare costs are higher as a result of loss of cheap manpower and the expenses of creating and enforcing the reform. The good and bad news is that patient mortality is unchanged; something the country was hoping would improve and residency programs were afraid would worsen.

Interestingly, the ACGME, in releasing its report on resident duty hours, stated "the only way residency program and their sponsoring institutions can achieve a true 'education' program, as well as provide high quality clinical care, is by attending to the issue of resident duty hours and by placing a higher value on resident education and safe patient care than on meeting service demands."[15] And yet, as the duty hours have been reduced, the emphasis on education seems to be even further reduced.

As D.F. Weinstein stated in his editorial in *The New England Journal*, "one way or another, the term "resident" will soon become a misnomer."[73]

References:

1. Leach DC. Residents' work hours: the Achilles heel of the profession? *Acad Med* 2000;**75**(12):1156-7.
2. Ludmerer KM, Johns MM. Reforming graduate medical education. *Jama* 2005;**294**(9):1083-7.
3. Killelea BK, Chao L, Scarpinato V, Wallack MK. The 80-hour workweek. *Surg Clin North Am* 2004;**84**(6):1557-72, x.
4. Donini-Lenhoff FG, Hedrick HL. Growth of specialization in graduate medical education. *Jama* 2000;**284**(10):1284-9.
5. Services NYSDoHsAHACoE. Supervision and residents' working conditions. New York, October 7, 1987.
6. Steele MT, Ma OJ, Watson WA, Thomas HA, Jr., Muelleman RL. The occupational risk of motor vehicle collisions for emergency medicine residents. *Acad Emerg Med* 1999;**6**(10):1050-3.
7. Bates DW, Spell N, Cullen DJ, et al. The costs of adverse drug events in hospitalized patients. Adverse Drug Events Prevention Study Group. *Jama* 1997;**277**(4):307-11.
8. Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients: results of the Harvard Medical Practice Study I. 1991. *Qual Saf Health Care* 2004;**13**(2):145-51; discussion 151-2.
9. Gaba DM, Howard SK. Patient safety: fatigue among clinicians and the safety of patients. *N Engl J Med* 2002;**347**(16):1249-55.
10. Horowitz C. The Doctor Is Out. New York Magazine. New York, 2003.
11. Medicine Io. To Err Is Human: Building a Safer Health System. In: America CoQoHCi, ed. Washington, D.C.: National Academy Press, 1999.
12. Thomas EJ, Lipsitz SR, Studdert DM, Brennan TA. The reliability of medical record review for estimating adverse event rates. *Ann Intern Med* 2002;**136**(11):812-6.
13. Steinbrook R. The debate over residents' work hours. *N Engl J Med* 2002;**347**(16):1296-302.
14. Oransky I. Limits imposed on residents' work hours. Reduced workload said to increase patient--and resident--safety. *Lancet* 2003;**362**(9381):378-9.
15. Education ACfGM. Report of the ACGME Work Group on Resident Duty Hours. Chicago: Accreditation Council for Graduate Medical Education, June 11, 2002.
16. (ACGME) TACfGME. The ACGME's Approach to Limit Resident Duty Hours 12 Months After Implementation: A Summary of Achievements: ACGME Accreditation Database, June 2004, 2004.
17. Nuckols TK, Escarce JJ. Residency work-hours reform. A cost analysis including preventable adverse events. *J Gen Intern Med* 2005;**20**(10):873-8.
18. Wu AW, Folkman S, McPhee SJ, Lo B. Do house officers learn from their mistakes? *Jama* 1991;**265**(16):2089-94.
19. Sheldon GF, Schroen AT. Supply and demand--surgical and health workforce. *Surg Clin North Am* 2004;**84**(6):1493-509, viii-ix.
20. Association AM. Overview of Overseas Experience in Regulating Hours of Work of Doctors in Training, January 1998.
21. Smith-Coggins R, Rosekind MR, Buccino KR, Dinges DF, Moser RP. Rotating shiftwork schedules: can we enhance physician adaptation to night shifts? *Acad Emerg Med* 1997;**4**(10):951-61.
22. Jeong B. Comparison of Variables Between Fatal and Nonfatal Accidents in Manufacturing Industry. *International Journal of Industrial Ergonomics* 1999(23):565-572.
23. Forbes M. A Study of Accident Patterns in Offshore Drillers in the North Sea: Royal College of Physicians, 1997.
24. Mitler MM, Miller JC, Lipsitz JJ, Walsh JK, Wylie CD. The sleep of long-haul truck drivers. *N Engl J Med* 1997;**337**(11):755-61.
25. Board NTS. U.S. Air Carrier Operations, Calendar Year 2000. Annual Review ofAircraft Accident Data. Washington, D.C., 2000.
26. Hossain JL, Reinish LW, Heslegrave RJ, et al. Subjective and objective evaluation of sleep and performance in daytime versus nighttime sleep in extended-hours shift-workers at an underground mine. *J Occup Environ Med* 2004;**46**(3):212-26.
27. Gottlieb DJ, Peterson CA, Parenti CM, Lofgren RP. Effects of a night float system on housestaff neuropsychologic function. *J Gen Intern Med* 1993;**8**(3):146-8.
28. Pilcher JJ, Huffcutt AI. Effects of sleep deprivation on performance: a meta-analysis. *Sleep* 1996;**19**(4):318-26.
29. Bellini LM, Baime M, Shea JA. Variation of mood and empathy during internship. *Jama* 2002;**287**(23):3143-6.
30. Baldwin DC, Jr., Daugherty SR. Sleep deprivation and fatigue in residency training: results of a national survey of first- and second-year residents. *Sleep* 2004;**27**(2):217-23.
31. Robbins J, Gottlieb F. Sleep deprivation and cognitive testing in internal medicine house staff. *West J Med* 1990;**152**(1):82-6.
32. Richardson GS, Wyatt JK, Sullivan JP, et al. Objective assessment of sleep and alertness in medical house staff and the impact of protected time for sleep. *Sleep* 1996;**19**(9):718-26.
33. Lockley SW, Brainard GC, Czeisler CA. High sensitivity of the human circadian melatonin rhythm to resetting by short wavelength light. *J Clin Endocrinol Metab* 2003;**88**(9):4502-5.
34. Friedman RC, Bigger JT, Kornfeld DS. The intern and sleep loss. *N Engl J Med* 1971;**285**(4):201-3.
35. Dawson D, Reid K. Fatigue, alcohol and performance impairment. *Nature* 1997;**388**(6639):235.

36. Arnedt JT, Owens J, Crouch M, Stahl J, Carskadon MA. Neurobehavioral performance of residents after heavy night call vs after alcohol ingestion. *Jama* 2005;**294**(9):1025-33.
37. Hillson SD, Rich EC, Dowd B, Luxenberg MG. Call nights and patients care: effects on inpatients at one teaching hospital. *J Gen Intern Med* 1992;**7**(4):405-10.
38. Grantcharov TP, Bardram L, Funch-Jensen P, Rosenberg J. Laparoscopic performance after one night on call in a surgical department: prospective study. *Bmj* 2001;**323**(7323):1222-3.
39. Eastridge BJ, Hamilton EC, O'Keefe GE, et al. Effect of sleep deprivation on the performance of simulated laparoscopic surgical skill. *Am J Surg* 2003;**186**(2):169-74.
40. Taffinder NJ, McManus IC, Gul Y, Russell RC, Darzi A. Effect of sleep deprivation on surgeons' dexterity on laparoscopy simulator. *Lancet* 1998;**352**(9135):1191.
41. Haynes DF, Schwedler M, Dyslin DC, Rice JC, Kerstein MD. Are postoperative complications related to resident sleep deprivation? *South Med J* 1995;**88**(3):283-9.
42. Pack AI, Pack AM, Rodgman E, Cucchiara A, Dinges DF, Schwab CW. Characteristics of crashes attributed to the driver having fallen asleep. *Accid Anal Prev* 1995;**27**(6):769-75.
43. Barger LK, Cade BE, Ayas NT, et al. Extended work shifts and the risk of motor vehicle crashes among interns. *N Engl J Med* 2005;**352**(2):125-34.
44. Marcus CL, Loughlin GM. Effect of sleep deprivation on driving safety in housestaff. *Sleep* 1996;**19**(10):763-6.
45. Klebanoff MA, Shiono PH, Rhoads GG. Outcomes of pregnancy in a national sample of resident physicians. *N Engl J Med* 1990;**323**(15):1040-5.
46. Klebanoff MA, Shiono PH, Rhoads GG. Spontaneous and induced abortion among resident physicians. *Jama* 1991;**265**(21):2821-5.
47. Todd BA, Resnick A, Stuhlemmer R, Morris JB, Mullen J. Challenges of the 80-hour resident work rules: collaboration between surgeons and nonphysician practitioners. *Surg Clin North Am* 2004;**84**(6):1573-86, x.
48. Whang EE, Mello MM, Ashley SW, Zinner MJ. Implementing resident work hour limitations: lessons from the New York State experience. *Ann Surg* 2003;**237**(4):449-55.
49. Gottlieb DJ, Parenti CM, Peterson CA, Lofgren RP. Effect of a change in house staff work schedule on resource utilization and patient care. *Arch Intern Med* 1991;**151**(10):2065-70.
50. Niederee MJ, Knudtson JL, Byrnes MC, Helmer SD, Smith RS. A survey of residents and faculty regarding work hour limitations in surgical training programs. *Arch Surg* 2003;**138**(6):663-9; discussion 669-71.
51. Trontell MC, Carson JL, Taragin MI, Duff A. Impact of a night float system on internal medicine residency programs. *Acad Med* 1991;**66**(6):370.
52. Charap M. Reducing resident work hours: unproven assumptions and unforeseen outcomes. *Ann Intern Med* 2004;**140**(10):814-5.
53. Lahey T. Residents' work hours. *Ann Intern Med* 2004;**141**(9):741; author reply 742.
54. Bedarida GV. Residents' work hours. *Ann Intern Med* 2004;**141**(9):740; author reply 742.
55. Skeff KM, Ezeji-Okoye S, Pompei P, Rockson S. Benefits of resident work hours regulation. *Ann Intern Med* 2004;**140**(10):816-7.
56. Shanafelt TD, Bradley KA, Wipf JE, Back AL. Burnout and self-reported patient care in an internal medicine residency program. *Ann Intern Med* 2002;**136**(5):358-67.
57. Kort KC, Pavone LA, Jensen E, Haque E, Newman N, Kittur D. Resident perceptions of the impact of work-hour restrictions on health care delivery and surgical education: time for transformational change. *Surgery* 2004;**136**(4):861-71.
58. Gelfand DV, Podnos YD, Carmichael JC, Saltzman DJ, Wilson SE, Williams RA. Effect of the 80-hour workweek on resident burnout. *Arch Surg* 2004;**139**(9):933-8; discussion 938-40.
59. Lofgren RP, Gottlieb D, Williams RA, Rich EC. Post-call transfer of resident responsibility: its effect on patient care. *J Gen Intern Med* 1990;**5**(6):501-5.
60. Laine C, Goldman L, Soukup JR, Hayes JG. The impact of a regulation restricting medical house staff working hours on the quality of patient care. *Jama* 1993;**269**(3):374-8.
61. Petersen LA, Brennan TA, O'Neil AC, Cook EF, Lee TH. Does housestaff discontinuity of care increase the risk for preventable adverse events? *Ann Intern Med* 1994;**121**(11):866-72.
62. Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med* 2004;**351**(18):1838-48.
63. Schenarts P, Bowen J, Bard M, et al. The effect of a rotating night-float coverage scheme on preventable and potentially preventable morbidity at a level 1 trauma center. *Am J Surg* 2005;**190**(1):147-52.
64. Morales IJ, Peters SG, Afessa B. Hospital mortality rate and length of stay in patients admitted at night to the intensive care unit. *Crit Care Med* 2003;**31**(3):858-63.
65. Fletcher KE, Davis SQ, Underwood W, Mangrulkar RS, McMahon LF, Jr., Saint S. Systematic review: effects of resident work hours on patient safety. *Ann Intern Med* 2004;**141**(11):851-7.
66. Barden CB, Specht MC, McCarter MD, Daly JM, Fahey TJ, 3rd. Effects of limited work hours on surgical training. *J Am Coll Surg* 2002;**195**(4):531-8.
67. Bollschweiler E, Krings A, Fuchs KH, et al. Alternative shift models and the quality of patient care. An empirical study in surgical intensive care units. *Langenbecks Arch Surg* 2001;**386**(2):104-9.

68. Gandhi TK. Fumbled handoffs: one dropped ball after another. *Ann Intern Med* 2005;**142**(5):352-8.
69. Lefrak S, Miller S, Schirmer B, Sanfey H. The night float system: ensuring educational benefit. *Am J Surg* 2005;**189**(6):639-42.
70. Conigliaro J, Frishman WH, Lazar EJ, Croen L. Internal medicine housestaff and attending physician perceptions of the impact of the New York State Section 405 regulations on working conditions and supervision of residents in two training programs. *J Gen Intern Med* 1993;**8**(9):502-7.
71. Wong JG, Holmboe ES, Huot SJ. Teaching and learning in an 80-hour work week: a novel day-float rotation for medical residents. *J Gen Intern Med* 2004;**19**(5 Pt 2):519-23.
72. Kelly A, Marks F, Westhoff C, Rosen M. The effect of the New York State restrictions on resident work hours. *Obstet Gynecol* 1991;**78**(3 Pt 1):468-73.
73. Weinstein DF. Duty hours for resident physicians--tough choices for teaching hospitals. *N Engl J Med* 2002;**347**(16):1275-8.
74. Halpern R, Lee MY, Boulter PR, Phillips RR. A synthesis of nine major reports on physicians' competencies for the emerging practice environment. *Acad Med* 2001;**76**(6):606-15.
75. Petersen LA, Orav EJ, Teich JM, O'Neil AC, Brennan TA. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. *Jt Comm J Qual Improv* 1998;**24**(2):77-87.
76. Van Eaton EG, Horvath KD, Lober WB, Rossini AJ, Pellegrini CA. A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours. *J Am Coll Surg* 2005;**200**(4):538-45.
77. Boex JR, Leahy PJ. Understanding residents' work: moving beyond counting hours to assessing educational value. *Acad Med* 2003;**78**(9):939-44.
78. Rogers F, Shackford S, Daniel S, et al. Workload redistribution: a new approach to the 80-hour workweek. *J Trauma* 2005;**58**(5):911-4; discussion 914-6.
79. Czeisler CA, Johnson MP, Duffy JF, Brown EN, Ronda JM, Kronauer RE. Exposure to bright light and darkness to treat physiologic maladaptation to night work. *N Engl J Med* 1990;**322**(18):1253-9.
80. Ying A. Impact of Hospital Computer Systems on Resident Work Hours. Medical Records Institute, 2002.
81. Biology DoMaC. Careers After Graduation: Physician Assistant: The University of Texas at Dallas, 2005.
82. Project TNANR. Texas Nurses Association: career info: earnings/salaries.