IMPORTANCE  The chief resident (CR) year is a pivotal experience in surgical training. Changes in case volume and diversity may impact the educational quality of this important year.

OBJECTIVE  To evaluate changes in operative experience for general surgery CRs.

DESIGN, SETTING, AND PARTICIPANTS  Review of Accreditation Council for Graduate Medical Education case logs from 1989-1990 through 2011-2012 divided into 5 periods. Graduates in period 3 were the last to train with unrestricted work hours; those in period 4 were part of a transition period and trained under both systems; and those in period 5 trained fully under the 80-hour work week. Diversity of cases was assessed based on Accreditation Council for Graduate Medical Education defined categories.

MAIN OUTCOMES AND MEASURES  Total cases and defined categories were evaluated for changes over time.

RESULTS  The average total CR case numbers have fallen (271 in period 1 vs 242 in period 5, \( P < .001 \)). Total CR cases dropped to their lowest following implementation of the 80-hour work week (236 cases), but rebounded in period 5. The percentage of residents' 5-year operative experience performed as CRs has decreased (30% in period 1 vs 25.6% in period 5, \( P < .001 \)). Regarding case mix: thoracic, trauma, and vascular cases declined steadily, while alimentary and intra-abdominal operations increased. Recent graduates averaged 80 alimentary and 78 intra-abdominal procedures during their CR years. Compared with period 1, in which these 2 categories represented 47.1% of CR experience, in period 5, they represented 65.2% (\( P < .001 \)). Endocrine experience has been relatively unchanged.

CONCLUSIONS AND RELEVANCE  Total CR cases declined especially acutely following implementation of the 80-hour work week but have since rebounded. Chief resident cases contribute less to overall experience, although this proportion stabilized before the 80-hour work week. Case mix has narrowed, with significant increases in alimentary and intra-abdominal cases. Broad-based general surgery training may be jeopardized by reduced case diversity. Chief resident cases are crucial in surgical training and educators should consider these findings as surgical training evolves.
many surgeons consider their experience as chief resident (CR) particularly formative. Within the paradigm of graduated responsibility, increasing independence may be entrusted to CRs by attending surgeons. Operative experience at this stage is especially important as trainees undertake more technically challenging procedures and assume a more substantive role during the case. Surgical training has undergone significant changes in the last 10 years. Given the importance of the CR year, this study was designed to address two questions: has the number or diversity of CR cases changed over time and are these changes temporally associated with the 80-hour work week?

Methods

Available case log data for all US general surgery residents were obtained from the Accreditation Council for Graduate Medical Education (ACGME) for academic year (AY) 1989-1990 through AY 2011-2012. Individual residents’ case logs represent total cases performed during the entire 5 years of residency. The ACGME aggregates individual case logs and provides a report containing summary statistics for that year’s graduating resident cohort. In addition to 5-year case volume, the reports also summarize operative volume performed during the CR year. Endoscopy and critical care were not included in this analysis.

Secular trends were evaluated in 2 complementary analyses. First, mean and median cases per resident were assessed in a year-by-year fashion; this was done for total major cases (TMCs) and for CR cases. Total major cases (cases performed over the entire 5 years of residency) is presented in addition to CR-specific data to provide context for the changes seen in CR case volume. For the second analysis, yearly data were combined into periods to smooth the impact of any individual year on overall trends and to group residents into similar training eras: period 1 (AY 1989-1990 to AY 1993-1994), period 2 (AY 1994-1995 to AY 1998-1999), period 3 (AY 1999-2000 to AY 2002-2003), period 4 (AY 2003-2004 to AY 2007-2008), and period 5 (AY 2008-2009 to AY 2010-2011). Period 3 represents the last 4 classes of residents who trained entirely without duty-hour restrictions. Transition period 4 represents those who trained partially in the unrestricted era and partially in the era of work-hour restrictions. Period 5 represents the first 4 classes of graduating surgery residents who trained entirely under the new ACGME work-hour rules. At the time analysis was performed, reports were available for residents graduating through AY 2010-2011. Prior to article preparation, data for AY 2011-2012 became available, and this was included in all analyses except those based on cumulative periods.

To generate cumulative data for each period, yearly averages and standard deviations (SDs) were combined into period averages and period SDs. This was done for TMCs, total CR cases, and cases performed as CR in certain defined categories. To evaluate changes in the mean number of cases performed during each period, a 1-way analysis of variance (ANOVA) was performed for periods 1, 2, 3, 4, and 5 using the Stata avsgsum command (Stata version 12, StataCorp), which can generate a statistical model from summary statistics (mean, SD, no.). We chose the conservative Bonferroni adjustment for multiple comparisons, and significance was set at α = 0.05. Trends in year-by-year data were evaluated using simple linear regression (SLR). 95% Confidence intervals were reported for each regression β-coefficient.

Coding practices and requirements have changed during the last 23 years; for example, the ACGME-instituted coding changes in AY 2001-2002 that resulted in an acute drop in resident operative volume. More recent examples include the change allowing deep-space abscesses to count as major cases and the change in AY 2011-2012 allowing more than 1 resident to claim credit for different portions of the same case. These and other changes have the potential to impact cumulative numbers of cases recorded by residents. For this reason, we also examined secular trends in the proportion of TMCs performed specifically during the CR year: (CR cases/TMCs for 5 years) × 100. Trends in the proportion of cases performed as CR may be less sensitive to changes in coding practices and more accurately reflect changes in CR operative experience. These proportions are reported by period. Differences were evaluated for significance using the Pearson χ² test (α = 0.05).

Results

Total Major Cases

A total of 23,334 residents graduated between 1990 and 2012. Analysis of reported TMCs discerns 2 dominant trends (Figure 1). From AY 1989-1990 until AY 2002-2003 (the last year prior to duty-hour restrictions), there was an overall increase in case volume of 4.8 cases per year (SLR 95% CI, 2.1-7.6) despite a significant ACGME coding change that caused a drop in recorded cases in AY 2001-2002.1 Prior to 2001, the increase was 7.6 cases per year (SLR 95% CI, 5.4-9.8). Total case numbers dropped after initiation of work-hour restrictions; however, subsequently, there was an increase of 8.8 cases per year (SLR 95% CI, 3.6-14.0). Indeed, the highest mean number of cases per resident reported since AY 1989-1990 was in AY 2011-2012 (980 cases/resident). Figure 2 shows these data grouped into periods. These grouped data reveal a significant decrease in TMCs from period 3 to transition period 4 (36.5 fewer cases, ANOVA P < .001) and a subsequent rebound from transition period 4 to period 5 (33.2 more cases, ANOVA P < .001). There was no difference between period 3 and period 5.

Chief Resident Cases

Chief resident cases showed somewhat different trends (Figure 3). Prior to initiation of work-hours restrictions in 2003, there was an overall loss in mean CR cases at an annual rate of 1.9 cases per year (SLR 95% CI, −3.2 to −0.65). Postwork-hour restrictions, CR case numbers increased but this was not statistically significant (SLR 95% CI, −0.62 to 2.6). When CR year case numbers were aggregated into periods (Figure 2), there was a significant decrease from period 2 to period 3 and from period 3 to transition period 4 (ANOVA P < .001). Following transition period 4, CR case volume rebounded in period 5 (ANOVA P < .001) but remained slightly below that of residents who graduated immediately prior to the 80-hour work week.
The proportion of total 5-year operative experience performed as CR was compared for periods 1 through 5 (Table). There was a nearly 5% drop in the percentage of cases performed as CR from period 1 to period 5 (30.0% vs 25.5%, \( P < .001 \)). Comparing the most recently graduated residents (period 5) with those who graduated in period 3 and with those who graduated in transition period 4, the proportion of CR cases was constant (26.5% vs 25.5%, \( P = .29 \), and 25.8% vs 25.5%, \( P = .67 \), respectively).

**Case Mix**

In each period, alimentary and intra-abdominal cases were those most frequently performed by CRs (Table). Compared with period 1, in which these 2 categories represented 47.1% of CR experience, in period 5, they represented 65.2% (\( P < .001 \)). Comparing the most recently graduated residents (period 5) with those who graduated in period 3 and with those who graduated in transition period 4, the proportion of CR cases was constant (26.5% vs 25.5%, \( P = .29 \), and 25.8% vs 25.5%, \( P = .67 \), respectively).

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**Discussion**

**Operative Volume**

This review of CR operative experience suggests that TMCs and CR operative volume dropped significantly within 1 to 2 years following initiation of the 80-hour work week. Situated within a broader chronological context, these reductions occurred in what had been, until that point, an overall increase in TMCs and an overall downward trend in CR cases. In 2 years, from AY 2002-2003 to AY 2004-2005, mean CR cases dropped by 16 cases, and, comparing across a broader time span, from period 3 to transition period 4, CR cases dropped by 15 cases. The importance of 15 or 16 chief cases to a resident’s training is debatable, but this would be at least 2 weeks’ worth of operating in many programs and 10% of the 150 CR cases required by the Resident Review Committee for Surgery.

After these initial declines in TMC and CR case volume, both categories of operative experience demonstrated a rebound. In analysis by period, both TMC and CR cases increased following transition period 4. For CR cases, year-by-year increases following implementation of the 80-hour work week were not significant by SLR, but this can be explained entirely by the fact that the initial drop in case volume did not occur until 1 year after restrictions were implemented. Indeed, if we evaluate trends from AY 2004-2005
onward (the second year of duty-hour restrictions), there was a significant increase in CR cases of 2.1 cases per year (SLR 95% CI, 1.3-3.0).

Given the available data, it appears as though institutional and/or individual behavior did not change abruptly after the 80-hour work week came into effect, as the CRs graduating in 2003 had very similar operative volumes to their predecessors graduating in 2002. An early mixed-methods study on the effects of duty-hour reform by Mendoza and Britt\(^3\) reached similar conclusions. One interpretation of these data suggests that CRs graduating in 2004, having trained up to that point in the era of unrestricted work hours, did not adjust their patterns of clinical work, but that work patterns of subsequent CR cohorts were more responsive to restrictions. Both TMC and CR case volume demonstrate this pattern; that is, both showed the most significant decline in the second year following implementation of the 80-hour work week. Another delayed effect of the 80-hour work week (in terms of discernible changes in reported case volumes) may relate to the fact that CRs often take home call but junior residents frequently take in-house call. Junior residents required to leave the hospital on their post-call day missed cases they would have performed in the past, but senior residents on home call were insolated from this potentially case-losing effect of duty-hour restrictions.

The proportion of graduating residents’ overall operative volume performed as CR declined in the 1990s then remained relatively stable. Because major differences were not seen across periods 3, 4, and 5, concerns that duty restrictions would shift case volumes up or down seem to have been unwarranted.\(^4\) Furthermore, as overall resident case volume returned to pre-80-hour work-week levels, it appears as though CR cases have increased roughly proportionately to TMCs. That R1-R4 and R5 case volumes rebounded in tandem suggests that no particular segment of trainees got more back as programs implemented changes to accommodate the 80-hour work week. The Resident Review Committee for Surgery-mandated minimums of 750 cases for 5-year operative experience and 150 cases for CR operative experience have been in place since AY 2009-2010 and may have been a factor in the rebound of cases after the initial declines.

**Diversity of Operative Experience**

The diversity of cases performed by CRs has narrowed considerably. Case volumes in thoracic, trauma, and, especially, vascular surgery have fallen substantially, and intra-abdominal and alimentary tract surgery now constitute nearly two-thirds of CR operative experience. These changes in CR case diversity are similar to patterns seen for surgery residency overall and are likely multifactorial. Intra-abdominal and alimentary tract cases may have increased as residents were shifted away from rotations such as cardiac surgery, where operative experience does not provide required cases. Residents may also have been shifted to general surgery services from rotations on orthopedic surgery, otolaryngology, neurosurgery, and other surgical specialties as the 80-hour work week resulted in a 20% to 30% work-hour reduction but no change in the demand for manpower. Declines in trauma operative experience began in the early-1990s, well before the 80-hour work week, and appear to have been driven mostly by changes in the epidemiology of trauma and nonoperative management of blunt abdominal trauma.\(^3\) The advent of endovascular techniques reduced the number of vascular cases residents could include in their case logs because, until 2009, endovascular cases were not considered major cases. Additionally, integrated training programs, such as the integrated vascular surgery residency, may have impacted case numbers reported by general surgery trainees. Because CRs cannot rotate on the same service as fellows, senior-level training in some surgical subspecialties may be obtained at the R4 level, but case logs are not broken down by individual postgraduate year (other than CR year), so it is not possible to test this hypothesis.

**Changing Paradigm for Surgical Education**

General surgery training is changing; this relates to changes in the profession, as well as to changes in graduate medical education.\(^6\) Although the 80-hour work week and subse-
quent 2010 limitations on interns represent the most high-profile changes, many factors have contributed to the trends documented by these ACGME data. Some are not related directly to education and include changes in disease management (eg, trauma), rapid technological advances (eg, vascular), and the changing nature of subspecialization.7 Other factors are more directly related to education: the development of integrated subspecialty programs whose residents compete with general surgery residents for cases and the dramatic increase in postgraduate subspecialty fellowships. Although some studies suggest that subspecialty fellowships do not hamper surgery resident operative experience,8 others offer different conclusions,9 and several leaders in surgical education suggest that this is still an unsettled question.10 Several studies have examined ACGME data since initiation of the 80-hour work week.11-16 Some have analyzed single-institution case logs and some have analyzed national data. The findings are conflicting, which is not surprising when one looks at the entire 23 years of data. Depending on where the snapshot was taken, a different picture may develop. The current study has two strengths in this regard: 9 full years of data are available since the advent of work-hour restrictions and this...
analysis includes 23 years of total data to illuminate long-term trends. Indeed, the ACGME suggested in 2010 that several more years of data collection were necessary before significant conclusions could be drawn about the impact of duty-hour reform on surgical education.15

A small number of previous studies have specifically evaluated changes in CR operative experience,11,17,18 and most authors posit that experience in the CR year is an integral step in the development of a surgeon. Any investigation into the operative experience of CRs invites consideration of the role that supervised autonomy plays in the current era of surgical training. Fillmore et al19 found that perceived autonomy had a measurable impact on the career expectations and anticipated practices of oral and maxillofacial surgery CRs. The authors stressed that “aloneness” per se did not appear to be a good measure of autonomy for these residents, but that supervised independence was sufficient for residents to report autonomous decision making (under the careful watch of supervising surgeons). Development of a fully trained professional requires “gradual transfer” of “entrustable professional activities.”19 For surgeons, performance of such professional activities (ie, operations, perioperative care, outpatient care, and critical care) is gradually entrusted to residents over 5 years. Although this transfer must now take place within a health care context more attuned to notions of proper supervision, it nevertheless has to take place.

Limitations

This study has several limitations. The current online system went live in July 2001, and recent case numbers may have been entered in nearly real-time by trainees, creating logs that more closely match their operative experience. However, prior to this, trainees accumulated and stored their own operative data then submitted them at the end of residency. Such a system was potentially more vulnerable to inaccuracies than the web-based system. Several other changes in case logging regulations have occurred over the last 23 years, and we attempted to identify the major ones (see Methods section). The most recent change allowing more than 1 resident to claim credit for different aspects of the same case would have impacted only the year-by-year analyses because AY 2011-2012 was not included in analyses by cumulative periods. Finally, summary statistics for a cohort of approximately 1000 graduating residents cannot be used to accurately predict operative volume for any individual resident or individual program; however, the summary data presented here do have value in evaluating trends over time for surgical education in the United States.

Conclusions

This analysis of ACGME data suggests that CR operative volume, while already declining, dropped more acutely after the 80-hour work week was implemented; however, after a transition period, a rebound in case numbers was evident as programs adapted to the new rules. Diversity of operative experience has decreased since the early 1990s, and this shows no sign of changing. This narrowed operative experience reflects changes that have been occurring in general surgery more broadly,5,20 but it may be cause for concern, particularly for communities not served by health systems capable of supporting numerous subspecialists.7,10,21 Several leaders in surgery education recently summarized the mission of general surgical residency as the development of surgeons who possess the “unique comprehensive skills that anchor the US health care delivery system in rural and urban communities and the military.”22

Creative responses will be required for surgical training to meet the high bar set by this mission statement,22 and a critical component of this training remains the CR experience. In their chief year, under carefully calibrated supervision, residents must begin to assume the mantle of independent surgeons—formulating preoperative evaluations, performing operations, and directing postoperative care—so that technical skills become surgical competence and fund of knowledge becomes good judgment.23 While operative experience is not the only component of a CR’s education—and number of cases is not a perfect metric for operative experience—the amount and variety of cases performed during a surgery resident’s chief year remain vital components of his or her education.24 We echo the call for innovation6,22,24 in making this cherished part of surgical training a robust educational experience.
However, looking at these numbers over such a long time frame completed the entirety of their training under the new rules. The restricted work hours on a cohort of residents who have had the effect, so that one might better see the true effects (if any) of the new period before and after work-hour restrictions went into effect. In fact, the changing of the general surgeon: national and local trends in resident operative experience. J Surg Educ. 2010;69(5):652-656.


### Chief Resident Operative Experience

#### A Moving Target

Karen Deveney, MD

The effect of Accreditation Council for Graduate Medical Education (ACGME) work-hour restrictions on surgical resident operative experience has been an appropriate concern of residents, faculty, program directors, and such bodies as the Residency Review Committee (RRC) and the American Board of Surgery (ABS). Several studies have already been published on this subject looking at individual program data, as well as national numbers, with varying findings. This study by Drake et al examined national data from the ACGME case log system to look at the volume of chief resident cases and total major cases, as well as case mix, over a 23-year period that encompasses the time before, during, and after work-hour restrictions were implemented by the ACGME in 2003. The authors looked at annual data but then also divided the annual data into 4- to 5-year periods, with a transition period from 2003-2007 during which chief residents’ experience was increasingly affected by work-hour restrictions.

This study has some notable strengths compared with other studies on this subject in that it includes national data and not that of a single institution and it encompasses a longer period before and after work-hour restrictions went into effect, so that one might better see the true effects (if any) of the restricted work hours on a cohort of residents who have completed the entirety of their training under the new rules. However, looking at these numbers over such a long time frame also means that many other factors may have come into play that affect the numbers and which might not all be easily discernible such as a change in what cases are deemed major and countable by the RRC and ABS, increased competition for cases by an ever-increasing number of fellows in both ACGME and non-ACGME accredited fellowships, more vigilance by program directors to assure that residents are entering all cases in the case log system, and a change in practice from operative to nonoperative treatment of specific conditions, to name just a few.

The authors document and attempt to explain changes in both the numbers and types of major cases performed by US surgical residents. Some of their findings are reassuring, including the fact that total case numbers during residency are increasing, not decreasing, most recently. However, the devil is in the details: additional procedures are now being counted as major cases and 2 residents can count different parts of a single operation. They also find that case variety has decreased and some procedures are done far less frequently by residents now. These findings could be viewed as alarming, but, in fact, they simply reflect changes that have occurred in the practice of surgery itself. Directors of the ABS and other surgical leaders have documented the national shift away from operative management of trauma and open surgery for most conditions in general and vascular surgery, as well as the increase in other types of procedures such as laparoscopic operations. The RRC and ABS have appropriately responded...