Conceptual Frameworks in the Study of Duty-Hour Changes in Graduate Medical Education: A Review

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Abstract

Purpose

Conceptual frameworks are approaches to a research problem that specify key entities and their relationships. The 2009 Institute of Medicine (IOM) report on resident duty hours, subsequent studies, and published responses to the report present a variety of conceptual frameworks for the study of the impact of duty-hour regulations. The authors sought to identify and describe these conceptual frameworks and their implications.

Method

The authors reviewed the IOM report and articles in both peer-reviewed and non-peer-reviewed literature for the period January 2008 through April 2010, identified using multiple electronic databases including Pubmed, EMBASE, CINAHL, BEME, and PsycInfo. Studies that explicitly described or argued for the effect of resident duty hours on any other outcome, as judged by consensus of multiple reviewers, were included. The authors selected 239 of 858 studies reviewed. Several of the authors reviewed articles to identify conceptual frameworks used implicitly or explicitly to describe the relationship between duty hours (or duty-hours regulations) and outcomes. Identification was by consensus.

Results

Twenty-three conceptual frameworks were identified, several of which made contradictory predictions about the impact of duty-hour regulations on patient outcomes, resident education, and other key outcomes.
Conclusions

The concept of *duty hours* itself is contested, and little attention has been paid to the nature and intensity of the activities that occupy residents' hours. Much research focuses on isolated outcomes of duty-hour changes without considering mediation or moderation. More studies are needed to define tradeoffs between outcomes and the value society places on these tradeoffs.
In 2003, the Accreditation Council for Graduate Medical Education (ACGME) instituted duty-hour regulations. U.S. residents of all specialties were limited to 80 hours per week (averaged over 4 weeks), 30 continuous hours (of which 24 could be spent in admitting patients), and overnight call no more than every third night (on average).¹ In addition, the ACGME mandated 10 hours off after each long shift and at least one day off per week (averaged over 4 weeks). Internal moonlighting was also included as hours worked.

In 2009, the Institute of Medicine (IOM) published Resident Duty Hours: Enhancing Sleep, Supervision, and Safety² (hereafter, "IOM report"), a review of the literature through 2008 on the impact of changes to the duty-hour regulations and the relationship between sleep, fatigue, and effective functioning in humans. Acknowledging the lack of key research studies, the IOM report nevertheless recommended changes to duty-hour regulations, including: 30-hour shifts with 16 hours of admissions and a 5-hour protected sleep period (or, alternatively, 16-hour shifts), overnight call no more than every third night (no averaging), additional time off after night shifts, one day off per week (no averaging), one 48-hour period off per month, and inclusion of both internal and external moonlighting as hours worked. The ACGME has recently adopted some of these recommendations.

Method

Conceptual frameworks
In this study, we reviewed and critiqued conceptual frameworks in which duty-hour changes were cast as predictors of important outcomes, particularly frameworks employed by the IOM report and responses to it.

*Conceptual frameworks* "represent ways of thinking about a problem or a study, or ways of representing how complex things work the way they do." ³ They are important in research because they contribute to programmatic scholarship in which researchers share common approaches and can build upon each other's work. Every argument advanced in favor of or against changes in duty-hour regulations, as well as every research study that seeks to measure the impact of changes, involves an explicit or implicit conceptual framework that underlies the reasoning. Some conceptual frameworks may be applied in studies both favoring and opposing changes; for example, two articles may both use a conceptual framework based in sleep biology, but one may argue that detrimental performance resulting from sleep deprivation represents a threat to patient safety, while another may argue that the effect of sleep deprivation is not substantial enough to threaten patient safety. Other conceptual frameworks draw attention solely to either advantages or disadvantages of duty-hour regulations.

A conceptual framework typically specifies a set of relevant entities of study or action (such as actors, organizations, and outcomes), processes acting on these entities, and the presumed, observed, or predicted relationships between entities and processes.⁴ Each conceptual framework includes and focuses on certain entities, processes, and relationships and excludes others.
Conceptual frameworks may be based on theories, best practices, or models. 

*Theories* are distinguished by being evidence-based, explanatory, and predictive in nature. *Best practices* reflect observed relationships between entities that have not developed into the level of prediction that characterizes theory, often because they have been observed in limited settings or amidst confounding relationships. *Models* describe presumptive relationships between entities; when well-specified, they may be empirically tested, but conceptual frameworks based on models generally do not (yet) have evidence behind them.

In summary, conceptual frameworks may be based on

- theories, where reasoning is deductive, insight is based on evidence, and the frameworks are explanatory and predictive,
- best practices, where reasoning is inductive, insight is based on evidence, and the frameworks are descriptive, or
- models, where reasoning is deductive, insight is based on presumptions, and the frameworks are descriptive.

**Sources of data**

The first source of data was the IOM report itself, which constitutes an important literature review and source of conceptual frameworks in its own right. The second source of data was articles published in the period 2008-2010; these would not have been incorporated in the IOM report. One of us (CP), an experienced health science librarian, designed and conducted searches across multiple bibliographic databases,
such as BEME, CINAHL, EMBASE, PsycInfo, and PubMed. Searches used terms specific to the controlled vocabularies of each database (e.g. MESH) as well as keyword searches on "resident" and "work hours or duty hours."

Two of us (AS, GB) reviewed abstracts by hand to eliminate articles that did not focus on duty hours. The initial search was conducted in July 2009 and was supplemented by a second search using the same process conducted in April 2010. Because conceptual frameworks are often presented in theoretical articles, letters to editors, and position statements of organizations, we did not limit the search to traditional peer-reviewed articles.

**Identification of conceptual frameworks**

To be included in the review, articles must have explicitly described or argued for the effect of resident duty hours on an outcome. After eliminating articles that clearly did not address such an effect, we reviewed articles and the IOM report to identify outcomes following changes in resident duty hours. We broadly defined an *outcome* as any consequence of duty-hour changes that was studied, reported, predicted, presumed, or assumed in any of the texts reviewed. We repeatedly reviewed outcomes to combine similar outcomes and to organize the outcomes into a general taxonomy.

Following identification of outcomes, we reviewed articles again to identify conceptual frameworks that had been used implicitly or explicitly to describe the relationship between duty hours (or duty-hours regulations) and outcomes. Several of us reviewed the identified frameworks to confirm their structures. We resolved disagreements by discussion and consensus.
Results

Our search identified 239 articles that were reviewed in full. The number of relevant articles retrieved by each search for articles published between July 2009 and April 2010 and the number included in the review are shown in Supplemental Digital Appendix 1. Figure 1 illustrates the results of the search process. Supplemental Digital Appendix 2 lists all 239 articles we reviewed. Of those articles, 11 had appeared in early 2008 and were also cited in the IOM report. The two supplemental digital appendices may be found at http://---[THE JOURNAL WILL SUPPLY THE URL. I WILL SEND THE EDITED APPENDICES NO LATER THAN TOMORROW, 9-21]-------------------

Conceptual frameworks

We identified 23 conceptual frameworks; a complete summary appears in Table 1. In this review, we focus only on those frameworks employed in the IOM report or across multiple publications.

Frameworks based on theory

Sleep deprivation. The IOM report incorporates multiple conceptual frameworks. The preface outlines its basic explicit conceptual framework, \(^2\) (p xii) in which the key outcome is patient safety. Fatigue reduces safety; sleep reduces fatigue; restricting duty hours can provide increased sleep, but will also increase handoffs, which may reduce safety. The IOM report emphasizes that more time for sleep, not merely reduced working hours, is predicted to result in reduced fatigue. This was also recognized by the ACGME investigators at the time of the 2003 regulations.\(^6\) The physiological effects of sleep deprivation in human beings have been been studied extensively, and constitute the
theoretical basis of this conceptual framework (for example, see Gohar et al 7 and Mitchell et al 8 for research about sleep deprivation in residents).

“Swiss cheese.” Many industries consider the relationship between work hours and work errors using Reason’s “Swiss cheese” conceptual framework,9 which posits that organizations erect multiple systems as barriers to error. Each system contains “holes” – opportunities for failure. When the holes of all the systems are aligned, error can occur. Residents have been conceptualized as one of the error-prevention systems employed by hospitals, and fatigue as a condition that may contribute to failure of this system.10 The Swiss cheese framework predicts when errors can occur and explains why stress on a single system (e.g. sleep-deprived residents) may not directly increase errors – for example, because of oversight by attending physicians.11 Perneger12 notes that users of the framework vary in their understanding of its entities and relationships.

Shift worker fatigue and risk. A set of conceptual frameworks focus on shift worker fatigue, shift worker risk, shift risk, long work hours, and day work versus night work. Night work reduces quality of sleep, overall health, and work-family balance in nurses; these observations may also apply to physicians.13 The 2006 National Occupation Research Agenda (NORA) Long Work Hours Team proposed a framework to study the impact of long working hours.14 Long hours result in less effective time for sleep and non-work activities and greater vulnerability to workplace hazards and demands. These, in turn, lead to fatigue, stress, and other conditions, which endanger workers, families, employers, and the community. Individual and job characteristics may moderate the impact of long work hours. A National Institute for Occupational Safety and Health review found that most studies reported increases in relative risk for accidents, higher
fatigue, and poorer cognitive performance among workers with longer shifts and longer work weeks.\textsuperscript{15}

Folkard and others \textsuperscript{16-17} developed a risk index, by reviewing studies of predictors of accidents and injuries, that has been used to recommend shifts for doctors in the United Kingdom.\textsuperscript{18} Reducing total work hours decreases risk only when all else is equal; shift length, number of successive shifts, and rest periods have larger effects. They suggest setting limits on fatigue or risk levels, rather than on specific features of the work schedule. However, determining "acceptable" fatigue requires making tradeoffs, and measuring actual fatigue to assess fitness for duty is a complex problem.

**Unique frameworks.** Two theoretical frameworks that we identified only in single publications were (1) a theoretical model of resident-reported contributions to patient care mistakes\textsuperscript{10} and (2) the use of Ericsson's deliberate practice framework\textsuperscript{19} to focus on practice hours during resident activities.\textsuperscript{20}

**Frameworks based on best practices**

Three conceptual frameworks, presenteeism,\textsuperscript{21} hourly productivity,\textsuperscript{22} and preceptor relationships,\textsuperscript{23} were based on best practices. However, each was employed in only a single article. These frameworks are not discussed in depth here; for further information, consult Table 1.

**Frameworks based on models**

**Regulation is constraint ("One size does not fit all").** Many responses by organizations to proposed regulation of resident duty hours point out differences among specialties and among residents at different stages of training.\textsuperscript{11,24-25} The American
Board of Surgery suggests that emergency care specialties require different working hours than elective care specialties and that working-hour restrictions should be relaxed as residents advance in training, to approach more closely what they will experience in practice.\textsuperscript{11} The American Association of Directors of Psychiatric Residency Training (AADPRT) noted that the IOM report’s recommendations will affect programs differently depending on their size and degree of financial support.\textsuperscript{26} The AADPRT cautions that "one size does not fit all," echoing sentiments expressed about the 2003 ACGME regulations.\textsuperscript{27} The American Gastroenterological Association highlights unique features of subspecialty fellowship services and proposes a conceptual framework in which intensity and nature of work determine duty-hour limitations.\textsuperscript{28}

A general underlying conceptual framework, “regulation is constraint,” is used to argue that uniform regulations restrict the ability of residencies to innovate to improve clinical care and resident education.\textsuperscript{26, 29} Of course, regulations also limit the ability of residencies to overwork residents or institute changes detrimental to patient care. Several organizations\textsuperscript{11, 26} simultaneously argue against additional universal work-hour regulations and yet favor the existing uniform 80-hour limit; Higginson\textsuperscript{30} suggests this inconsistency reveals a bias for the status quo.

**Role of sleep deprivation.** Several publications propose conceptual frameworks in which sleep deprivation is manageable, necessary, or an important symbol. The first we refer to as "Sleep-deprived practice is a skill." For example, a study of neurology residents demonstrated that sleepiness increased with call or night shifts, but cognitive performance did not decline; the authors conclude that "sleep-deprived neurology residents may be able to overcome sleep loss-related performance difficulties for short
periods.” The American College of Surgeons argues that residents are responsible for their sleep, capable of managing fatigue, and experience fatigue when they fail to regulate their personal and professional activities. It also assumes that residents must prepare to practice as attending physicians under conditions of extended duty hours and fatigue. However, research suggests that attending physicians may not have such practice patterns. Moreover, work-hour restrictions for attending physicians in the United States may be instituted in the future.

A second variant of the framework is that sleep-deprived practice is evidence of commitment to patient needs over physician needs. Proponents suggest that duty-hour limits lead residents to see themselves as “shift workers” rather than responsible for a patient’s complete course of care. However, the assumption that a shift worker cannot be a dedicated professional has been questioned. Some note that attending physicians seem to practice within an 80-hour week with little concern for “shift mentality.” Sometimes, this model also incorporates the idea that sleep deprivation is a rite of passage in physician development. Lopez and Katz criticize this framework, noting that research suggests that habituation to stress leads to ethical erosion rather than to stronger professional identity.

**Worker rights.** The United Kingdom (UK) and European Union (EU) duty-hour regulations are based on the Community Charter of the Fundamental Social Rights of Workers, a conceptual framework emphasizing worker (physician) health, safety, and stress, rather than patient safety (although patient safety frameworks are also applied). Under the European Working Time Directive (EWTD), residents were limited to a working week of 58 hours (average) in 2004, 56 hours in 2007, and 48 hours beginning
August 2009. EWTD limits shift lengths to 13 hours with 20-minute breaks every 6 hours. As a result, traditional resident call is not feasible; 24-hour coverage is provided through two 13-hour or three 9-hour shift periods.\textsuperscript{18} Physicians may "opt out" of the EWTD.

Because of the recent EWTD 48-hour week, there has been little research to date with objectively measured outcomes. Claims of adverse effects are generally supported by citations to essays, position papers, and surveys of health care professionals.\textsuperscript{13, 41-43} A pilot study of 48-hour versus 56-hour schedules at one UK hospital found that amount of sleep did not differ; doctors in the 48-hour group reported worse educational opportunities but made significantly fewer medical errors.\textsuperscript{44} A Finnish study found that patients in wards where physicians and nurses worked, on average, longer than 8.75 hours per day, were at over 3 times greater odds of hospital-acquired infections.\textsuperscript{45} The Association of Surgeons in Training at the Royal College of Surgeons of England observed a reduction in operative cases performed by trainees and recommended a European Union of Medical Specialties proposal\textsuperscript{46} to extend working hours to 48 hours of combined service and training and 12 hours of dedicated training time.\textsuperscript{47}

We also identified a more general "Ethical treatment of workers" framework. In the United States, the Committee of Interns and Residents of the Service Employees International Union supports the immediate implementation of the IOM report’s recommendations to improve conditions for residents.\textsuperscript{48} Residents in Québec, Canada, and their union filed a grievance arguing that 24-hour call schedules violate the Canadian Charter of Rights and Freedoms.\textsuperscript{49}
Fixed pie / zero sum. A common conceptual framework that we term fixed-pie / zero-sum assumes fixed resources (resident hours, residency program length, educational dollars, faculty hours, patients) and a simple interdependent equilibrium model. Thus, reduction of resident hours must be accompanied by an increase in another resource. The Orthopedic Trauma Association\textsuperscript{38} expressed concerns about the potential of increased handoffs, greater faculty workload, and cross-coverage to reduce resident education and patient safety. They also noted the potential for longer training programs and increased monitoring costs, as do editorials in the \textit{Journal of Clinical Sleep Medicine}\textsuperscript{50,51} and the American Osteopathic Association's response to a letter in their journal.\textsuperscript{52}

Another suggested response to fewer resident duty hours is to increase utilization of other health professionals as physician extenders so that non-educational patient care work is not performed by residents.\textsuperscript{24,50,53} Increased responsibility assigned to physician extenders may promote their recognition as important patient care professionals, but may also subject them to increased workloads. In Europe, advanced practice nurses have undertaken procedures such as cannulation, intubation, and prescribing. In turn, health care support workers substitute for nurses in patient comfort and support roles. An unanticipated consequence of duty-hour regulations may thus be increasing the medicalization of the nursing profession.\textsuperscript{41}

The fixed-pie conceptual framework depends on the zero-sum assumption. If society will provide additional resources, or if innovations produce organizational slack,\textsuperscript{54} the pie may be expandable, rather than fixed.
Degradation of skill. Many training organizations fear that reduced duty hours will translate into less skilled residents.\textsuperscript{24} The most basic variation of this conceptual framework assumes that duty hours are spent primarily in educational activities. Reduction in duty hours reduces educational time, which leads to less skilled residents.\textsuperscript{25, 55-56} Duty-hour regulations have been in force for just barely long enough to see impact on trainees in normed examinations, and there is evidence of worse performance on one board examination among surgical residents trained since the 2003 regulations\textsuperscript{57} (but see Froelich et al.\textsuperscript{58} and Sneider et al.\textsuperscript{59} for demonstrations of no difference in surgical in-training exam scores).

In the "covert" variation, the impact of duty-hour restrictions is masked by an additional clinical workload assumed by more senior trainees and attending physicians, for whom the work is less educational.\textsuperscript{11} In the "self-assessment" variation, residents themselves perceive their lesser skill and increasingly seek subspecialty fellowships, effectively lengthening their training and increasing their debt.\textsuperscript{60} This leads to fewer and less-skilled primary care physicians. Although there is as yet little evidence that supports a general lessening of resident skill, these frameworks suggest that such evidence may emerge in the next five years.

Compensatory improvement. Some IOM report recommendations employ an implicit conceptual framework that we term compensatory improvement. In this framework, hospitals strive to maintain an equilibrium position from which they can achieve their mission. Changes that threaten the mission (such as increasing handoffs leading to worse patient outcomes) induce the organization to apply resources to restore equilibrium. For example, the institution may implement new handoff systems
that increase continuity of care. This framework assumes that organizations can and will proactively improve in response to regulatory changes rather than simply meet requirements.

**Professional role.** Several conceptual frameworks have been proposed with roots in models of professional or societal ethics. Professional ethics is an essentially contested concept; although everyone may agree on the basic structure of an ethic, differing assumptions may lead to wholly different entailments. For example, the professional ethics of medicine require physicians to place the needs of their patients ahead of their own. Opponents of additional duty-hour restrictions consider protected sleep (derisively, “nap time”) to be a physician need that should be subordinated to continuity of care, a patient need. In contrast, restriction proponents consider a well-rested physician to be good for patients and to promote empathy, and they argue that the service needs of hospitals should be subject to this need.

### Discussion

**Summary of results**

Conceptual frameworks vary in their ideological and empirical bases. Many are in opposition, some making directly contradictory predictions. For example, the "sleep deprivation" framework is often used to posit a beneficial patient impact from less fatigue, while the "degradation of skill" framework posits a detrimental impact from reduced physician skill as the result of fewer hours on duty. Key outcomes predicted by the conceptual frameworks reviewed are summarized in Table 2 and described below.
Conceptual frameworks focusing on patient outcomes either emphasize reduction in errors from better-rested residents or increases in errors from decreased continuity and increased handoffs. Recent large-scale studies comparing patient outcomes before and after the 2003 ACGME regulations find no effect, or small positive effects, of those regulations. 62-64

Conceptual frameworks focusing on resident outcomes are frequently proposed and usually emphasize either improvements in health, safety, and quality of life for residents from increased sleep, or concerns about reduced educational opportunities and skill degradation. Other frameworks suggesting positive impacts of regulations (on empathy, worker rights) and negative impacts (on professional identity, patient ownership, post-residency practice) have also been espoused, but not studied extensively.

Conceptual frameworks focusing on faculty outcomes uniformly predict negative impacts from duty-hour changes. Conceptual frameworks focusing on institutions or residencies are often driven by the high expected costs of implementing the IOM report’s recommendations. These costs may be partially recouped by society through increased patient safety, but significant costs will fall largely on training programs. Without additional resources, educational missions may be jeopardized, and smaller programs may face a crisis of viability. Conceptual frameworks focusing on the activities of other health professionals note the increased workload likely to fall on physician extenders in order to implement the IOM report’s recommendations.
Limitations

There are several limitations to our review. We focus on conceptual frameworks raised in the IOM report or in subsequent literature published after or in response to the report. Accordingly, we may not have identified the complete universe of conceptual frameworks that have been employed in this discourse since the earliest discussions of duty-hour restrictions in graduate medical education. As a consequence, we focus on the existence, rather than the prevalence, of the frameworks we identify. Our identification of frameworks is a subjective process, and although we confirmed findings through review of multiple investigators, it is possible that our own biases might have caused us to specify a framework incorrectly or fail to identify additional frameworks. Our own conceptual framework for the study of frameworks is likely to illuminate some aspects of the greater discourse and conceal others.

Conclusion: Gaps in the discourse and directions for future study

The concept of duty hours itself is contested. As shown in Figure 2, residents engage in a variety of activities (inner circle), including uninterrupted protected sleep, interruptible rest (e.g., home call or call room), patient care tasks with low educational value (e.g., "scut"), patient care tasks with high educational value, non-patient educational activities (e.g., didactic conferences or practice with simulators), and administrative activities. Whether non-patient educational activities and on-call rest are duty hours is controversial enough to have spawned legal cases in the European Court\textsuperscript{65} and proposals for distinguishing "purely training" hours from "combined service and training hours."\textsuperscript{46} In addition, residents and program directors vary in their understanding of the ACGME guidelines.\textsuperscript{66} Concerns about the balance of education and service for
housestaff have a long history in medicine and remain an important unresolved issue in medical education.\textsuperscript{67-68} Theories of fatigue suggest that fatigue and risk depend on the relationship between hours worked and the content of the work. The nature of this relationship, as well as methods of measurements of work intensity and consequent fatigue, need further study.

Much research in and since the IOM report focuses on isolated outcomes of duty-hour changes. Few conceptual frameworks we identified posit mediational relationships or address endogenous changes in residency choice or work patterns as a result of new regulations. For example, reconfiguring duty hours is expected to reduce fatigue and thus enhance resident learning,\textsuperscript{2} but is also expected to reduce opportunities to practice and thus could degrade resident learning.\textsuperscript{29, 38, 69}

There is a dearth of frameworks that provide models for the net tradeoffs between key outcomes such as patient safety, resident safety, resident education, resource costs, and quality of life for resident and attending physicians (Nuckols et al.\textsuperscript{70} is a notable exception). Investigations should be designed to guide the development of a theory of the relationships between outcomes, which may not be simply additive.

To recommend policy, we must understand not only the inherent tradeoffs, but also the value society places on such tradeoffs, and its willingness to pay to maximize value. As an extreme example, a society that values safety above all might spend lavishly to institute overlapping short shifts and extend residency by several years. Studying societal values is time-consuming. Rigorous short-term, practice-based research on innovate implementation of duty-hour changes is also necessary.\textsuperscript{71}
Duty hours are likely to be regulated in some fashion for the conceivable future. The rationale, implementation, and evaluation of different approaches to the work time of residents (and, potentially, students and attending faculty), however, will continue to be an important focus of debate in medical education and practice. We believe that there is value for residents, program directors, and society as a whole in defining – and in some cases broadening – the terms and understanding this debate.

Conceptual frameworks underlie arguments about the impact of duty-hour changes. They frame assumptions about research hypotheses and designs to develop evidence about these hypotheses. Despite their importance, the conceptual frameworks our study revealed were often implicit, serving as a backdrop to argument and research rather than receiving attention themselves. We encourage researchers and advocates to make their conceptual frameworks explicit and to detail their bases, workings, and implications. Such practices will help researchers position their work in relation to other studies, better select key variables for their investigations, and foster knowledge-building.

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Other disclosures: Dr. Schwartz serves as a consultant to the American Board of Pediatrics and Association of Pediatric Program Directors on projects unrelated to the subject of this report. Dr. Bashook serves as a consultant to the Royal College of Dentists of Canada on projects unrelated to the subject of this report, and is a partner in an educational consulting company.

Ethical approval: Not applicable

Previous presentations: Earlier versions of this report, or data from it, have been used in a commissioned report to the Accreditation Council for Graduate Medical Education in 2009, in an invited presentation for the University of Illinois at Chicago Department of Medical Education in 2010, and in an invited seminar in 2010 as part of the University of Chicago Department of Medicine Research in Medical Education Seminar Series.
References

1. Accreditation Council for Graduate Medical Education. Common program requirements for duty hours. Chicago, IL: ACGME; 2003.
   
   http://www.acgme.org/acWebsite/dutyHours/dh_ComProgrRequirmentsDutyHours0707.pdf.

2. Institute of Medicine. Resident Duty Hours: Enhancing Sleep, Supervision, and Safety.


67. Ludmerer K. *Time to Heal: American Medical Education from the Turn of the Century to the Era of Managed Care*: Oxford University Press, USA; 1999.


Figure 1 The process for choosing the articles included in this report’s analysis.

Figure 2 Resident activities, and types of hours potentially subject to regulation.

Resident time can be divided into at least six kinds of activities (inner circle) and combinations of these activities may represent different definitions of working hours (outer arrows).
Table 1

The Twenty-Three Conceptual Frameworks Identified in the Present Review

<table>
<thead>
<tr>
<th>Name of framework</th>
<th>Predictors</th>
<th>Outcomes</th>
<th>Relationships highlighted in the framework</th>
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<td></td>
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<tr>
<td>Frameworks based on theory</td>
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| **Sleep deprivation**<sup>2</sup> | Quantity and quality of sleep  
General human performance | Resident skills | Lack of quality sleep leads to worse performance.  
Changes in duty hours can increase quality sleep and improve performance. |
| **Swiss cheese**<sup>5,9,34</sup> | Hazards  
Systems to prevent harm (the “cheese”)  
Active failures and latent conditions allowing failure (“holes” in the cheese)  
Resident fatigue as a particular limitation of the health care system | Patients’ medical outcomes | Safety is compromised when multiple systems fail simultaneously.  
Fewer duty hours lead to less resident fatigue, which limits the chance of the resident system failing at the same time other systems fail. |
<p>| <strong>Day vs. night work</strong>&lt;sup&gt;12&lt;/sup&gt; | Start and end times of work shifts | Resident quality of life | Night work leads to lower-quality sleep, worse health, and less work/family balance. |</p>
<table>
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<th>Name of framework</th>
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<th>Outcomes</th>
<th>Relationships highlighted in the framework</th>
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<tbody>
<tr>
<td>National Occupation Research Agenda Long Work Hours Team framework$^{13}$</td>
<td>Work hours and other schedule characteristics, Availability of time for recovery and non-work activities, Exposure to job demands and hazards, Worker characteristics and job characteristics</td>
<td>Workers, immediate negative outcomes: Reduced/disturbed sleep, fatigue, stress, negative mood, dysfunction, Long-term outcomes: Workers’ quality of life, workers’ family members’ quality of life, institutional productivity and injury costs, patient/community safety</td>
<td>(1) Work hours and schedule result in reduced time for recovery and non-work activities as well as greater exposure to job demands and hazards. (2) Reduced time for recovery/non-work and exposure to job demands/hazards lead to immediate negative outcomes. (3) These contribute to multiple long-term adverse outcomes for workers, family, employers, and community. Relationships (2) and (3) are moderated by worker and job characteristics.</td>
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<tr>
<td>National Institute for Occupational Safety and Health report$^{14}$</td>
<td>12-hour or longer, including “on-call” shifts vs. 8-hour shifts</td>
<td>Worker safety, illness, health behaviors, Worker performance</td>
<td>Relative to 8-hour shifts, overtime, extended duty, and on-call schedules were associated with more illness and injury, worse health behaviors, and lower performance.</td>
</tr>
<tr>
<td>Shift risk$^{15}$</td>
<td>Relative risk for first shift in the span RR$_T$, Additional risk for number of successive shifts CR$_N$, Additional risk for length of shifts CR$_L$, Additional risk for interval between breaks CR$_B$</td>
<td>Worker relative risk of accident or incident for a given span of shifts, denoted RR$_S$. Risk is relative to five 8-hour day shifts with a single mid-shift break. $\text{RR}_S = \text{RR}_T + \text{CR}_N + \text{CR}_L + \text{CR}_B$</td>
<td></td>
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<tr>
<td>Name of framework (^{16-17})</td>
<td>Predictors</td>
<td>Outcomes</td>
<td>Relationships highlighted in the framework</td>
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| **Shift worker fatigue** \(^{16-17}\) | Cumulative fatigue C, based on complete pattern of shift schedules  
Duty timing T, based on when a particular shift starts and ends  
Job type/breaks J, based on shift content including activity and breaks  
Each modeled, and varies from 0-1 | Resident fatigue, specifically average probability of a high score on the Karolinska Sleepiness Scale | \( FI = 100 \left[ 1-(1-C)(1-J-T) \right] \) |
| **Shift worker risk** \(^{16-17}\) | Cumulative fatigue C, based on complete pattern of shift schedules  
Duty timing T, based on when a particular shift starts and ends  
Job type/breaks J, based on shift content including activity and breaks  
Each modeled, and varies from 0-1 | Resident relative risk of accident on a particular shift | \( RI = C \ast J \ast T \) |
<table>
<thead>
<tr>
<th>Name of framework</th>
<th>Predictors</th>
<th>Outcomes</th>
<th>Relationships highlighted in the framework</th>
</tr>
</thead>
</table>
| Resident-reported contributors to patient care mistakes⁹ | Resident quality of life  
Patient continuity of care  
Institution entropy  
Resident handoffs  
Resident experience  
Resident workload  
Professional work ethic  
Resident fatigue | Patient safety | Duty-hour changes lead to intended consequences of less time in hospital and improved resident well-being.  
Duty-hour changes lead to unintended consequences of more discontinuity and duty hours themselves as a goal.  
Improved well-being mitigates factors that lead to patient care mistakes; other consequences aggravate these factors. |
| Deliberate practice¹⁸⁻¹⁹                               | Hours of deliberate practice | Resident education | Reduced duty hours overall can be compensated for by increasing the proportion of time spent in learning |
| Frameworks based on best practices                    |                                                                            |                        |                                                                                                           |
| Presenteeism⁶⁻¹⁹                                        | Workload  
Available coverage  
Professional work ethic | Resident safety  
Patient medical outcomes | Residents with a strong work ethic and a high work load relative to available coverage will attempt to work even when they are sick.  
Reporting to work sick leads to risk of contagion for other residents and patients. |
| Hourly productivity²¹                                 | Length of shifts  
Patients seen per shift hour | Resident case volume per rotation  
Institutional patient admissions | Medium-length shifts (e.g. 9 hours) increase resident hourly productivity.  
Increased hourly productivity results in a greater number of patients seen overall and per-resident. |
<table>
<thead>
<tr>
<th>Name of framework</th>
<th>Predictors</th>
<th>Outcomes</th>
<th>Relationships highlighted in the framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preceptor relationship&lt;sup&gt;22&lt;/sup&gt;</td>
<td>Number of different preceptors, e.g., continuity clinic</td>
<td>Faculty satisfaction</td>
<td>Duty-hour restrictions increase the total number of preceptors residents work with to accommodate scheduling needs. Preceptors feel less attached to individual residents and less satisfied with their relationships.</td>
</tr>
</tbody>
</table>

### Frameworks based on models

<p>| Regulation is constraint, aka &quot;One size does not fit all&quot;&lt;sup&gt;25, 26&lt;/sup&gt;, and many other organizational responses | Rigidity of regulation enforcement Flexibility within regulations | Institutions’ ability to adapt, innovate | Rigid constraints limit movement (innovation) to within the constraints. If constraint is too tight, movement within the constraints may not be sufficient for innovation. |
| Successful sleep-deprived practice is a skill | Resident skills | The ability to practice successfully without adequate rest is learnable and improves through experience in such practice. |
| Sleep-deprived practice is evidence of commitment&lt;sup&gt;35,38&lt;/sup&gt; | Resident professionalism | A physician demonstrates dedication through caring for patients regardless of his/her personal discomfort and needs, including fatigue. Practice is often connected to sleep-deprivation as a rite of passage in the development of a physician. |
| Community Charter of the Fundamental Social Rights of Workers (1989, basis of the 1993 EU Working Time Directive 93/104/EC; doctors in training included as workers by amendment 2000/34/EC) | Resident safety | Excessive work hours reduce worker safety and health, which are fundamental social rights. |</p>
<table>
<thead>
<tr>
<th>Name of framework</th>
<th>Predictors</th>
<th>Outcomes</th>
<th>Relationships highlighted in the framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethical treatment of workers(^3)</td>
<td>Resident safety</td>
<td>Societal ethics</td>
<td>Extended duty may be coercive and deceptive and thus unethical treatment of workers, and may lead to inequities in the labor market.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patient safety</td>
<td>There is a societal interest in protecting workers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The medical profession’s ethics prohibit practice in ways that would cause harm to patients.</td>
</tr>
<tr>
<td>Fixed pie / zero-sum (Conceptual framework used in many organizational responses)</td>
<td>Funding available for residency program</td>
<td>Resident education</td>
<td>Total residency resources – funding, hours, years, attending time – are fixed.</td>
</tr>
<tr>
<td></td>
<td>Resident hours available to see clinical cases</td>
<td>Institution cost to residency program</td>
<td>Reduced hours will need to be made up for by shifting funding from education to clinical care (e.g., to hire physician extenders), or teaching time from attending physicians, or by increasing residency length.</td>
</tr>
<tr>
<td></td>
<td>Length of residency program in years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time available to attending physicians to teach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degradation of skill(^35,45,59)</td>
<td>Resident skills</td>
<td>Patient medical outcomes</td>
<td>Residents are receiving less training time and becoming less skilled.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Patient outcomes have been maintained because faculty have taken over work previously done by residents.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>When residents eventually become faculty, however, patient outcomes will decline; alternatively, residents will recognize their limits and be more likely to see subspecialty training, leaving the least prepared residents to become attending physicians in primary care.</td>
</tr>
<tr>
<td>Name of framework</td>
<td>Predictors</td>
<td>Outcomes</td>
<td>Relationships highlighted in the framework</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Compensatory improvement</td>
<td>Number of handoffs &lt;br&gt; Health care organizations &lt;br&gt; Continuity of care &lt;br&gt; Patient safety</td>
<td>Patient medical and non-medical outcomes</td>
<td>Decreased duty hours increase handoffs. &lt;br&gt; Increased handoffs result in decreased continuity of care, which results in risks to patient safety. &lt;br&gt; Health care organizations wishing to maintain safety will devise improved mechanisms for maintaining continuity across handoffs.</td>
</tr>
<tr>
<td>Professional role (aka &quot;shift-worker mentality&quot;)</td>
<td>Professional attitude putting needs of the patient before those of the physician</td>
<td>Resident professional behavior, ethical development &lt;br&gt; Patient continuity of care</td>
<td>Arbitrary limits on duty hours lead residents to see themselves as shift workers, not as responsible for a patient's complete course of care. &lt;br&gt; Residents may be ill-prepared for independent practice post-residency.</td>
</tr>
<tr>
<td>Empathy</td>
<td>Resident quality of life</td>
<td>Resident professionalism</td>
<td>Rest and work/life balance lead to an appreciation of life. &lt;br&gt; Appreciation of life leads to increased empathy with suffering of others. &lt;br&gt; Empathy is a defining characteristic of a physician.</td>
</tr>
</tbody>
</table>

* Conceptual frameworks are approaches to a research problem that specify key entities and their relationships. They are important in research because they contribute to programmatic scholarship in which researchers share common approaches and can build upon each other's work. Every argument advanced in favor of or against changes in duty-hour regulations, as well as every research study that seeks to measure the impact of changes, involves an explicit or implicit conceptual framework that underlies the reasoning.

† Superscripted numbers refer to citations in the reference list that is part of this report.
Table 2

Direction of Key Outcomes Predicted by the Three Types of Conceptual Frameworks Identified in the Present Review *

<table>
<thead>
<tr>
<th>Type of framework</th>
<th>Patient outcomes</th>
<th>Resident outcomes</th>
<th>Faculty outcomes</th>
<th>Institution outcomes</th>
<th>Outcomes affecting other health professions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on theory</td>
<td>Error from fatigue</td>
<td>ACCidents</td>
<td>NA</td>
<td>Costs</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sleepiness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on best practices</td>
<td>NA</td>
<td>Productivity</td>
<td>Preceptor</td>
<td>Productivity</td>
<td>Workload</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality of life (rest)</td>
<td>relationships</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality of life (night shifts)</td>
<td></td>
<td>Quality of life (Workload)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presenteeism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on models</td>
<td>Quality of handoffs</td>
<td>Empathy</td>
<td>Future skill</td>
<td>Resources for</td>
<td>Autonomy</td>
</tr>
<tr>
<td></td>
<td>(compensatory improvement)</td>
<td>Rights</td>
<td>Skilled primary</td>
<td>education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuity</td>
<td>Commitment</td>
<td>care physicians</td>
<td>Sustainability of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handoffs</td>
<td>Ownership</td>
<td></td>
<td>small programs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-residency practice</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Conceptual frameworks are approaches to a research problem that specify key entities and their relationships. They are important in research because they contribute to programmatic scholarship in which researchers share common approaches and can build upon each other's work. Every argument advanced in favor of or against changes in duty-hour
regulations, as well as every research study that seeks to measure the impact of changes, involves an explicit or implicit conceptual framework that underlies the reasoning.
Potentially relevant articles screened for retrieval
(n = 858)

Abstracts retrieved and reviewed
(n = 560)

Articles retrieved in full
(n = 239)

Articles included in analysis
(n = 239)
Supplemental Digital Appendix 1

Data sources, literature review strategy, and results for searching the published literature (searches conducted in July 2009 and April 2010, combined)

<table>
<thead>
<tr>
<th>Data source</th>
<th>Search strategy</th>
<th>Retrieved</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEME</td>
<td>“Find on page” search for the term “80”</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CINAHL</td>
<td>keyword search of resident AND 80 hours</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>COCHRANE database of systematic reviews</td>
<td>“ACGME” in title, abstract, or keywords (&quot;resident&quot; in abstract or “registrar” in abstract) and “duty” in abstract and “hour” in abstract and “restriction” in abstract</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Conference Papers Index</td>
<td>residents AND 80 AND hours</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Dissertations and Theses</td>
<td>(residents) AND (80) AND (hours) (residents) AND (work hours)</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>EMBASE</td>
<td>resident AND 80 hours limited to human and 2008-2010</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>EMBASE</td>
<td>(workload OR &quot;work schedule&quot; OR &quot;work schedule tolerance&quot; OR fatigue OR “mental fatigue” OR “work hours” OR “personnel staffing” OR scheduling) AND (sleep OR “sleep deprivation” OR “sleep disorder” OR “circadian rhythm” OR chronobiology) AND (residency OR “education, medical, graduate” OR “internship and residency” OR “night float”), limited to 2005-2010</td>
<td>170</td>
<td>167</td>
</tr>
<tr>
<td>ERIC</td>
<td>exp Graduate Medical Education/ limited to yr “2007 - 2010”</td>
<td>58</td>
<td>0</td>
</tr>
<tr>
<td>Proceedings First</td>
<td>Residents AND 80 hours</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PsycINFO</td>
<td>residents and 80 and hours limited to 2008-2010</td>
<td>43</td>
<td>18</td>
</tr>
<tr>
<td>PubMed</td>
<td>(80 hour AND residents)</td>
<td>297</td>
<td>119</td>
</tr>
<tr>
<td>PubMed</td>
<td>Related articles search related to Fletcher et al., and related articles on relevant related articles</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>PubMed</td>
<td>(workload OR &quot;work schedule&quot; OR &quot;work schedule tolerance&quot; OR fatigue OR “mental fatigue” OR “work hours” OR “personnel staffing” OR scheduling) AND (sleep OR “sleep deprivation” OR “sleep disorder” OR “circadian rhythm” OR chronobiology) AND (residency OR “education, medical, graduate” OR “internship and residency” OR “night float”), limited to 2008-2010</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Web of Science (Current Contents)</td>
<td>“80 hours”AND medical AND education + related articles search on relevant articles, limited to 2008-2010</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>Overall</td>
<td>All above combined, duplicate articles removed, limited to 2008-2010</td>
<td>239</td>
<td></td>
</tr>
</tbody>
</table>
Supplemental Digital Appendix 2

Literature published in 2008-2010 and reviewed


41. Committee of Interns and Residents/SEIU Healthcare. (2009). Not whether, but how...Not if, but when: Time to act on the Institute of Medicine recommendations on patient and resident physician safety [Electronic Version] from http://www.cirseiu.org/assets/assetcontent/a96df179-


125. Lang, D. L. (2009). Burnout rate is lower among academic physicians when time is spent on meaningful work. *Gastroenterology.*


132. Lipsett, P. A. (2009). Resident work-hours or "duty hours": Evidence versus emotion *. Critical Care Medicine, 37(9), 2661-2662 10.1097/CCM.0b013e3181ad7774.


