



# Do working hour limitations have an impact on surgical training: a narrative review

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**Background and Objective:** During the last 20 years working hour limitations (WHL) for medical doctors have been introduced worldwide. Especially for surgical specialties these might pose a risk, as residents' training time is significantly reduced. Also, a higher amount of shift rotations is required as maximum continuous working hours are reduced. The aim of this review was to analyze available literature regarding the impact of WHL on residents' education, patient safety and quality of life.

**Methods:** For this narrative review, a syntax was predefined and used to search MEDLINE, PubMed Central and Bookshelf from database inception until February 13<sup>th</sup> 2022. The syntax delivered 91 publications, with 42 being included in this review (49 excluded due to not addressing the topic of this review or being letters/comments/abstracts). Only manuscripts addressing surgical residents were included. Publications were assessed by two authors independently.

**Key Content and Findings:** Perceived resident education was mostly negatively impacted by WHL with no publication reporting of positive perceived effects. Three publications, analyzing objective measurement of resident education, showed an increase in test scores or at least no change after WHL. Decreased operative case load was reported by 50% of publications, no change by 29% and an increase by 21%. A trend for shift of work load from younger residents towards more senior ones was found. No study reported improved perceived patient safety after WHL. Impact on objectively measured patient safety remained inconclusive with a trend towards impaired patient safety. Most included publications showed positive effects of WHL on residents' quality of life, well-being and time available for family/education.

**Conclusions:** Definitive impacts of WHL on residents' education and patient safety remain inconclusive, although a trend towards reduced operative case load can be seen. Patient safety may suffer due to reduced operative experience, impaired continuity of care, more shift changes and sign-outs as possible sources of errors. Nevertheless, residents' quality of life improved with WHL. Under current WHL, measures have to be taken to facilitate adequate resident education, thereby keeping patient safety high but without prolonging training programs.

**Keywords:** Work hour limitation (WHL); surgical training; education; patient safety

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## Introduction

Medical professions, especially surgical specializations, are well known for their heavy workload. To achieve appropriate technical skills, extensive training is necessary with a high number of hours spent in the operating theatre or hospital in general, working continuously for 24 hours and more. Traditionally this was taken for granted without much thought put into possible ramifications of working schedules, with residents working weeks without a day off and reaching over 100 working hours per week (1,2). One of the most impactful events to cause a paradigm shift in this matter was the tragic Libby Zion case, which caused lawmakers and the public to take notice of overworked residents and take actions to enhance resident education (RE) and patient safety (3). This was mainly done by the implementation of working hour limitations (WHL), such as the 80 hours per week limit by the Accreditation Council for Graduate Medical Education (ACGME) or the 48 hours per week limit by the European Working Time Directive.

Although this solution might seem rather simple, it also possesses some pitfalls, mostly for surgical residents. WHL not only reduce working time, but also time available for surgical training, posing the risk of graduates from residency being less skilled than the generations before WHL. As a result, consultants and experienced surgical staff seem to have more negative sentiments towards WHL. Negative perceptions are also based on WHL requiring more residents and shift changes to provide the same amount of work for patients, which might lead to impaired continuity of care and problems with inadequate sign-outs. Additionally, residents might lose the opportunity to follow up on patients they saw during their time-reduced shift, leading to decreased self-reported quality control. These effects even contradict the original objective of improved patient safety behind WHL, with some literature reporting a significantly increased postoperative surgical complication and mortality rate. Nevertheless, these drawbacks of WHL might be combated through structural changes in medical care to create more efficient RE systems. In contrast to clinical and operative RE, WHL have shown to positively impact residents' quality of life, well-being and time spent with their family. Because of less clinical work residents benefit from having more time available for theoretical education and therefore improving their out of the operating room training (1,4). Even though WHL improve residents personal life, and educational disadvantages can be tackled through system changes, surgeons seem to routinely

disobey WHL, which makes it debatable if WHL should be implemented anyways (1,4-9). Available literature seems to be rather heterogenous regarding methods and results and report contradictory data about the effects of WHL on residents.

The aim of this narrative review was to assess available literature regarding the influence of WHL on residents' surgical training and their possible consequences. We present the following article in accordance with the Narrative Review reporting checklist (available at <https://asj.amegroups.com/article/view/10.21037/asj-22-15/rc>).

## Methods

A search syntax was predefined and used for querying MEDLINE, PubMed Central and Bookshelf: "(work\* [ti]) OR (hour\* [ti]) AND (restriction\* [ti] OR limit\* [ti]) AND (surgery [ti] OR surgical [ti])".

Search timeframe was set from the inception of the database until February 13<sup>th</sup> 2022.

The syntax delivered 91 publications, with 42 being included in this narrative review. Only manuscripts addressing surgical residents were included. The other 49 manuscripts were excluded due to not addressing the topic of this review or being letters/comments/abstracts. As a result of the heterogeneity of publications a narrative review was performed and no systematic review or meta-analysis. All queried publications were assessed by two authors (FP and FA) independently. A summary of the search strategy can be found in *Table 1*.

## Discussion

### *Perceived resident education*

Residents' surgical education and training represents a heavily discussed issue, when arguing for or against work hour restrictions. Concerns are raised, that residents might receive inadequate teaching or have a small case load. As this is a difficult to quantify area, mostly survey studies are available examining the perceived education.

No publications reporting a perceived positive effect of WHL on RE were found by our search query.

Literature query delivered two systematic reviews focusing on work hour restrictions in the United States and reporting a perceived worsening of RE. Ahmed *et al.* show that 36% of available articles report a perceived decline in RE in comparison to only 9% showing the opposite

**Table 1** The search strategy summary

Items	Specification
Date of search	13/02/2022
Databases and other sources searched	MEDLINE, PubMed Central and Bookshelf
Search terms used	“work*”, “hour*”, “restriction*”, “limit*”, “surgery”, and “surgical”
Timeframe	From January 1st 1977 to February 13th 2022
Inclusion and exclusion criteria	All study designs, English language only. No letters, comments or abstracts
Selection process	Selection and consensus through first and senior author

(10,11). An analysis by Peabody of two surveys performed by the American Orthopaedic Association showed that 61% of program directors and chairs evaluated WHL as negative for orthopaedic residency education programs, with 50% of responding residents coinciding. Thirty hour maximum working shifts were criticized the most for having harmful effects on orthopaedic education, because this limits the residents possibility to operate on the cases they evaluated themselves the night before (6). Lee *et al.* assessed the influence of the 16-hour duty period limitation, which was implemented in 2011 by the ACGME, with a multicenter survey consisting of 464 responding residents. Most of the respondents (87%) believed that the 16-hour duty period limitation will have a negative impact on the education of postgraduate year (PGY) I residents. The number of residents having a negative sentiment about the implemented limitation correlated to the stage of residency with 97% of PGY IV-V reporting a negative impact (*vs.* 75% of PGY I residents) (5). A survey study by Coverdill *et al.* showed that 60% of residents have the opinion that the 16-hour intern shift limit “diminishes the preparation of interns for more senior roles”, which was shared by 87% of faculty (12). Moreover, only 16% feel that their sign-out training and corresponding feedback is adequate, which negatively impacts shift changes (13). According to a study by Nakayama *et al.* not even 50% of surgeons think that “graduates of surgery residencies today are prepared in the clinical practice of surgery” (9). Two Canadian survey studies also express perceived negative effects on RE. Hamadani *et al.* showed in their single center study that after the implementation of 12-hour shifts, to avoid 24-hour shifts, 79.4% of residents feared that they were not able to obtain sufficient surgical skills. Only 8.8% saw a benefit in the abolishment of 24-hour shifts on RE (14). A multicenter survey study by Lachance *et al.* corresponds to the above mentioned results reporting that

53% of residents experienced worse clinical supervision and learning opportunities with 50.6% even answering that residency should be prolonged. In comparison to residents, responding professors perceived a significantly worse impact on teaching and surgical learning (15). Only one European study analyzing RE from Switzerland was included. Businger *et al.* performed a multicenter survey assessing the Swiss 50-hour work-week limitation. Similarly to North American results, most Swiss residents (62.8%) and consultants (77.2%) reported adverse effects on surgical training, again showing more estimated impact in more experienced surgeons. Nevertheless, 39.8% of residents answered that WHL allowed for more time spent for studying and preparation, but only 17.9% perceived that their overall knowledge improved because of the Swiss WHL (16). In contrast, Vanderveen *et al.* reported that 68% of surgeons believe that WHL decreases residents time for learning, but at the same time does not negatively influence knowledge or technical skills (76%, 68% respectively) (17).

Antiel *et al.* performed two survey studies analyzing the effect of the ACGME duty-hour regulations on surgical residents at the beginning of their education and over a longitudinal time frame. Residents’ opinions at the beginning of the implementation of the WHL restrictions were inconclusive believing that the new WHL will decrease their acquisition of surgical skills (52.8%) and their overall educational experience (51.1%) (18). In the longitudinal analysis by Antiel *et al.* these initial worries were confirmed in a follow-up study by 52% for a decrease of their development of surgical skills and 49% for their overall educational experience (19). In a study by Coverdill *et al.*, 48% of residents thought that implemented WHL improve surgical training. Noteworthy, only 12% of faculty shared this opinion (20). A survey study by Dennis *et al.* compared records, maintained by residents, of their in-hospital activities in the year before and after the 2011

ACGME WHL. Herein, interns reported no reduced in-hospital time, but also no change on time spent for educational activities or time spent in the operating room (OR), while junior residents (PGY2 and PGY3) spent less time on education and senior residents (PGY4 and PGY5) spent more time in the OR (21). Stamp *et al.* performed a prospective survey study before and after their implementation of WHL in 2004 showing no difference in time spent in the operating room, basic knowledge or teaching by faculty; only for time spent for educational reading an improvement was noticed (22). Spencer *et al.* reported no significant difference in pediatric surgery residents' responses regarding quality of education, time available for reading or overall qualitative assessment of educational value before and after the 80-hour ACGME WHL (23). An analysis of Canadian plastic surgery residents showed that 53% of responding residents think that without working post call the time for achieving adequate surgical skills during their residency is lacking, despite respondents "somewhat agreeing" that working post call negatively impacts their learning and operative capacity (24).

#### *Measured resident education*

Literature regarding objective measurement of RE is scarce. Only three publications were found to match our criteria and all of them report a positive impact on RE. Barden *et al.* and Durkin *et al.* used the ABSITE scores to measure RE before and after the implementation of 80 hours WHL. Durkin *et al.* and Barden *et al.* report of an increase of ABSITE scores for their residents after WHL, but also state that ABSITE scores for PGY1 and PGY2 increased significantly, while chief resident scores were comparable (1,25). A systematic review by Jamal *et al.* found no publication, which reported a negative impact on examination scores (4).

Noteworthy, a study by Freiburg *et al.* tried to answer which measures would improve RE after WHL. The top three rated measures by residents were (I) hospital information technology, (II) use of nurse practitioners and (III) use of physician assistants to support the daily routine of residents (26). Similarly, Peabody's survey showed most of the adaptations for WHL were by increasing the availability of physician assistants or related professions (6). Nevertheless, the quality of training and program reputation remain the leading influencing factors for applicants in their choosing of a surgical residency program, although the majority of medical students would prefer training programs

with WHL if other factors were comparable (27,28).

#### *Operative cases*

Operative case load, as an important factor in surgical RE, was analyzed in 24 of the included publications. Twelve (50.0%) report a decrease in operative cases after WHL, 7 (29.2%) a rather unchanged amount and 5 (20.8%) an increase in operative case load, as can be seen in *Table 2*.

Antiel *et al.* analyzed residents reported operative case load in two surveys at the beginning of their education and over a longitudinal time frame. Most interns believed that WHL will reduce their time performing surgery (67.4%). The longitudinal follow-up study revealed that this fear was confirmed by 57% reporting that their time in the operating room actually was reduced (18,19). Two other US American survey studies by Kort *et al.* and Peabody *et al.* similarly report reduced perceived operative case load by 57.3% and 41%, respectively (6,29). Reduced measured operative case load was shown by four retrospective studies set in the United States with Connors *et al.* describing a reduced effect in later cardiothoracic residency stages and no significant difference in residency year-3. A subgroup analysis of cases revealed that although cardiac cases significantly decreased during each year of residency (pre-WHL 219–251 cases *vs.* post-WHL 187–214 cases, depending on residency year), thoracic case load remained the same at all levels of residency. Overall, after implementation of WHL a decrease in operative cases of about 4–26% for residents was seen (30–32,34). A systematic review by Awan *et al.* expressed a mostly negative sentiment with a trend towards reduced OR cases, especially for junior residents, and a shift of work volume to more senior residents, which reduces their available time for training younger residents (11). All included non-US American studies reported less operative cases for residents after WHL. Following Quebec's 16-hour workday restriction 53% thought that there were too less possibilities to further their operative experience. A two-center retrospective analysis of the impact of an 80-hour WHL in Korea showed that the number of cases with residents participating decreased 5% and 27%, respectively. After the even stricter Swiss WHL with a 50-hour work-week, 76.9% and 73.8% of residents reported a negative impact on OR time and experience (15,16,33).

All seven publications with neutral or inconclusive result are discussing US American residency with various surgical subspecialties, including gynecology and

Table 2 Change of operative case load

Reference	Unit of measurement	Before WHL	After WHL	Change
<b>Reduction of case load</b>				
Antiel <i>et al.</i> (18), 2012, USA	Survey	NDA	NDA	-67%*
Antiel <i>et al.</i> (19), 2013, USA	Survey	NDA	NDA	-57%*
Businger <i>et al.</i> (16), 2010, Switzerland	Survey	NDA	NDA	-77%* in OR time, -74%* in OR experience
Kort <i>et al.</i> (29), 2004, USA	Survey	NDA	NDA	-57%*
Lachance <i>et al.</i> (15), 2014, Canada	Survey	NDA	NDA	-53%* in OR sessions
Peabody (6), 2006, USA	Survey	NDA	NDA	-41%*
Connors <i>et al.</i> (30), 2009, USA	Mean number of cases per year of residency	Year 1: 251.1; Year 2: 218.5; Year 3: 234.6	Year 1: 195.2; Year 2: 187.4; Year 3: 213.8	Year 1: -22%; Year 2: -14%; Year 3: not significant
Damadi <i>et al.</i> (31), 2007, USA	Mean number of cases per resident	1,287.4	1,101.3	-14%
Fairfax <i>et al.</i> (32), 2010, USA	Mean number of cases per resident	949±18	911±14	-4%
Kim <i>et al.</i> (33), 2018, South Korea	Total number of surgeries with residents participating	Center 1: 317; Center 2: 657	Center 1: 302; Center 2: 461	Center 1: -5%; Center 2: -30%
Schwartz <i>et al.</i> (34), 2013, USA	Median annual number of total cases per intern	88.8	65.9	-26%
<b>Increase of case load</b>				
Barden <i>et al.</i> (1), 2002, USA	Mean number of cases performed by chief residents	1,015±148	1,116±176	+10%
Baskies <i>et al.</i> (35), 2008, USA	Mean number of cases per resident	363.6±145.0	410.2±163.6	+13%
Jamal <i>et al.</i> (4), 2011, USA	Systematic Review	NDA	NDA	13 high quality studies reported positive or neutral effect; 2 negative effect
Smith <i>et al.</i> (36), 2017, USA	Total number	45,363	51,144	13%
Smith <i>et al.</i> (37), 2017, USA	Total number	34,685	39,770	15%
<b>Inconclusive results</b>				
Dennis <i>et al.</i> (21), 2013, USA	Mean hours per week spent in the OR	Junior residents: 5.0±7.9; senior residents: 13.7±7.5	Junior residents: 6.0±6.1; senior residents: 20.6±10.7	Inconclusive; change for junior residents not significant
Durkin <i>et al.</i> (25), 2008, USA	Mean number of cases per resident	1,052	1,011	No significant change
Kane <i>et al.</i> (38), 2010, USA	Mean number of cases per resident	723.8	781.7	No significant change
Markelov <i>et al.</i> (39), 2011, USA	Weighted average change in total number of cases	NDA	-1.20 at authors institution; +1.78 for the national program	Inconclusive; no significant change at authors institution
Sadaba <i>et al.</i> (40), 2011, USA	Best evidence topic	NDA	NDA	Inconclusive; best evidence topic publication
Spencer <i>et al.</i> (23), 2005, USA	Mean total number of cases per day performed by residents	Junior residents: 0.70±0.21; senior residents: 1.58±0.42	Junior residents: 0.71±0.15; senior residents: 1.84±0.82	No significant change
Stamp <i>et al.</i> (22), 2005, USA	Mean responses; Likert scale; change in time operating	3.9	3.5	No significant change

\* , data from surveys reports experienced/expected impact. NDA, no data available; OR, operating room; WHL, working hour limitations.

pediatric surgery. Dennis *et al.* reported no difference in the number of hours per week spent in the OR for interns (PGY1) and junior residents (PGY2 and PGY3), but saw an increase for senior residents (PGY4 and PGY5) from 13.7 to 20.6 hours (21). Four publications analyzed the number of OR cases involving residents and did not detect a significant change after WHL (Markelov *et al.* reported a significant increase for the national program, but not for their institution) (23,25,38,39). In a survey study by Stamp *et al.* residents reported of no significant impact on their operative time (22). A “Best Evidence Topic” by Sadaba *et al.* also showed inconclusive results in the literature, with the majority reporting a decrease in operative volume for residents through WHL (40,41).

Four retrospective studies and one systematic review reporting a positive impact of WHL on the number of OR cases were found through our search syntax. Two studies reported that the mean number of cases performed by (chief) residents, before and after WHL, increased by 10–13% (1,35). Two studies by Smith *et al.*, querying the National Inpatient Sample, showed a rise of the total number of head and neck surgeries by 13–15% after the implementation of WHL (36,37). A systematic review by Jamal *et al.* found that out of 15 high-quality publications thirteen showed a positive or at least neutral impact on the number of OR cases (4).

## Patient safety

### Perception of patient safety

Our screening for literature regarding the impact of WHL on patient safety delivered 21 publications of which 14 only reported perceived patient safety, six reported quantifiable objective variables for patient safety and one both. Out of all 15 studies reporting perceived patient safety none reported an improvement after WHL with seven studies reporting a negative and eight a neutral impact. Only one systematic review was found. One European publication was included: Businger *et al.* reported that residents and consultants have a negative perception of their 50-hour WHL on patient care and continuity of care (40% and 70.1%; 48.8% and 72.8% respectively); no difference could be seen between academic and non-academic hospitals (16). Two Canadian survey studies showed that only 2.9% of the residents believed that the newly implemented WHL helped them improve their patient knowledge. Worsening of quality of care was reported by 37% of residents and 47% of professors, with the latter having a significantly stronger

perception of reduced patient safety (14,15). Data by Lee *et al.* showed that US American residents also thought that 16-hour duty limitations lead to insufficient patient sign-outs (57%), which is an important part of continuity of care and a possible source of information loss (5). A similar outcome is measured by Coverdill *et al.* with 55% of residents agreeing that patient safety worsened as a result of impaired communication of information (12). Also, Kort *et al.* reported that the majority of residents (61.8%) believed that continuity of care was worse after WHL, with 36.2% even reporting decreased patient safety (29). A systematic review by Ahmed *et al.* found that the majority of articles (67%) reported a perceived decrease in quality of care. When analyzing perceptions of 16-hour duty limitations 79% of articles reported of a worsening of patient safety (10).

Publications reporting neutral or inconclusive perceived effects on patient care were mostly (7 out of 8) originating from US American data. Antiel *et al.* reported that 80.3% of interns feared that WHL will limit the continuity of care, while at the same time 66.5% answered that WHL will increase or have no effect on quality and safety of patient care (18). A follow-up study by Antiel *et al.* confirmed initial doubts by residents about the benefits of WHL on patient care with 70% of surgical residents believing that continuity of care decreased, while only 63% still thought that patient care increased or did not change (19). Seven publications (including studies with mostly negatively perceived outcomes) also included data of perceived effects on patient care by faculty, professors/directors. In all studies comparing the opinions of residents and faculty/professors/directors, the latter had a more negative sentiment towards the effect of WHL on patient care and safety with 33% to 78% responding with a negative answer in comparison to 24% to 55% of residents (6,12,15,17,20,42). One study by McInnes *et al.* analyzed resident errors due to fatigue post-call and reported that 49% of residents think that medical errors have occurred due to post-call fatigue (*vs.* 40% of directors sharing the same believe) (24). A survey by Stamp *et al.* reported no statistical difference, but a trend towards a decrease in continuity of care, patient care, and an increase of errors in patient care after the implementation of WHL (22).

### Measured patient safety

Dumont *et al.* analyzed morbidity and mortality rates after the implementation of WHL and reported that morbidity significantly increased from 70 to 89 cases per 1,000 patients,

while mortality did not significantly change. In a subgroup analysis the rate of “avoidable” or “possibly preventable” morbidities was also significantly elevated (7). When Switzerland implemented their 50-hour WHL, improving patient safety was one of the main goals. Nevertheless, Kaderli *et al.* reported a higher postoperative surgical complication (2.5% *vs.* 5.0%) and in-hospital mortality rate (OR =3.61), while the intraoperative complication rate remained unchanged (8).

A systematic review by Ahmed *et al.*, including European and US American WHL, found that out of 35 moderate to high quality articles 30% reported impaired patient safety, 19% an improvement and 48% no difference after WHL (10). Awan *et al.* included eight studies comparing patient outcome and did not find significant differences for patient safety after the implementation of the ACGME 2011 duty-hour restrictions. Only one of their included studies (Schroepel *et al.*) found a higher intensive care unit length of stay and longer overall length of stay with the WHL time period being a predictor for LOS ( $\beta=0.74$ ;  $P=0.002$ ) (11,43). Although a meta-analysis by Jamal *et al.* found a 28% increased risk of death in surgical patients associated with long duty hours, the results proved to be not significant. Also, changes in morbidity rates were not significant (44). A retrospective multicenter study performed by Smith *et al.* analyzed complications and mortality for head and neck key indicator procedures and reported no significant difference in both after WHL, regardless of being performed in a teaching or nonteaching hospital (36).

Literature reporting positive effects on morbidity and mortality after WHL implementations remains scarce. Privette *et al.* found significantly decreased complications attributed to providers and mortality rates in surgical patients after the 2003 ACGME WHL, with a reduction from 48.3% to 38.6% and 1.9% to 1.1%. Also patient care hours by attending surgeons increased significantly from 924.1 to 1,683 hours, which might attribute to the lower morbidity and mortality rate. Accordingly, the billing modifier “no qualified resident available” rose by 1,250% (45).

### **Resident quality of life/well-being**

As quality of life and personal well-being is a rather heterogeneous and subjective variable, various publications discussing different outcome parameters were found. Awan *et al.* reported in a systematic review that all three included studies showed impaired “professional and personal well-

being” and only 25% of residents were generally satisfied with the newly implemented duty hour restrictions for PGY1 residents (5,11). Although resident and faculty opinions on WHL often greatly differ, a survey by Coverdill *et al.* showed that 48% of residents and faculty (strongly) agree that the implemented 16-hour shift limit improves quality of life and well-being (12).

In contrast, Lee *et al.* reported that 73% of PGY2 to PGY5 residents feel more fatigued by 16-hour duty WHL due to a higher number of calls (5). Canadian data from McGill University showed that after the implementation of new WHL with 12-hour shifts, the majority of residents (93.8%) answered they feel more sleep deprived and 59.4% described themselves as overworked (14). Also, Lachance *et al.* reported in their study of residents in Quebec (Canada) that 54% of residents perceived their quality of life worse after WHL and 48% even reported a negative impact on their well-being (15).

Contrary to above mentioned results, most included publications reported of positive effects on residents’ quality of life and well-being, which might be a result of over 50% of residents suffering from performance impairment as a result of fatigue prior to WHL (2). The majority of Barden *et al.*’s cohort (85%) experienced a positive effect on quality of life and expressed that they feel more rested and 76% spent more time with their families (1). These results are concurrent with data by Coverdill *et al.* and Kort *et al.* who report that the majority of residents stated to suffer less from fatigue at work and at home, while being able to spend more time with their families. Interestingly, only 23% seem to be more satisfied with choosing surgery as their specialty (20,29). WHL also increased programs directors’ awareness for sleep deprivation (6). Stamp *et al.* reported that all five statements, regarding residents’ quality of life, in their study showed a significantly improved perception by residents (general quality of life, time for rest, time for family, time for socializing and impact on resident well-being) (22). A systematic review by Jamal *et al.* showed no high-quality studies reporting negative effects of WHL on resident well-being or quality of life, although the included study by Zaré *et al.* found no difference in perceived stress (4,46). Also when including the European Working Time directive, a systematic review by Ahmed *et al.* showed mostly (71% *vs.* 29%) positive effects of WHL on resident wellness (10). Only one European survey study, reporting a positive impact of WHL on the quality of life of Swiss surgical residents, was identified and included in our review (16).

## Conclusions

Although extensive literature is available, the benefits and disadvantages of WHL remain mostly inconclusive. A non-negligible part of literature reports of residents' disapproval for new WHL, because of the fear for reduced education and surgical experience. Results are quite inconclusive as perceived and measured RE differ. None of the included studies reported of overall positively perceived effects of WHL on RE. Residents reported of either unchanged or increased time for studying and preparation, but without benefits for their overall knowledge (16,21-23). In total, a trend towards a negative impact of WHL on RE was seen with a larger negative sentiment in more experienced residents (5). Noteworthy, professors and faculty had generally worse perception of WHL comparing to residents (6,12,15,20). Nevertheless, all studies investigating measured RE reported of positive effects on ABSITE scores or at least of no negative impact on examination scores, which should be considered positive, as residents were able to keep their level of knowledge although clinical hours have been reduced (1,4,25). Perhaps these theoretical improvements can also be achieved, at least partly, for surgical skills by providing residents with visual material depicting surgical techniques and procedures (47). For surgical residents, operative case load is a crucial part of training. Half of our included publications thematizing operative case numbers support the thesis of a decrease in case load as a result of a work load shift from younger residents to more advanced ones. Data was given either through surveys or retrospective analysis. Worth mentioning, in thoracic surgery this development could not be reproduced (30). It seems obvious that with less working hours, also operative time and cases should decrease correspondingly, but some studies report unchanged OR cases per residents or even an increase in case load. Interestingly, a trend of an operative work load shift from younger residents to more advanced ones can be observed, which, although benefiting senior residents, restricts the time available for teaching their younger peers. Unfortunately, most studies do not explain their measures undertaken to adapt to WHL. Suggested hypotheses are an increase of surgeries performed by residents during night float rotations, improved OR scheduling for residents, and different time allocations by residents (1,4,35). However, the latter point is only possible if structural changes are performed, which allow residents to reduce their time spent for e.g., charting, rounds or for the outpatient department. For better comparison of the impact of WHL on case load

multicenter studies comparing implemented measures, staffing ratios and working schedules should be performed.

Patient safety is often measured in morbidity and mortality rates, but a deeper understanding of the mechanisms influencing safety requires the analysis of preceding factors. Such factors include, but are not limited to, the number and quality of sign-outs, inconsistent treatments as a result of a higher fluctuation of involved staff, or a higher proportion of administrative work. Reduced duty hours require shorter and more shifts, which inevitably results in more sign-outs. Each sign-out presents the possibility of miscommunication or loss of information. Moreover, because of the higher number of shift and staff changes more medical doctors become involved in patient treatment, potentially hindering streamlined patient care and treatment. Subsequently impaired continuity of care, in combination with reduced operative experience, can lead to worsened patient safety. This may be the reason for such little literature reporting of significant improvements for patient safety and care, with the majority of questions regarding perceived patient safety reporting of a decrease. Even in studies reporting no significant or little decrease in perceived patient safety, residents believed that continuity of care suffered (18,19,29). Objectively measured patient safety was mostly reduced, expressed through increased morbidity and mortality rates after implementation of WHL. According to this review, only a small part of residents is generally satisfied with implemented WHL and some studies even report of decreased personal well-being (5,11). Nevertheless, a trend towards residents being able to spend more time with their family is recognizable (1,22,29). Even though WHL reduce clinical hours for residents, data suggests that corresponding shift scheduling adaptations lead to a higher level of sleep deprivation, as shorter maximum working hours might require a higher number of shifts per resident. Moreover, without changes in staffing ratios these developments result in work intensification, which explains why WHL did not reduce the level of perceived stress for residents (4,5,14,46).

To counter these developments and organize residency more efficiently, WHL will also require restructuring of residency programs and the daily routine in hospitals. New measures, such as implementing additional help with administrative work and IT systems, have to be undertaken. Obviously, also administrative work, time spent on wards and work in outpatient departments is a crucial part of residency to acquire sufficient knowledge of operative indications and possible postoperative complications and their management.



Nevertheless, with WHL, residents need to focus on surgical education and should be at least partly released from administrative tasks. This may be done by creating additional positions for nurse practitioners, physician assistants and related medical profession or introducing up-to-date IT systems (electronic referral, charting, etc.), which might help with performing some repetitive tasks faster and more effectively (6,26,48). Corresponding IT systems might also represent a possibility to standardize patient documentation, treatment decision and sign-outs to reduce information loss. One should consider, even when using these measures, implementing 12-hour shifts instead of 24-hour shifts, for example, may lead to twice the amount of sign-outs and possible sources of error. To provide residents with a sufficient number of surgical cases, while working under WHL, and reduce patient waiting times for surgery, one might also consider to perform elective surgery during duty periods if adequate staffing is available. If not, above mentioned measures might assist in reducing non-operative time for residents to allow for a more 'resident-centered' OR scheduling. This is of importance for providing residents with the possibility to operate the cases they evaluated the day or shift before, to receive feedback on their clinical judgement. Without this quality control residents training of surgical autonomy might require considerably longer periods of education. These suggested changes are not only crucial for the surgical education of current residents, but also for again increasing the popularity of the surgical profession for future aspiring surgical residents. Otherwise, the surgical field will be impaired by reduced hours worked per resident and a progressing shortage of surgeons.

Finding the right working hours for medical professionals, while at the same time considering their educational and socioeconomic consequences, remains a challenge and will most likely require further objective analysis of nationwide data, work processes and already performed measures to adapt for WHL throughout various surgical specialties. Until then surgical societies might even need to evaluate if future training plans necessitate a prolonged residency to at least maintain the current level of surgical training and quality. On the other hand, a prolongation of residency will likely magnify the problem of medical students deciding against becoming surgeons and make professions without extensive practical training more appealing. Considering the current situation and the missing discussion of disadvantages of WHL, it seems unfeasible to further advance WHL without fundamental structural changes in

residency at this point.

### **Limitations**

As a result of literature regarding the influence of WHL on residents' training, well-being, and patient safety being rather heterogeneous compared studies should be interpreted accordingly.

Survey studies often do not report quantifiable measurements or clear definitions of negatively or positively perceived effects.

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