SYMPOSIUM: PATIENT SAFETY: COLLABORATION, COMMUNICATION, AND PHYSICIAN
LEADERSHIP

What Effects Have Resident Work-hour Changes Had on Education, Quality of Life, and Safety? A Systematic Review

Joshua D. Harris MD, LT, Greg Staheli MD, MC, USN, LCDR,
Lance LeClere MD, MC, USN, Diana Andersone BS,
Frank McCormick MD

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Abstract

Background More than 15 years ago, the Institute of Medicine (IOM) identified medical error as a problem worthy of greater attention; in the wake of the IOM report, numerous changes were made to regulations to limit residents' duty hours. However, the effect of resident work-hour changes remains controversial within the field of orthopaedics.

Questions/purposes We performed a systematic review to determine whether work-hour restrictions have measurably influenced quality-of-life measures, operative and technical skill development, resident surgical education, patient care outcomes (including mortality, morbidity, adverse events,

sentinel events, complications), and surgeon and resident attitudes (such as perceived effect on learning and training experiences, personal benefit, direct clinical experience, clinical preparedness).

Methods We performed a systematic review of PubMed, Scopus, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and Google Scholar using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Inclusion criteria were any English language peer-reviewed articles that analyzed the effect(s) of orthopaedic surgery resident work-hour restrictions on patient safety, resident education, resident/surgeon quality of life, resident technical operative skill development, and resident surgeon attitudes toward work-hour restrictions. Eleven studies met study inclusion criteria. One study was a prospective analysis, whereas 10 studies were of level IV evidence (review of surgical case logs) or survey results.

Results Within our identified studies, there was some support for improved resident quality of life, improved resident sleep and less fatigue, a perceived negative impact on surgical operative and technical skill, and conflicting evidence on the topic of resident education, patient outcomes, and variable attitudes toward the work-hour changes. **Conclusions** There is a paucity of high-level or clear evidence evaluating the effect of the changes to resident work hours. Future research in this area should focus on objective measures that include patient safety as a primary outcome.

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This work was performed at The Methodist Hospital, Houston, TX, USA, and Holy Cross Orthopedic Institute, Fort Lauderdale, FL, USA.

J. D. Harris
Department of Orthopedic Surgery, The Methodist Hospital,
Houston, TX, USA

G. Staheli, L. LeClere
Department of Orthopedic Surgery, Naval Medical Center San
Diego, San Diego, CA, USA

D. Andersone, F. McCormick (✉)
Holy Cross Orthopedic Institute, 5597 N Dixie Highway,
Fort Lauderdale, FL 33334, USA
e-mail: fmccormick@partners.org;
drfrankmccormick@yahoo.com

Introduction

Nearly 15 years after the publication of the Institute of Medicine's (IOM) "To Err Is Human," medical injury

continues to be a serious problem. Despite substantial efforts, recent studies demonstrate no change in the frequency of major medical errors [19, 34]. In addressing ways to improve the healthcare delivery system, leaders look to highly reliable organizations (HROs) for methods to improve safety. The airline industry, nuclear power plants, and military organizations are examples of HROs where the error rates are ameliorated with better precautionary and investigative standards of protocol. The organizing principle surrounding HROs is the development of safe systems [20]. The surgical timeout is a successful example of applying HRO principles in the operative room to improve outcomes, reduce complications, and costs of care [18, 25, 30]. Moreover, patient care handoff using mnemonics mirroring military parlance has demonstrated a reduction in medical errors [33].

In an effort to address potential unsafe working conditions within the US residency training programs, the American College of Graduate Medical Education (ACGME) has implemented progressive work-hour restrictions to resident training. Implementation of the work-hour changes has been met with much controversy [30–32]. Advocates for duty-hour limits in the surgical subspecialties cite improvements in patient safety, whereas opponents claim that limiting resident duty-hours jeopardizes resident education and preparedness for independent surgical practice [8, 29]. However, the unique factors associated within the surgical field of orthopaedics and the orthopaedic surgical training are questioned as they relate to these work-hour changes and the factors relating to patient safety. To date, nearly 15 years after the IOM report and implementation of work-hour restrictions, the impact or effect on patient safety remains controversial within the field of orthopaedics.

Thus, we performed a systematic review to determine whether work-hour restrictions have measurably influenced quality-of-life measures, operative and technical skill development, resident surgical education, patient care outcomes (including mortality, morbidity, adverse events, sentinel events, complications), and surgeon and resident attitudes (such as perceived effect on learning and training experiences, personal benefit, direct clinical experience, clinical preparedness).

Search Strategy and Criteria

We performed a systematic review using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and with a PRISMA checklist [26]. Two independent reviewers, both orthopaedic surgeons (FM, JDH), separately completed the search. The search was completed on December 28, 2013. The following databases were used: PubMed, Scopus, CINAHL (Cumulative Index

to Nursing and Allied Health Literature), and Google Scholar. Search terms were selected based on priori-selected inclusion and exclusion criteria. An iterative search strategy was used: (((((((((((safety[Title/Abstract]) OR error[Title/Abstract]) OR errors[Title/Abstract]) OR mistake[Title/Abstract]) OR mistakes[Title/Abstract]) OR complication[Title/Abstract]) OR complications[Title/Abstract]) OR adverse[Title/Abstract]) OR death[Title/Abstract]) OR mortality[Title/Abstract]) OR morbidity[Title/Abstract]) OR fatality[Title/Abstract]) OR sentinel[Title/Abstract])) AND (((((fatigue[Title/Abstract]) OR tired[Title/Abstract]) OR sleep[Title/Abstract]) OR rest[Title/Abstract]) OR weary[Title/Abstract]) OR exhausted[Title/Abstract])) AND (((((orthopedic[Title/Abstract]) OR orthopaedic[Title/Abstract]) OR surgery[Title/Abstract]) OR surgical[Title/Abstract])) AND (((resident[Title/Abstract]) OR residency[Title/Abstract]) OR training[Title/Abstract])). Inclusion criteria were any English language peer-reviewed articles that analyzed the effect(s) of orthopaedic surgery resident work-hour restrictions have had on patient safety, resident education, resident and/or surgeon quality of life, resident and/or surgeon technical operative skill development, and resident and/or surgeon attitude/opinions toward work-hour restrictions. Exclusion criteria were any non-English language article, any conference abstract subsequently unpublished, any article that analyzed a nonorthopaedic surgery specialty, and any article that failed to analyze the effect of orthopaedic surgery resident work-hour restrictions on patient safety, resident education, resident and/or surgeon quality of life, resident and/or surgeon technical operative skill development, and resident and/or surgeon attitude/opinions toward work-hour restrictions (Fig. 1). Both print and e-published articles were eligible for inclusion. In the event of disagreement on final study inclusion for analysis, discussion and consensus among all study authors based on study participant(s), intervention(s), comparator(s), and outcome(s) were obtained. Within all included studies, individual bibliographies were crossreferenced for potential identification of studies omitted from the initial search. In the event of duplicate study participant(s) and/or intervention(s), only one study was included (greater amount of participant, intervention, and/or outcome detail; more recent publication date; or longer followup).

To put together a search strategy that allowed us to take a more evidence-based approach to our literature search, PICO criteria [11] (patient/population, intervention, comparison, outcome) were sought from individual studies and extracted, when applicable. Participant details included number of orthopaedic surgery resident physicians, number of board-eligible and/or -certified orthopaedic surgeons, and their respective years of experience (eg, postgraduate years and/or years in independent practice). Intervention details included reduction in resident work hours (both

Fig. 1 A PRISMA flowchart demonstrates the results of our search strategy.

quantitative [number of hours] and qualitative [pre- and postwork-hour reduction]). Outcome parameters included patient safety measures (eg, mortality, morbidity, adverse events, sentinel events, complications), resident and/or surgeon quality-of-life measures (eg, fatigue, rest, sleep, weariness, satisfaction, happiness, perception of quality of education), and education and/or technical operative skill development (eg, manual dexterity tests, skills, and oral and/or written examinations).

Eleven studies met study inclusion criteria. One study was a prospective analysis, whereas the rest of the studies were of level IV evidence (review of surgical case logs) or results of surveys (Table 1). Four of the 11 studies were published within the last 5 years. Five of the 11 studies addressed resident quality of life, resident operative and technical skill was studied in nine of the 11 studies, resident surgical education was addressed in seven of the 10 studies, and six of 10 studies addressed patient care outcomes.

Study heterogeneity precluded meta-analysis. Descriptive statistics were calculated for each investigation's variable analyzed. Continuous variable data were reported

as mean $\pm$ SD (weighted means where applicable). Categorical data were reported as frequencies with percentages.

Results

Quality of life for residents has improved through subjective surveys/questionnaires based on three studies [12, 25, 38]. One study asked residents on a 1 to 5 scale with 1 denoting strong disagreement and 5 denoting strong agreement. On average all residents reported a 4.2 (average responses of junior residents was 4.7 versus senior residents was 3.6). This study also found that residents agreed that they were more rested (4.3 overall, 4.5 among junior residents, 4.1 among senior residents) and more neutral on whether they thought they could spend more time with family (3.0 overall, 3.1 among junior residents, 2.8 among senior residents) [2]. Fifty-eight percent reported most fellow residents were generally happier and 57% felt more rested (68% junior residents versus 57% senior residents) [38]. Similar findings that residents and program directors generally agreed that quality of life had improved were

Table 1. The majority of the 11 research manuscripts addressing our questions are level V reviews of surgical case logs, OITE examination scores, or large-scale surveys

Studies	Study Characteristics	
	Level of Evidence	Study Design
“Effect of Duty Hour Standards on Burnout...” (2006) [3]	N/A	Administration of surveys before and after the implementation of ACGME work-hour restrictions
“The Early Effects of Code 405 Work Rules on Attitudes...” (2005) [38]	N/A	Comparison of questionnaires given to junior residents, senior residents, and staff surgeons
“Measuring the Attitudes and Impact of the Eighty-hour...” (2006) [17]	N/A	Nationwide survey of orthopaedic surgery residents
“Residents Work-hour Rules: A Survey...” (2007) [12]	N/A	Nationwide survey of orthopaedic surgery residents and program directors
“Impact of the 80-hour Workweek on Surgical Exposure...” (2009) [10]	Level IV	Retrospective comparison of number of CPT codes logged by orthopaedic surgery residents after implementation of work-hour restrictions to an historical control cohort
“The Impact of the ACGME Work-hour Regulations...” (2006) [7]	Level IV	Retrospective comparison of case logs from a cohort of residents after work-hour restrictions to an historical control cohort
“The Effect of Resident Work Hour Regulations...” (2007) [36]	Level IV	Retrospective review of case log data and subjective estimates of cases lost by residents after work-hour restrictions compared with historical cohort
“Long-term Follow-up on the Educational...” (2012) [9]	N/A	Yearly administration of a survey on duty-hour limits to orthopaedic surgery residents at a single orthopaedic residency program
“Operative Experience in an Orthopaedic Surgery...” (2008) [4]	Level IV	Retrospective review of a resident case logs over a 6-year period
“Orthopaedic Resident and Program Director” (2011) [26]	N/A	National survey of orthopaedic surgery residents’ and program directors’ opinions on resident duty hours
“Surgeon Fatigue: A Prospective Analysis of the Incidence...” (2012) [25]	Level II	Prospective study of a cohort of residents to measure sleep and awake data to measure sleep, activity, fatigue, and effectiveness

CPT = Current Procedural Terminology; N/A = not applicable.

noted in another study [25]. Objectively, it was interesting to note that there was actually no significant change in the average reported hours of sleep during the previous week (35 hours in 2003 versus 34 hours reported between 2004 and 2009) ($p = 0.801$). [14]. Resident work hours have also objectively reduced resident burnout [3].

Results for operative and technical skill varied among the studies. Overall, the average number of cases performed per resident increased each year after implementation of the work-hour restriction (464 versus 516, but this was not statistically significant per year [Postgraduate Year {PGY}-2 $p = 0.29$; PGY3 $p = 0.06$; PGY4 $p = 0.85$; PGY5 $p = 0.49$]) [10]. Another study noted similar findings in the average number of operative cases per resident per year increasing (364 versus 410, with a mean increase of 47 cases per resident [$p = 0.02$]), most significantly increasing for PGY-5 residents (275 before 80-hour work week versus 348 post change to 80-hour work week, a 74 average increase in cases performed per work week ($p = 0.001$)) [4]. This is in

contrast to a decrease in the total number of hours performing major procedures (31 in 2003 versus 25 in 2004–2009) [9]. However, small programs’ caseloads may have a negative impact [36].

Studies have demonstrated variable support for work-hour changes on resident education. The only objective data analyzed were Orthopaedic In-training Exam (OITE) scores before and after the changes, which did not show a change. The average raw OITE scores before the work-hour change was 160 for PGY-2, 180 for PGY-3, 187 for PGY-4, and 196 for PGY-5. OITE score postwork-hour changes were 161 for PGY-2, 180 for PGY-3, 186 for PGY-4, and 197 for PGY-5. These scores were analyzed from a single orthopaedic residency but show no significant difference ($p > 0.05$) when compared with national raw scores (prework-hour change: 148 for PGY-2, 168 for PGY-3, 181 for PGY-4, 181 for PGY-5 versus postwork-hour change: 145 for PGY-2, 165 for PGY-3, 176 for PGY-4, and 184 for PGY-5 [10]).

We identified no studies that objectively assessed resident work-hour impact on orthopaedic patient outcomes. Several studies found variable subjective opinions. For example, Immerman et al. found junior residents saw the changes as a positive on patient care, whereas senior residents and residency directors did not [12]. The majority of studies addressing this topic found variable opinions within the study samples [17, 25, 38].

Attitudes and perceptions from residents and program directors were generally negative. One study, which surveyed 4207 orthopaedic residents from July 2004 to November 2004, found that 40% of residents believed the work-hour changes resulted in favorable changes to training programs (56% junior residents, 38% senior residents), 24% felt it caused deficits in learning and training experiences, 23% believed the 80 hours per week appropriate, whereas 34% felt the 80 hours per week was insufficient [17]. A similar study found that, between April and July of 2011, 71% of residents believed the 80-hour per week was appropriate to only 38% of program directors, 26% of residents believed they would have to do fellowships to compensate for decreased surgical volume to 45% of program directors, and 56% of residents believed they were being prepared as an attending surgeons to only 17% of program directors [25].

Discussion

Since 2003, there have been major changes to graduate medical education. Changes in duty-hour restrictions and levels of supervision have been made to the residency framework with improved resident fatigue and patient safety as goals. These broad changes apply across residency specialties, postgraduate years, and rotations. Controversy surrounds whether these changes have improved resident education and patient safety. We aimed to critically evaluate the supporting orthopaedic literature on the effects of duty-hour restrictions on quality of life, resident education, surgical training, patient safety, and resident attitudes/perceptions about the changes (Table 2). This systematic review demonstrates evidence of improved resident quality of life and resident fatigue but insufficient evidence supporting duty-hour restriction on improving patient safety and surgical training (Table 3).

This study had several limitations. First, the heterogeneity of study outcomes and results must be taken into account. The lack of studies and the lack of scientific quality highlight the difficulty and substantial resource allocation needed for these types of studies. Second, the methods of study provide a lack of objective outcomes. Questionnaire-style, self-reporting, and pre-/postsurveys were the most commonly used tools. These study designs

create challenges regarding validity. Inherent to these methodologies is bias. Only one study was a prospective cohort study; thus, one must consider selection bias of retrospective review as potentially influential on the results observed. There is a performance bias in that many studies were of residency programs at large, academic centers. Lastly, there may also be substantial publication bias within the literature that misrepresents negative effects on patient safety secondary to duty-hour restrictions. The results of our study must be viewed critically given their small numbers and heterogeneity. Although the number of studies that met inclusion criteria is quite low, perhaps the most remarkable finding of this systematic review is the overall low level of evidence of available data. The majority of studies are survey-based studies administered to residents asking them to opine on the effects of the 80-hour work week as it relates to fatigue, burnout, case volume, and actual hours worked. Nearly all of the available objective data is a product of reviews of resident case logs after implementation of the 80-hour work week or OITE scores and a comparison to historical controls from before the work-hour restrictions. There is one study that includes prospective objective data on resident sleep and fatigue [24] and no studies addressing objective patient care issues and medical errors. This lack of scientific rigor in study design and analysis may indicate an overall attitude of relative apathy toward the effect of the 80-hour work week on these issues. Conversely, methodologically strong studies are difficult to design and implement. Large database reviews may allow further insight to the implication of the work-hour changes across the specialty within the United States and other countries embarking on similar changes.

A primary goal of this review was to assess for any change in resident quality of life after the work-hour changes. We identified evidence of improvement. Six of our 11 studies included quality of life as a defined outcome measure with five showing substantial improvements. This area was often the most common area of study but difficult to quantify. We identified supportive survey results [28] in terms of improvements in resident fatigue and sleep. However, fatigue is still prevalent despite the restrictions. This is in agreement with other specialties, in which a recent systematic review demonstrated only a modest improvement in sleep and less fatigue [23]. Moreover, orthopaedic residents may be offsetting their activities into other academic pursuits [28]. It is unclear how quality-of-life improvements during residency affect resident education or patient safety within orthopaedics.

An additional goal of this review was to assess for any change in resident surgical skill development after the work-hour changes. The duty-hour restrictions and operative volume during training were evaluated in four studies.

Table 2. A summation of the studies' specific findings as they relate to the question of interest, specifically in regard to resident quality of life, resident surgical and technical training, resident education, fatigue and sleep, patient outcomes, and attitudes is presented

Effect of Duty-hour Restrictions on:						
Studies	Resident Quality of Life	Operative Experiences	Surgical Education	Sleep and Fatigue	Patient Care	Attitudes
"Effect of Duty Hour Standards on Burnout..." (2006) [3]	N/A	N/A	N/A	Decrease in Burnout in Orthopaedic Residents.	Depersonalization Scores Declined.	Personal Accomplishment Score Was High and Decline in Emotional Exhaustion.
"The Early Effects of Code 405 Work Rules on Attitudes..." (2005) [38]	Quality of Life Has Improved	Junior Residents Felt It Was Negatively Impacted. Seniors Did Not.	Senior Residents Felt It Was Negatively Impacted. Juniors were Neutral.	Most Residents Reported Feeling More Rested.	Mixed Reviews on Lack of Errors, Continuity, and Improvement of Patient Care.	Mixed Reviews.
"Measuring the Attitudes and Impact of the Eighty-hour..." (2006) [17]	Quality of Life Has Improved	Most Residents Believed Training Environment Has Improved. Perceive That the Quality of Training is Diminished.	Educational Experiences Are Currently Unknown.	More Time for Rest Voted by the Majority.	Mixed Reviews.	Mixed Reviews.
"Residents Work-hour Rules: A Survey..." (2007) [12]	Quality of Life has Improved and Agreed by All	Junior Residents Saw It as Positively Affecting Surgical Experience. Seniors and Directors Did Not.	Junior Residents Thought Education Had Not Been Effected, Seniors and Directors Did Not.	N/A	Junior Residents Saw It as Positively Affecting Patient Care. Seniors and Directors Did Not.	Overall Were Mixed, but Agreed on Quality of Life Improving.
"Impact of the 80-hour Workweek on Surgical Exposure..." (2009) [10]	N/A	Increase in Operative Experiences. Increase in PGY-2 and PGY-3 Cases.	OITE Scores Remained the Same, So Education Has Not Been Effected.	N/A	N/A	N/A
"The Impact of the ACGME Work-hour Regulations..." (2006) [7]	N/A	No Significant Changes in Number of Operative Cases. PGY-2, PGY-3, and PGY-5 Showed Slight Increase.	N/A	N/A	N/A	N/A
"The Effect of Resident Work Hour Regulations..." (2007) [36]	N/A	Subjective Data: Residents Missed Cases. Objective Data: Decrease in Case Volume.	Long-term Analysis Must Be Done to Show Impact on Education.	N/A	N/A	N/A

Table 2. continued

Studies	Effect of Duty-hour Restrictions on:					
	Resident Quality of Life	Operative Experiences	Surgical Education	Sleep and Fatigue	Patient Care	Attitudes
“Long-term Follow-up on the Educational...” (2012) [9]	More Studies Needed	Clinical Experience Experienced No Change. Perceived Quantity of Clinical Experience Decreased. Decrease in Hour of Performing Major Procedures. Decrease in Perception of Opportunity to do Relevant Procedures.	Decrease in Satisfaction With Educational Experience. Perceived Decrease in Quality of Inpatient Clinical Instruction and Didactics. No Significant Changes in Perceived Teaching Staff Availability and Quality of Teaching. More Studies Needed to See Effect on Education	No Correlation Between Time Spent Sleeping and Work Hours. Perception of Fatigue Decreased.	More Studies Needed.	Decrease in Clinical Preparedness.
Operative Experience in an Orthopaedic Surgery...” (2008) [4]	N/A	No Effect of Duty-hour Restrictions on Caseload. Increase in Caseload in PGY-5 Residents.	N/A	N/A	N/A	N/A
“Orthopaedic Resident and Program Director...” (2011) [26]	Improved Quality of Life	Majority of Residents and Directors Agreed That the New 2011 Standards will Decrease Case Numbers.	Attending Surgeons Perceived a Negative Impact on Education of the 2003 Restrictions. Residents Disagreed.	N/A	Attending Surgeons Perceived a Positive Impact on Patient Care of the 2003 Restrictions. Residents Disagreed.	Mixed Reviews. Residents and Program Directors Agreed That Further Reductions Would Be Detrimental.
“Surgeon Fatigue...” (2012) [36]	N/A	Residents Fatigue Levels Are Predicted to Increase the Chances of Medical Error by 22% as Compared With Well-rested Subjects.	N/A	Resident Fatigue is present.	Resident Fatigue Increases the Chances of Medical Errors.	N/A

N/A = not applicable.

Table 3. A review is shown of the study findings based on the available literature

Area of Study Focus	Supported/Unsupported	Findings
Resident Quality of Life	Supported	Improved Resident Quality of Life
Resident Operative and Technical Skill Development	Unsupported	Perceived Negative Impact
Resident Surgical Education	Unsupported	N/A
Resident Sleep and Fatigue	Supported	Improved Resident Sleep and Fatigue
Patient Care Outcomes	Unsupported	N/A
Attitudes Toward Work Hours	Unsupported	N/A

The quality of our findings is supported primarily by low-level evidence. N/A = not applicable.

This study outcome was easier and more objectively studied based on case logs or institutional records. An increase in overall case volume was seen in three studies. It is unclear if there was truly an increase in case volume or if higher emphasis was placed on accurate case log recording. A confounding factor is the concurrent development of orthopedic trauma cases transitioning to being performed in a dedicated trauma operating room during the data instead of as add-on cases after elective cases. In comparison, other surgical specialties have seen decreases in surgical caseload volume [15] but no change in obstetric and gynecology [16]. Further study correlating case volume and patient outcomes and safety would be beneficial and would support residency duty-hour changes.

We also identified no major decline in resident education during the changes. Much of this may be attributed to the lack of available tools to assess the change. The best objective data comparison may be using OITE scores. However, this may not be an accurate measurement for resident surgical knowledge. To our knowledge, work-hour changes in the American Board of Orthopedic Surgery Step I and Step II pass rates have not been addressed. This may be the best assessment regarding the effect of work hours on resident education. A lack of influence on surgical outcomes is consistent with findings in other surgical fields [7, 13, 35]. The surgical field in general appears to be embracing computer simulation, standardization, and annual knowledge base assessments performed by the respective surgical societies.

We did not find supportive objective data to address patient-reported outcomes as they relate to the work-hour changes. Addressing the patient outcomes with resident work-hour changes is difficult and amenable to significant confounding variables. A recent systematic review suggested a mortality reduction after work-hour implementation but noted inadequate study quality and that this change was present in teaching and nonteaching hospitals alike [2]. A review of the National Trauma Data Bank demonstrated a mortality reduction after work-hour changes but could not link the two variables [27]. A comprehensive review of the Swiss work-hour changes demonstrated no effect on patient safety [6]. In related studies, there was no difference between

patient outcomes during specific months of training (ie, the July effect) [1]. HRO organizations have found significant utility assessing the influence of fatigue on human error after a sentinel event. This may be a viable path forward to optimize patient outcomes in the hospital.

A tertiary goal of this review was to assess and quantify resident and surgeon attitudes toward the implemented changes. This was done to assess the cultural support and early perceptions of those involved with the changes. As expected, there is substantial variability in junior resident, senior resident, and attending attitudes and responses regarding work-hour restrictions and the effects of these new changes. Each of these entities has different goals and perspectives on resident education and work-hour restrictions. This variability is not unique to the field of orthopedics; similar results have been found in other specialties and cross-sectional surveys of residents/program directors [5, 21, 22, 37]. Further study is warranted to evaluate the reason for this resident-attending attitude divergence. We feel that for progressive change to occur, all parties should agree on a common vision.

In summary, this systematic review did identify supportive data for an improved resident quality of life, improved resident sleep and less fatigue, a perceived negative impact on surgical operative and technical skill, and inconclusive results on resident education, patient outcomes, and attitudes toward the work-hour changes. However, there is a paucity of high-level evidence evaluating the effects of the changes made. It is uncertain how the past ACGME changes and possible future changes will affect patient care and safety. Changes in resident education should be made to improve patient care and resident education with evidence-based evaluations that support the changes made. Future research in this area should focus on objective measures that include patient safety as a primary outcome.

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