ACGME Common Program Requirements:

Potential Cost Implications of Changes to Resident Duty Hours and Related Changes to the Training Environment Announced on September 28, 2010

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Executive Summary

The principal objective of this analysis was to estimate the potential direct costs of changes to resident duty hours and the training environment planned by the Accreditation Council for Graduate Medical Education (ACGME). A secondary objective was to estimate the net costs at major teaching hospitals, meaning costs after accounting for any savings that might occur through reductions in preventable adverse events (injuries due to medical errors).

To estimate the direct costs of the planned changes, we first reviewed recent literature pertaining to duty hours. Next, we examined the ACGME's revised Common Program Requirements and selected requirements for inclusion in the cost analysis based on two criteria: the requirement appears to differ from practices in most residency programs today and it would generate quantifiable costs. The planned changes that met these criteria included a maximum shift duration of 16 hours for PGY1s, a maximum shift duration of 28 hours for specialty and subspecialty residents above the PGY1 year, several requirements to educate residents and faculty members about fatigue and safety issues, a requirement for standardized procedures for handing over patient care, a requirement that programs offer sleep facilities or transportation after residents have overnight shifts, and a requirement for annual site visits by the ACGME to assess the implementation of the planned changes.

We estimated costs by determining the resources involved in adhering to each of the planned changes and then multiplying by the cost per unit of each resource. To determine the cost of the planned changes to duty hours, we considered residents' baseline working patterns, the hours of work that they would transfer to other providers after the planned changes are implemented, and the cost of the other providers per hour. In our base case analysis, we made several important assumptions pertaining to the extended shift requirements: (1) that PGY1s at small programs would transfer 14 or more hours of work per extended shift to a mixture of attending physicians and nurses, (2) that PGY1s at larger programs would continue to work the same number of hours as they do now through a reorganization of those hours rather than a transfer of hours to other providers, (3) that specialty residents above the PGY1 year would transfer two or more hours of work per extended shift to other specialty residents, and (4) that subspecialty residents would transfer two or more hours of work per extended shift to attending physicians. These assumptions were based on how the ACGME anticipates the reforms to be implemented. One set of sensitivity analyses examined the effect of uncertainty in model parameters. A second set of sensitivity analyses examined the effect of uncertainty in how the changes may be implemented, such as whether more residents would need to transfer work to alternative providers, or alternative types of substitutes might be used.

For the cost of the planned changes to the training environment, little published literature was available. Consequently, we made assumptions about resource use in conjunction with ACGME representatives and then obtained published estimates of the cost per unit of each resource.

We found that the total direct annual cost of the planned changes (including both recurring costs and amortized start-up costs) would be $380,766,262 nationwide (in 2008 dollars). In the sensitivity analysis reflecting uncertainty in model parameters,

such as the frequency of extended shifts and the numbers of weeks with extended shifts, total direct annual costs ranged from $226,463,205 to $694,274,461.

Uncertainty in how the reforms may be implemented had a much greater effect on the cost estimates. If all PGY1s transferred work to a mixture of attending physicians and nurses, the cost would reach $1,187,014,278. If only PGY1s at small programs transfer work but all other work beyond the current extended shift limits is transferred to substitute providers, the cost would be $817,388,224 using all attendings, $561,769,401 using all midlevels, and $335,141,689 to $739,503,992 using an expanded population of residents (depending on whether the cost of hiring additional residents is based on wages and benefits or average per resident expenditures on graduate medical education from all sources, respectively). The efficiency of the substitutes relative to the residents whose work they are assuming is another factor that could affect the cost. .

To estimate net costs at major teaching hospitals (defined as members of the Council of Teaching Hospitals), we developed a probability model representing direct costs as well as costs associated with PAEs. The model simulated hypothetical changes in PAEs, ranging from a 10% increase to a 10% decrease. We considered this range because reductions in fatigue, improved handover procedures, and other changes could reduce preventable adverse events but the effect of the planned changes on PAEs is not yet known and, if discontinuities of care rise, preventable adverse events might also. Two different versions of the model represented the hospital and societal perspectives; the teaching-hospital version included event costs that are absorbed by hospitals whereas the societal version included all PAE costs. Both versions included the portion of the total direct annual costs associated with residents training at major teaching hospitals (members of the Council of Teaching Hospitals).

We found that, under the base case analysis assumptions pertaining to direct annual costs, the revised policy would be cost-saving for society if it reduced preventable adverse events by 2.4%, and cost-saving for major teaching hospitals if it reduced preventable adverse events by 10.9%. If the direct annual costs are higher, greater reductions in preventable adverse events would be required for the change to be cost-saving from both the major-teaching-hospital and societal perspectives.

This analysis has several limitations, including the fact that data on the baseline working patterns of residents is somewhat sparse and data relevant to the resources and costs associated with the planned changes to the training environment are minimal. Our methods of estimating costs may yield different results from the expenditures that programs ultimately incur when hiring other providers or additional residents because programs may implement the changes in a manner that differs from what the ACGME anticipates. However, we addressed limitations to available data through the use of numerous sensitivity analyses, which offer insight into the effect of model parameters on the direct annual costs.

I. Objectives

The Accreditation Council for Graduate Medical Education (ACGME) has recently announced major new changes to resident duty hours as well as to the training environment in which duty hours are implemented. The planned changes were released for public comment in June 2010, are to be finalized later this year, and the final changes may be implemented nationwide in July 2011.[1, 2] The planned changes would modify several of the duty hour limits that were established in 2003 (see Appendix I) and establish standards for many aspects of the training environment that are relevant to patient safety (see Appendix II).[3-5]

The objective of the current analysis is to consider the potential cost implications of these planned changes. In 2008, we examined the cost implications of duty hour limits proposed by the Institute of Medicine.[6, 7] The ACGME has requested that we use similar methods in order that readers of the two analyses can compare them, if they so choose.

In the first part of our current analysis, we focused on the direct annual (i.e., recurring) costs associated with reducing resident duty hours. The second part considered the ACGME's planned changes to the training environment, which may also generate costs, including both initial and recurring types of costs. In the third part, we used a decision-analytical model to examine the net cost of the planned changes, including potential changes in the costs associated with preventable adverse events (PAEs, injuries due to medical errors). Studies have found that sleep deprivation is associated with reduced clinical performance [8] and medical errors. [9] Discontinuities in the residents who are caring for patients, which may rise when the planned changes are implemented, have also been associated with preventable adverse events.[10] PAEs increase hospitalization costs, outpatient medical care costs, and costs associated with patient disability as well as harm patients.[11] We considered net costs from both the perspectives of teaching hospitals and society.

II. Methods

A. Literature Review

To inform this analysis, we used multiple different methods for identify potentially relevant information. First, we conducted MEDLINE searches using PubMed to identify articles describing original research (as opposed to opinion pieces, consensus statements, etc.) on duty hours and relevant elements of the training environment since July 2003. Second, we examined recent systematic reviews commissioned by the ACGME,[12, 13] one of which was updated in the spring of 2010.[14] These reviewed addressed resident duty hour limits and their effects on residents and patients. Third, we used references identified during our prior analysis [15] and accessed relevant publicly available data sources.

MEDLINE Search: Our MEDLINE search (Table II-1) focused on residents and duty hours. It was conducted on July 15, 2010 and resulted in 1,328 articles. By reviewing titles of the articles, one investigator (TN) identified 321 articles as potentially relevant to the current analysis. to identify papers relevant to specific model parameters, this investigator reviewed titles and abstracts of articles within this collection.

Table II-1: PubMed Search Addressing Residents and Duty Hours

Concept	Search Terms	Operator
Resident	graduate medical education[Majr] OR internship and residency[Majr]	AND
Duty Hours	duty hour*[tw] OR duty-hour*[tw] OR work hour*[tw] OR work-hour*[tw] OR work[tw] OR working[tw] OR schedule*[tw] OR scheduling[tw] OR shift length[tw] OR night float[tw] OR cross-coverage[tw] OR cross cover*[tw] OR shift[tw] OR call[tw] OR extended shift*[tw] OR work week[tw]	AND
U.S. Only	Nigeria[tw] OR Nigerian[tw] OR developing country[tw] OR international[tw] OR European[tw] OR Danish[tw] OR Japan[tw] OR Istanbul[tw] OR Australia[tw] OR Brazil[tw] OR Guyana[tw] OR China[tw] OR Germany[tw] OR German[tw] OR Canada[tw] OR Candadian[tw] OR United Kingdom[tw] OR british[tw] OR England[tw] OR France[tw] OR French[tw] OR Sweden[tw] OR Swedish[tw] OR Saudi[tw] OR Turkey[tw] OR Turkish[tw] OR Pakistani[tw] OR Pakistan[tw] OR Austria[tw] OR Austrian[tw] OR Ireland[tw] OR Irish[tw]	NOT
Not original research	Symposium[ti] OR symposia[ti] OR consensus statement*[ti] OR position paper*[ti] OR interview*[ti] OR commentar*[ti] OR comment[Publication Type] OR editorial[Publication Type]	NOT
Unrelated topics	gene[tw] OR genome[tw] OR genomics[tw] OR genomic[tw] OR genetic[tw] OR in vitro[tw] OR in vivo[tw] OR mouse[tw] OR mice[tw] OR rat[tw] OR rats[tw] OR protein[tw] OR	NOT

	proteins[tw] OR embryonic[tw] OR imaging[tw] OR image-based[tw] plasma[tw] OR residential[tw] OR long-term care[tw] OR long term care[tw] OR nursing home[tw] OR skilled nursing facility[tw] OR recovery house OR organelle[tw] OR dental[tw] OR dentist[tw] OR dentistry[tw] OR screening[ti]	
Search Limits	Humans, Clinical Trial, Meta-Analysis, Practice Guideline, Randomized Controlled Trial, Review, Classical Article, Comparative Study, Controlled Clinical Trial, Corrected and Republished Article, Duplicate Publication, Evaluation Studies, Government Publications, Guideline, Historical Article, Introductory Journal Article, Journal Article, Technical Report, English, Publication Date from 2003/07/01	

Recent Systematic Reviews: In examining the recent systematic reviews commissioned by the ACGME, we examined a total of 439 citations (counting articles twice if they were cited by two reviews). The systematic review by the group affiliated with Jefferson University included 87 citations.[13] The systematic review by Fletcher, Reed, and Aurora included 232 citations.[12] The updated bibliography from Fletcher updated in approximately May 2010 included 174 citations.[14]

Selecting Articles for Current Analysis: To identify relevant articles relevant to baseline conditions from among the citations identified by our literature search and those by the other investigators, one of us reviewed, in sequence, titles, any article summaries included in the systematic reviews, abstracts, and full text articles. We excluded articles from consideration if they referred to conditions before but not after July 1, 2003, and if the article did not represent original research or a description of conditions at one or more residency programs. This resulted in a list of 267 articles potentially pertinent to baseline conditions in residency programs after July 1, 2003. We obtained 255 full text articles (in PDF format) and were unable to obtain 15. We reviewed the full text of all 255 articles to extract information relevant to the current analysis.

In addition, we conducted a focused search for articles that described call frequency. Using the 255 full text articles, we searched within the PDFs for the following terms: call schedule, frequency of call, call frequency, calls per, q 3, q3, every third, every 3rd, q 4, q4, every fourth, every 4th, q 5, q5, every fifth, every 5th, q 6, q6, every sixth, every 6th, q 7, q7, every seventh, every 7th, overnight call, night call, extended shift, in-hospital call, in hospital call, in-house call, in house call, on call, 24 on. This resulted in 192 articles, which we then reviewed in their entirety to identify any information on call frequency. Forty six articles described call frequency at one or more residency programs after July 1, 2003. These articles are summarized in Appendix III. For the 63 of the 255 articles that were excluded by our search for terms within the PDFs, we reviewed the articles in their entirety, confirmed that call frequency had not been discussed, and extracted any other information relevant to this analysis.

B. Definitions

Except where noted below, these definitions are based on the ACGME Glossary of Terms that was last updated in May 2010.[16]

At-Home Call: A call taken from outside the assigned site.

Duty-Hours: All clinical and academic activities related to the residency/fellowship program, i.e., patient care (both inpatient and outpatient), administrative duties related to patient care, the provision for transfer of patient care, time spent in-house during call activities, and scheduled academic assignments such as conferences. (See Common Program Requirements)

Graduate-Year Level: Refers to a resident's current year of accredited GME. This designation may or may not correspond to the resident's particular year in a program. For example, a resident in pediatric cardiology could be in the first program year of the pediatric cardiology program but in his/her fourth graduate year of GME (including the 3 prior years of pediatrics.) Also referred to as post graduate year or "PGY".

In-House Call: Duty hours beyond the normal work day when residents are required to be immediately available in the assigned institution.

Night Float: Rotation or educational experience designed to either eliminate in-house call or to assist other residents during the night. Residents assigned to night float are assigned on-site duty during evening/night shifts and are responsible for admitting or cross-covering patients until morning and do not have daytime assignments. Rotation must have an educational focus.

Resident: a physician in an accredited graduate medical education specialty program.

PGY1 Resident: Resident in post-graduate year 1, also called intern.

PGY2+ Resident: Resident in post-graduate year 2 or above, including subspecialty residents.

PGY2+ Specialty Resident: Resident in post-graduate year 2 or above in a specialty program, excluding subspecialty residents.

Preventable Adverse Event: an injury to a patient that was caused by a medical error.[11]

Program: A structured educational experience in graduate medical education designed to conform to the Program Requirements of a particular specialty/subspecialty, the satisfactory completion of which may result in eligibility for board certification.

Program Director: The one physician designated with authority and accountability for the operation of the residency/fellowship program.

Resident: A physician in an accredited graduate medical education specialty program.
Residency: A program accredited to provide a structured educational experience designed to conform to the Program Requirements of a particular specialty.

Rotation: An educational experience of planned activities in selected settings, over a specific time period, developed to meet goals and objectives of the program.

Specialty Program: A structured educational experience in a field of medical practice following completion of medical school and, in some cases, prerequisite basic clinical education designed to conform to the Program Requirements of a particular specialty; also known as “core” programs.

Specialty Resident: a resident in a specialty program.

Sponsoring Institution: The sponsoring institution is the entity that assumes the ultimate financial and academic responsibility for a program in graduate medical education. The Institutional Review Committee assumes the responsibility for reviewing institutions that sponsor multiple programs. A single site sponsoring institution is reviewed by the Residency Review Committee only during a review of the sponsored program.[17]

Subspecialty Program: A structured educational experience following completion of a prerequisite specialty program in GME designed to conform to the Program Requirements of a particular subspecialty.

Subspecialty Resident: a resident in a subspecialty program, also called a fellow.

Please refer to the Glossary on the ACGME website for additional definitions.

C. Planned Changes to Duty Hour Limits

To assess major direct costs of the planned changes to the duty hour limits, we first reviewed each of the planned limits and compared them with the current limits to identify changes. We then made judgments about which changes are likely to generate costs that would be both substantial and potentially quantifiable; we included these changes in our analysis. Appendix I lists the current and planned duty hour limits, indicates those representing a material change, identifies and comments on the planned changes that we included in our analysis, and provides a brief rationale for those that we excluded. The planned changes that we included in our analysis were:

1. For PGY1s, extended shifts would be reduced from 30 to 16 hours; and

2. For residents in the PGY2 year and beyond, extended shifts would be shortened by two hours.

To calculate the cost of each of the planned changes we included in the analysis, we determined the difference between what residents work at baseline and what they would work under the planned changes, which we call "excess work." As noted above, the baseline period is after July 2003, when the ACGME last changed resident duty hour limits. For each of the planned changes, we identified potential strategies for handling the excess work, such as shifting work among residents or hiring substitute providers or additional residents, and we determined the cost per hour for each strategy. We assumed that individual substitutes would perform excess work transferred from multiple residents, meaning that work would distribute naturally among any substitutes. We then determined nationwide costs by multiplying the total number of excess work hours across all residents by the hourly cost. Tables II-2 and II-4 at the end of this section include parameters used in this analysis that were based on published literature, Table II-3 includes assumptions. The equation below summarizes our approach to estimating costs:

Cost of Planned Change = Excess Work x Cost per Unit of Substitute Labor
x Number of Residents Affected

Excess work = Baseline Duty Hours - Planned Duty Hours

<u>i. Baseline Duty Hours</u>

Holt et al. recently published the results of a national survey of all residents, except for fellows in very small programs, which the ACGME conducted during January to June in 2007 and in 2008. Eighty nine percent of surveyed residents responded (more than 91,000 individuals). This study asked residents to answer ten questions regarding compliance to the current (i.e., 2003) ACGME duty hour limits. The stem for the ten questions asked "Have you met the following ACGME duty hours requirements?," followed by a list of ten of the ACGME duty hour requirements.[18]

According to the 2007/2008 version of the survey posted on the ACGME website, response options were “always/usually,” “sometimes,” “rarely/never,” and “not applicable”.[19] In the published paper, results were presented as the percentage of residents indicating that they were “noncompliant” with each limit. No specific data were reported on the frequency or extent to which limits were exceeded. The responses relevant to the planned changes to duty hours and the training environment include the following:

- For the duration of the workweek, 6.3% of respondents indicated that they were non-compliant with the current requirement, “Duty hours must be limited to 80 hours per week (88 for those programs having duty hours exceptions), averaged over a four-week period, inclusive of all in-house call activities.”
- For days off, 3.7% of respondents indicated that they were non-compliant with the current requirement, “Residents and fellows must be provided with one day in seven free from all educational and clinical responsibilities, averaged over a four-week period, inclusive of call.”
- For rest between duty periods, 8.5% of respondents indicated that they were non-compliant with the current requirement, “Adequate time for rest and personal activities must be provided. This should consist of a 10-hour time period provided between all daily duty periods and after in-house call.”
- For the frequency of in-house call, 1.7% of respondents indicated that they were non-compliant with the current requirement, “In-house call must occur no more frequently than every third night, averaged over a four-week period.”
- For the duration of extended shifts, 7.3% of respondents indicated that they were non-compliant with the current requirement, “Continuous on-site duty, including in-house call, must not exceed 24 consecutive hours. Residents and fellows may remain on duty for up to 6 additional hours to participate in didactic activities, transfer care of patients, conduct outpatient clinics, and maintain continuity of medical and surgical care.”
- For admitting new patients during extended shifts, 6.7% of respondents indicated that they were non-compliant with the current requirement, “No new patients may be accepted after 24 hours of continuous duty.
- For at-home call,
    - 4.0% of respondents indicated that they were non-compliant with the current requirement, “At-home call must not be so frequent as to preclude rest and reasonable personal time for each resident/fellow.”
    - 2.1% of respondents indicated that they were non-compliant with the current requirement, “Residents/fellows taking at-home call must be provided with one day in seven completely free from all educational and clinical responsibilities, averaged over a four-week period.”
    - 2.6% of respondents indicated that they were non-compliant with the current requirement, “When residents and fellows are called into the hospital from home, the hours they spend in-house are counted toward

the 80-hour limit. (The limit is 88 hours for those programs with duty hours exceptions.)"

- For moonlighting, 0.7% of respondents indicated that they were non-compliant with the current requirement, "Internal moonlighting must be considered part of the 80-hour weekly limit on duty hours. (This limit is 88 hours for those programs with duty hours exceptions)".[18]

In July 2010, Antiel et al. conducted a national survey of residency program directors in Internal Medicine, Pediatrics, and General Surgery to assess attitudes toward selected changes to duty hours and the training environment that had been proposed but not yet finalized by the ACGME, as well as to assess whether programs have already implemented the proposed changes. The results regarding whether certain proposed changes to duty hours have already been implemented are as follows:

- For the maximum length of the duty period, 94% of programs report that they do not currently adhere to the standard that "Duty hours for PGY-1 residents must not exceed 16 hours."
- For the frequency of in-hospital call, 25% of programs report that they do not currently adhere to the standard that "Residents in PGY-2 or later years limited to in-hospital on-call frequency of every third night, with no averaging."
- For the minimum time off between scheduled duty periods, 6% of programs report that they do not currently adhere to the standard that "Residents should have 10 hours off between duty shifts and must have 8 hours free of duty between duty periods."
- For the maximum frequency of in-hospital duty (meaning night float), 16% of programs report that they do not currently adhere to the standard that "Residents must not be scheduled for more than 6 consecutive nights of night duty."
- For moonlighting, 8% of programs report that they do not currently adhere to the standard that "PGY-1 residents must not be permitted to moonlight"[20].

Unfortunately, national surveys have seldom documented the actual distributions of hours worked by residents across various specialties and class years. Consequently, our current understanding of baseline work hours is a compilation of data from a variety of studies, each with its limitations. Some studies have included multiple specialties but only one class year or only one or two hospitals. Other studies have included multiple class years or hospitals but only one specialty. Existing data do not permit a detailed analysis of current work hours for each specialty and subspecialty, or for each class year. Nevertheless, many studies have described duty hours since 2003, providing a reasonably complete picture of typical experiences in specialties such as Internal Medicine, General Surgery, and Pediatrics. One or more studies have also described some aspects of duty hours for Orthopedics, Otolaryngology, Obstetrics and Gynecology, Anesthesia, Family Medicine, Psychiatry and Neurology. We addressed uncertainty in the data by conducting a "base case" analysis that represents the conditions that appear most probable, as well as numerous sensitivity analyses that examine how altering certain parameters and assumptions would affect costs.

In the paragraphs below, we summarize the available literature relevant to the planned changes to duty hours that we consider in this analysis. Where literature is incomplete, we explain relevant assumptions. The planned changes that we included in the cost analysis would affect the durations of extended shifts; therefore, we needed information on the amount of time currently spent on inpatient rotations, the current frequency of extended shifts during inpatient rotations, and the current duration of extended shifts. We needed this information for PGY1 residents, PGY2+ specialty residents, and subspecialty residents. Table II-2 lists the estimates that we used for the base case scenario and sensitivity analyses.

Time on Inpatient Rotations: With regard to the percentage of weeks spent on inpatient rotations, we considered the following information.

In a national survey of PGY1s residents conducted in the 2003-2004 academic year, PGY1s spent 50.6% of their weeks on inpatient rotations (where non-inpatient rotations included vacation).[21] We assumed that PGY1s would primarily have extended shifts during inpatient rotations; we ignored any extended shifts that might occur during non-inpatient rotations and assumed that night float duties and home call do not represent a substantial percentage of the time that PGY1 residents typically spend on inpatient rotations.[22] When it was necessary to estimate the number of weeks residents worked during the entire year (including inpatient and outpatient), we assumed 49 for all class years.[23]

We identified no national surveys of PGY2+ residents that have addressed the question of the frequency of inpatient rotations. In one internal medicine program, PGY1 residents took nine months of call, PGY2s took 8, and PGY3s took 4.[24] However, virtually all General Surgery rotations are inpatient. Consequently, we assumed used the data from the national survey for PGY1s above (50.6%) as the base case value and sensitivity analyses considered the possibility that PGY2+ residents might have half as many inpatient rotations.

Estimating the percentage of weeks that PGY2+ residents spend on inpatient rotations is complicated by the fact that, in many specialty programs, residents have night float rotations and sometimes they take call from home. On night float rotations, residents cover one or more clinical services for several nights in a row. Night float rotations are inpatient rotations but do not involve extended shifts, so they should be excluded when considering the cost of shortening extended shifts. About 20-35% of Specialty programs in Pediatrics, Surgery, Family Medicine, and Orthopedics use night float systems and 75% do in Internal Medicine and in Obstetrics and Gynecology.[12, 25 26-32] In Internal Medicine, 48% of programs added night float rotations after 2003.[33] In one internal medicine program and in one General Surgery program, residents spend four weeks or one month on night float.[34, 35] In another General Surgery program, residents spent eight to 15% of their time (which equals 1 to 2 months) on night float rotations.[36] Currently, the ACGME Program Requirements for Internal Medicine stipulate that residents must not be assigned more than two months of night float during any year of training, or more than four months of night float over the three years of residency training.[37] In Pediatrics, residents are limited to one night float rotation during their residency.[38] Given that many programs do not use night float systems, the average number of weeks on night float per year for PGY2+ specialty residents is likely

to be under four. With regard to home call, we found limited published information on the current frequency during inpatient rotations. Consequently, we assumed that PGY2+ specialty residents would have, on average across all specialties, three weeks of night float or home call during inpatient rotations, leaving 23 weeks per year during which extended shifts would occur. In sensitivity analyses, we considered the possibility that these PGY2+ specialty residents would have between 7 and 25 weeks of inpatient rotations with extended shifts.

When implementing the planned changes to duty hour limits, residency programs may choose transfer work from PGY1s to PGY2+ specialty residents, as discussed in the section below on selecting substitutes. Doing so could increase the number of inpatient rotations worked by PGY2+ specialty residents. For the purpose of this analysis, we assumed that any additional weeks on inpatient rotations would largely be comprised of night float, rather than traditional extended shifts, so this transfer of work would not affect the number of extended shifts worked by PGY2+ specialty residents.

Studies do not appear to have described the current duty hours of subspecialty residents. According to the ACGME, subspecialty residents usually take call from home. In only a few specialties, such as cardiology and other fields that provide emergent surgical or interventional therapy, do subspecialty residents take in-hospital call. Subspecialty residents generally do not have night float rotations[39]. Consequently, for the base case scenario, we assumed that, on average across all specialties, subspecialty residents spend four weeks per year on inpatient rotations with extended shifts (2-12 weeks in sensitivity analyses).

Frequency of Extended Shifts during Inpatient Rotations: Despite the fact that extended shifts are a near universal aspect of residency training, the frequency of extended shifts has seldom been examined systematically on a large scale. However, many studies have reported call frequency for the residents in a particular program, or for the control group in an analysis of a particular intervention. In studies of residents on Internal Medicine rotations, the frequency of call was every fourth night in 19 single-institution studies (four of the studies were at one institution), and every third to sixth night in another single-institution study.[40] In studies of residents on General Surgery rotations, the frequency of call was more variable. In a study of 19 General Surgery programs in New England, residents described their current call schedule as every other night (3.2%), every third night (26.4%), every fourth night (30.5%) every fifth night (23.2%), and home call (16.8%).[41] In a survey of 80 General Surgery programs in 2004, call was described as being every fourth or fifth night.[28] In a survey of residents on General Surgery rotations at 52 hospitals, the mean number of in-hospital calls per month was 5.7 (equivalent to call approximately every fifth night).[42] According to the ACGME, PGY1 residents in programs with three or fewer PGY1s per year may sometimes have call every other or every third night currently, such as in family medicine programs at community hospitals and in certain surgical subspecialties.[39] Single-institution studies of other specialties include the following: Pediatrics, every fourth night[43] or every fourth to sixth night;[40] Anesthesia, every fourth or fifth night;[44] Family Medicine, every fourth to sixth night;[40] and Psychiatry, every fourth to seventh night.[40] In light of these findings, we assumed a call frequency of every third night for PGY1 residents in programs with three or fewer residents per year. For residents

overall (including all class years), we selected call every fifth night as the value for the base case analysis, and considered every third to sixth night in sensitivity analyses.

Duration of Extended Shifts: With regard to the current duration of extended shifts, 7.3% of residents report being non-compliant with the current limit of 30 hours per shift.[18] In the national survey of PGY1s in 2003-2004, the mean reported duration of extended shifts was 29.9 (95% CI, 29.8- 30.0) hours and, in 22.5% of weeks with extended shifts, the mean duration of extended shifts exceeded 30 hours.[21] In a study at two large teaching hospitals that included residents from multiple class years and multiple specialties and subspecialties, Jagsi et al. observed that 22% of residents worked a mean of 21.7 hours as their longest shift in the past week with a standard deviation of 10.6 hours. Another 78% of residents worked a mean of 16.9 hours with a standard deviation of 9.2 hours.[45]

It is possible to impute shift length from this second study by extrapolating from the mean and standard deviation and assuming normal distributions for the two groups. Doing so suggests that 0.4% of the total population worked $\geq$42.9 hours, 1.6% worked $\geq$35.3 hours, 3.0% worked 31.3 to 42.9 hours, 10.6% worked 25.1 to 35.3 hours, and 7.5% worked 21.7 to 31.3 hours.

Based on the available information on shift length, we made the following assumptions. We assumed that 92.7% of residents work no more than 30 hours per shift and 7.3% work more than 30 hours. For the former group, we assumed that they actually work 30 hours. For the latter group, drawing from the Jagsi study, we assumed that they work 35 hours per shift (32-38 hours in sensitivity analyses).

ii. Calculating "Excess Work"

As noted above, we use the term "excess work" to describe the difference between the hours residents work at baseline and the planned duty hour limits. We needed to estimate excess work for PGY1 residents, for PGY2+ specialty residents, and for subspecialty residents. We calculated the number of hours of excess work per resident per year using the following equation:

Excess Work per Year = Number of Residents Affected x
Weeks per Year on Inpatient Rotations x
Frequency of Extended Shifts during Inpatient Rotations x
(Baseline Length of Extended Shift – Planned Length of Extended Shift)

For the change that reduces extended shifts for PGY1 residents from 30 to 16 hours, we took the following approach to estimating excess work for the base case analysis, based on how the ACGME anticipates that programs will implement the changes. At larger training programs, implementation may not generate any excess work because the programs can reorganize PGY1's work hours within existing inpatient rotations to adhere to the shorter shift requirement without reducing their work hours. For example, PGY1s could work two sixteen hour shifts rather than one 30-hour shift during one 48-hour period. Shifting PGY1 work in this fashion raises the question as to who will cover the nighttime period in the place of the PGY1; this can be accomplished by moving the individuals who currently cover for the PGY1 during the post-call period

to nights, such as having a night float instead of a day float. Alternatively, if PGY1s are taking call alongside PGY2+ specialty residents at baseline, the PGY2+ residents can continue to take overnight call and the PGY1 resident can pick up the service on the post-call day. Thus, programs may need to reorganize the work schedules of other residents but are less likely to need to increase residents' hours. Such approaches to adhering to this requirement preserve learning opportunities for PGY1s, ensure continuity of care, and minimize costs. At small residency programs, however, there may not be enough residents to achieve the planned limit of 16 hours without transferring some work from residents to other providers. However, the manner in which programs will implement the changes is currently unknown. At some larger programs, program directors may find it necessary to transfer work from PGY1s to other providers rather than restructuring call schedules.

In our base case analysis for this planned change, we determined excess work only for the population of PGY1 residents training at small programs that have three or fewer residents per year (690 residents nationwide).[39] In a sensitivity analysis, we determined excess work for all PGY1s, meaning that they would all transfer work to other providers (in Table II-2 and elsewhere, this is sensitivity analysis #1).

To calculate the average excess work per resident per year, we multiplied the number of weeks on inpatient rotations, the frequency of extended shifts per week, and the number of hours of excess work per extended shift. We stratified these calculations to account for compliance vs. non-compliance with the current 30-hour limit on extended shifts, as reported in the Holt study.[18]

For the change that reduces extended shifts for PGY2+ residents from 30 to 28 hours, we included all specialty and subspecialty residents. To determine excess work per resident per year, we multiplied the number of weeks on inpatient rotations, the frequency of extended shifts per week, and the number of hours of excess work per extended shift. We stratified these calculations by specialty vs. subspecialty residents, and to account for compliance vs. non-compliance with the current 30-hour limit on extended shifts.

iii. Selecting Suitable Individuals to Perform the "Excess Work"

Next, we needed to identify individuals with qualifications that would enable them to perform the excess work. Programs and the hospitals with which they are affiliated have a variety of options, which can be placed in three basic categories. First, the excess work could be shifted among existing residents. This occurred following the implementation of the 2003 duty hour limits, with an increase in the use of night float coverage. Second, programs could hire other providers to perform some or all of the work, such as nurses, midlevel providers, and attending physicians. After 2003, the number of nurses working in teaching hospitals increased nationwide.[46] Many residency programs, particularly surgical programs, hired midlevel providers (nurse practitioners or physician assistants). In some programs, the hours worked by attending physicians increased or non-teaching services were added.[25, 27-33, 46] Third, programs could increase the number of residents in training such that existing work could be shared among them. This does not appear to have been a common strategy after the 2003 duty hour changes. The number of residents in training has remained relatively

unchanged over time due to limits that the Balanced Budget Act has placed on federally funded residency positions.[47] However, the Council for Graduate Medical Education (COGME) has recommended increasing the number of residents in training (ref: COGME).[48]

Each approach has advantages and disadvantages. When work is shifted among existing residents, the residents do not miss out on the training opportunities associated with that work. For example, night float rotations can preserve the opportunity to admit patients who present during the night. Also, shifting work among residents minimizes costs to residency programs. However, such shifts can mean that residents miss out on other valuable rotations, such as when night float rotations replace electives and research blocks. In one national study of Internal Medicine programs, an increase in the use of night float rotations after 2003 was significantly associated with a decline in elective rotations.[33] One of the alternative approaches, hiring other providers to assume the excess work, may preserve high-yield educational opportunities and reduce the time spent on non-educational activities. For example, surgical residents may spend more time in the operating room if the paperwork burdens of routine admissions and discharges are shared by midlevel providers. However, hiring substitutes tends to be more costly than shifting resident labor.[49, 50] The last approach, expanding the population of residents in a program, can also reduce the burden of work on each resident, but some programs may find it challenging to offer the necessary breadth of clinical experiences to a larger pool of residents. The cost associated with hiring additional residents is also substantial.[51, 52]

With these various considerations in mind, we evaluated the following strategies for the duty hour changes included in the cost analysis, which are summarized in Table II-3. We considered four different scenarios: a base case (or most plausible) scenario, an all-midlevel scenario, an all-attending scenario, and an expanded-population of residents scenario. We also considered the number of hours of substitute labor that can be used to replace one hour of excess work, using a substitution ratio of 1:1 for the base case scenario. In sensitivity analyses, we used ratios of 0.8 to 2.4 for midlevel providers and 0.5 to 1.0 for attending physicians. For the fourth approach, when considering an expanded population of residents, existing data did not permit us to calculate the amount of additional resident time needed in a specialty-specific manner or at the program level; rather, we estimated averages at the national level. Given that the work to be transferred would be relatively modest per extended shift (about 2 to 7 hours, depending on compliance with current limits), we assumed that the substitutes would assume the excess work of multiple residents or have other responsibilities unrelated to resident duty hours. For example, midlevel providers often work alongside surgeons or hospitalists in community hospitals. This assumption means that, ultimately, we calculated only the portion of the substitutes' salaries and benefits that would be attributable to the planned changes to resident duty hours.

Shortening extended shifts for PGY1 residents: For this planned change, the base case analysis assumed that excess work from PGY1s in small programs would be shifted to attending physicians receiving additional support from nurses. We chose this approach over using midlevel providers because shortening shifts for PGY1s may not generate enough excess work per program to justify a full-time equivalent position for a midlevel provider, but attending physicians and nurses will already be present.

Attending physicians are likely to be substantially more efficient than interns, perhaps twice as efficient. However, residents continue to spend much time performing scut (non-educational tasks that could be performed by lower level providers),[45] which attendings may be less willing to perform. Consequently, we assumed that one hour of PGY1 time could be replaced by 0.5 hours of attending time combined with 0.25 hours of nursing time. In a sensitivity analyses, we examined using 0.5 to 1 hours of attending work per hour of intern work (i.e., without including nursing time).

As noted above, one of the sensitivity analyses (#1 in Table II-2) considered the possibility that all PGY1s would experience reductions in their total hours worked on inpatient rotations, rather than reallocating their work within a rotation. For this sensitivity analyses, we assumed that PGY2+ specialty residents would assume nighttime duties and used a substitution ratio of 0.8:1 (these assumptions are not included in Table II-3).

Shortening extended shifts for PGY2+ specialty residents: For this change and population, we considered four alternative approaches: (1) shifting work among existing residents, such as to residents on day float duties, (2) hiring midlevel providers to perform some daytime work for residents, (3) hiring attendings to perform some daytime work for residents, and (4) expanding the pool of residents. Our other assumptions were similar to those described above for PGY1s, except that we assumed attendings and PGY2+ residents would work at a similar pace.

Shortening extended shifts for subspecialty residents: For this change and group, we considered only the last three of these approaches because most programs would have too few residents to share daytime assignments. Because subspecialty residents have completed specialty training, attending physicians are the most qualified to assume these residents tasks; however, we did consider the possibility that midlevel providers could perform some of the less complicated and non-educational tasks of subspecialty residents. Other assumptions are the same as for PGY2+ specialty residents.

iv. Cost per Hour of Substitute Labor

We determined the cost of resident substitutes by considering hourly wages or salaries as well as benefits. For shifting work to nurses, midlevel providers, or attending physicians, we used mean hourly wages and benefit rates from the U.S. Department of Labor. In our prior analysis,[52] we considered alternative sources for information on providers' wages; midlevel providers' wages were very similar to those from the U.S. Department of Labor. For attending physicians, we considered a new alternative estimate of wages. We derived faculty members' hourly wage from median annual compensation (excluding benefits) for assistant professors in U.S. medical schools ($181,000),[53] assuming 48 weeks of work per year and a mean workweek of 49.6 hours[54]; the resulting hourly wage, $76.02 is almost the same as the wage from the U.S. Department of Labor.

For shifting work among existing residents, estimating the hourly cost requires consideration of the value of resident labor. Actual expenditures on resident wages and benefits will not change when work is shifted among residents. Nevertheless, the shifted hours of work represent an opportunity cost because residents cannot spend the

time in alternative activities that are also of value either in terms of education or in terms of providing patient care. Residency programs that increased night float rotations after 2003 often pulled residents from elective rotations, for example.[33] The minimum value of resident labor is the average hourly wages and benefits that residents receive. For this analysis, we calculated the average hourly wage of PGY1 residents, PGY2+ specialty residents, and subspecialty residents using their annual stipends as reported by the American Association of Medical Colleges,[23] 49 workweeks per year, and published estimates of the average hours worked per week (66.6 for PGY1s, 59.3 for PGY2+ specialty and subspecialty residents) (see Table II-2 for parameter values).

For hiring additional residents, we estimated costs based on residents' wages and benefits. Because hiring additional residents can involve indirect costs for teaching institutions, we also calculated mean per-resident expenditures on graduate medical education (GME) from a variety of sources. We obtained information on direct and indirect GME expenditures by Medicare in 2008 from information reported by the American Association of Medical Colleges[51] and on other public and private GME expenditures from a 2006 RAND report.[55] We inflated the other public and private GME expenditures to 2008 using the medical care component of the consumer price index, and added them to the Medicare expenditures for 2008 to determine total national expenditures as of 2008. Finally, we calculated mean per-resident GME expenditures by dividing the total national expenditures in 2008 by the number of residents that year. To determine expenditures per hour of resident labor, we divided mean per-resident expenditures by the number of weeks worked per year (49) and the mean number of hours worked per week in national surveys.[21, 54] We focused on average per-resident expenditures from all public sources excluding Medicare indirect GME payments, and average per-resident expenditures from all sources.

v. Calculating the Costs of Substitutes

To determine the average cost of substitutes per resident in a particular stage of training, we multiplied the total hours of excess work per resident annually, the hours of substitute work per hour of resident work (substitution ratio), and the hourly costs of substitutes. To determine the cost of substitutes across all ACGME-accredited programs, we multiplied the average cost per resident by the size of the population in that year of training. The following equation summarizes these calculations:

Cost per Resident per Year = Excess Work per Resident per Year x
Hours of Substitute Work per Hour of Resident Work x
Cost per Hour of Substitute Labor

Nationwide Cost per Year = Cost per Resident per Year x
Number of Affected Residents

vi. Planned Changes Omitted from Cost Analysis and Rationale

As seen in Appendix I, the ACGME has planned several changes to duty hour limits for which we did not estimate cost. Notable ones include the elimination of continuity clinics after extended shifts, a slight shortening of the minimum time off between scheduled duty periods (which could yield savings), the elimination of moonlighting for PGY1 residents, and a limit of 6 consecutive nights during night float rotations.

Although eliminating continuity clinics on the mornings after extended shifts could have a moderate to substantial effect on the schedules of primary care specialty residents on both inpatient and outpatient rotations,[33] we excluded it from our cost analysis for several reasons. First, continuity clinics are an essential component of training and a minimum level of participation in these clinics is required by the ACGME Program Requirements for Internal Medicine, Family Medicine, Pediatrics, and Obstetrics and Gynecology.[38, 56-58] Thus, such programs would generally respond to the planned change by moving the clinics to a non-call day or instituting other changes that would preserve the clinics as educational opportunities. Second, many Family Medicine and Internal Medicine programs have already eliminated clinics on post-call days.[31] Third, if residents' participation in clinics were reduced, the cost associated with this would be limited from both the teaching hospital and societal perspectives. Hospitals may be likely to pay for substitutes to perform resident work in outpatient than inpatient settings. From the societal perspective, attending physicians who are supervising residents in clinic may spend somewhat more time per patient without residents' help but they would generally continue to bill the same amount for the work. Finally, data on the current frequency of continuity clinics on post-call days is limited, making it challenging to estimate the cost of eliminating them.

For the maximum frequency of in-hospital duty (meaning night float), Antiel et al. reported that 16% of programs appear to allow residents to be scheduled for more than 6 consecutive nights of night duty.[20] Fletcher et al. report that most studies have examined durations of night float that last five to seven nights.[12] Consequently, it appears that the 16% of the surveyed programs may have some night float responsibilities lasting 7 consecutive nights. The cost associated with eliminating one night in seven is unlikely to be substantial nationwide. The Antiel study included only time-intensive specialties, so the overall percentage of all programs allowing longer periods of night float is probably much less than 16%.[20] In addition, the use of night float is limited in many specialties. Consequently, the average cost of this planned change is likely to be limited.

For the exclusion of PGY1s from moonlighting, 8% of program directors indicated that they are not currently adherent to this standard. However, it seems very unlikely that this means 8% of PGY1 residents are moonlighting. Fletcher et al. note that most states require a medical license to moonlight, and residents only obtain these after the PGY1 year.[12] Consequently, the program directors reporting non-adherence may be reporting an absence of a policy within their program rather than the presence of moonlighting by PGY1s.

Lastly, we did not include the relaxation of the minimum time off between duty periods. Savings are unlikely to be substantial because the specialty with the most

residents in training nationwide, Internal Medicine, already allows the time between shifts to be 8 hours up to twice a week.[56] In addition, in the ACGME's recent national survey, 8.5% of residents indicated that they were non-compliant with the current 10 hour limit;[18] relaxing the limit will not yield savings for these individuals. The Antiel survey suggests the opposite, in fact: with the relaxed standard, 6% of programs would be non-compliant.[20]

Table II-2: Model Parameters: Baseline Resident Working Patterns

Model Parameters	Base Case Scenario	Sensitivity Analysis (SA) Range	SA Number*	References
Current Resident Working Patterns				
Numbers of Programs and Residents, Academic Year 2008-2009				[59]
Accredited Specialty Programs				
Programs, #	4,100			
Residents, #	90,907			
Accredited Subspecialty Programs				
Programs, #	4,594			
Residents, #	17,269			
Numbers of Hospitals				
With Accredited Programs	1,094			[60]
Members of the Council of Teaching Hospitals	366			[60]
Residents, % of Total	75.6%			[51]
Workweeks per Year, #	49			[23]
PGY1 Specialty Residents				
All PGY1s, #	25,848			[59]
PGY1s in Small Programs, #	690		1	[39]
Mean Weekly Work Hours, #	66.6			[21]
Weeks on Inpatient Rotations, %	50.6%			[21]
Weeks per Year Excluding Night Float and Home Call, #	26			[33]
Extended Shifts on Inpatient Rotations				
All PGY1s, Frequency	every 5th night	every 3rd to 6th	2	See Appendix III
PGY1s in Small Programs, Frequency	every 3rd night	every 3rd to 6th	2	[39]
Compliance with Current 30-Hour Limit, % of Residents				[18]
% at Small Programs	92.7%	75-95%	3	
Extended Shift Duration, Hours	Compliant, 30 Non-compliant, 35	Non-compliant, 32-38	4	[18] [45]

				21
PGY1 Residents in Small Programs, # Extended Shift Frequency on Inpatient Rotations at Small Programs				
PGY2+ Specialty Residents	65,059			59
Mean Weekly Work Hours, #	59.3			54
Weeks on Inpatient Rotations, %	50.6%			21
Weeks of Night Float or Home Call Rotations, #	3			34
Weeks Excluding Night Float and Home Call, #	23	7-25	5	36
Extended Shifts on Inpatient Rotations, Frequency	every 5th night	every 3rd to 6th	2	See Appendix III
Compliance with Current 30-Hour Limit, % of Residents	92.7%			18
Extended Shift Duration, Hours	Compliant, 30 Non-compliant, 35	Non-compliant, 32-38	4	18 45 21
Subspecialty Residents	17,269			59
Mean Weekly Work Hours, #	59.3			54
Weeks on Inpatient Rotations per Year Excluding Night Float & Home Call, #	4	2-12	6	
Extended Shifts on Inpatient Rotations, Frequency	every 5th night	every 3rd to 6th	2	See Appendix III
Compliance with Current 30-Hour Limit, % of Residents	92.7%			18
Extended Shift Duration, Hours	Compliant, 30 Non-compliant, 35	Non-compliant, 32-38	4	18 45 21

Table II-3: Model Parameters: Assumptions about Substitutes

	Base Case Scenario		**Midlevel Provider Scenario**		**Attending Physician Scenario**		**Additional Residents Scenario**	
For PGY1 residents, reducing extended shifts to 16 hours								
PGY1s at Small Programs								
Types of Substitutes	Attending and nurses		Midlevel providers		Attending and nurses		New residents	
Substitution Ratio*	*Base Case*	*SA† Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*
	0.5 MD + 0.25 nurse	0.5-1 MD	1	0.8-2.4	0.5 MD + 0.25 nurse	0.5-1 MD	1	n/a
SA Number		7		8		9		
For PGY2+ specialty residents, reducing extended shifts to 28 hours								
Types of Substitutes	Existing PGY2+ specialty residents		Midlevel providers		Attending physicians		Expanded population of residents	
Substitution Ratio	*Base Case*	*SA Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*
	1	n/a	1	0.8-2.4	1	0.5-1	1	n/a
SA Number				8		9		
For subspecialty residents, reducing extended shifts to 28 hours								
Types of Substitutes	Attending physicians		Midlevel providers		Attending physicians		Expanded population of residents	
Substitution Ratio	*Base Case*	*SA Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*	*Base Case*	*SA Range*
	1	0.5-1	1	0.8-2.4	1	0.5-1	1	n/a
SA Number		7		8		9		

* Substitution Ratio: Hrs of Substitute Work to Replace 1 Hr of Resident Work Range

† SA = Sensitivity analysis. Numbers are listed to facilitate cross-referencing with Results.

Table II-4: Model Parameters: Cost of Labor (2008)

Model Parameters	All Scenarios	References
Wages and Benefits		
Substitute Providers		
Hourly Wages		[61]
Licensed Vocational Nurse	$19.04	
Physician Assistant	$42.58	
Physician	$76.46	
Benefits, % of Total Compensation	30.2%	[62]
Residents, Academic Year 2008-2009		
Annual Stipends, Mean		[23]
PGY1 Specialty Residents (based on PGY1 Stipends)	$46,245	
PGY2+ Specialty Residents(based on PGY3 Stipends)	$50,128	
Subspecialty Residents (based on PGY5 Stipends)	$54,164	
Benefits, % of Stipends, Mean	32%	
Graduate Medical Education (GME) Expenditures		
Medicare, 2008		[51]
Direct GME Expenditures	$2.70 billion	
Indirect GME Expenditures	$5.74 billion	
Other Public Sources, 2003	$4.1 billion	[55]
Private Sources, 2003	$7.2 billion	[55]
Medical Care Component of Consumer Price Index, 2003 to 2008	1.22	[63]
Derived GME Expenditures for 2008		
All Public Sources Excluding Medicare Indirect	$7.4 billion	
All Sources	$22.2 billion	
Derived Averages per Resident in 2008-2009		
All Public Sources Excluding Medicare Indirect	$71,000	
All Sources	$205,000	

D. Planned Changes to Training Environment

In this section, we consider the potential cost of the ACGME's many planned changes to the training environment that are related to duty hour limits. The planned changes address: professionalism, personal responsibility, and patient safety; transitions of care; alertness management; supervision of residents; clinical responsibilities; and teamwork.

Information on baseline adherence to the revised standards was published recently. In July 2010, Antiel et al. conducted a national survey of residency program directors in Internal Medicine, Pediatrics, and General Surgery to assess attitudes toward selected changes to the training environment, as well as to assess whether programs have already implemented the planned changes. The results regarding whether certain requirements have already been implemented are as follows:

- For the supervision of PGY1 residents, 29% of programs report that they do not currently adhere to the standard that "PGY1 residents must have direct supervision from an MD who is physically present with the resident or the supervising MD must be on site and available to provide direct supervision."
- For the workloads of residents, 9% of programs report that they do not currently adhere to the standard that "Learning objectives must not be compromised by excessive non-physician service obligations." However, this is not a change from the current Common Program Requirements.[3, 20]

While these planned changes would establish many new standards, we included only changes that appear to represent a material change from prevailing practices in most programs, appear likely to result in direct costs to hospitals, and for which estimating the resources involved in implementing the change appeared feasible. Appendix II includes all of the planned changes as well as a brief rationale for including or excluding them. The planned changes that represented material changes and for which cost estimation appeared feasible included: educating residents and supervising faculty members about duty hours and safety issues, offering transportation or sleep facilities to post-call residents, instituting structured procedures for hand-overs, and ensuring accurate reporting of duty hours. For each of these included changes, we needed to make several assumptions about the resources that may be involved, and performed sensitivity analyses that considered alternative assumptions (Table II-3). Other parameters relevant to these estimates were based on data in Tables 3 and 5.

There were several other planned changes to the training environment that we did not include. With regards to the requirement for greater supervision of PGY1s, there are several reasons that this planned change seems unlikely to generate substantial costs above and beyond the costs associated with adhering to the new duty hour limits. The time that PGY1s are most likely to be in the hospital without direct supervision immediately available is at night. For example, interns rotating at a community hospital or on a subspecialty service might answer calls at night while a senior resident, subspecialty resident, or attending is available by pager. Some programs that are not currently compliant with the requirement for supervision of PGY1s may become compliant if extended shifts for PGY1s are eliminated. Alternatively, senior physicians

who are already on duty in the same hospital may be enlisted to supervise any interns on duty alone, which means that supervision could be accomplished without altering current physician staffing patterns—and, therefore, with a minimum effect on costs. At a community hospital, interns could call an on-site emergency room physician or hospitalist for patient-care emergencies that cannot wait for a supervising physician to come in from home. At an academic hospital fully staffed by residents, a senior resident in the same or related disciplines could be available. For example, an intern on an otolaryngology service could call a senior resident in general surgery regarding patient care emergencies.

Some of the other planned changes to the training environment would not generate substantial costs because they codify practices that appear to be standard in most programs, such as assigning supervising physicians to all patients. For yet other planned changes, quantifying the staff time or other resources involved is not feasible because the change involves an abstract concept. It is not possible, for example, to quantify the cost of trainees putting patients' needs before their own, or programs ensuring a culture of safety. For other planned changes, the recommendations do not include enough detail to determine how programs would implement them. For example, one section stipulates that programs must design clinical assignments to minimize the number of transitions in patient care. Without information on how programs might minimize transitions, it would be challenging to estimate or even make assumptions about the resources involved. In a few instances, the planned changes would be challenging to quantify because data on baseline conditions appears limited.

i. Educating Residents and Supervising Faculty Members

The planned changes require residents and faculty members to be educated about many issues: their professional responsibilities to be fit for duty; assuring the safety and welfare of patients entrusted to their care; providing patient- and family-centered care; managing their time before, during, and after clinical assignments; recognizing impairment, including illness and fatigue, in themselves and in their peers; paying attention to lifelong learning; monitoring their patient care performance improvement indicators; honestly and accurately reporting duty hours, patient outcomes, and clinical experience data; recognizing that responsiveness to patient needs supersede self-interest and that, under certain circumstances, the best interests of the patient may be served by transitioning a patient's care to another qualified and rested provider; conducting effective, structured hand-over processes to facilitate both continuity of care and patient safety; recognizing the signs of fatigue and sleep deprivation; and implementing fatigue mitigation processes.

Programs will need detailed safety curricula and provide it to all residents and the faculty members who supervise them. One cost to consider is that of developing these curricula. According to the ACGME, several curricula on fatigue mitigation and patient safety already exist. National bodies, such as perhaps Residency Review Committees, may undertake the task of selecting the curricula that programs will then implement. We, therefore, did not include the cost of developing new curricula within the scope of this analysis.

Programs will experience actual costs or opportunity costs when residents and faculty members spend time learning the curricula. Although some programs may already be training residents and faculty members in these required topics, studies have not quantified this. To be conservative, we assumed that the baseline rate of implementation was zero. The first year the planned changes are implemented (2011), all residents and faculty members will need to be trained. We estimated the number of faculty members affected based on the ACGME's minimum requirement that programs have one faculty member per resident in the training program, and considered up to 1.5 times as many faculty members in a sensitivity analysis. We assumed, with input from the ACGME, that the initial training would require four hours of time, ranging from two to six in a sensitivity analysis. In subsequent years, programs will need to educate incoming specialty residents (PGY1s) and new faculty members. We assumed that PGY1 residents would receive the comprehensive training, and that the annual turnover among faculty members would be 7% (5-10% in sensitivity analyses). Continuing residents and faculty members may need modest refresher training on an annual basis; with input from the ACGME, we assumed one hour of training per year. Table II-5 lists assumptions about the resources involved in developing and implementing the safety curriculum. We applied these estimates to the populations of residents listed in Table II-2, and used the costs of residents and attending physicians listed in Table II-4.

ii. Offering Transportation or Sleep Facilities to Post-call Residents

The planned changes require that programs either offer residents facilities where they may sleep before driving home, or transportation home so that they don't have to drive while fatigued. For individual programs, the costs of adhering to these requirements will depend on whether the program has extra capacity in the facilities that they use for residents who are on call. If not, these facilities might need to be expanded, and doing so could be quite costly for programs in hospitals with limited physical space, particularly if they needed to convert patient rooms to call rooms. The cost of the alternative, offering transportation to post-call residents, is more feasible to estimate, although it does depend on how far residents live from the hospitals at which they work. Although some programs are already providing transportation home, we assumed that baseline adherence to this requirement would be zero.

We estimated the cost of hiring taxicabs to drive residents to work before call and back home again after call, since residents are unlikely to use the transportation if it is only provided in one direction. We estimated that an average taxicab fare one direction would be $25. This is likely to be high at programs where many residents live within a mile or two of the hospital, and low for rural programs or programs where residents live far away. We used information in Table II-2 to determine how frequently residents have extended shifts. Because the proposed changes would virtually eliminate extended shifts for PGY1s, we focused on PGY2+ residents. To calculate the total cost, we multiplied the number of extended shifts for PG2+ residents per year across all programs by the cost per round trip taxicab fare.

iii. Instituting Structured Procedures for Hand-overs

The planned changes require programs to ensure that transfers of patient care from one provider or service to another is accomplished in a manner that ensures continuity of care and patient safety. Satisfying this requirement would involve both educating residents and faculty members about effective hand-over practices, which we included among the educational activities discussed above. In addition, the planned change requires programs to institute structured hand-over procedures, ensure that residents are competent in communicating with team members in the hand-over process, and ensuring that all members of the healthcare team have access to schedules addressing who is currently responsible for each patient's care.

In a 2005 survey of Internal Medicine programs, Horwitz et al. determined that 55% of programs did not consistently require both a written and an oral signout at transfers of care, 34% left sign-out to interns alone, 59% had no means of informing nurses that a transfer had taken place, and 60% did not provide any lectures or workshops on sign-out skills. Web-based sign out systems were used in 14% of programs.

One potential cost of satisfying the planned requirements is that programs will need to develop, purchase, or subscribe to a computerized sign-out system. In discussion with the ACGME, we made the following assumptions. First, programs can limit the cost of developing or purchasing a sign-out program by making the purchase together with other programs based at the same sponsoring institution (a sponsoring institution is a hospital or other entity that is ultimately responsible for a residency program). The ACGME reports that there are 190 large sponsoring institutions (with 10 or more residency programs), 250 medium sponsoring institutions (with 2-9 programs), and 300 small sponsoring institutions (1 program). The medium and large institutions are generally, but not exclusively, members of the Council of Teaching Hospitals. According to the ACGME, the potential cost of developing an institution-wide sign-out system may be approximately $60,000 for large sponsoring institutions, $40,000 for medium institutions, and $10,000 for small institutions.[39] We ignored the cost of sign-out systems at hospitals that have rotating residents but are not sponsoring institutions because the ACGME's priority is to institute structured sign-out at sponsoring institutions.

A second type of cost associated with these requirements is the opportunity cost of resident labor. Residents at programs that are not currently using structured sign-out procedures may spend more time preparing written materials for sign out and/or giving oral sign out. We assumed that sign-out would only occur during inpatient rotations and that PGY1 residents would be responsible for sign-out. We assumed that PGY1 residents work 6 days per week on inpatient rotations, and spend 22 of 26 inpatient weeks per year at their sponsoring institution. We assumed that the residents would spend 1 hour per day more on sign-out than they do now; in sensitivity analyses, we explored the possibility that more or less time would be required, or that efficiency gains could occur due to improved availability of information for cross-covering residents (see Table II-5).

iv. Enhanced Oversight of Duty Hours and Training Environments

At the time the planned changes are implemented, the ACGME will initiate a new system for monitoring adherence to duty hour limits and requirements for the training environment: annual site visits. Under this new system, sponsoring institutions will incur two types of costs. First, the ACGME will assess a fee to each institution; the estimated fees, based on the size of the sponsoring institution, are listed in Table II-5. Second, the institution will incur opportunity costs when the ACGME makes site visits because representatives of ACGME will meet with residents, program directors, faculty members, and members of administration. The duration of the site visit will also vary with the size of the sponsoring institution. The ACGME estimates that about 1/3 of the time during the visit will be spent with residents, 1/3 will be spent with program directors and other faculty members, and 1/3 will be spent with members of administration. At large institutions, one ACGME representative will spend three days with residents, another will spend three days with faculty members, and a third will spend three days with administrators. At medium and small institutions, about 1/3 of the duration of the visit will be spent with each of these types of individuals. At both large and small institutions, managerial support staff will work with ACGME representatives during their visits to identify and obtain requested information.

We derived the hourly wage for institutional administrators with clinical backgrounds using the median annual compensation (excluding benefits) for department chairpersons in U.S. medical schools in 2008 ($430,000),[53] assuming 48 weeks of work per year and a mean workweek of 49.6 hours;[54] the resulting hourly wage is $180.61.

Table II-5: Model Parameters: Assumptions Pertaining to Costs of Planned Changes to Training Environment

Model Parameters	Base Case Scenario	Sensitivity Analysis (SA) Range	SA Number	References
Educating Residents and Supervising Faculty Members				
Baseline Adherence to Relevant Requirements, % of Programs	0%			
Initial Year (2011)				
Faculty Members, #	108,176	108,176-162-264	10	[39]
Percentage at COTH Hospitals	75.6%			
Initial Training per Resident or Faculty Member, Hrs	4	2-4	11	
Subsequent Years				
Initial Training				
PGY1 Residents, #	25,848			
New Faculty Members, % of Faculty	7%	5-10%	12	
Annual Refresher Training				
PGY2+ Residents, #	82,328			
Continuing Faculty Members, % of Faculty	93%	90-95%	12	
Refresher Training per Resident or Faculty Member, Hrs	1			
Offering Transportation to Post-call PGY2+ Residents				
Baseline Adherence to Relevant Requirements, % of Programs	0%			
PGY2+ Residents, #	82,328			
Taxicab from Hospital to a Resident's Home, Cost per Extended Shift	$50	$20-80	13	
Instituting Structured Procedures for Hand-overs				
Baseline Adherence to Relevant Requirements, % of Programs Using Computerized Sign-Out	23.2%	0-40%	14	[22]
Sponsoring Institutions				[39]
Large: $\geq$ 10 Residency Programs per	190			

Institution, # of Sponsoring Institutions				
Medium: 2-9 Programs per Institution, # of Sponsoring Institutions	187			
Small: 1 Program per Institution, # of Sponsoring Institutions	305			
Sponsoring Institutions based at COTH Hospitals	Medium and Large Institutions			
Computer Sign-out System, Initial Cost of Development or Purchase			15	
Large Sponsoring Institutions	$60,000	$35,000-$80,000		[39]
Medium Sponsoring Institutions	$40,000	$10,000-$50,000		
Small Sponsoring Institutions	$10,000	$5,000-$35,000		
Use of Sign-Out System by Residents				
Weeks on Inpatient Rotations at Sponsoring Institution per Year	22	18-26	16	
Work Days per PGY1 Resident per Week on Inpatient Rotations, #	6			
Use of Sign-out Program, Hours Spent per PGY1 Resident per Inpatient Work Day	1	0.5-1.5	17	
Efficiency Gains from Sign-Out Program, Hours Saved per PGY1 Resident per Inpatient Work Day	0	0-2	18	
Enhanced Oversight of Duty Hours and Training Environments				[39]
Site Visit Fees to Be Paid to ACGME per Year				
Large Sponsoring Institutions	$18,000			
Medium Sponsoring Institutions	$15,000			
Small Sponsoring Institutions	$12,000			
Duration of Site Visit per Year, Days				
Large Sponsoring Institutions	3			
Medium Sponsoring Institutions	2			
Small Sponsoring Institutions	1			
Time Spent by Institution Staff Members During Site Visit, Total Days by Type of Staff Member			19	
Large Sponsoring Institutions				
Residents	3	2-6		

Faculty Members	3	2-6		
Institutional Administrators, Clinical	1.5	1-3		
Institutional Administrators, Non-Clinical	1.5	1-3		
Managerial Support Staff	6	3-9		
Medium Sponsoring Institutions				
Residents	1	0.5-2		
Faculty Members	1	0.5-2		
Institutional Administrators, Clinical	0.5	0.25-1		
Institutional Administrators, Non-Clinical	0.5	0.25-1		
Managerial Support Staff	3	2-5		
Small Sponsoring Institutions				
Residents	0.3	0.3-1		
Faculty Members	0.3	0.3-1		
Institutional Administrators, Clinical	0.16	0.16-0.5		
Institutional Administrators, Non-Clinical	0.16	0.16-0.5		
Managerial Support Staff	1	1-2		
Wages of Administrators and Support Staff				
Institutional Administrators, Clinical:				
Median Annual Compensation of Medical School Department Chairperson	$442,000			[53]
Weeks of Work per Year	48			
Hours Worked per Week, Mean	49.6			[54]
Institutional Administrators, Non-Clinical: Mean Hourly Wage of Hospital Management Occupations (Highest Level)	$52.24			[61]
Managerial Support Staff: Mean Hourly Wage of Managerial, Professional, and Related Staff	$33.56			

E. Net Costs of Planned Changes Including Preventable Adverse Events

If the planned changes succeed at reducing PAEs in teaching hospitals, this would likely yield cost-offsets both during and after hospitalization, due to the high costs of PAEs. However, the unfortunate possibility exists that the changes could increase PAEs rather than reduce them. Discontinuities of care have been associated with a substantial increase in the rate of PAEs, for example, although this risk can be mitigated by a structured computerized system for handovers.[10, 64] PAEs could also rise if the providers assuming residents' work are insufficiently rested themselves or poorly suited for the tasks required. If PAEs were to rise, costs would likely increase also. Therefore, this analysis estimated net costs over a range of possible changes in PAE rates (-10% to +10%).

The net costs of the planned changes are likely to differ for teaching hospitals and for society as a whole. Obviously, teaching hospitals will incur the costs of hiring any substitutes or additional residents. However, because most PAE costs occur after hospital discharge, teaching hospitals would experience smaller cost offsets than society if the changes do reduce PAEs.[11] An analysis of the 2003 ACGME reforms determined that its net costs were likely to differ substantially from teaching hospital and societal perspectives.[49] Consequently, the current analysis considers net costs from both the hospital and societal perspective.

We used a decision-analytical model to calculate net costs. The framework for this analysis can be described by the equation below; the decision model is included in Appendix IV. The methods used to estimate each component in the equation, including data sources, assumptions, and ranges considered in sensitivity analyses, are described in this section; except that the methods for calculating the direct costs associated with the planned changes are discussed in the preceding sections. All calculations were performed in Microsoft Excel.

Net cost = [Direct cost of planned changes] – [(Baseline cost of PAEs)(Δ in PAE rate)]

<u>i. Baseline Costs of Preventable Adverse Events</u>

We sought to estimate the costs of PAEs experienced by patients admitted to teaching hospitals after 2003 but before the currently planned changes, using 2008 as the reference year. We determined the baseline costs of PAEs by multiplying average costs per PAE by the estimated number of PAEs in teaching hospitals across the U.S. In turn, the number of PAEs in those hospitals was estimated by multiplying a baseline PAE rate by the number of teaching hospital admissions in the U.S. Ideally, the current study would be based on the actual rates and costs of PAEs across U.S. teaching hospitals after the 2003 ACGME reform was implemented. Such data do not appear to exist at this time, however, so we used the best data sources that are currently available. Table II-6 lists parameters we used to estimate the rate and costs of PAEs in teaching hospitals. The following equation describes our calculations:

Baseline costs of PAEs = (PAE rate)(Cost per PAE)(# of Teaching Hospital Admissions)

Preventable Adverse Event Rate

To estimate the rate of PAEs per hospitalization, we examined a recent systematic review by de Vries et al. The median incidence of in-hospital adverse events across a variety of studies from several different countries was 9.2%, with a median of 43.5% of the events being judged to be preventable, leading to an incidence of preventable adverse events of 4.0%. Across the studies, 7.4% of adverse events (including non-preventable ones) resulting in death.[65] Only one study by Thomas et al. has reported rates of preventable adverse events from a representative sample of U.S. hospitals; other published studies have considered subsets of preventable adverse events, such as negligent events, events related to medications, events affecting children or the elderly, events in intensive care units, and so forth. The study by Thomas et al. was conducted in Utah and Colorado in 1996. It found that preventable adverse events occurred during 1.9% of hospitalizations and 6.9% of these events resulted in death. Event rates did not vary with hospital teaching status.[66, 67]

The study by Thomas et al. was based on data from before the current residency work-hour reforms were implemented in 2003. For the current analysis, we considered whether PAE rates might have changed in teaching hospitals since 2003 by examining a systematic review commissioned by the ACGME. According to a review by Fletcher et al., studies are roughly split as to the effect of duty hour limits on mortality, with about half of studies showing no effect and half showing a favorable effect. Studies of medical and surgical outcomes are even more mixed, with many studies showing no effect, some showing improvements, and some showing worsening of outcomes.[12]

Cost per Preventable Adverse Event

The Utah/Colorado study also determined the total costs of an estimated 8,859 PAEs across hospitals in the two states in 1996. We derived mean costs per PAE from these estimates. However, the estimates require adjustment for geographic differences in the cost of living and wages nationally, and for the decade that has elapsed between 1996 and 2008. In our prior study of the costs of the 2003 ACGME reform, we applied geographic and temporal inflation factors to the Utah/Colorado cost estimates, inflating them to national costs in 2001.[49] For our analyses for the Institute of Medicine, we inflated the 2001 costs to 2006 dollars using medical components of the Consumer Price Index components and the Employment Cost Index for total compensation.[52] We also considered the fact that the use of health care services in the U.S. also rose between 1992 (when the Utah/Colorado study actually collected its data) and 2006. Utilization of physician services increased 50% per Medicare beneficiary between 1992 and 2002.[68] Hospitalizations at ACGME-accredited hospitals increased 13.5% between 2001 and 2006. It seems plausible that a PAE today would result in a greater use of health care resources than an equivalent one in 1996. For the current analysis, we assumed that utilization per PAE did not change between 2006 and 2008. Table II-7 shows the costs per PAE of inpatient care, outpatient care, and lost wages and household production before and after inflating to 2008 dollars.

Although the costs of PAEs do not appear to have been compared between teaching and non-teaching hospitals, there is reason to believe that they might be

higher in teaching hospitals. Care in general is more costly in teaching hospitals; for example, length of stay is greater.[69] Further, a study of preventable adverse drug events in one academic hospital and one non-academic hospital did find that costs can sometimes be higher in academic settings[15], although these results need to be confirmed across a larger number of hospitals.

Number of Teaching Hospital Admissions

To examine the net cost of the planned changes, we focused major teaching hospitals, which we defined as hospitals that are members of the Council of Teaching Hospitals (COTH hospitals). About 75% of residents train in COTH hospitals. Table II-6 lists the number of COTH hospitals and the number of admissions to them in fiscal year 2008.

The ideal statistic would be the number of patients actually cared for by residents when at their home institution and when rotating at other hospitals; however, this number does not appear to have been reported. Focusing on major teaching hospitals has limitations but avoids the more substantial limitations associated with including admissions to all hospitals with ACGME-accredited programs. Residents at major teaching hospitals rotate at community hospitals that have no programs of their own; therefore, focusing on COTH hospitals means that our analysis omits some patients treated by residents. However, programs at community hospitals have only a few residents and the hospitals have many non-teaching patients, so including all hospitals with ACGME-accredited programs would overestimate the number of patients treated by residents. The 1,094 hospitals with ACGME-accredited programs had 17,304,107 admissions in 2008 and the 366 COTH hospitals had 8,777,458 admissions.[60] Thus, roughly half of patients admitted to teaching hospitals are admitted to hospitals where teaching plays a major role. Admissions to the hospitals with ACGME-accredited programs appear to substantially overestimate the true number of inpatients treated by residents. Consequently, the COTH hospital admissions are likely to yield a more accurate estimate of the *percentage* of PAEs that could be affected by reform, although it would underestimate the *absolute number* of PAEs affected by residents' care.

ii. Change in Preventable Adverse Event Rate

As discussed above, the intent of both the 2003 ACGME reform and of the currently planned changes is to improve patient safety. Both the reductions in duty hours and the many new standards for the training environment have the potential to reduce PAEs. While it appears unlikely that the planned changes would increase PAEs, particularly in light of the neutral-to-favorable results of the 2003 duty hour limits,[12] the effect of the planned changes has not been examined. Consequently, we examined a range of possible effects, changes in PAE rates of -10%, -5%, 0%, +5%, and +10%.

iii. Calculating Net Costs

Finally, we calculated net costs across COTH hospitals, meaning net costs per year. To do so, we needed to determine the direct costs of the planned changes to duty

hours and the training environment that would occur at COTH hospitals. We modified the analyses of direct costs discussed in the sections above to consider only the costs associated with residents and training programs at COTH hospitals (see Table II-2 for percentages of residents and programs at COTH hospitals). We identified one-time costs that would occur only during the initial year (training educating residents above the PGY1 year and faculty members who are not new, and purchasing or developing computerized hand-over systems) and amortized those costs over five years (reasoning that residents will generally graduate within five years and computerized hand-over systems may need to be updated or replaced), using a five percent interest rate per year. We then calculated the total annual cost including both the recurring costs and amortized one-time costs. We used this as the costs of the planned changes when assessing net costs.

Next, we calculated net costs across major teaching hospitals by subtracting the changes in costs due to changes in the PAE rate from the direct costs of the planned changes. To consider the teaching hospital perspective, we included the costs of the planned changes and the cost of inpatient medical care resulting from PAEs. Because hospitals pass some of the inpatient costs on to insurance companies and patients, we considered only the portion of costs absorbed by hospitals from the hospital perspective (extrapolating from a recent analysis based on the Utah/Colorado study, about 63% of inpatient PAE costs are absorbed by hospitals).[70] From the societal perspective, we considered the costs of the planned changes and all PAE costs. For both the hospital and societal perspective, we calculated the break-even point (the threshold at which the reform would be cost-neutral), meaning the cost of the planned changes would be balanced by savings due to reduced PAEs.

Table II-6: Model Parameters: Preventable Adverse Event (PAE) Incidence, Mortality and Costs

Model Parameters	Base Case Scenario	References
PAE Rate before 2003, % of Hospitalizations	1.9%	11 65
PAEs Resulting in Death, %	6.9%	11 65
Costs Across Utah and Colorado, 1996		11
PAEs Across Utah and Colorado, 1996, #	8,859	
Inpatient Medical Care	$83,505,000	
Outpatient Medical Care	$75,740,000	
Lost Wages and Household Production	$149,137,000	
Percentage of Inpatient PAE Costs Absorbed by Hospitals	63%	70
Geographic Cost Adjustments, Utah/Colorado vs. U.S.		
Population-weighted Cost of Living Index, 1996	1.045	49 71 72
Wages, 1997	1.075	61
Temporal Cost Adjustments		
Medical Cost Inflation		
1996 to 2006	1.349-1.737	52
2006 to 2008	1.040-1.139	73
Increases in Utilization, 1996 to 2008	1.30	68
Wage Inflation		
1996 to 2006	1.420	52 74-76
2006 to 2008	1.066	77
Council of Teaching Hospitals Members, #	366	60
Hospital Admissions per Year, #	8,777,458	60

Table II-7: Model Parameters: Costs per PAE in 2006, Inflation to 2008, and Total PAE Costs Across All COTH Hospitals

Type of Cost	Cost Per PAE (2006)	Inflation Factor (2006 to 2008)	Cost Per PAE (2008)	Total PAE Costs Across All COTH Hospitals (2008)
Inpatient Medical Care				
ICU	$4,682	1.139	$5,333	$889,414,741
Inpatient Non-ICU	$16,648	1.139	$18,963	$3,162,520,966
Physician care	$711	1.067	$759	$126,508,366
Subtotal	$22,042		$25,055	$4,178,444,073
Outpatient Medical Care				
Nursing Home	$14,353	1.095	$15,716	$2,621,035,735
Outpatient Rehabilitation	$1,674	1.095	$1,832	$305,602,851
Home Health Care	$1,077	1.141	$1,229	$204,902,089
Outpatient Physician Care	$365	1.067	$389	$64,946,849
Medications	$241	1.040	$251	$41,852,815
Equipment	$114	1.083	$123	$20,587,605
Subtotal	$17,824		$19,541	$3,258,927,945
Non-Medical Costs				
Lost Wages	$10,906	1.066	$11,625	$1,938,753,714
Lost Household Production	$14,785	1.066	$15,760	$2,628,368,064
Subtotal	$25,691		$27,385	$4,567,121,778
Total	$65,557		$71,982	$12,004,493,796

III. Results

Table III-1 lists the potential costs of the planned changes to duty hour limits that were included in the cost analysis, under the assumptions used in the base case analysis. This table also includes three alternative scenarios reflecting uncertainty in how the changes may be implemented. Table III-2 lists the results of sensitivity analyses, each of which represents a range of costs generated by varying a single model parameter (with one exception that varied two parameters). The number of PGY1s who will transfer work to others has a substantial effect on the total annual recurring costs of the proposed changes, which range from $176,988,602 if only PGY1s in small programs transfer work to $983,236,618 if PGY1s in all programs do.

Table III-3 includes the potential costs of the planned changes to the training environment that would represent material changes from current conditions and for which quantifying costs appeared feasible. Table III-4 includes the results of sensitivity analyses focusing on changes to the training environment.

Table III-5 lists the total direct annual costs, including the one-time costs amortized over five years.

Figure III-1 summarizes the total direct annual costs from the sensitivity analyses that focused on uncertainty in model parameters. Figure III-2 summarizes the total direct annual costs from the sensitivity analyses focused on uncertainty in implementation approach. We found that the total direct annual cost of the planned changes (including both recurring costs and amortized start-up costs) would be $380,766,262 nationwide (in 2008 dollars). In the sensitivity analysis reflecting uncertainty in model parameters, such as the frequency of extended shifts and the numbers of weeks with extended shifts, total direct annual costs ranged from $226,463,205 to $694,274,461. Uncertainty in how the reforms may be implemented had a much greater effect on the cost estimates. If all PGY1s transferred work to a mixture of attending physicians and nurses, the cost would reach $1,187,014,278. If only PGY1s at small programs transfer work but all other work beyond the current extended shift limits is transferred to substitute providers, the cost would be $817,388,224 using all attendings, $561,769,401 using all midlevels, and $335,141,689 to $739,503,992 using an expanded population of residents (depending on whether the cost of hiring additional residents is based on wages and benefits or average per resident expenditures on graduate medical education from all sources, respectively).

Table III-6 lists the net cost of the planned changes from the perspectives of major teaching (COTH) hospitals and society. The net cost estimates include the direct cost of the planned changes to duty hour limits and the training environment at COTH hospitals, as well as potential changes in the rate of costly preventable adverse events during hospitalization. All of these results are based on the total direct annual costs at COTH hospitals under the base case scenario. If the total direct annual cost is higher, such as due to the use of alternative implementation strategies, the net costs will also be higher and the percentage decline in PAEs required to make the changes cost saving to COTH hospitals or society would be higher.

Table III-1: Results: Recurring Annual Costs of Planned Changes to Duty Hours across All ACGME-accredited Programs (2008)

Affected Residents and Recommendation	Base Case Scenario	Uncertainty in Implementation Approach		
		Midlevel Provider Scenario	Attending Physician Scenario	Additional Residents Scenario†
PGY1 Residents: Reducing Extended Shifts to 16 Hours*				
Cost per resident transferring work to others				
Compliant with 30-hr shift	$53,025	$52,519	$53,025	$16,078 - $53,994
Non-compliant with 30-hr shift	$71,962	$71,276	$71,962	$21,820 - $73,277
Cost across All ACGME-accredited Programs	$37,540,903	$37,182,871	$37,540,903	$11,382,922 - $38,226,886
PGY2+ Specialty Residents: Reducing Extended Shifts to 28 Hours				
Cost per resident				
Compliant with 30-hr shift	$1,486	$3,988	$7,162	$1,486 - $4,605
Non-compliant with 30-hr shift	$5,202	$13,959	$25,066	$5,202 - $16,118
Cost across All ACGME-accredited Programs	$114,353,545	$306,834,124	$550,975,507	$114,353,545 - $354,282,081
Subspecialty Residents: Reducing Extended Shifts to 28 Hours				
Cost per resident				
Compliant with 30-hr shift	$1,229	$684	$1,229	$276 - $790
Non-compliant with 30-hr shift	$4,301	$2,395	$4,301	$965 - $2,766
Cost across All ACGME-accredited Programs	$25,094,154	$13,974,746	$25,094,154	$5,627,561 - $16,135,761
Total Costs across All ACGME-accredited Programs	$176,988,602	$357,991,741	$613,610,564	$131,364,029 - $408,644,727

* Assumes costs are only incurred for residents in small programs.

†Lower number represents stipends and benefits, higher number represents average per-resident GME expenditures from all sources.

Table III-2: Sensitivity Analyses of Recurring Annual Costs of Planned Changes to Duty Hours across All ACGME-Accredited Programs (2008)

Affected Residents and Recommendation	SA #	Cost per Resident per Year, PGY1 *	Cost per Resident per Year, PGY2+ Specialty Residents *	Cost per Resident per Year, Subspecialty Residents *	Total Recurring Annual Cost of Duty Hours Changes across All Programs
Uncertainty in Model Parameters					
Extended Shift Frequency (Q3 to Q6)	2	*Q6:* $26,512 - $35,981 Q3: $53,025 - $71,962	*Q6:* $1,239 - $4,335 *Q3:* $2,477 - $8,671	*Q6:* $1,024 - $3,584 *Q3:* $2,048 - $7,168	$134,976,868 - $269,953,735
Compliance with 30-Hour Shift at Small Programs (75-95%)	3	n/a	n/a	n/a	$176,688,066 - $179,301,425
Duration of Extended Shift if Non-Compliant at Baseline (32 to 38 Hours)	4	*32 Hrs:* $60,600 *38 Hrs:* $83,324	*32 Hrs:* $2,973 *38 Hrs:* $7,432	*32 Hrs:* $2,458 *38 Hrs:* $6,144	$163,503,361 - $190,473,844
PGY2+ Specialty Residents, Weeks on Inpatient Excluding Night Float and Home Call (7-25 Weeks)	5	n/a	*7 Wks:* $446 - $1,562 *25 Wks:* $1,594 - $5,579	n/a	$96,972,515 - $185,268,835
Subspecialty Residents, Weeks on Inpatient Excluding Night Float and Home Call (2-12 Weeks)	6	n/a	n/a	*2 Wks:* $614 - $2,151 *12 Wks:* $3,687 - $12,903	$164,441,525 - $227,176,910
Uncertainty in Implementation Approach					
Number of PGY1s Affected (in Small Programs vs. in All Programs)	1	*Small:* $53,025 - 71,962 *All:* $31,815 - $43,177	n/a	n/a	$176,988,602 - $983,236,618
Number of PGY1s Affected (in Small Programs vs. in All Programs) and Extended Shift Frequency (Q3 to Q6)	1 & 2	*Small, Q6:* $26,512 - $35,981 *All, Q3:* $53,025 - $71,962	*Q6:* $1,239 - $4,335 *Q3:* $2,477 - $8,671	*Q6:* $1,024 - $3,584 *Q3:* $2,048 - $7,168	$134,976,868 - $1,638,727,697

Base Case Scenario, Attending: Resident Substitution Ratio (0.5:1 to 1:1)	7	*0.5:1:* $47,154 - $63,994 *1:1:* $94,307 - $127,988	n/a	*0.5:1:* $614 - $2,151 *1:1:* $1,229 - $4,301	$160,284,868 - $206,216,190
Midlevel Provider Scenario, Midlevel: Resident Substitution Ratio (0.8:1 to 2.4:1)	8	*0.8:1:* $42,015 - $57,021 *2.4:1:* $126,046 - $171,062	*0.8:1:* $3,191 - $11,167 *2.4:1:* $9,572 - $33,502	*0.8:1:* $547 - $1,916 *2.4:1:* $1,642 - $5,749	$286,393,393 - $859,180,179
Attending Scenario, Attending: Resident Substitution Ratio (0.5:1 to 1:1)	9	*0.5:1:* $47,154 - $63,994 *1:1:* $94,307 - $127,988	*0.5:1:* $3,581 - $12,533 *1:1:* $7,162 - $25,066	*0.5:1:* $614 - $2,151 *1:1:* $1,229 - $4,301	$321,419,076 - $642,838,152

* Lower numbers in ranges of per-resident costs represent residents who are compliant with 30-hour shift limit at baseline, higher number represent those who are non-compliant.

Table III-3: Results: Costs of Changes to Training Environment across All ACGME-Accredited Programs (2008)

	Initial Year		Later Years
Components	**One-Time Costs**	**Recurring Costs**	**Recurring Annual Costs**
Educating Residents and Supervising Faculty Members	$38,834,074	$18,202,029	$18,202,029
Offering Transportation to Post-call PGY2+ Residents	--	$111,001,199	$111,001,199
Instituting Structured Procedures for Hand-overs	$16,842,240	$49,015,169	$49,015,169
Enhanced Oversight of Duty Hours and Training Environments	--	$12,699,437	$12,699,437
Total Across All ACGME-Accredited Programs	$55,676,314	$190,917,834	$190,917,834
	$246,594,148		

Table III-4: Sensitivity Analysis of Costs of Changes to Training Environment across All ACGME-Accredited Programs (2008)

Components	SA #	Total Cost of Training Environment Changes in Initial Year	Total Cost of Training Environment Changes per Year (Recurring)
Educating Residents and Supervising Faculty Members			
Faculty Members, #	10	$246,594,148 - $270,332,311	$190,917,834 - $198,098,628
Initial Training per Resident or Faculty Member, Hrs	11	$218,076,097 - $275,112,200	$188,289,165 - $193,546,503
New Faculty Members, % of Faculty	12	No change	$190,205,689 - $191,986,051
Offering Transportation to Post-call PGY2+ Residents			
Taxicab from Hospital to a Resident's Home, Cost per Extended Shift	13	$243,692,956 - $249,495,340	$188,016,642 - $193,819,026
Instituting Structured Procedures for Hand-overs			
Baseline Adherence, % of Programs Using Computerized Sign-Out	14	$232,187,840 - $266,488,574	$180,195,766 - $205,724,500
Computer Sign-out System, Initial Cost of Development or Purchase	15	$237,466,468 - $256,804,708	No change
Weeks on Inpatient at Sponsoring Institution per Year	16	$237,682,300 - $255,505,997	$182,005,985 - $199,829,683
Use of Sign-out Program, Hours Spent per PGY1 Resident per Inpatient Work Day	17	$222,086,564 - $271,101,733	$166,410,250 - $215,425,418
Efficiency Gains from Sign-Out Program, Hours Saved per PGY1 Resident per Day	18	$124,056,227 - $271,101,733	$68,379,912 - $215,425,418
Enhanced Oversight of Duty Hours and Training Environments			
Time Spent by Institution Staff Members During Site Visit	19	$245,623,091 - $249,393,005	$189,946,776 - $193,716,690

Table III-5: Subset of Results: Total Direct Annual Costs of Changes to Duty Hours and Training Environments at COTH Hospitals (2008)

Affected Residents and Recommendation	One-Time Costs in Initial Year	Recurring Annual Costs	Total Direct Annual Cost Nationwide*	Total Direct Annual Cost per COTH Hospital*	Total Direct Cost per Hospital Admission*
Duty Hour Limits	--	$133,803,383	$133,803,383	$365,583	$15.24
Educating Residents and Supervising Faculty Members	$29,358,560	$13,760,734	$20,541,821	$56,125	$2.34
Offering Transportation to Post-call PGY2+ Residents	--	$83,916,906	$83,916,906	$229,281	$9.56
Instituting Structured Procedures for Hand-overs	$14,499,840	$37,055,468	$40,404,566	$110,395	$4.60
Enhanced Oversight of Duty Hours and Training Environments	--	$8,694,497	$8,694,497	$23,755	$0.99
Total	$43,858,400	$277,230,988	$287,361,173	$785,140	$32.74

* Including one-time costs amortized over five years

Figure III-1: Sensitivity Analysis Focusing on Uncertainty in Model Parameters: Total Direct Annual Costs (Including Amortized One-Time Costs) across All ACGME-Accredited Programs

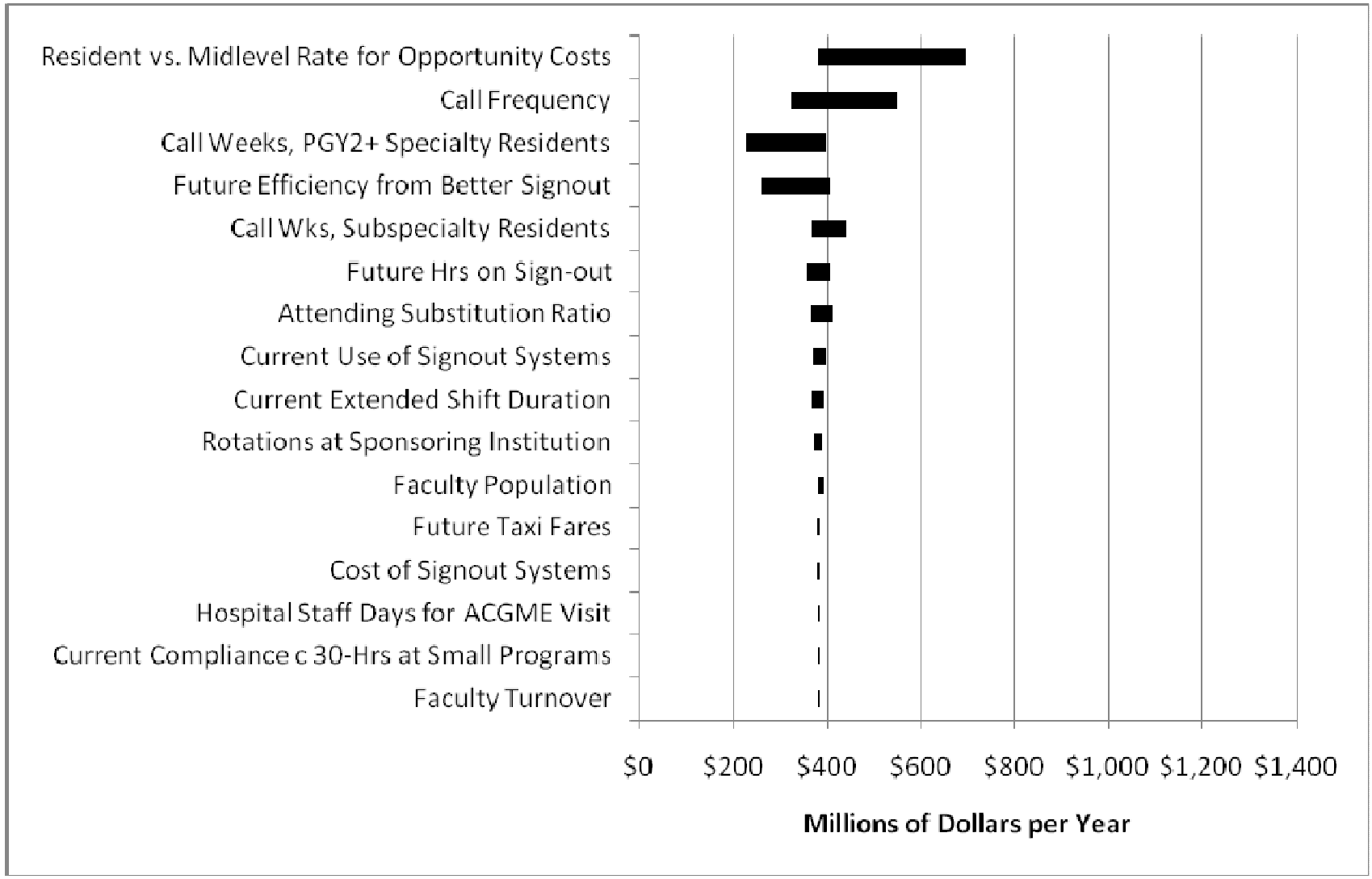

Figure III-2: Sensitivity Analysis Focusing on Uncertainty in Implementation Approach: Total Direct Annual Costs (Including Amortized One-Time Costs) across All ACGME-Accredited Programs

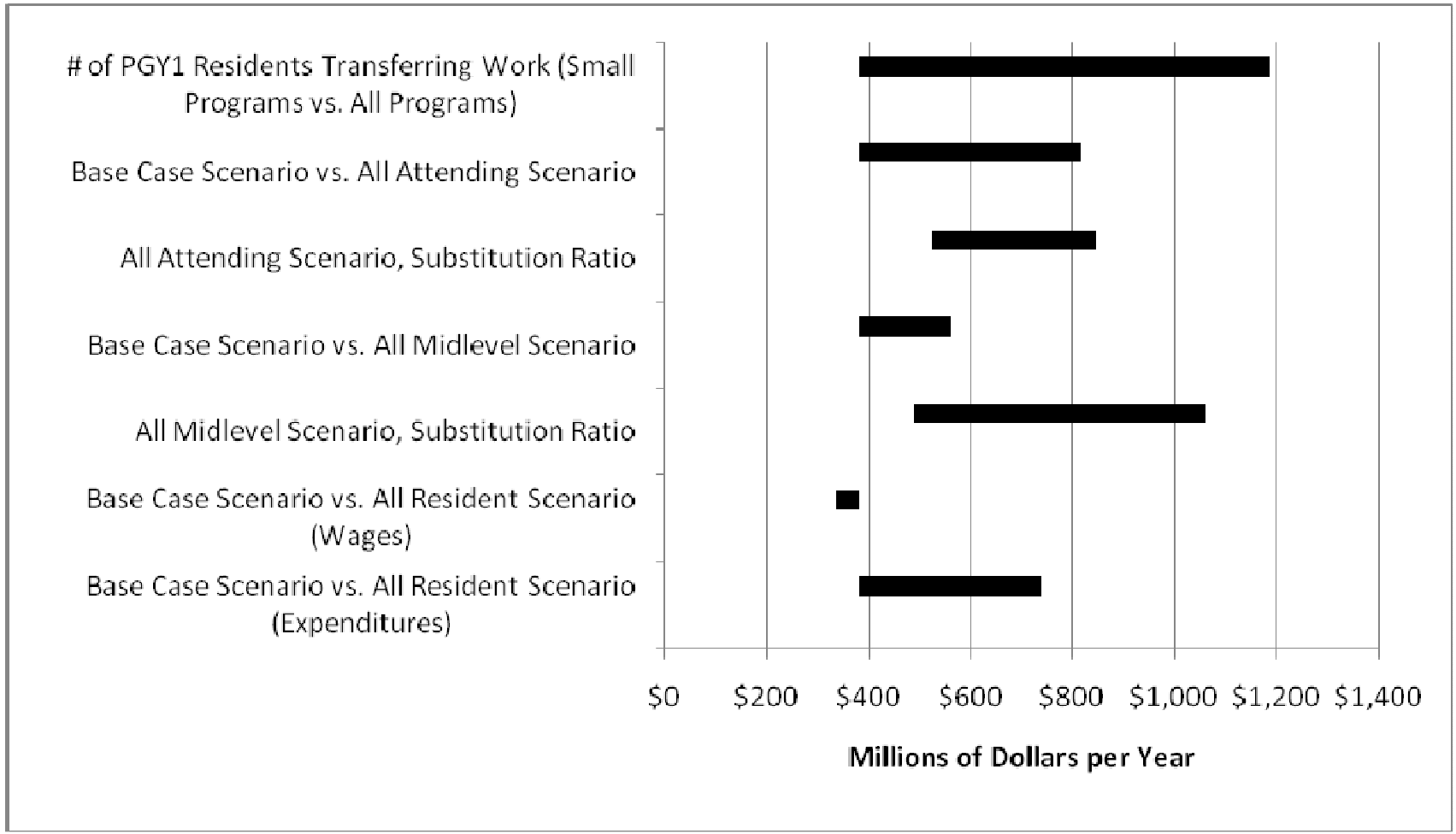

Table III-6: Results: Net Recurring Annual Costs of Planned Changes at COTH Hospitals, Including Possible Changes in PAEs (2008)

	Net Costs			Breakeven Point
Possible Change In PAE Rate After Implementation	Across All COTH Hospitals per Year	Per COTH Hospital per Year	Per Admission	Decline in PAEs
Hospital Perspective				-10.9%
+10%	$550,603,150	$1,504,380	$62.73	
+5%	$418,982,161	$1,144,760	$47.73	
0%	$287,361,173	$785,140	$32.74	
-5%	$155,740,185	$425,520	$17.74	
-10%	$24,119,196	$65,899	$2.75	
Societal Perspective				-2.4%
+10%	$1,487,810,553	$4,065,056	$169.50	
+5%	$887,585,863	$2,425,098	$101.12	
0%	$287,361,173	$785,140	$32.74	
-5%	-$312,863,517	-$854,818	-$35.64	
-10%	-$913,088,207	-$2,494,777	-$104.03	

VI. Limitations

This study has several limitations. One that can be readily identified from the method section is the fact that no studies have comprehensively described the distributions of duty hours worked by residents in training, even after the limits were passed in 2003. Consequently, our assessment of the costs of the duty hour limits is a compilation of data from disparate sources, each with its own limitations. Limitations to available data are even more of an issue for the planned changes to the training environment, for which we needed to estimate costs almost entirely based on assumptions. We addressed the uncertainty in our model parameters by conducting numerous sensitivity analyses and, with one exception, uncertainty in individual parameters had relatively modest effects on total costs. The one notable exception is the number of PGY1 residents who would transfer work to other providers to comply with the 16-hour limit on extended shifts, which was associated with a 5.6-fold variation in the total cost of the duty hour changes.

A second major limitation is the fact that we modeled rather than measured costs. Programs could choose to implement these recommendations in a wide diversity of ways, and may use a combination of approaches. We addressed this limitation through sensitivity analyses and found that, if a greater number of interns needed to transfer work to other providers, the cost of the reforms could be much higher. Greater use of midlevels or attendings could also increase the cost relative to having some work shifted among existing residents.

Further, while we examined the cost of using all midlevels or all attendings, programs may use a combination. In addition, transferring work hour for hour to substitutes and assuming that it will naturally distribute among the substitutes is much different than hiring new full-time equivalent staff members at the program level. Nevertheless, our estimates do isolate the cost of complying with the planned requirements and any estimates generated by studying actual expenditures would be limited by the fact that any newly hired providers may do some work that is attributable to duty hour limits and some work that is unrelated.

We did not quantify the cost of all of the planned changes to duty hour limits and training environments. Based on our review of the literature and own judgments, the omitted changes seemed unlikely to generate substantial costs, often because they represent practices that are already commonplace or even standard in residency programs today. The literature in this regard is incomplete, however, and it is possible that omitting these changes has underestimated the total costs.

Programs' actual expenditures related to the planned changes may also differ from what we have estimated because we included the opportunity cost associated with transferring work among residents or engaging in new activities, such as patient safety training, computerized sign out, and site visits. However, including opportunity costs is important because it acknowledges that both programs and residents may give up some alternative and potentially valuable applications of residents' time.

With regard to our analysis of net costs, the data on the incidence, mortality and costs of preventable adverse events are now several years old. While we have accounted for trends in healthcare costs and wages in the intervening years, little is known about the rate of preventable adverse events in teaching hospitals today. Studies using data from before 2003 have found that rates of preventable adverse

events do not differ according to teaching status.[66, 67] The studies that have examined changes in outcomes on teaching services vs. non-teaching services since the 2003 duty hour limits were implemented have generally yielded mixed results.[12]

Finally, some authors have expressed concern that the incidence and mortality rates in the Utah and Colorado study may be overestimated by 50-100% because the authors did not account for limitations in agreement between reviewers as to when PAEs had occurred.[78] In addition, failing to account for the underlying mortality rate among patients admitted to the hospital can over-estimate the mortality rate associated with PAEs by a factor of four.[79] On the other hand, some other studies have found higher PAE incidence and mortality rates than detected in the Utah and Colorado study.[65]

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Appendix I: ACGME Common Program Requirements (CPRs), Draft Revisions to Section VI. Resident Duty Hours in the Learning and Working Environment: Changes to Duty Hours (ref: ACGME Proposed Standards 2010)

Requirement Established in 2003	Requirement Proposed for 2011	Section in Proposed CPRs	Material Change?	Included in Cost Analysis?	Comment
Maximum Hours of Work per Week:		VI.G.1.			
Duty hours must be limited to 80 hours per week, averaged over a four-week period, inclusive of all in-house call activities.	Duty hours must be limited to 80 hours per week, averaged over a four-week period, inclusive of all in-house call activities and all moonlighting.		No	No	
A Review Committee may grant exceptions for up to 10% or a maximum of 88 hours to individual programs based on a sound educational rationale.	A Review Committee may grant exceptions for up to 10% or a maximum of 88 hours to individual programs based on a sound educational rationale.		No	No	
Moonlighting:		VI.G.2.			
Moonlighting must not interfere with the ability of the resident to achieve the goals and objectives of the educational program. Internal moonlighting must be considered part of the 80-hour weekly limit on duty hours.	Time spent by residents in Internal and External Moonlighting (as defined in the ACGME Glossary) must be counted towards the 80-hour Maximum Weekly Hour Limit.	a)	Yes	No	Costs of counting external moonlighting toward the limit are unlikely to be substantial because most moonlighting occurs during lighter rotations such as electives and research[12][80].
(See above. Moonlighting requirements do not vary with year of post-graduate training.)	PGY1 residents are not permitted to moonlight.	b)	Yes	No	Costs are unlikely to be substantial because few PGY1 residents moonlight[12].
Mandatory Time Free of Duty:		VI.G.3.			
Residents must be provided with one day in seven free from all educational and clinical responsibilities, averaged over a four-week period, inclusive of call.	Residents must be scheduled for a minimum of one day free of duty every week (when averaged over four weeks). At-home call cannot be assigned on these free days.		No	No	
Maximum Duty Period Length:		VI.G.4.			
Continuous on-site duty, including in-house call, must not exceed 24 consecutive hours.	Duty periods of PGY1 residents must not exceed 16 hours in duration.	a)	**Yes**	**Yes**	For PGY1 residents, shifts currently lasting up to 30 hours (24+6) will be reduced to 16 hours.

(See above. Currently, the maximum duty period length does not vary with year of post-graduate training.)	Duty periods of PGY2 residents and above may be scheduled to a maximum of 24 hours of continuous duty in the hospital. Programs must encourage residents to use alertness management strategies in the context of patient care responsibilities. Strategic napping, especially after 16 hours of continuous duty and between the hours of 10:00 p.m. and 8:00 a.m., is strongly suggested.	b)	Yes (see below)	Yes (see below)	Encouraging alertness and strategic napping are unlikely to generate substantial costs but the subcomponents (1) and (2) below would.
Residents may remain on duty for up to six additional hours to participate in didactic activities, transfer care of patients, conduct outpatient clinics, and maintain continuity of medical and surgical care. No new patients may be accepted after 24 hours of continuous duty.	It is essential for patient safety and resident education that effective transitions in care occur. Residents may be allowed to remain on-site in order to accomplish these tasks; however, this period of time must be no longer than an additional four hours.	(1)	**Yes**	**Yes**	For residents in PGY2 year and above, shifts currently lasting up to 30 hours (24+6) will be reduced to 28 hours (24+4).
(See above. Conducting outpatient clinics is permitted.)	Residents must not attend continuity clinics after 24 hours of continuous in-house duty.	(2)	Yes	No	Continuity clinics are an essential component of training in several specialties and most of them will need to be scheduled on non-post-call days. Many programs have already done so.
(Not addressed.)	In unusual circumstances, residents, on their own initiative, may remain beyond their scheduled period of duty to continue to provide care to a single patient. Justifications for such extensions of duty are limited to reasons of required continuity for a severely ill or unstable patient, academic importance of the events	(3)	Yes	No	Costs are unlikely to be substantial because this will be an uncommon event.

	transpiring, or humanistic attention to the needs of a patient or family. *(See CPRs for additional details)*				
Minimum Time Off between Scheduled Duty Periods: Adequate time for rest and personal activities must be provided. This should consist of a 10-hour time period provided between all daily duty periods and after in-house call.	PGY1 residents should have 10 hours, and must have eight hours, free of duty between scheduled duty periods.	VI.G.5. a)	Yes	No	Savings are unlikely to be substantial because break periods of fewer than ten hours are permitted in some specialties already, and are not uncommon in general [18, 20, 56].
(See above. Minimum time off between duty periods does not vary with year of post-graduate training.)	Intermediate-level residents [as defined by the Review Committee] should have 10 hours free of duty, and must have eight hours between scheduled duty periods. They must have at least 14 hours free of duty after 24 hours of in-house duty.	b)	Yes	No	See above.
(See above. Minimum time off between duty periods does not vary with year of post-graduate training.)	Residents in the final years of education should have 10 hours free of duty, and must have eight hours between scheduled duty periods. However, residents must be prepared to enter the unsupervised practice of medicine and care for patients over irregular or extended periods. Under circumstances defined and approved by the Review Committee, residents in their final years of training (as determined by the Review Committee) may be permitted to return to duty with fewer than eight hours between in-hospital activities. This must occur only within the context of the 80-hour	c)	Yes	No	See above.

	and one day off in seven standards. Circumstances of return to hospital activities with fewer than eight hours away from the hospital by residents in the final years of training must be monitored by the program director.	d)	Yes	No	See above.
Maximum Frequency of In-House Night Float: *(Not addressed)*	Residents must not be scheduled for more than six consecutive nights of night float. (The maximum number of consecutive weeks of night float, and maximum number of months of night float per year may be further specified by the Review Committee)	VI.G.6.	Yes	No	Costs are unlikely to be substantial because periods of night float that last longer than 6 consecutive nights do not appear to be common [20](see Appendix III).
Maximum In-House On-Call Frequency: In-house call must occur no more frequently than every third night, averaged over a four-week period.	In-house call must occur no more frequently than every third night, averaged over a four-week period.	VI.G.7.	No	No	Per ACGME, the proposal change that would eliminate averaging has been dropped in response to comments [39].
At-Home Call: a. The frequency of at-home call is not subject to the every-third-night, or 24+6 limitation. However at-home call must not be so frequent as to preclude rest and reasonable personal time for each resident. b. Residents taking at-home call must be provided with one day in seven completely free from all educational and clinical responsibilities,	Time spent in the hospital by residents on at-home call must count towards the 80-hour maximum weekly hour limit. The frequency of at-home call is not subject to the every-third-night limitation. (1) At-home call must not be so frequent or taxing to preclude rest or reasonable personal time for each resident. *(The section on mandatory time free of duty, section VI.G.3.,*	VI.G.8. a)	No	No	

averaged over a four-week period. c. When residents are called into the hospital from home, the hours residents spend in-house are counted toward the 80-hour limit.	*addresses the requirement for one day in seven off when taking at-home call).* Residents are permitted to return to the hospital while on at-home call to care for new or established patients. Each episode of this type of care, while it must be included in the 80-hour weekly maximum, will not initiate a new "off-duty period."	b)	No	No	

Appendix II: ACGME Common Program Requirements, Draft Revisions to Section VI. Resident Duty Hours in the Learning and Working Environment: Changes to Training Environment (ref: ACGME Proposed Standards 2010)

Requirement Established in 2003	Requirement Proposed for 2011	Section in Proposed CPRs	Material Change?	Included in Cost Analysis?	Comment
Professionalism, Personal Responsibility, and Patient Safety		VI.A.			
	Programs and sponsoring institutions must educate residents and faculty concerning the professional responsibilities of physicians to appear for duty appropriately rested and fit to provide the services required by their patients	VI.A.1.	**Yes**	**Yes**	This would entail additional time for education of residents and faculty.
The program must be committed to and be responsible for promoting patient safety and resident well-being and to providing a supportive educational environment.	The program must be committed to and be responsible for promoting patient safety and resident well-being in a supportive educational environment.	VI.A.2.	No		
	The program director must ensure that the residents are integrated and actively participate in interdisciplinary clinical quality improvement and patient safety programs.	VI.A.3.	No	--	Participation in quality improvement and safety programs overlaps with existing requirements for Practice-based Learning and Improvement (CPR Section IV.A.5.c)).
The learning objectives of the program must not be compromised by excessive reliance on residents to fulfill service obligations. Didactic and clinical education must have priority in the allotment of residents' time and energy.	The learning objectives of the program must: a) be accomplished through an appropriate blend of supervised patient care responsibilities, clinical teaching, and didactic educational events; and, b) not be compromised by excessive reliance on residents to fulfill non-	VI.A.4.	No	--	

	physician service obligations.				
Duty hour assignments must recognize that faculty and residents collectively have responsibility for the safety and welfare of patients.	The program director and institution must ensure a culture of professionalism that supports patient safety and personal responsibility. Residents and faculty must demonstrate: a) assurance of the safety and welfare of patients entrusted to their care; b) provision of patient and family-centered care; c) assurance of their fitness for duty; d) management of their time before, during, and after clinical assignments; e) recognition of impairment, including illness and fatigue, in themselves and in their peers; f) attention to lifelong learning; g) monitoring their patient care performance improvement indicators; and, h) honest and accurate reporting of duty hours, patient outcomes, and clinical experience data.	VI.A.5.	**Yes**	**Yes**	This would entail additional time for education of residents and faculty. Adherence to these proposed principles and adherence to duty hour limits will be assessed during annual site visits.
	All residents and faculty must demonstrate responsiveness to patient needs that supersede self-interest. Physicians must recognize that under certain circumstances, the best interests	VI.A.6.	Clarification of principle	No	Estimating resources involved is not feasible because this is an abstract concept rather than a specific task or resource.

	of the patient may be served by transitioning that patient's care to another qualified and rested provider.				
Transitions of Care		VI.B.			
	Programs must design clinical assignments to minimize the number of transitions in patient care.	VI.B.1.	Yes	No	Estimating resources involved is not feasible because it is unclear exactly how this requirement would be implemented.
	Institutions and programs must ensure and monitor effective, structured hand-over processes to facilitate both continuity of care and patient safety.	VI.B.2.	**Yes**	**Yes**	Adhering to this requirement may entail implementing computerized sign-over systems at sponsoring institutions.
	Programs must ensure that residents are competent in communicating with team members in the hand-over process.	VI.B.3.	**Yes**	**Yes**	This would entail additional time for education of residents and faculty.
	Institutions must ensure the availability of schedules that inform all members of the health care team of faculty and residents currently responsible for each patient's care.	VI.B.4.	Yes	No	The proposed change would either require additional staff time to maintain current resident schedules, or simply that residents sign over their pagers to covering physicians.
Alertness Management Faculty and residents must be educated to recognize the signs of fatigue and sleep deprivation and must adopt and apply policies to prevent and counteract its potential negative effects on patient care and learning.	The program must: a) educate all faculty and residents to recognize the signs of fatigue and sleep deprivation; b) educate all faculty and residents in fatigue mitigation processes. c) The program must: adopt fatigue mitigation processes to manage the potential negative effects of fatigue on patient care and learning, including naps and back-up	VI.C.1.	**Yes**	**Yes**	The proposed change is somewhat more detailed and specific than the prior principle, suggesting that programs will need to devote additional time for education of residents and faculty.

	call schedules. Each program must have a process to ensure continued patient care in the event that a resident may be unable to perform his/her patient care duties. The Sponsoring Institution must provide adequate sleep facilities and/or safe transportation options for residents who may be too fatigued to safely return home.	VI.C.2. VI.C.3.	Maybe **Yes**	No **Yes**	Most programs are likely to have such a system already. An exception may be very small programs with few residents, such as fellowship programs. The proposed change would require sleep facilities or transportation before and after extended shifts.
Supervision of Residents The program must ensure that qualified faculty provide appropriate supervision of residents in patient care activities. *(See above)* *(See above)* *(See above)*	In the clinical learning environment, each patient must have an identifiable, appropriately-credentialed and privileged supervising faculty who is ultimately responsible for that patient's care. The program must demonstrate that the appropriate level of supervision is in place for all patients cared for by all residents. Levels of Supervision: To ensure oversight of resident supervision and graded authority and responsibility, the program must use the following classification of supervision: (see Common Program Requirements for categories) The privilege of progressive responsibility, authority and a supervisory role in patient care delegated to each resident must be assigned by the program director and faculty.	VI.D. VI.D.1. VI.D.2. VI.D.3. VI.D.4.	 No Maybe Maybe No	 No No --	 This requirement codifies something that may already be standard practice in most programs. Estimating resources involved is not feasible because it is unclear exactly how this requirement would be implemented. Defines levels of supervision for VI.D.2. This requirement codifies something that may already be standard practice in most programs.

	a) The program director must evaluate each resident's abilities based on specific criteria. When available, evaluation should be guided by specific national standards-based criteria. b) Faculty functioning as supervising physicians should delegate portions of care to residents, based on the needs of the patient and the skills of the residents. c) Senior residents or fellows should serve in a supervisory role of junior residents in recognition of their progress toward independence, based on the needs of the patient and the skills of the resident/fellow.				
(See above)	Programs must set guidelines for circumstances and events in which residents must communicate with appropriate supervising faculty, e.g., transfer to an intensive care unit, end-of-life decisions. a) The resident is responsible for knowing the limits of his/her scope of authority, and the circumstances under which they are permitted to act with conditional independence. In particular, during the PGY1, residents must be supervised either directly or indirectly, with direct supervision immediately available.	VI.D.5.	Yes	No	This requirement codifies something that may already be standard practice in most programs. The one exception is the requirement for PGY1s to have direct supervision immediately available means that "the supervising physician is physically within the confines of the site of patient care, and is immediately available to provide Direct Supervision." Thus, PGY1s cannot be on call in the hospital without a supervising physician also physically present in the hospital. Costs may not be substantial because PGY1s usually have senior back-up available in the hospital now, are

(See above)	Faculty supervision assignments should be of sufficient duration to assess the knowledge and skills of the resident and delegate to them the appropriate level of patient care authority and responsibility.	VI.D.6.	Maybe	No	probably on overnight call when they are without backup, and may have fewer overnight calls if the duty hours changes are implemented. Estimating resources involved is not feasible because it is unclear exactly how this requirement would be implemented.
Clinical Responsibilities *(See above regarding Supervision)*	The clinical responsibilities for each resident must be based on the PGY-level, patient safety, resident education, severity and complexity of patient illness/ condition and available support services. [As further specified by the Review Committee]	VI.E.	Maybe	No	Estimating resources involved is not feasible because it is unclear exactly how this requirement would be implemented.
Teamwork *(Not addressed)*	Residents must care for patients in an environment that maximizes effective communication. This must include the opportunity to work as a member of effective interdisciplinary teams that are appropriate to the delivery of care in the specialty.	VI.F.	Maybe	No	Estimating resources involved is not feasible because it is unclear exactly how this requirement would be implemented.

Appendix III: Summary of Literature Search Addressing the Frequency of Extended Shifts

Author and Year	Summary	Setting	Sample Size*	Call Frequency	Night Float
[1]	Yale University	Trauma service	15 residents on service	PGY2 q4 PGY1 q5	PGY4 night float, weekend call
[2]	One tertiary referral center	Medical ICU	Not reported	PGY3 & PGY1, Q4	
[3]	University of Chicago	Internal Medicine wards	38 PGY1s	PGY1 & resident, Q4	
[4]	University of Chicago	Internal Medicine Wards	58 PGY1s	PGY1 & resident, Q4	
[5]	University of Chicago	Internal Medicine Wards	56 PGY1s	PGY1 & resident, Q4	
[6]	NY University and affiliated hospitals	Orthopedics	190 PGY2-5	No in house call for PGY4 and PGY5	None
[7]	University of Michigan	Inpatient cardiology service	Not reported	PGY1 Q4	Yes (no details) (also day float)
[8]	University of Virginia	Pediatrics wards	26 residents	PGY1 & PGY3, Q4	
[9]	UC San Diego	Anesthesia residents	14 residents 9 PGY1 1 PGY2 4 PGY3	Q4 or Q5	
[10]	Henry Ford Hospital	Trauma/emergency General Surgery	58 residents	Q4	Cross-coverage Q5 or Q6
[11]	Cleveland Clinic	General Surgery	Not reported	PGY1-3 Q4-5	
[12]	Survey of residents on genera/vascular surgery services at 52 hospitals	General/vascular Surgery	844 residents PGY1 36% PGY2 15% PGY3 12% PGY4 9.5% PGY514% PGY6 4.7% PGY7 4.1% >PGY7 2%	In-hospital calls per month, mean 5.71 ± sd 5.50	Nights not on call per month mean 12.9 ± sd 6.33
[13]	Harbor UCLA General Surgery	General Surgery	5 residents per yr	Q 6.4	
[14]	University of Chicago	Internal Medicine	46 residents 52% PGY2, 45% PGY3	Q4	

Author and Year	Summary	Setting	Sample Size*	Call Frequency	Night Float
[15]	Ben Taub General Hospital	General surgery	PGY4 and PGY5	Q4	
[16]	University of Kentucky	Internal Medicine wards	43 PGY1 residents	Q4 at two hospitals	Sunday through Thursday at one hospital
[17]	Massachusetts General Hospital	General surgery	Not stated but included all years	Q4 in-hospital, home call used as back-up	Yes, no detail
[18]	Three hospitals (1 community, 1 university, and 1 medical college hospital)	Internal Medicine wards	28 residents PGY1 39% Remainder above PGY1	Q4 at all three hospitals	
[19]	Yale New Haven	Surgical ICU	Not reported	PGY3 or 4, Q5-Q6	5 nights in a row
[20]	UC San Francisco	Internal Medicine, Family and Community Medicine, Pediatrics, and Psychiatry	66 PGY1s in survey	IM Q3-q6 (inpt 9/12 mo) FCM Q4-6 (inpt 8/12 mo) Peds Q4-6 (inpt 9/12 mo) Psych Q4-7 (inpt 7/12 mo)	
[21]	University of Minnesota	Internal Medicine wards	39 residents	Q4 on wards	
[22]	University of Washington	Internal Medicine wards	118 residents	Q4 on most ward rotations	
[23]	University of Colorado	Internal Medicine wards	106 residents	<= Q4 (PGY1 inpt 9/12 mo, PGY2 inpt 8/12 mo, PGY3 inpt 4/12 mo)	
[24]	Survey of pediatric surgery programs (including U.S. and few Canadian)	Pediatric surgery programs	25 fellows at 31 programs	RESIDENTS: Q3 at 11 programs; Q4 at 13; less call at 7 programs FELLOWS (in house call): 4 programs Q3; 6 programs Q4; 1 program Q5	RESIDENTS: 2 programs started night float rotations
[25]	Yale New Haven	Internal Medicine wards	20 residents	PGY1 & resident, Q4	
[26]	Academic surgery program	General surgery	58 residents	Q4	yes
[27]	19 general	General surgery	238	Current call	

Author and Year	Summary	Setting	Sample Size*	Call Frequency	Night Float
	surgery programs in New England		residents 31% PGY1	schedule Q2 3.2% Q3 26.4% Q4 30.5% Q5 23.2% Home call 16.8%	
[28]	One general surgery program	General surgery	PGY4 or 5	Q6	6 nights
[29]	University of Connecticut	General surgery	PGY-1 to PGY-5	Q4	
[30]	University of Washington	Internal Medicine wards	Not reported	Q4	yes
[31]	Washington University	Internal Medicine wards	52 PGY1	Q4	yes
[32]	University of Colorado	Ob/Gyn	33 residents	30% decrease in call frequency compared with before 2003	yes
[33]	Olive-View Medical Center	Internal Medicine wards	Not reported	Q4	
[34]	MetroHealth in Cleveland, OH	Trauma and emergency surgery	Not reported	PGY4/5, Mean of Q5	
[35]	University of Cinncinatti	Internal Medicine	105 residents	Q4	
[36]	80 general surgery programs in 2004	General Surgery	80 programs	Q4-Q5	15 of 80 programs using night float
[37]	Loyola University Medical Center	Medical ICU	34 Internal Medicine residents, 10 Critical Care fellows	Residents Q4, Fellows home call	
[38]	Baylor	Internal Medicine ICU rotation	20 residents	Q4	
[39]	54 Otolaryngology programs, including program directors and residents	Otolaryngology	54 PDs 312 residents	Compliance c Q3 limit: Mostly 23.2% of residents, Sometimes 5.6% of residents, Never 3.0% of residents	
[40]	Santa Clara Valley Medical Center	Internal Medicine wards	43 residents	Q4	Day float team
[41]	Baylor University	Internal Medicine wards	55 residents	Q4	
[42]	University of	Pediatric Surgery	27	Q3	

Author and Year	Summary	Setting	Sample Size*	Call Frequency	Night Float
	Michigan		residents		
[43]	Wright State University / US Air Force	General Surgery	28 residents, PGY1-4	Q4	Yes
[44]	Harbor-UCLA Medical Center	General Surgery	Unclear, possibly 48 residents	Q6.5 median PGY1 14.75 calls/91 days PGY2 23.5 PGY3 16.75 PGY4 14.25 PGY5 1.25	
[45]	Survey at Mercer University School of Medicine	General Surgery	15 residents	PGY4 and PGY5 q6	5 nights/wk for 1 mo,
[46]	Harbor-UCLA Medical Center	General Surgery	Not reported	Q6.4	

* Sample size represents the number of residents who completed any surveys or, if that was not reported, the number in the residency program.

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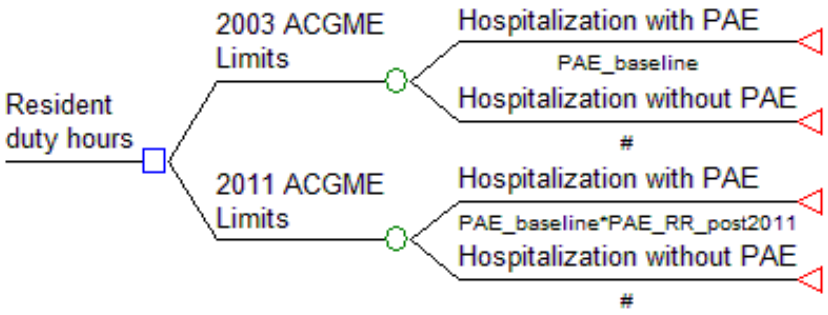
Appendix IV: Decision-Analytical Model for Estimating Net Costs of Proposed Changes, Including Preventable Adverse Events (PAEs)



PAE_baseline: PAE rate from Utah-Colorado Study, i.e., percentage of hospitalizations affected by one or more PAEs

PAE_RR_post2011: Relative risk (RR) of PAE following implementation of the proposed 2011 duty hour limits and changes to the training environment. A 5% decline in the tables corresponds to a RR of 0.95.

#: This symbol represents 100 minus the probability value assigned to the alternative branch.