



Durham
University

Centre for Medical
Education Research

Literature Review

The Impact of the Working Time Regulations on Medical Education and Training: Literature Review

A Report for the General Medical Council

August 2012

Dr Gill Morrow

Dr Bryan Burford

Dr Madeline Carter

Prof Jan Illing

Centre for Medical Education Research

Durham University

Acknowledgements

The authors would like to thank Heather Robb, Librarian at Durham University, for her advice in constructing the literature searches.

Executive Summary

Introduction

This report presents an overview of English-language literature relating to the legislated restriction of trainee doctors' working time. It encompasses subjective and objective indicators of the effects of restrictions on trainee doctors' working hours.

The initial intention for the review was to simply update that carried out by Moonesinghe et al. (2011). However, early discussions with the GMC led to a new search strategy being developed, to answer the broader research question of 'What are the effects of working time restriction on medical education and training?'

Method

The research question was mapped to a search strategy consisting of four key concepts: {working time}, {restriction}, {medicine} and {training}. The final search combined the search terms so that all hits contain at least one term within all of the concepts, and was run in three databases: Medline, EMBASE and ERIC. Hits were limited to those in English, with a publication year of 1990 onwards, and fulfilling criteria establishing relevance to the research question. The search (run in October 2011) identified a total of 1,141 papers.

An initial review of titles against inclusion criteria led to the exclusion of 368 titles. The abstracts of the 773 remaining papers were reviewed against the inclusion criteria in more detail, and sorted into initial themes to provide an outline structure for the review. Full papers, and other reports identified through grey literature, Google searches, journal searches and ancestry searching were then considered in more detail. 401 papers were included in the final review.

The review is structured under the main themes identified: (i) fatigue and wellbeing, (ii) perceptions and attitudes, (iii) impact on educational opportunities, (iv) impact on patient care, safety and outcomes, and (v) interventions and solutions.

Findings

Studies were of varying quality and relevance to the UK setting. Some are robust but of questionable relevance while others have small sample sizes or low response rates, but make relevant points. For this reason individual papers taken in isolation may be less informative than the consistency of some findings from different sources.

A major caveat associated with much of the research identified is that it comes from the USA, where hours are restricted to 80 hours per week. Conclusions about the relevance of findings to the 48-hour limit in the UK should therefore be drawn with caution.

Many studies also note the confounding effects of changes to care delivery, education or organisations coinciding with working time restrictions. Any observed effects cannot necessarily be attributed to the restrictions.

Key findings: Fatigue and wellbeing

The physiological and cognitive effects of fatigue are unquestionable, and are demonstrated by a large amount of rigorous research using robust methodologies:

- Fatigue is likely to arise from long shifts or long periods of work.
- Negative effects of fatigue are identified on indicators including subjective and objective stress, with consequences for doctors' health.
- Fatigue is associated with adverse effects on cognitive and psychomotor skills, such as working memory capacity, attentional issues, and performance on simulator tasks.
 - Fatigue has demonstrated negative consequences for personal safety, such as the occurrence of needlestick injuries and sleepiness and increased risk of accidents while driving after long shifts.
 - There are therefore potential consequences for patient safety, such as increased clinical errors and diagnostic mistakes.
- There is some evidence that doctors do not recognise the dangers of fatigue for their clinical practice. Education about the consequences of insufficient sleep may be needed to inform them about the risks of fatigue, to develop strategies for dealing with it and avoiding risk, and to change organisational cultures where long hours are accepted. Organisational strategies may be needed to improve sleep quality and reduce stress. Short naps may be an effective countermeasure to fatigue and its consequences.
- A reduction in working hours alone may not decrease fatigue, which is also affected by different work schedules (e.g. number of consecutive days or nights worked, lengths of intervals between shifts). Effects of fatigue have been found to be more pronounced after night shifts than after day shifts.
- Nonetheless, the reduction in working hours, in conjunction with consideration of work patterns, can contribute to a decrease in fatigue, improve quality of life, and may impact on burnout.

Key findings: Perceptions and attitudes

- Doctors' attitudes towards restrictions are often negative, although studies have found mixed results.
- Junior doctors are often more positive about restricted hours – in terms of the effects on education and patient care as well as their quality of life – than senior trainees and clinical faculty.
- Working hour restriction may be linked to a changing professionalism among younger doctors, but there is no objective evidence that any detrimental changes are occurring.

Older doctors' attitudes may reflect their embeddedness in the previous structure of work; they are more adapted to the previous system, and may be consciously or unconsciously resistant to change.

Key findings: Impact on educational opportunities

- Doctors' perceptions of the educational impact of restrictions are largely negative, although some positive effects are reported.
- There is evidence that restricted working hours need not present obstacles to medical education, and need not have adverse effects on patient safety, despite negative perceptions.
- Studies of educational impact focus on quantity, in terms of the number of cases seen, rather than quality of experience.
 - Concentration on easily quantified indicators such as caseload may disguise effects (positive or negative) on other aspects of education and practice which are not as easily measured. It also contains a bias towards craft specialties which lend themselves to such metrics. No studies were found that reported comparable effects on cases seen in non-craft specialties.
 - They generally identify a reduction in exposure with the introduction of working time restrictions, but many also identify confounding changes to service delivery meaning hours alone cannot be seen as responsible.
 - There is some evidence that caseload may be being maintained at the expense of other activity, e.g. clinic attendance. Other educational indicators show little change.
- There may be a knock-on effect of restrictions through training grades. Junior trainees' experience may suffer in order to give seniors more experience. This means that senior trainees may be able to take on fewer advanced surgical procedures as they are still performing the basic procedures they did not have the opportunities to practice as juniors. This may increase seniors' workload, but also risks their having less advanced experience at the end of training.

Key findings: Impact on patient care, patient safety and clinical outcomes

- There is limited objective support for clinicians' fears and perceptions of negative effects of working time restrictions.
- Studies looking at indicators of patient care and patient outcomes are limited and confounded by other factors, and the findings are mixed.

- Many studies did not detect a significant difference in mortality or clinical outcomes before and after working time restrictions.
- Some studies reported positive outcomes, including: decreased mortality, improved adherence to evidence-based guidelines, reduction in the rate of intensive care utilisation, improvement in the rate of discharge to home or rehabilitation, and a decrease in pharmacist interventions to prevent errors.
- Some studies reported negative outcomes, including: higher morbidity, delayed clinical review, higher risk of in-hospital complications, and increased delays ordering diagnostic tests.
- A UK study of patient outcomes found a trend of improvement spanning the introduction of the WTR, suggesting they are not a primary influence.
- Several studies have found that continuity of care is affected by reduced working hours, and that consequently effective handover is of increased importance.
- Cross-cover between specialties in which doctors have limited experience is a concern, but no studies have considered whether any patient safety issues may arise from this.

Key findings: Interventions and solutions

- A number of strategies for adjusting service and education to meet restricted hours have been reported. These include the redesign of working hours (shifts and rotas, including specific initiatives for night-time services), the redistribution of trainee workload to other professionals (usually nurses or other groups, although sometimes other doctors), and the use of technology to improve monitoring and time management, or to facilitate more flexible learning.
- There is no 'one size fits all' solution to rota design, nor should rotas be set in stone, rather they should be adapted to specific circumstances, and open to revision.
 - Interventions are likely to be most effective when they are developed from the specific local service demands, and with the collaboration and cooperation of the staff involved.
 - People's circadian rhythms should be taken into account in rota design, e.g. by rotating through evening shifts before night shifts, rather than an abrupt change from day to night.
 - Shorter shifts do not seem to be detrimental to education and can be beneficial to residents.
- There are general guidelines for best practice in things that should be avoided:

- A full shift system with blocks of seven nights has been linked to increased stress and fatigue, and found to be less manageable on a personal level compared to blocks of three or four nights.
- Long sequences of daytime work – such as seven long shifts in a row - should also be avoided; with a recommended maximum of four.

Metrics and indicators of impact

- A number of potential indicators of the effects of working time restrictions were identified, but these are situated in their specific locality, and even objective measures (such as hospital standardised mortality rate) will be subject to confounding factors.
- Any longitudinal study, even a prospective one, would therefore need to be alert to these confounds.
- Past and on-going changes to medical education in the UK, and the wider NHS, mean that working time should not be seen as an isolated factor in considering changes in any indicators.

Conclusion

While there are many confounding variables in the literature, not least the difference between European and American restrictions, and the quality of literature is variable, there are consistent patterns of results, indicating some robust findings. The balance of evidence appears to be that while working time restriction is neutral or beneficial in terms of its effects on medical education, patient care and patient safety, attitudes towards it still tend to be negative.

The fact that younger trainees are more positive than their seniors suggests there may be a generational shift, and attitudes may change with time.

Successful interventions or changes in practice seem to be those which are designed around the requirements of a particular clinical context. A successful change in service design or practice in one organisation may not simply transfer to another, even if both are working within the same restrictions. Interventions to address the effects of restricted hours, including redesigned rotas, therefore need to involve the clinical staff who will be affected. Shift design should also consider the physiological aspects of sleep and fatigue, for example by rotating shifts in accordance with circadian rhythms.

As noted above, any future research into the effects of the working time regulations would need to be aware of local circumstances, and the possible confounding effects on any measures used. Future research questions are however identified around doctors' perceptions of work and the effects of specific patterns of working.

Contents

Acknowledgements	ii
Executive Summary	iii
Contents	ix
1 Introduction.....	1
1.1 Search strategy	1
1.2 Inclusion and Exclusion Criteria	2
1.3 Stage 1 – initial filter by title.....	3
1.4 Stage 2 – secondary filter and initial thematic sort by abstract.....	3
1.5 Stage 3 – review of full papers and revision of structure	4
2 General introduction to the literature	6
3 Types of working time restriction and policy.....	7
3.1 Current UK Policy	7
3.2 Current US Policy	11
4 Opinions and commentaries	12
5 Fatigue and wellbeing	14
5.1 Effects of fatigue on doctors.....	15
5.2 Impact of work hour restrictions on fatigue.....	18
5.3 Impact of work hour restrictions on wellbeing and burnout	21
5.4 Summary.....	23
6 Perceptions and attitudes	25
6.1 Compliance with restrictions and perceptions of hours worked	25
6.2 European studies	27
6.3 American studies	28
6.4 Changing attitudes with seniority.....	33
6.5 International comparisons.....	35
6.6 Patient and public attitudes.....	36
6.7 Working time and professionalism.....	36
6.8 Summary.....	37
7 Impact on educational opportunities.....	39
7.1 Perceptions of educational impact.....	39
7.2 Impact of working hour restrictions on caseload	41
7.3 Factors confounding changes in caseload	49
7.4 Other educational opportunities	50
7.5 Teaching time	52
7.6 Examination scores	53
7.7 Summary.....	54
8 Impact of work hour restrictions on patient care, patient safety and clinical outcomes	56
8.1 Perceptions of impact on patient care and patient safety	56
8.2 Objective evidence of impact on patient care and patient safety	58
8.3 Objective evidence on clinical outcomes.....	61
8.4 Summary.....	65
9 Interventions and Solutions	67
9.1 Development of service changes.....	68
9.2 Rota changes.....	69
9.3 Hospital at Night	72

9.4	Redistribution of workload	73
9.5	Technological changes	75
9.6	Other approaches	77
9.7	Summary	78
10	Discussion	80
10.1	Metrics and indicators of impact	83
11	Conclusion	85
11.1	Future research	85
12	References	86

1 Introduction

This report presents an overview of English-language literature relating to the legislated restriction of junior doctors' working time. It encompasses junior and senior doctors' perceptions of the effects of restrictions on juniors' working hours and wellbeing, and measurable effects on education and patient outcomes.

The GMC has had full oversight of the continuum of undergraduate and postgraduate medical education since the merger with the Postgraduate Medical Education and Training Board (PMETB) in April 2010. It has a responsibility to monitor medical training against its standards. As the WTR have been highlighted by some as presenting a threat to postgraduate medical education and training, the project of which this review is a part aims to elaborate whether that threat exists and what form it may take.

The original objective was to identify and review the consequences that WTR-compliant rotas have for trainees, with respect to the impact of new ways of working on the quality of trainee education and training that they receive. There was also particular interest on the part of the GMC in the impact of fatigue and how working time restriction may improve it.

The initial intention for the review was to simply update that carried out by Moonesinghe et al. (2011). However, on closer examination the inclusion criteria for that review were felt to be unnecessarily restrictive, and attempts to replicate their search strategy did not result in a matching set of hits. A new search strategy was therefore developed, to answer the broader research question 'What are the effects of working time restriction on medical education and training?'. This review therefore extends the work carried out by Moonesinghe et al. (2011).

1.1 Search strategy

The research question was mapped to a search strategy consisting of four key concepts: {working time}, {restriction}, {medicine} and {training}. These concepts were developed into search terms using keywords as follows (for the main Medline and EMBASE searches using the OVID portal [<http://ovidsp.tx.ovid.com/>]). In these expressions '*' indicates a wildcard for one or more character, so 'work*' will also capture 'working' and 'worked', as well as 'work'. Double inverted commas "" indicate that the search should return phrases, not individual words. Advice was taken from a Durham University librarian on the construction of the search terms.

{Working time}: "work* time" OR "work* hours" OR "duty hours" OR rota OR shiftwork* OR "shift work*" OR "work* schedule" OR "work* week"

{Restriction}: restrict* OR regulat* OR limit* OR directive OR EWTD OR WTR (the full expressions for the abbreviations are covered in combination of the individual terms).

{Medicine}: medic* OR doctor* OR surg*

{Training}: train* OR educ* OR residen* OR "junior doctor*" OR registrar* OR intern* OR "foundation programme" OR FP

The final search combined these terms with logical AND, meaning that all hits contain at least one of the terms within all of the concepts. Hits were limited to those with a publication year of 1990 onwards.

For the ERIC database, accessed through the FirstSearch portal (firstsearch.oclc.org) which uses a different syntax, the search was entered as:

((kw: restrict* OR kw: regulat* OR kw: limit* OR kw: directive* OR kw: EWTD OR kw: WTR) AND (kw: medic* OR kw: doctor* OR kw: surg*) AND ((kw: shift w work?3) OR (kw: work?3 w schedule*) OR (kw: work?3 w week) OR (kw: work?3 w time) OR (kw: work?3 w hours) OR (kw: duty w hours) OR kw: rota+)).

Table 1 summarise the number of hits from the three main databases targeted: Medline, EMBASE and ERIC, in the first week of October 2011.

Table 1. Number of articles identified

	Search for {Working time} AND {Restriction} AND {Medicine} AND {Training}
Medline (to October 2011week 1) EMBASE (to 2011 week 41)	1,801
ERIC (NB {Training} omitted as it produced too many hits in an education database)	13
Total number of papers following removal of duplicates. (The majority removed automatically during importation to Endnote, and others during title inspection.)	1,141

1.2 Inclusion and Exclusion Criteria

The following inclusion and exclusion criteria were applied when subsequently filtering the papers identified above:

Inclusion Criteria:

- Papers about working time/hour restrictions, directives or regulations.
- Papers in the context of medical education and/or training.
- Papers published between 1990 and October 2011.
- Papers using a range of subjective and objective outcome measures, including
- physiological, psychometric and qualitative responses.

- Papers about rota design and/or implementation.
- Papers concerned with patient safety if related to working time restrictions.
- Papers suggestive of organisational metrics.

Exclusion Criteria:

- Papers not concerned with working time/hour restrictions, directives or regulations.
- Studies which include working time only incidentally.
- Papers that are not in the context of medical education and training.
- Papers not published in the English language.
- Papers published before 1990.
- Clinical and biomedical studies.
- Studies relating to continuing professional development.
- Papers relating to perceptions of anticipated impact.

While English-language publication was a criterion for inclusion, papers were not excluded on the basis of the location of the study.

1.3 Stage 1 – initial filter by title

The retrieved set of 1,141 papers were initially filtered by considering titles against the inclusion criteria, which led to the exclusion of 368 titles, leaving 773 for abstract review. Where titles were not clear, abstracts were considered at this stage, but erring on the side of inclusion for further consideration.

Papers were initially sorted using the ‘Document type’ field in Medline to separate primary research (524 papers) and other documents such as reviews, letters, editorials and commentaries (239 papers). This field was found to not be entirely reliable however – with some reviews and empirical studies not being tagged as ‘journal articles’, while others were, despite being editorials or letters. The field was therefore used only as a rough indicator to prioritise abstract review – the distinction was not subsequently used.

1.4 Stage 2 – secondary filter and initial thematic sort by abstract

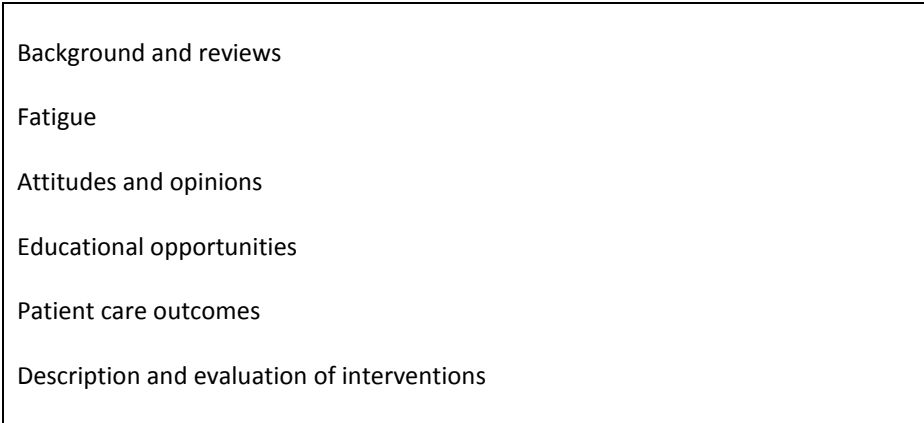
The abstracts of the 773 included papers were reviewed against the inclusion criteria in more detail, and sorted into initial themes to provide an outline structure for the review. The focus at this stage was on sorting primary research papers by the dependent variables or outcome measures included, but also to retain papers which considered the context of working time restriction.

At this stage papers and reports identified in the grey literature were added to the database, and reflected in the outline structure. Google searches, journal searches and ancestry searching (tracking back references in the papers already identified) were also used here, and into stage 3, to identify any additional relevant studies (Haig & Dozier 2003).

1.5 Stage 3 – review of full papers and revision of structure

The final stage of the review was to consider papers in more detail, identifying the key findings from abstracts and full papers, and locating each paper within the themes. Further papers were rejected following closer examination against exclusion criteria. The thematic structure was modified slightly, and subthemes identified at this stage. Figure 1 summarises the main structure followed in the text. Many commentary-only papers were excluded as they provided only observations with no reference to data, and while empirical studies were not automatically excluded on grounds of questionable quality if they raised interesting points or contributed to a weight of evidence, some which were felt to contribute little are omitted for brevity.

Figure 1. Thematic structure for literature review.



The approach in presenting these points was not always to summarise the findings of each paper in detail (although details are provided for some if it was felt to aid interpretation), but to identify patterns of similarity and difference, and to give an overview of the quality of evidence, and any trends or dominant findings in the literature.

Many of the papers included in the review contained measures relevant to more than one theme. To avoid too much repetition, while key results from some papers mean they are referred to in more than one section, the majority are referred to only once. So for example, some studies that included perceptions of educational impact will be included in the ‘Attitudes and opinions’ section, if more general attitude measures were also reported. Where many papers have covered similar ground, more recent literature has been prioritised, although older work is also included.

401 papers are included in the final review, including some identified from snowballing relevant references, papers indexed after the cut-off date for our search, searches of the grey literature, college and other websites, and direct contacts with appropriate individuals. The expansion of the scope of the review from the initial brief means that the review focuses predominantly on the published, peer-reviewed and indexed literature.

2 General introduction to the literature

The nature of much of the literature identified means that there is not a theoretical or empirical coherence to the work: many papers are isolated studies of data in particular localities, and do not build upon one another as may be found in other literatures. Extension or generalisation to wider populations is often not their intention. There are also significant differences in the type of restriction, which should be borne in mind when evaluating evidence and applicability to the current UK situation.

Much of the literature is from the USA, particularly following the ACGME 80-hour restrictions. Issues around the application of possible learning from these studies to the UK setting will be discussed later in this report. When summarising and describing these papers, the American terminology will be used; so 'residents' refer to postgraduate trainees, 'clerkships' to undergraduate clinical placements, 'attendings' to consultant-level doctors, 'hand-off' to handover, etc. Duty-hour limitation or regulation is the preferred term in many of these papers, and will be used where appropriate, although 'working time restriction' is used as a generic phrase throughout.

Our search of the indexed literature identified a number of literature reviews. Those which addressed specific themes are included in their respective sections. Some reviews have been cross-speciality while others have focused on relevance for particular clinical specialties (psychiatry: Rasminsky et al. 2008, surgery: Schenarts et al. 2006, Pape & Pfeifer 2009). Fletcher et al. (2005) proposed a conceptual model placing continuity of care at the centre of considerations of working hour restrictions, feeling it would bring the important perspectives of patients as well as doctors into the identification and definition of measurable outcomes – the consequences of change for continuity of care encompassing a range of outcomes for patient care, as well as educational and trainee wellbeing outcomes.

The cross-specialty review by Moonesinghe et al. (2011) identified conflicting evidence of the impact of restrictions on patient and education outcomes, concluding there is still insufficient evidence to draw firm conclusions about impact. The more robust studies they identified were in the USA, with European studies generally of a lower quality. Swide and Kirsch (2007) observed that the evidence was largely that residents perceive improvement in educational environment and quality of life, but that effects on patient care and outcomes were unclear. Jamal et al. (2011) similarly identified positive effects on residents' education and lifestyle, and no detrimental effects on time in operating theatres. Adverse effects on surgical faculty, in terms of work hours, workload, job satisfaction and quality of life, were identified however.

Of general interest is a review by Schwartz et al. (2011), who identified 23 'conceptual frameworks' around the discussion of working time, from a review of 239 papers. These included a range of outcomes, and a number of ways of operationalising working hours that fall into three broad categories – based on theory, based on best practices, and based on models. The implication is that there is little consistency of approach in the way the impact of working time restriction is discussed. Furthermore, the authors argue that "The concept of duty hours itself is contested" (p26), by which they mean the nature of work in medical training is not simple; should it be regarded as study, and rest when on call, as well as active clinical work? (This resonates with the SIMAP ruling in Europe

which contentiously defined all time spent on the hospital premises as work). They note that there are trade-offs not only between education and patient safety, but resident safety and quality of life, and resource costs. They state that policy should recognise these trade-offs, and society's expectations of how they should be managed.

Woodrow et al. (2006) compared reforms in the USA, France and Canada, illustrating the different drivers for working time restriction in different settings. In the USA the drivers were fundamentally responses to patient safety and resident dissatisfaction, but the actual ACGME regulations were developed to avoid congressional legislation imposing restrictions on the profession, and so were in part an assertion of professional independence. Perhaps because of this, the ACGME monitors hours closely. In Canada, according to Woodrow et al., the introduction of restrictions was driven by unionised residents, and so developed with the protection of resident wellbeing at the forefront. The regulator for doctors in secondary care was not involved, and while it does review hours during accreditation of programmes, it does not have specific policies. In France, working hours were obviously limited by the EWTD, thus presenting a third model, where health and safety legislation is explicitly the primary driver.

These international differences are important to bear in mind in the course of the present review. Underlying issues may be the same, but the policy drivers which actually enable restrictions, and the circumstances in which responses are designed, implemented and received, can vary. Therefore, it is not just the restrictions themselves, or the number of hours worked, that vary, but also their context. This may influence the way in which restrictions are received, and so their effectiveness.

3 Types of working time restriction and policy

The European Working Time Directive (EWTD) was a directive from the Council of Europe to protect the health and safety of workers in the European Union. The Directive was enacted into UK law as the Working Time Regulations (1998) (the WTR), which took effect from 1 October 1998. A deferment for doctors in training was negotiated Europe-wide (although following substantial lobbying from the UK) to provide time to prepare for full implementation.

While this literature review was driven by interest in the WTR, there are several other relevant instances of working time restrictions. Table 2 summarises the main restrictions which are referred to in the literature from the UK and the USA.

3.1 Current UK Policy

The UK policy environment has been defined by dialogues between governments and the medical profession, particularly the Royal Colleges. The most recent significant report from the Department of Health was the Temple Review (Temple 2010), resulting from a Medical Education England consultation exercise carried out between December 2009 and February 2010. The review received oral and written evidence from stakeholders including Royal Colleges, NHS Employers, trainee groups and other organisations. The report noted a lack of 'hard' evidence on the effects of EWTD on training and stated that 'the short timeframe since the introduction of the 48-hour limit in August 2009 means that the conclusive effect on training has not been identified' (p.iv).

Temple concluded that high quality training can be delivered within a 48-hour limit, however 'This is precluded when trainees have a major role in out of hours service, are poorly supervised and access to learning is limited' (p.v). It recommended fundamental changes to the way training and service are delivered including: the implementation of a consultant delivered service; service delivery designed to support training; recognition, development and reward of trainers; regular planning and monitoring of training, and making 'every moment count'.

The GMC has a responsibility to monitor and improve training when compliance with WTR is having a negative impact. It welcomed Temple's report as an important contribution to their understanding of the impact of the WTR.

Several UK Royal Colleges have issued statements and guidance in response to the EWTD, both as distinct papers and as responses to the 'Temple Review'. The Royal College of Paediatrics and Child Health (RCPCH) (2011a, 2011b) published 'Facing the Future', a review and statement of standards reflecting the requirements of WTR (including a consultant led service). The Royal College of Physicians (RCP) published guidance on rota design in 2006 (Horrocks & Pounder 2006), while the Royal College of Surgeons of England (RCS 2007a, 2007b, 2008) published three guidance documents.

General principles of good rota design identified in guidance from the Royal College of Surgeons (RCS) (2007), the Royal College of Physicians (RCP) (Horrocks & Pounder 2006), National Workforce Projects (2009), the BMA Junior Doctors Committee (no date) include:

- Take into account delivery of service; continuity of service; training and supervision (map trainees' work to their training needs); resources/hours available.
- Rota design requires involvement and a degree of 'ownership' by doctors working the rota, as well as senior medical and nursing staff.
- Knowledge/training are required with respect to both New Deal and WTR.
- Preliminary stages of information gathering and consultation are important.
- Profile the activities of the hospital within a region-wide context.
- Analyse whether all tasks currently being performed by doctors, especially out of hours, need to be done at that time and by that class of professional. Look at the activities of the average day and consider how many doctors are required, of which grade, at what times. Consider cross-cover arrangements or Hospital at Night.
- Consider timings and facilities for rest periods.
- Do not design rotas that involve working right up to the maximum allowable number of hours per week.
- Ensure sufficient time is provided for proper handover at the end of a shift (up to an hour according to specialty) and robust and explicit handover procedures are in place.

Table 2. Main instances of working time restrictions referred to in the literature review.

Date	Restrictions	Description
United Kingdom		
1991	New Deal for junior doctors	The New Deal is a contractual obligation that changed junior doctors' contracts to alter the way in which doctors were paid for working long hours. The number of <i>contracted</i> hours of work for junior doctors was restricted to 56 hours (or 72 hours on call) per week. Hours of rest were also defined. In practice this meant that hours worked between 48 and 56 hours were paid at a higher rate than those below and hours worked above 56 still higher (antisocial hours attracted a further premium). This gave employers a financial incentive to restructure working hours.
1993	European Working Time Directive	The European Working Time Directive (EWTD), passed in 1993. While not law in itself, all member states had to pass legislation to implement the directive by 1999. This restricted maximum weekly working hours to 48, with a reference period of typically 26 weeks (including for junior doctors). In the UK it is health and safety legislation. It is not linked to pay.
2009	Working Time Regulations (1998)	The Working Time Regulations (1998) or WTR were the UK mechanism by which the EWTD was implemented. Junior doctors were exempted until 2004, with final compliance with the 48-hour week required on 1 August 2009. In addition, there are rest requirements of: <ul style="list-style-type: none"> • 11 hours continuous rest in 24 hours • 24 hours continuous rest in 7 days or 48 hours in 14 days • 20 minutes break in every shift over 6 hours • weeks annual leave. There have been two associated European Court of Justice rulings. The SiMAP ruling (2000) defines all time spent on duty on Trust premises as work, including on-call but asleep. The Jaeger ruling (2003) confirms this and dictates that compensatory rest must be given for interruptions or delays to rest periods, and taken immediately after the end of the working period.
United States		
1989	New York 405	New York State Department of Health Code, Section 405 (1989) limiting resident physicians' working hours to 80 per week.
2003	ACGME 80 hour	The national implementation of the 80-hour restriction from 2003. The ACGME resident work week restrictions (beginning 1 July 2003) specified: <ul style="list-style-type: none"> • an 80-hour work week, averaged over 4 weeks • in-hospital on-call no more than every third night on average • one day off per week (averaged across 4 weeks) • a 24-hour limit to consecutive in-house call (with a 6-hour extension for continuity of care and educational objectives) • 10 hours minimum off between shifts (12 hours for emergency room) • internal moonlighting counted against 80-hour weekly limit • 88 hour limit for select programmes with a sound educational rationale • 12-hour shift limit in emergency room; 60-hour workweek +12 hours for education
2009	Institute of Medicine of the National Academies (IOM)	The IOM made recommendations for changes including restricting maximum shift length to 16 hours or adding 5 hour breaks to current 30 hour shift; mandating one day off each week (no averaging); maximum in-hospital on-call frequency every third night (no averaging); 4 night maximum frequency of in-hospital night shifts with 48 hours off after every 3 or 4 nights of consecutive duty; 12 hours off after night shift, external moonlighting to be counted against 80-hour weekly limit, in addition to internal moonlighting.

The National Workforce Projects (2009) guidance on rota design suggests a seven-step rota design cycle involving: problem identification; feasibility study; analysis; design and testing; implementation; evaluation; review. Good practice guidelines included: consideration of handover (written/electronic/extended shift to enable overlap); sleep policies; exception reporting; issuing rota information at induction.

The RCS and the RCP have both recommended avoiding rotas involving seven consecutive 13-hour shifts. The RCS (2008) further recommended that, if full shifts are implemented for early years surgical trainees (F1, F2, CT1, CT2) night shifts should ideally not exceed more than two-three consecutive nights and should be followed by two uninterrupted nights' sleep before returning to daytime working, whilst recognising that a combination of 4/3 nights might still be practical with appropriate rest in between. For senior trainees (ST3 and above) it advised avoiding full-shift working wherever possible, unless required on training grounds. It also recommends that work is brought into the extended day wherever possible to ensure maximum training opportunities. The RCP (Horrocks & Pounder 2006) recommended a maximum of four consecutive night shifts, with the length of each night shift to be reduced wherever possible. It further recommended three nine-hour shifts to cover 24 hours, and at least one whole day off for every two nights on duty.

Horrocks and Pounder (2006), on behalf of an RCP working group, published guidance for trainees on how to prepare for, survive and recover from working night shifts, the main advice being to minimise sleep debt by taking two-hour sleeps in the afternoon before a shift, and 20-45 minute naps during the night shift. The RCS has issued policy statements on safe shift working for surgeons in training (RCS 2006, 2007).

Two joint reports were also produced – by the RCPCH and the Royal College of Obstetricians and Gynaecologists (2008) and by the RCS and The Royal College of Anaesthetists (2009). Other statements from the Royal Colleges of Psychiatrists (date unknown), Ophthalmologists (Royal College of Ophthalmologists 2008), and Anaesthetists (Simpson, date unknown) set out concerns and responses from these specialties, while the Association of Surgeons in Training (Marron et al. 2006), British Orthopaedics Trainees Association (2009) and the British Medical Association Junior Doctors Committee (2010) have also published statements.

The UK context has been complicated, in terms of understanding, monitoring and enforcing compliance, by the co-existence of WTR and New Deal: “This has often resulted in confusion for employers and doctors and, as the ministerial New Deal returns are used as a proxy for WTD [sic] compliance, the differences between New Deal and WTD [sic] result in an overestimation of WTD [sic] compliance” (RCPCH/RCOG 2008, p5).

The introduction of the WTR was also piloted (Davies et al. 2007), with final reports on these pilots (including Skills for Health/ Workforce Projects Team 2009, Spurgeon et al. 2008) published on the Healthcare Workforce portal (www.healthcareworkforce.nhs.uk). These include a compendium of solutions to WTR compliance identified in the pilots, summarised by Ahmed et al. (2009).

The European Commission is currently reviewing the European Working Time Directive by means of a two-stage consultation of the social partners at EU level and an impact assessment

(<http://ec.europa.eu/social/main.jsp?catId=706&langId=en&intPageId=205>). The British Government supports maintaining the British opt-out for individual workers, and reversing the SiMAP and Jaeger case judgements (The Guardian 20 November 2011). Organisations such as the RCP, the RCS and the NHS European Office support changes, however the BMA has expressed satisfaction with the EWTD as it stands (Goddard 2011).

3.2 Current US Policy

Although the 80-hour restriction has been in place for some time in the USA, Schlueter et al. (2009) found that the understanding and interpretation of the guidelines by residents and programme directors in different specialties varied. When presented with difference scenarios, perception of whether each scenario represented compliance or not varied.

Following a review of the scientific literature on sleep issues, patient safety and resident training, and new recommendations from the IOM (IOM 2008), the ACGME Board of Directors approved new requirements for residency programmes in September 2010, to be implemented in July 2011. Those specifically relating to duty hours include: the maximum number of work hours remains at 80 hours per week, averaged over four weeks; consecutive duty hours to be limited to 16 hours (first-year residents only); and external as well as internal moonlighting (voluntary, compensated, medically-related work not related with training requirements) to be counted against the 80-hour weekly limit (<http://www.iom.edu/Reports/2008/Resident-Duty-Hours-Enhancing-Sleep-Supervision-and-Safety/ACGME-Board-of-Directors-Approved-New-Requirements-for-Residency-Programs.aspx>).

The new rules were reported by Blum et al. (2011) to have stopped considerably short of the Institute of Medicine's recommendations and those endorsed by a 2010 conference on implementation of these recommendations, in particular by only applying the limitation of 16 consecutive hours to first-year resident physicians. Many respondents to a survey by Drolet et al. (2010) felt their programmes would not be compliant with the new regulations.

4 Opinions and commentaries

The WTR, and working hour restrictions in general, have been the subject of much discussion on the periphery of the peer-reviewed literature. While the bulk of this review is concerned with the evidence base emerging from that literature, the context in which that evidence has developed is relevant.

There have been a large number of commentaries, editorials, position papers and letters in the indexed literature and professional journals. Many of these present plausible concerns about adverse effects on training (e.g. Charap 2004, Caldicott & Holsapple 2008), but with varying reference to evidence. Papers which are based more in rhetoric than evidence – editorials with titles such as 'A well-planned and organized assassination of surgery' (Mestres et al. 2006) and 'Resident Work Hours: The five stages of grief' (Barone & Ivy 2004) – will not be considered in detail. However they are acknowledged here because the existence of such rhetoric frames the evidence presented in empirical studies and influences its perception. The political and practical engagement indicated by this element of the literature may be an important determinant of the successful management of restricted working hours.

While much of the commentary, like the empirical literature, comes from the USA and UK, commentaries have come from other areas of the world including Canada (Urowitz et al. 2003, Romanchuk 2004) and Australasia (Lewis 2002, Mann 2005, Gough 2011). This review was limited to English-language publications, but foreign-language papers, including primary research indexed on Medline, included work from Germany (Albert et al. 1998, Kienzle 1998, Deitmer 2004), France (Moubarak & Leenhardt 2008), Switzerland (Dusmet et al. 1993), Mexico (Haro-Garcia et al. 2007), Spain (Lobato et al. 2008) and Japan (Mogi et al. 2008).

Commentaries and editorials have appeared in many specialties, including radiology (Mainiero et al. 2010), emergency medicine (Wagner et al. 2010), otolaryngology (Singer 2010), maxillofacial surgery (Ramsey et al. 2007), neurosurgery (Grady et al. 2009), psychiatry (Rabjohn & Yager 2008), paediatrics (Brion et al. 2009), and perinatology (Muraskas 2007). Surgical specialties, in particular, have identified concerns about the impact of working time restriction on training (Wallack & Chao 2001, Sakorofas & Tsiotos 2004, Lamont & Scott 2005, Thomas 2006, Brennan et al. 2007, Page 2010, Canter 2011, Collins 2011). EWTD-enabling legislation has not always been popular in other countries (Montgomery 2003).

Some of these papers have proposed changes to mitigate against the anticipated adverse effects of restrictions, such as a model in which protected teaching time is additional to the 48-hour working week (Benes 2006, and others), or changes in patterns of care such as shorter stays and quicker procedures (Romanchuk 2004). Conversely Giles (2010) identified the development of informal workplace learning as one means of minimising adverse educational impact of WTR, by ensuring that learning takes place within service delivery time. Some argued that continuity of care would be a casualty of the changes (Fischer 2004, Ramsey et al. 2007).

Some have considered ethical issues around WTR, such as balancing the potential benefits for doctors against effects on patient care (Holzman & Barnett 2000, Wiesing 2007, Czeisler 2009,

Higginson 2009, Lopez & Katz 2009), and potential consequences for the approach to patient care have been described as part of a wider concern about potential effects of restricted working hours on professionalism (Lowenstein 2003, van Eaton 2006). Working time restriction has been a political issue in medicine, and much of the entrenchment of opinion of certain sectors of the profession has been framed in terms of a challenge to professional autonomy and identity.

Note on the empirical literature

The reviewed literature is of varying quality and relevance. Some high quality studies, particularly from the USA, are limited in their application to the UK setting because they are concerned with restrictions to considerably higher working hour limits (e.g. >80 hours). Other studies which are very relevant in their dealing with the EWTD may be limited in terms of their sample size and methodology, but are nonetheless of value because they have looked at the specific restrictions in question here.

Each section of the review begins with a box giving a brief appraisal of the strength and quality of the literature presented in that section ('The evidence in this section'), highlighting any concerns about the relevance and quality of papers referred to. Although limitations are frequently highlighted regarding individual studies, the consistency of some findings across several studies mitigates against these concerns. When considered together, key findings may be drawn from the weight of evidence, triangulated from different sources, augmenting the conclusions. These are also summarised at the beginning of each section.

5 Fatigue and wellbeing

One of the major drivers for the restriction of working hours has been concern over fatigue and its consequences. Studies have focused specifically on the relationships between fatigue and key outcomes such as clinical performance, errors, patient care, education, risk of injury, and wellbeing. Some have examined the effects of different shift patterns and restricted working hours on fatigue, burnout and wellbeing.

Fatigue is a distinct area of literature, and there have been several reviews looking at its impact in medicine. Jha et al. (2001) presented a detailed review of the effects of fatigue and sleep disturbance on different aspects of clinical practice. A meta-analysis by Philibert (2005) identified significant detrimental effects of lack of sleep on physicians' performance, the most pronounced effects being on tests of vigilance and sustained attention. The effects were however smaller than those displayed on comparable measures by non-physicians. A number of reviews have considered concerns relating to the potential reduction in learning opportunities from restricted time as offset against the benefits of a potential reduction in fatigue and improvements in patient safety (Rosenbaum 2004, Papp et al. 2006). Others have focused on specific areas, such as the effects of fatigue on patient care (Owens 2001, Olson et al. 2009). Vorona et al. (2009) draw from their review that physicians do suffer sleep loss in the course of their training and practice, that sleep loss affects mood, physiology and all areas of performance, and that impaired performance leads to errors and less than optimal outcomes. They comment though that the data are often sparse and weak.

The evidence in this section

The quality of much of the evidence in this section is reasonably high, because the physiological basis of fatigue is the same regardless of context and may be less prone to confounding than some subjective measures. There have been several reviews in this area, and empirical studies have taken a number of approaches. Much of the work looking at physiological effects of fatigue is experimental, but there have also been retrospective studies looking at effects on clinical performance, errors, and personal accidents, and survey studies of subjective fatigue and tiredness. Many of these studies draw on fairly large samples ($n < 60$), although response rates have varied.

Despite methodological robustness, there are risks in taking this evidence at face value. Much of the data comes from the USA, and focuses on the extent and effects of fatigue arising from working more than 80 hours, or of reducing hours to 80 hours. However, comparisons between fatigue following 80+ hours and 48 hours are not clear. A similar point arises in relation to shift length which, in American studies, refers to extended shifts of over 24 hours. The relatively small number of UK and European studies in this area mainly used self-report measures or self-selected samples, and as such may be subject to bias.

Key points in this section

1. Fatigue has adverse effects on cognitive and psychomotor skills, with consequences for personal and patient safety, and on physiological indicators, with consequences for doctors' health.
2. Restricted hours can reduce short term fatigue and tiredness, but some patterns of work, such as some combinations of shifts and night duties, can have as much of an adverse effect as the simple number of hours worked.
3. Fatigue may be mitigated by education about its management, and by avoiding unhealthy shift patterns (for example limiting the number of consecutive night shifts).
4. Restricted hours may have longer term benefits for wellbeing and mental health, including reduced burnout.

The first part of this section summarises evidence on the effects of fatigue on doctors. The second part reports on studies that have looked at the effects of restricted working hours on both fatigue over the short term, and stress and burnout over a longer period.

5.1 Effects of fatigue on doctors

Effects of fatigue have been well-studied in other domains, but have been a particular concern in medicine for several years (Vorona et al. 2009). This section focuses on studies which have specifically looked at the effects of fatigue as they relate to medicine. These effects fall into three main areas – cognitive effects, psychomotor effects, and stress.

A number of studies identify cognitive effects. The study by Gohar et al. (2009), conducted over two months in an internal medicine training programme adhering to ACGME work-hour restrictions, found that, during a 'call month' requiring 30-hour call rotations every fourth night, internal medicine residents (n=39 of 66 eligible residents) showed adverse effects when compared to a 'noncall' month (mainly fixed shift working in outpatients or subspecialty clinics). Effects were identified on the ability to retain and manipulate information or sensory input to perform multiple tasks. Lockley et al. (2004) found that attentional failures by interns on a traditional 24-hour shift (n=20, 27% of the population, response rate per se is not clear) occurred at more than double the rate during the night (2300h-0700h) than by interns on an intervention schedule of 16 or fewer consecutive hours, and at 1.5 times the rate during the day. On average interns on the intervention schedule also worked significantly fewer hours per week and slept significantly more. Arnedt et al. (2005) compared performance on a battery of tests following light call schedules with and without alcohol, to that following heavy call schedules with and without a placebo (n=34, response rate 30%). On tests of sustained attention, vigilance, and simulated driving, performance impairment following a heavy call rotation with a placebo was comparable to that with 0.04-0.05% blood alcohol content following a light call rotation (for comparison the legal blood alcohol content limit for driving in the UK and most states of the USA is 0.08%, while the limit for flying aircraft is 0.019-0.020%). This could be confounded by a placebo effect, but does highlight the very real deficits arising from fatigue.

Psychomotor effects are apparent in particular aspects of performance. Jakubowicz et al. (2005) observed, in their study of eight general surgical residents, a trend towards improved speed at the expense of accuracy during simulated endoscopic sinus surgery after a 24-hour on-call period (although with no significant diminution of overall performance). Gander et al. (2008) tested anaesthetic trainees (n=28) on a Psychomotor Vigilance Performance Test (PVT), and compared their performance after day and night shifts. Performance was poorer following night shifts (on median reaction time and the slowest 10% of responses). Increasing shift length was also generally associated with slower reaction times in trainees, particularly following a night shift. They also found that qualified anaesthetists (n=20, overall response rate across trainees and specialists 91%) showed similar patterns, but were also more affected by sleep loss. However, Lehmann et al. (2010) found no performance impairment for surgical residents with a virtual surgery simulator or for standardised cognitive tests after a night of relative sleep loss (n=17, compared with a reference group of medical students, n=13). Ellman et al. (2004), in a retrospective review of 6,751 cases, found no significant effect of acute sleep deprivation among thoracic surgical residents on operative efficiency, or morbidity or mortality in cardiac surgical operations. Brandenberger et al. (2010) found significant

decreases both in psychomotor proficiency measures on simulator tasks and cognitive function for surgical residents (n=14) at the end of both day and night-float shifts of 12 hours compared with baseline. The night-float group showed more significant declines than the day-shift group, suggesting that the increase in fatigue was higher in the night-float group, potentially leading to more errors in practice.

A higher incidence of personal injury may be associated with detriments to psychomotor skills – for example Ayas et al. (2006) reported a greater likelihood of suffering a percutaneous injury when performing a procedure after the 20th hour of work than during a shift averaging less than 12 hours. Fisman et al. (2007) also found that long hours and sleep deprivation were associated with a three-fold increase in the risk of sharps injury among medical trainees, as reported in structured interviews with 350 healthcare workers, including 109 medical trainees.

Studies of the effects of doctors' fatigue outside clinical practice have found reports of falling asleep, or being close to falling asleep, while driving and increased likelihood of vehicle accidents. Gander et al. (2007) reported on a survey of house officers and registrars in New Zealand working ≥ 40 hours a week (n=1,366, response rate 63%), which found that 24% of respondents reported falling asleep driving home since becoming a doctor and 66% had felt close to falling asleep at the wheel in the past 12 months. In the USA, Barger et al. (2006, also reported by Lockley et al. 2006) found a greatly increased risk of a motor vehicle crash among interns (n=2,737, tracked over a year) during their commute home from an extended duration shift (>24 hours). Following an extended duration shift, interns were 2.3 times more likely to have a motor vehicle crash, compared to after a non-extended duration shift; increasing to 5.9 more likely for a near-miss incident.

Cognitive and psychomotor skills may be behind findings of increased medical errors (Veasey 2002) and self-reported fatigue-related clinical errors (Gander et al. 2000, 2007), including mistakes causing injury or leading to death of a patient (Barger et al. 2006). Lack of sleep has been associated with increased attentional failures, serious errors and serious diagnostic mistakes in ICUs with shifts of over 24 hours, compared to shifts of up to 16 hours (Landrigan et al. 2004, Lockley et al. 2006). Grantcharov et al. (2001) found residents' error rates on simulated laparoscopic surgery doubled after a night on call compared to when more well rested.

A paper by Trew et al. (2011) reporting on a survey distributed through internet forums for cardiovascular perfusionists (n=445, response rate not known) indicates that similar problems regarding extended working hours may be faced by members of the clinical team other than doctors. For example, 6.9% of respondents reported automobile accidents that were attributed to an extended period of work and fatigue, and 44.4% of respondents reported a near-miss motor accident due to fatigue. Fatigue-related minor errors were reported by 66%; 6.7% reported having a serious perfusion accident they believed to be due to fatigue, and 75.9% reported they had been concerned about their ability to do their job adequately due to fatigue-related acute sleep deprivation.

Fatigue is also related to indicators of physiological stress. In a study of six participants, long shifts (>24 hours) and a long working week (mean 65 hours) were linked to ketonuria in 21% of shifts, and occurrence of arrhythmia or other heart abnormalities in all six participants tested (Parshuram et al. 2004). In a study of eight doctors by Kohen-Raz et al. (1996) effects were also found of both work

fatigue and circadian rhythm on postural responses such as stability, resulting in, for example, vestibular stress.

A comparative, cross sectional study by Smith et al. (2006) of male junior doctors (n=32, age 24-38 years) examined psychological and hormonal changes when working a full shift system involving blocks of seven nights. It found significant falls in cortisol levels (a reduction in cortisol being associated with chronic stress), and a reduction in general well being, as measured by GHQ-12, following both a normal working week (9.00am-5.00pm) and, more so, following a week of nights, in comparison to after a week of holiday. GHQ-12 scores indicated that 24% of these doctors (n=6) experienced lowered wellbeing (i.e. scoring >3) after a normal working week and 33% of them (n=10) after a week of nights, compared to 4% (n=1) after a week of holiday, suggesting that working a full shift rota is detrimental to mental health despite an overall reduction in the number of hours worked.

In a study by Vidyarthi et al. (2007) internal medicine residents (n=125, response rate 76%) were asked to report the frequency of, and contributing factors to, suboptimal care practices and medical errors. 'Suboptimal care' was operationalised as a set of items including 'working while fatigued'. 'Working while fatigued' was the only one of these items to score higher than the neutral midpoint of a five-point scale (i.e. to be indicated as a possible problem). Fatigue and excessive workload were the most frequent reasons given for committing errors and suboptimal care was the only significant predictor of reported error. Working more than 80 hours was *not* associated either with suboptimal care or errors, and Vidyarthi et al. concluded that the structure of work, not just hours worked, was the key factor. While the data are not straightforward (and there are some concerns about the robustness of the analysis), one possible inference is that hours alone do not contribute to fatigue and its consequences. A similar conclusion was drawn by Friesen et al. (2008) in a study involving interns in cognitive specialties at one large academic centre (n=66, 59%). Working more than 80 hours a week did not have a statistically significant association with perceived stress, quality of sleep or fatigue. Greater perceived stress was significantly associated with diminished sleep quality, and lower perceived teamwork functioning was significantly associated with perceived increased stress. Friesen et al. suggest that there needs to be consideration of strategies to enhance the quality of trainees' sleep and sense of teamwork and to decrease perceived stress. Chen et al. (2008), in their study of attending physicians (n=180, 45%), also found that reduced sleep both on and off call, but not hours worked, was associated with increased subjective sleepiness (using the Epworth Sleepiness Scale).

Willis et al. (2009) reported an interesting result from a survey of surgery programme directors (n=118, 47%), that while 62% of respondents felt that fatigue was detrimental to driving a vehicle, only 17.5% felt it was detrimental to technical skills at work, and 20-26% felt decision-making would be impaired. This may be telling about the way in which doctors perceive their own skills and the risks to those skills.

Tomasko et al. (2012) found no difference between a control group and a sleep-deprived group of medical students (total n=31) in either performance of previously learned simulated surgical tasks or learning a novel task, although sleep-deprived students showed increased cognitive workload to achieve the same level of performance compared with the control group. The sleep-deprived group

were unable to adequately estimate the amount of time taken to complete the tasks, indicating some impairment of cognitive function.

Liu and Wissow (2008) reported a known issue of residents staying on voluntarily beyond their official hours, and looked at the effects of this and implications for training. Their study of paediatric residents in 1990 (n=52) found that those who cared for critically ill children were more likely to stay late even if not on call. Residents who stayed late when not formally on call displayed less patient-centred talk and greater verbal dominance the following day than those who had been on call or left on time; they also reported feeling less fulfilled than those who left on time and, if their clinic was in the afternoon, more fatigue. The suggestion was that helping paediatric residents to learn to manage their work while under clinical stress could promote better adherence to working hour guidelines, and have a positive impact on patient interactions and care.

Arora et al. (2007) however found no significant beneficial effect of a 60- to 90-minute lecture, the Sleep, Alertness, and Fatigue Education in Residency (SAFER) program, on sleep loss and recovery sleep in interns (n=58, 72%, participating for 147 intern-months), and argued for the adoption of proven countermeasures to fatigue and promotion of a culture that facilitates healthy sleep habits. Czeisler (2009) also argues for the provision of education about the impact of sleep deprivation and sleep disorders on performance, health and safety.

5.2 Impact of work hour restrictions on fatigue

Several American studies have examined the effect of work hour limitations on fatigue and on its consequences, for example on sleepiness, including during teaching and while driving; trainee wellbeing and mood; patient care, and errors.

A questionnaire study (Conigliaro et al. 1993) examined the effects of the New York 405 Regulations two years after implementation in 1989 (total n=345, 58%). Doctors who had been first- or second-year residents in internal medicine at the time of the introduction agreed that the regulations had decreased their fatigue on the wards and reduced emotional stress. They also felt they now provided better patient care and their ability to learn about the full impact of interventions on their patients had not diminished, however attendings disagreed.

The ACGME work hour limitations were implemented in 2003, and studies on their effects have been conducted in several specialties, including paediatrics, intensive care and surgery.

Cull et al. (2006) compared responses of a national random sample of 500 paediatric residents graduating in 2002 (response rate 65%) and 2004 (response rate 61%), and all US paediatric residency programme directors (2004 only; response rate 83%). Despite improvements, the results showed that there were still problems related to fatigue. The proportion of residents reporting falling asleep during an educational conference reduced only from 81% to 73%, and those reporting falling asleep while driving from work reduced from 32% to 20%. There was a proportionally larger reduction in the number reporting making errors in patient care due to fatigue (17% to 8%). Resident wellbeing was the area most often identified as having improved since the limitations (57% of residents, 43% of programme directors).

Kort et al. (2004) found that surgical residents (n=98, response rate 59%) reported increased personal time and decreased fatigue at home and work, although the latter was not perceived to decrease the rate of medical errors. A separate study of surgical residents by Kiernan et al. (2006) (n=51, 100% response rate) found no differences in mood scores between residents who were fatigued (<4 hours sleep) and rested, or between residents tested in a post-call period and after nights off call, in contrast to earlier studies demonstrating a link between increased fatigue and worsening mood. The authors suggested that working hour restrictions may have relieved chronic sleep deprivation and proposed that, without this chronic fatigue, residents are better able to cope with periodic acute sleep loss and experience less mood disturbance.

Reddy et al. (2009) found a severe degree of sleepiness on post-call days in medical residents (n=20) working in a medical intensive care unit despite the reduction in work hours, using an objective test of sleepiness, but found no correlation between the objective and subjective measures of fatigue, suggesting that the residents had poor perceptions of, and were underestimating, their sleepiness on the post-call day, with potential implications for resident errors and patient care. Similarly, improvements in sleep time and subjective sleepiness were not reflected in objective sleepiness in a study by Parthasarathy et al. (2007) with 44 ICU clinicians surveyed before and after the 80-hour restrictions were introduced. This study also found a reduction in symptoms of sleepiness during driving (although driving accidents were not measured) and increased time spent reading. The work-hour limitation was also independently associated with a reduction in the number of intercepted written medication order entry errors (the only type of errors examined, compared with the larger set of errors examined by Landrigan et al. 2004, reported in Section 9 of this review).

Findings of these relatively small studies may not be generalisable outside their own centres or their specialty setting.

In light of the broad range of shift systems introduced following implementation of the WTR, Tucker et al. (2010) carried out a questionnaire study of all junior doctors working in specialties undertaking acute medicine throughout Wales (n=336, response rate 46%) to compare groups of junior doctors working on different schedules. The purpose was to identify which features of schedule design most negatively affected their fatigue and wellbeing in recent weeks, using four dependent variables: fatigue, sleep duration, psychological strain (measured through the General Health Questionnaire, GHQ-12), and work-life interference. It was found that working seven consecutive nights resulted in substantially higher levels of fatigue than working just three or four nights in a row, possibly because sleep periods during days between night shifts were over one hour shorter than sleep periods during nights between successive day shifts; it was also associated with greater work-life interference. Having only one day of rest after night shifts resulted in the effects of fatigue spilling over into the first subsequent day shift. Working a weekend on-call between two consecutive working weeks was associated with increased work-life interference and somewhat greater, although marginally non-significant, psychological strain. More frequent on-calls, at weekends and on weekdays, were associated with increased work-life interference and psychological strain. Intervals of less than ten hours between shifts were associated with shorter periods of sleep and increased fatigue. As noted by the authors, this study relied on self-report measures and may have been subject to bias according to respondents' preference for different shift systems, and also may not be generalisable

to other specialties, however it does identify issues regarding fatigue and wellbeing in the design of work schedules.

A qualitative study (Brown et al. 2010) conducted after partial implementation of the WTR, involving interviews with ten junior doctors (FY1, FY2 and ST grades) and four focus groups with a total of 24 participants (from FY1, FY2, ST, SpR and staff grades) found that night shifts were of particular concern to participants, especially sequences of seven consecutive night shifts. Towards the end of these, excessive fatigue was reported to have a negative effect on patient care, training opportunities and safety, with some participants raising concerns about fatigue when driving home. Split nights (three or four consecutive shifts) tended to be seen as more manageable and less fatiguing, and improvements in concentration were associated with fewer errors, although some considered them to be more disruptive of life outside work, and the transition between different sleep routines to be difficult. Shifts of 12 consecutive days were associated with increased fatigue and errors; reduced alertness, concentration, work speed and motivation, and impaired information processing.

Arora et al. (2006) looked at the effects of a call-night nap on the sleep and fatigue of internal medicine interns (n=38, 95%), with participants involved for between one and five months between July 2003 and June 2004. For two weeks of every month, interns were assigned to a nap schedule in which resident physicians provided coverage to on-duty interns from midnight to 0700 so that they could finish their work and take a nap; for the other two weeks the interns worked a standard schedule. Using wristwatch actigraphy, it was found that interns with the nap schedule received 41 more minutes of sleep while on call (185 vs. 144 minutes, $p < 0.001$). If they also forwarded their pager to the night-float physician they were able to receive protected sleep time and slept longer (68 more minutes). Subjective responses of sleepiness were also lower when on the nap schedule than the standard schedule (1.74 vs. 2.26 on the 7-point Stanford Sleepiness Scale from responses obtained through random alerts on a PDA during shifts, 2.23 vs. 3.16 post-call). Short naps may therefore be an effective countermeasure to fatigue and its possible consequences. 26 of the interns were interviewed and all preferred the nap schedule. It was also found, however, that pagers were forwarded on only 22% of available opportunities and interns preferred to only forward the care of their cross-cover patients and to retain care of their own patients.

A conference paper by Berios et al. (2009) reported excessive sleepiness among emergency medicine residents (n=6) at the end of both 9-hour and 12-hour shifts and an increasing trend in mean reaction time as shift length increased.

Czeisler (2009) notes that there have been suggestions, despite a lack of evidence, that physicians may be more resistant than others to the known detrimental effects of sleep deprivation on performance. He refers to the development of the ACGME work hour policy limits being based on an implicit and inaccurate assumption of a population of residents who are entirely healthy, highly resistant to the effects of sleep deprivation and free of family responsibilities. He considers this to raise ethical issues both in relation to residents and to patients. Similarly Mercurio and Peterec (2009) argue in favour of restricted shift length from an ethical position regarding patient safety.

5.3 Impact of work hour restrictions on wellbeing and burnout

The study by McIntyre et al. (2010) of one UK district general hospital found a notable increase in episodes of sick leave among junior doctors in the year following implementation of EWTD-compliant rotas. The proportion of junior doctors taking sick leave increased by 90% ($p < 0.001$), and the total episodes taken increased by 170%. This corroborates data presented by Goddard et al. (2010) indicating that 58% of consultants reported sickness rates in juniors to be higher under the WTR than before.

A survey was conducted by the BMA Junior Doctors Committee in December 2009-January 2010 with junior doctors across the UK. The final response rate was only 10.6% (1,567/14,754), representing approximately 5% of junior members. 35.7% of respondents reported that compliance with an average 48-hour week had had a positive effect on quality of life, 22.1% that it had had a negative effect, and 42.2% no effect. Considered by hospital specialty, respondents in neurosurgery were most likely to report a negative effect (55%), and respondents in psychiatry and emergency medicine (50.7% and 46.5% respectively) a positive effect.

In Belgium a reduction to a maximum of 48 duty hours was introduced for all residents in 1999. Heller (2008) reported that surveys conducted in that country found that a reduction of duty hours appears to improve the mental health and the security and quality of life of the trainees.

Elsewhere in Europe, Businger et al. (2010) surveyed 52 out of 93 surgical departments in Switzerland, a year after a 50-hour work-week limitation was introduced in January 2005. There was a 65.5% response rate from these 52 departments (221/281 residents; 184/337 consultants; total $n=405$). At this time residents were working a mean of 55 hours per week. Whilst both residents and consultants thought residents' quality of life had improved, this was the view of a significantly smaller proportion of residents than consultants (58.4% compared to 81.5%).

In the American context, Cull's (2006) study of paediatric residents graduating in 2002 ($n=323$, 62%) and 2004 ($n=301$, 61%) and programme directors (2004 only, $n=161$, 83%), found that resident wellbeing was the area most often identified as having improved since the limitations (57% of residents, 43% of programme directors). Parthasarathy et al. (2007) reported improvements in some aspects of quality of life (vitality, social functioning and general health) for ICU residents (but not fellows).

Several studies have investigated the prevalence of burnout in doctors. Burnout is typically defined using Maslach's three-component conceptualization: "Burnout is a prolonged response to chronic emotional and interpersonal stressors on the job, and is defined by the three dimensions of exhaustion, cynicism, and inefficacy" (Maslach et al. 2001, p. 397). The exhaustion component refers to feeling overextended and that one's emotional and physical resources are depleted; cynicism (also referred to as depersonalisation) refers to a negative or overly detached response to aspects of work (e.g. treating patients as objects rather than people); and inefficiency refers to feelings of incompetence and a lack of accomplishment at work (Cordes & Dougherty 1993, Maslach et al. 2001). A number of American studies have measured burnout using the Maslach Burnout Inventory (MBI), before and after the introduction of the 80-hour working week restrictions. The MBI assesses emotional exhaustion, depersonalisation (both correlating with burnout) and personal achievement

(inversely related to burnout). Results vary, but there is some indication that burnout remains an issue post-implementation. Furthermore, a review by McCray et al. (2008) identified that despite a high prevalence of burnout among health professionals, particularly resident physicians and medical students, there is a paucity of research into interventions.

Martini et al. (2006) surveyed all years of training in different medical specialties, before and seven to ten months after the introduction of the 80-hour work hour limits. The response rate for the second survey was 31% (n=118), of whom 34% indicated they had taken part in the previous year's survey. Burnout prevalence reported by first year residents was significantly lower (43%) in 2004 than before July 2003 (77%), and somewhat lower overall (41% in 2004; 49% in 2003). Some residents (11.1%) were still working over 80 hours a week and had higher prevalence of burnout (69.2%) than those working fewer hours.

Hutter et al. (2006), in a survey of surgical residents (n=58) and attending surgeons (n=58, overall response rate=61%), found improvements in burnout measures and also in job motivation for residents one year after the introduction of restrictions, but no significant changes in these areas for attending surgeons.

Goitein et al. (2005) compared responses on measures including the MBI from a sample of 118 internal medicine residents in 2004 (response rate 73%) with data collected in 2001 (Shanafelt et al. 2002). Improvement was detected in the emotional exhaustion component of the Maslach Burnout Inventory (but not in depersonalisation or personal accomplishment), as well as in happiness with career choice, and a depression screening measure. Barrack et al. (2006) and Gopal (2005) also found strong trends (albeit non-significant) towards a decrease in emotional exhaustion, and shallower trends towards reduction in the other dimensions. Barrack et al. compared survey responses from orthopaedic surgery residents in 2002 (n=21) and 2005 (n=34, response rates not given), while Gopal et al. compared responses from internal medicine residents in 2003 (n=121, 87%) and 2004 (n=106, 74%).

Landrigan et al. (2008) found that burnout may not relate simply to sleep or hours worked. They found that, although scheduling changes were made to accommodate the standards and the mean length of on-call shifts decreased (to 28.5 hours, within the 30 consecutive hours limit), total hours of work and sleep reported by 220 residents did not change. However, the rate of resident burnout decreased significantly (from 75.4% to 57%). Other measures in the study showed that resident depression did not improve, nor did outcomes regarding patient or resident safety such as rates of motor vehicle crashes, occupational exposures, self-reported medication errors and resident injuries. There was also no improvement in educational ratings.

Two surveys that included a question about burnout also found a decrease. A survey of residents by Myers et al. (2006) (n=159, response rate 80%) looked at those who trained both before and nearly two years after duty hours reform at six residency programmes (three internal medicine, three surgery) at five US academic medical centres. They identified reduced self-reported burnout, with larger reported decreases among surgical than medical residents (where 1 was "decreased a lot" and 3 was neutral, surgery=2.4, medicine=2.8, p=0.006). Kim and Wiedermann (2011) also identified a significant decrease in burnout (67.8% to 46.6%, p=0.005) in a survey distributed to residents in one

large paediatric programme in 2011 (n=56, 66%), compared to 2003-2004. There was also a significant reduction in rates of motor vehicle crashes, personal body fluid exposure and regret about job choice, although rates of near-miss motor vehicle crashes (44%), self-reported errors (35.7%), depression (12.7%), dissatisfaction with job (16%) and overall educational ratings remained largely unchanged.

However, other studies, also using the MBI, have not been as positive. A pre- and post-implementation survey of surgery residents (n=33, 89%) found no significant effect on measure of burnout (Gelfand et al. 2004). Golub et al. (2007) reported on a national study of all US otolaryngology/head and neck surgery residents (n=684, response rate 50%; 514 from relevant target group used for analysis), conducted two years after introduction of the 80-hour working week. The mean response for number of hours worked per week was 71 hours, with 8% of respondents reporting working over 80 hours. Moderate burnout was seen in the majority of respondents (76%), high burnout in 10% and low burnout in 14%. After adjusting for potential confounds, a strong positive linear relationship was found between number of hours worked and burnout, particularly emotional exhaustion.

Two studies suggest that the first year of residency is a potential target for interventions regarding burnout. Using the MBI, Campbell et al. (2010) found evidence of burnout after the restrictions through all three years of residency training in a longitudinal study (2003-2008) of internal medicine residents (n=86, 48%), although there was a trend towards decreased burnout over the years and incidence of new burnout after internship was lower than during internship. Persistent burnout (continuing through the three years in 42 (72%) of 58 who had reported being burned out during their internship) was more likely to occur in men, and was associated with screening positive for depression as an intern. A survey of internal medicine and combined medicine-paediatrics residents at six US programmes conducted at the beginning and end of their first year of residency (n= 201, response rate 60% across both surveys) found an increase in prevalence of burnout from 35% at the beginning of the year to 80% near the end using the MBI as a measure, but no significant association between burnout incidence and duty hours, It did find associations with disorganised personality style, lack of feedback and uncertainty regarding choice beyond residency (Ripp et al. 2010).

A limitation of all studies involving burnout measures may be that non-responders may be more or less burned out than responders.

One possible consequence of improved wellbeing is reported in a study by Jones and Jones (2007). They found that the proportion of residents becoming parents in the four years either side of the introduction of the 80-hour limit increased from 27% to 43%. Jones and Jones interpret this as indicative of the extent to which restricted working hours can positively affect residents' personal lives, although the mediating variable – wellbeing or available time – is not clear.

5.4 Summary

The detrimental effects of fatigue on doctors' performance are no different to those in any other domain, but there is a risk that doctors do not recognise that they may be subject to those effects. Fatigue is generally associated with deficits in cognitive abilities and psychomotor skills (e.g. memory,

attention, simulator performance), as well as negative consequences for patient safety (e.g. clinical errors, diagnostic mistakes), personal safety (e.g. injury at work, vehicle accidents), and wellbeing (cardiovascular problems, burnout).

Reduction of working hours has positive effects on fatigue and related variables in many cases, but not always. It is important to recognise the role of different work patterns and schedules, as fatigue is also affected by, for example, the number of consecutive days or nights worked, the lengths of intervals between shifts, and the timing of shifts (day/evening/night). Short naps may ameliorate the negative effects of fatigue.

However the use of subjective fatigue scales may mean some results cannot be taken at face value. Furthermore, simply reducing the number of work hours may be insufficient to address issues relating to fatigue and its consequences. Successful interventions may also require strategies to improve sleep quality and reduce stress, as well as education regarding the consequences of insufficient sleep (e.g. Chen et al. 2008, Friesen et al. 2008, Liu & Wissow, 2008, Czeisler 2009), and cultural change (Arora et al. 2007).

A major caveat associated with a number of the studies presented in this section is that they are US studies typically examining the effects of fatigue and burnout following very long working hours (e.g. >24 hour shifts or 80-hour weeks). As such, it is unknown whether burnout and the detrimental effects of fatigue would be as evident in studies of WTR-compliant shifts.

Buyse et al. (2003) suggest that the active involvement of numerous parties including trainees, training programme directors, hospital administrators, sleep and circadian scientists, government funding agencies and regulatory agencies, will be required to find solutions to the problem of sleep and fatigue in medical education, informed by research and education on its effects.

6 Perceptions and attitudes

This section describes papers that mainly report surveys of perceptions of and attitudes towards working time restriction. An inclusion criterion for these papers was that studies should include a retrospective measure – that is, opinions should be based on actual experience of working under restricted hours, rather than anticipation of what the effects may be. Subjective responses after the fact may still be open to bias, but they are at least based on some experience. Studies which included measures taken before and after the introduction of restrictions are included.

The majority of studies describe quantitative data derived from electronic or paper-based surveys, although qualitative studies are also included. Studies which looked at attitudes as part of the evaluation of particular interventions or solutions are included in Section 9: Interventions.

6.1 Compliance with restrictions and perceptions of hours worked

Jagannathan et al. (2009) reported an audit of resident hours showing that restrictions were being adhered to, with a 20% reduction in average reported working hours per week (from 103 to 78), a 35% reduction in theatre time, and 20% increase in on call time, and a 47% decrease in 'conference/academic' time. However, evidence from several other self-reported surveys is that compliance with the restrictions is low.

Cockerham et al. (2004) found that in one hospital in November 2003, following introduction of new rotas, 14% of junior residents, and 33% of senior residents were still working more than 88 hours per week. Landrigan (2006) found that 83% of a national US sample of residents (n=1,278, response rate 6.8%) reported exceeding ACGME restrictions in one or more months between July 2003 and May 2004, while 43% exceeded an average of 80 hours across four weeks. However, overall the restrictions did decrease weekly working hours (from 70.7 to 66.6 hours), and increase nightly rest (from 5.91 to 6.27 hours). Drolet et al. (2010) reported that 84% of 2,561 residents in the USA (22%

The evidence in this section

Studies in this section are of variable quality. No review articles are considered here. The majority are quantitative surveys, although some qualitative studies are included. Some studies from the USA involve large or very large samples (many with n>100, some with n>1000, with the highest at nearly 20,000), but generalisation of the findings of even these studies is limited by their reference to perceptions of the 80-hour restriction. Studies from the UK tend to have smaller samples (n<40 in many cases, n<20 in some), and many lack details of recruitment, meaning that systematic biases in responses cannot be excluded. Self-selecting samples are a particular risk on contentious issues such as working time as those with particularly strong opinions or an 'axe to grind' may be more likely to respond.

The value of the literature in this section is limited to some extent simply by being based only on subjective data, which will be subject to other confounds. Some are also based on retrospective views, which are open to other biases. However, subjective data is a useful indicator of potential problems which may need to be overcome to successfully change policy.

Key points in this section

1. Substantial survey evidence indicates that there are negative attitudes towards restrictions, around issues such as training opportunities and continuity of care. However, findings are mixed.
2. Junior trainees are less negative about changes than senior trainees and faculty.
3. Doctors in different specialties may have different opinions, but these may be confounded by other local factors beyond the nature of the clinical care provided.
4. Working hour restriction may be linked to a changing professionalism among younger doctors, but there is no objective evidence that any detrimental changes are occurring.

of a nationwide sample) felt they were compliant with the 2003 regulations, but many expressed concern that they would not be able to meet the 2010 restrictions.

Vidyarathi et al. (2007) found that 35% of respondents (n=125, 76%) said they still worked more than 80hrs, and 20% reported feeling 'overwhelmed' at work. Ladd (2006) surveyed 40 paediatric surgery fellows/trainees (response rate 74%) and found 45% compliance with restrictions, with reported violations 1-3 times a month. However, there was a difference in reported compliance between those with and without formal tracking of their hours: of those respondents who had formal tracking, 30% estimated working more than 90hrs, compared to 60% of those with no formal tracking. This could be an illustration of bias, or could suggest that tracking effectively reinforces compliance.

Todd et al. (2010) provide evidence that actual working hours can be estimated accurately by doctors, by comparing 22 residents' self-reported estimates of working time violations with figures obtained through an electronic 'clocking in' system. Barger et al. (2005) report validation of the instrument used by Landrigan et al. (2006), with a correlation of 0.76 between self-report on the survey, and daily diary completed by a sub-sample of residents (while not an objective record of hours, this does suggest some validity).

Kusuma et al. (2006) reported that 33% of their sample (n=554, 13.2%) had worked more than 80 hours and 33% had under-reported hours, with reasons including concerns that their training programme would be penalised or that they personally would be penalised, as well as disagreement with the importance of the 80-hour rule. 32% said they never report violations.

Carpenter and colleagues (Carpenter, Austin, Tarpley, Griffin & Lomis 2006; Carpenter, Spooner, Arbogast, Tarpley, Griffin & Lomis 2006) have also reported interesting findings regarding residents' reasons for exceeding restricted hours, and their willingness to report such violations. In studies of residents on paediatric, medicine and general surgery programmes (Carpenter, Austin et al. 2006 n=137, response rate 80%; Carpenter, Spooner et al. 2006 n=125, response rate 71.4%), large proportions of residents worked beyond the 80-hour limit, and under-reported the extent to which they did so. Maintaining patient care was the highest rated reason for violation and for under-reporting. There were some differences between junior and senior residents' reasons for violating restrictions, relating to education, fulfilling senior resident perceptions and having a 'sense of duty to team' – but overall violation/reporting differences were not related to inexperience. Surgical residents were more likely to exceed guidelines, and to under-report hours. Similarly Tabrizian et al. (2011) report that 72% of a sample of 141 surgical residents (response rate 11%) worked more than 90 hours per week in 2007-08, with education and continuity of care given as the main reasons for noncompliance.

A few studies have asked about the hours that respondents would like to work. These American studies found that following the restriction to 80 hours there were mixed opinions on its suitability. Kusuma et al. (2006) report that 41% of their sample felt 80 hours was too long, 34% that it was too short, and 23% that it was appropriate. Moalem et al. (2009) found that 52% of their sample (n=599, 7.3% of population via electronic distribution) would prefer to work 60-80 hours, compared with 43% who would prefer 80-100 – a preference for higher hours correlated with respondents identifying restricted hours as a substantial or moderate barrier to care. Nuthalapaty et al. (2006) found that

more female than male obstetrics and gynaecology programme directors (n=123, 58%) supported a limit of more than 80 hours.

Two UK surveys following the introduction of the 48-hour WTR conducted by Remedy UK (a pressure group for junior doctors: <http://www.remedyuk.org/>) reported perceived compliance in the UK. A 2009 survey (Remedy UK 2009) of 309 trainees found that 39% said their rota was compliant, but 36% said that it would not be compliant in practice, with surgeons reporting the lowest compliance in practice. Textual responses illustrated a range of trainee views about WTR and its implementation, positive and negative. A 2011 Remedy UK survey of 366 surgeons in training (Dean & Pereira 2011) elaborated on this, finding that most respondents reported working 5-10 hours over their contracted hours in order to gain sufficient training exposure, and 53% would work longer than 60 hours a week. Most thought WTR was a 'moderate to huge' issue. Both of these surveys were advertised to the population of trainees, and so responses represent proportionately small, self-selected samples.

One interesting item on the Remedy (2009) survey was the wording of the question 'Were you offered an opt out?'. This is similar to the GMC trainee survey's 'Have you been asked to sign [an opt out]?'. Under WTR, opt outs are voluntary, and any trainee has the right to ask for one, but should not be asked to sign one. The constructions 'offered' and 'asked' do not represent the regulations, and may reflect a lack of understanding of how an opt out is defined.

6.2 European studies

Surprisingly few published studies of attitude surveys looking at WTR were found. While the fairly recent full introduction of the WTR in 2009 may mean some studies are still in progress, there was also a surprising lack of publications looking at the effects and perception of the New Deal. Of the few studies published on WTR, the majority of the responses reported are negative.

Some UK-based studies were extremely small scale, with very few respondents. For example, Giles et al. (2011) reported findings from a survey of 12 trainees and 7 new consultants in the particular subspecialty of paediatric gastroenterology, hepatology and nutrition. They found that consultants reported having spent more time on subspecialty specific training than current trainees. This validity of retrospective perceptions should be treated with caution though. The same is true of Parsons et al. (2011), who compared the perceptions of competence of current junior surgical trainees (SHOs, n=37) in 2009, with higher surgical trainees' (SPRs, n=48; total response rate 70%) perceptions of their own competence at that stage. Concerns over the retrospective measure notwithstanding, more of the SpRs felt they had been competent to perform procedures in their equivalent SHO year (e.g. 90% reporting they had been confident to perform an open appendectomy, compared to 28% of the current SHOs). Both groups felt that the level of skill of junior trainees was getting worse (free text responses indicating that working time and the introduction of shifts were factors, along with loss of the 'firm' structure and loss of patient continuity).

Two studies do not provide a sample size, raising concerns about their rigour and validity. Nonetheless, Kelly and Gale (2008) found that junior cardiologists felt that WTR affected availability for training sessions, and Wilkinson (2008) found that newly qualified doctors were less aware of their hours being limited than those who had experienced the change directly. Kelly, Curtin and

Corcoran (2011) found that Irish surgical trainees (n=25, 100%) felt the implementation of the EWTD had detrimental effects for care, training and morale, although improvements in fatigue and lifestyle were identified. West et al. (2007) also report on a small survey of 33 cardiothoracic trainees (response rate 25%) in the UK and Ireland, finding that 93% of that sample felt WTR had a negative effect on training, although 52% felt their quality of life improved.

Some studies have included larger samples. Bowhay (2008) found a large proportion (>70%) of a regional sample of anaesthetic trainees (n=73, 62%) felt that training was harmed by the WTR restrictions, but in contrast to other studies which have found positive effects outside work, 69% felt their quality of life outside work was 'worse' or 'much worse'.

Tsouroufli and Payne (2008) report qualitative data from interviews with twenty consultants in six Welsh NHS trusts. They report that consultants were able to identify detriments to the experience gained by trainees and consequent competency. However their respondents do not make explicit links between working hours and those judgements (then limited to 56 hours in the first wave of WTR) and identify other factors such as the introduction of shifts and loss of the firm, alongside hours restriction, as leading to this perceived decline.

An important point raised by one of their respondents is that consultants' embeddedness in the current system, having 'grown up' professionally within it, may limit their vision in terms of considering alternative solutions – "it was a good method for me" (p. 4). This should be borne in mind with many of the studies reporting attitudes of senior clinicians. The lack of formal development of consultants as educators, and the resistance of some to an educational role different from that with which they were familiar was also identified as a problem.

Outside the UK and Ireland, one English language paper referring to working time was found (Vogel et al. 2008), comparing the experience of junior doctors and former junior doctors in Germany with those in Switzerland (which has a 50 hour limit, not being subject to the EWTD). This paper reported that those in Germany found it hard to carry out their work in restricted hours, while those in Switzerland were more positive and felt it did not have a negative effect on training. This was attributed to the German doctors performing more non-clinical tasks within their role. This indicates that working hours per se are not a problem, but that the organisation of work within those hours can be.

6.3 American studies

In contrast to Europe, a large number of studies were identified in the USA, across specialties and states. Some studies are of a similarly small scale to the UK studies, but others have involved much larger samples. Some studies considered residents alone, but several surveyed faculty (including attending doctors and programme directors).

While most of the studies identified are quantitative, a qualitative study by Fletcher et al. (2008) involving interviews with 28 internal medicine residents found that participants reported improvements in their wellbeing and levels of fatigue following restrictions, but concerns about continuity of patient care. This pattern of results echoes many of the quantitative studies.

In the study with the largest sample (n=19,605, around 18% of total resident population), Kashner et al. (2010) conducted a complex statistical analysis, calculating 'ratio of odds ratio' statistics which compared satisfaction scores controlled for whether respondents had identified any effect of restrictions on their educational programme. They found that those working under restrictions had increased satisfaction with the clinical environment and faculty. This varied across specialties, with medical residents being more satisfied across five domains (faculty/preceptors, learning environment, clinical environment, working environment, physical environment), while surgery residents were more satisfied only on two (clinical faculty or preceptors and clinical environment). Kashner et al. calculated the greatest effect of restrictions, in terms of respondents moving from unsatisfied to satisfied, in the clinical environment domain: for surgery residents they calculated the satisfaction rate as increasing from 60% to 93%, and for medicine from 58% to 83%.

Jagsi and colleagues (Jagsi et al. 2006, 2008) report data from a large scale study (n=1,770, 60%) of residents across specialties. A pre- and post-restriction questionnaire contained items on working hours, clinical experience, education and fatigue, with the 2008 paper also reporting data on perceived influences on mistakes. Results were generally positive or neutral for reduced hours, with an increase in reported self-directed learning and an increased opportunity for research for those whose hours had reduced. There was also a reduction in the perceived negative effects of fatigue (on the quality of care and patient safety, ability to learn, satisfaction, and interaction with co-workers) (Jagsi et al. 2006). Working too many hours and cross-covering too many patients were more likely to be perceived as reasons for mistakes by those whose hours had reduced than those whose hours had not reduced (Jagsi et al. 2008). There were no differences in the number of reported errors, and no changes in the attribution of errors to poor handoffs, too many patients and inadequate supervision. However, the independent variable was whether hours had changed, rather than the hours worked per se – so if a rota was already compliant in 2004, it would be included in a 'no change' condition. Therefore, while there are positive effects of changing hours, there is not a clear indication of whether a reduction in hours has these effects, or just a change. There are also some concerns about the lack of a correction for multiple analyses being applied.

Vidarthi et al. (2006, 2007) report generally positive results from a survey of internal medicine residents in San Francisco carried out shortly after the restrictions were introduced (n=125, 76%). There were trends towards spending more time on some educational activity, and less time on administration (e.g. 60% reported spending the same amount of time reading, 31% said they spent more time). 32% reported a positive effect on education overall (28% negative, 40% no change). 78% had experienced a positive effect on their quality of life. In a regression analysis (although no coefficient is reported), working more than 80 hours was a negative predictor of work satisfaction. However 20% of the sample reported feeling 'overwhelmed' at work, which was a negative predictor of both work and educational satisfaction.

Gopal et al. (2007) considered work intensity, and whether residents would prefer a longer training programme with lower work-hour limits. They found that 84% of a sample of 106 residents (response rate 74%) opposed extending training, although those who met the criteria for burnout on the Maslach Burnout Inventory were less averse, and more disposed to a 60-hour limit.

Arora et al. (2010) reported a survey of incoming interns (n=299, response rate 88%) undertaken in late June 2009 following the IOM recommendations. 59% of respondents agreed that residents should not work over 16 hours, whilst 50% felt duty hours should remain in their present form. A majority (78%) felt they should be able to exceed their shift limit for a rare case or clinical opportunity.

Choi et al. (2006) considered a cohort of residents at a single site, conducting a pre- and post-restriction survey of residents (in 2002 n=327, response rate 56%; 2004 n=450, 72%). They found that those who breached the working hours limit agreed more with negative descriptors of their emotional state ('depressed', 'fatigued', 'inferior', 'lonely') than those who did not breach it. Those who had breached the restrictions were also more negative about some items relating to practice, including 'Exercising good clinical judgement', 'Having to see too many patients in too little time', 'Being criticized or put down by consulting staff'.

Some studies found data that was more neutral – meaning that while there were no negative changes, there was no evidence of improvement. Stamp et al. (2005) compared responses in 2003 and 2004 (n=28 completing both rounds of surveys, response rate 97%), before and after the introduction of the 80-hour limit. Data included a validated health survey, depression inventory and 20 novel items concerning experience of teaching, quality of life and patient care. Of the validated scales, the only significant difference found was an improvement on the 'energy level' item on the Beck Depression Inventory. For the education items, an improvement was found on the item 'I have time enough to read', while all five quality of life items (relating to overall quality of life, getting enough rest, time with family, socialising, and wellbeing) also showed improvement.

Goitein et al. (2005) compared responses from a sample of 118 internal medicine residents in 2004 (response rate 73%) with data collected in 2001 (Shanafelt et al. 2002). Measures covered a similar range to Stamp et al. (2005): a burnout inventory (results referred to above in Section 5: Fatigue and wellbeing), screening for depression, items about career satisfaction, and effects of working time restriction on wellbeing, care and education. Within the 2004 data there was split opinion on the positive or negative effect of the 80-hour limit on most items. 75% disagreed that there was a lower commitment to individual patients (linked to continuity of care), and 70% said increased cross-cover meant patients were treated less actively. However, 54% felt that on occasions they had had to leave hospital because of working hours when they would otherwise have stayed to ensure continuity. Other negative outcomes were that 29% said they cut corners, 36% handed over prematurely, and 26% felt confusion over responsibility. In terms of education, there were positive effects on 'being receptive to learning', but many felt they missed educational opportunities including reviewing tests in person and observing a specialty procedure.

Zonia et al. (2005) reported data from a sample of 128 residents (response rate 56.4%) from several specialties. While there was agreement that restrictions would improve patient safety and residents' own wellbeing, there was a concern that patient access to care would be reduced. However, there were also effects of both specialty and the sex of the respondent. Internal medicine residents were more positive than others, and general surgery residents the most negative. Internal medicine also regarded lack of fatigue as more important than continuity of care whereas surgeons and obstetrics and gynaecology residents felt the reverse. Women, overall, were more positive than men.

Two studies report surveys of obstetrics and gynaecology residents. Lund et al. (2005) found an improvement in several measures of satisfaction with the residents' training programme (n=32, 91%), with their being happier in residency and having more free time. However, there were no changes with respect to interest in teaching or a healthier lifestyle. Bailit et al. (2005) conducted a small study with 10 residents and 25 former residents. They found improvement in respondents' satisfaction with their personal lives, but not with work (although there was no reported detriment either). Hours worked per week reduced, but the residents also reported getting less sleep while on call.

Ladd (2006) surveyed 40 paediatric surgery fellows/trainees (response rate 74%). 80% noted no impact on caseload, but 44% felt there were limited opportunities for elective rotations, and 35% felt that formal teaching was limited. Time available for instruction of others was felt to be limited by 35% of respondents, but 54% felt they had more time for self-directed learning. 64% reported a subjective improvement in quality of life, but 56% felt no improvement in the quality of their fellowship and 46% felt no improvement in their satisfaction in fellowship. Many programmes employed additional roles to enhance compliance (nurse practitioners and physician extenders - see Section 9: Interventions).

6.3.1 Studies of Clinical Faculty

Some American studies have surveyed the perceptions clinical faculty – mainly programme directors and attending doctors – have of the effects of restrictions.

Harrison and Allen (2006) found from two focus groups with attending physicians (n=18) that they felt they had increased clinical work and less time for teaching (a concurrent survey of residents' perceptions agreed with this). As a consequence more focused teaching methods were used.

Several quantitative surveys of attending physicians also found that they felt their workload increased. Goitein et al. (2008) found that attending physicians (n=282, response rate 77%) felt that they spent more time on clinical work and felt more responsible for supervising care, while having less time for research and teaching, and that this was associated with less longer-term commitment to academic medicine. Nearly half of the sample reported by Reed et al. (2007, n=111, 72%) felt their clinical workload had increased, and they felt less satisfied with teaching. Tcharmtchi et al. (2010) found that while two-thirds of attendings (sample size not known) felt that residents were less fatigued, they themselves were more fatigued. The majority of this sample felt that the restrictions had not improved patient safety or reduced residents' errors. Espey et al. (2007) found that 63% of respondents (n=100 conference attendees) felt education was worse, surgical volume decreased, and the time available for residents to teach also reduced.

Coverdill et al. (2006, 2010, 2011) conducted surveys of residents and faculty in surgical programmes. The 2006 study (n=259, 60%) found that work shifted to faculty from residents, leading to increased faculty stress and decreased satisfaction, even as residents showed the opposite effects. There was no difference between academic and non-academic programmes. This shift of work was associated with the responsibility and 'ownership' of care moving to faculty, meaning they would pick up 'loose

ends', and cover skill gaps at night. This was linked to perceived conflict between limited hours and professional values. They also lost time for research.

Winslow, Berger and Klingensmith (2004) found in a survey of surgical faculty (n=88, 75%) that faculty hours had not changed six months after the introduction of the 80-hour week, compared to responses six months before the introduction. Half of their sample felt though that patient care had suffered. Vanderveen et al. (2007) also surveyed faculty perceptions of effects on faculty members themselves, and found some differences between faculty of different specialties (n=248, 41%), with surgeons more likely to report negative effects including increased hours, lower job satisfaction and relationships outside work. One third of all respondents felt patient care was worse.

Samuels et al. (2005) report a sample of New York residency directors (n=21, response rate 68%) having marginally negative attitudes, with the most negative relating to logistics around maintaining residents' time in inpatient settings and to patient continuity.

Nuthalapaty et al. (2006) also surveyed O&G programme directors (n=123, 58%). They found that over half of respondents felt there was a negative effect of the restrictions on work ethic, skills, and education, but a positive effect on wellbeing and recruitment to the specialty. Opposition to restrictions was associated with negative perceptions across these and other items.

Abraham et al. (2006) found a majority of 82 trauma director respondents (response rate 48%) felt that duty hours restrictions did not positively affect education (in terms of reading and gaining operating experience), and that patient care had suffered. A link with residents' career decisions was also identified, specifically that excessive attending hours were off-putting to residents.

Willis et al. (2009) surveyed 118 surgery programme directors in the USA (47.6% of the population), identifying perceptions of adverse effects on clinical education, teaching, and patient safety. Additionally, the further restrictions under the IOM recommendations were felt to be near impossible to implement.

Griner et al. (2010) found that 92% of surgical faculty respondents (n=77, 33%) felt there was a difference in residents following the 80-hour restriction. The majority (68% of respondents) attributed changes to a change in work ethic arising from restricted hours, rather than the restriction per se (10%). Numbers feeling items had improved were small though. Most questionnaire items had modal responses that elements were the 'same', with only a few being felt to be 'worse' (work ethic, technical skills, decision making/critical thinking, patient ownership and continuity, 'trust to take care of patients' and 'ready to operate independently'). Only 'patient ownership and continuity' had more than a small number feeling it was 'markedly worse'. However, there were some differences between institutions, and two items (stamina and 'ready to operate independently') differed between critical care and other specialties.

Overall, faculty opinions were that restrictions had negative effects on education and at least some elements of professionalism.

6.4 Changing attitudes with seniority

Several studies surveyed both residents and faculty, comparing the views of the two populations. Others also compared responses of junior and senior trainees (for example postgraduate year 1 and 2 compared to years 4 and 5). A common finding from such analyses, implicit in the studies of the separate groups described above, is that attitudes are generally less positive with seniority – so attendings are less positive than trainees, and senior residents less positive than juniors.

Whang et al. (2003) surveyed surgical residents (n=344, 52%) across New York State in 2003, where 80-hour regulations had been in force for some time, and found that while overall opinions were positive, senior residents were less positive than juniors, and felt workload had moved to them from juniors. 35% of respondents felt training had suffered, compared to 22% who felt it had improved. 51% felt they had missed learning opportunities as a result of restrictions. 35% felt restrictions impacted negatively on patient care, and 60% believed continuity of care had suffered (again, these proportions were higher for senior residents).

Moalem et al. (2009, see p.34 of this report) found that senior residents were more negative than juniors, and no effect of specialty or programme size was reported. Kusuma et al. (2006) found a similar pattern in responses from 554 orthopaedic residents, although overall opinions were mixed. 58% said they were happier after the change, with 57% getting more rest. 38% felt there was some decline in the quality of care, but 51% reported no decline in quality of care. 82% of respondents said programmes had made changes – night float, physician assistant, ‘home call assignments’ - with 57% stating that residents had been included in design.

Goitein et al. (2005) found a similar result, with 50% of senior residents, compared to 83% of juniors, agreeing that the restriction is overall a positive thing (n=118, 73%). In a survey of 36 oral and maxillofacial residents (no response rate given) Noroozi and Philbert (2008) found that those in postgraduate year 4 or above were less positive about questions of compliance, effects on patient care and training quality.

Chung et al. (2004) described a number of interventions in one small programme (with only two graduating residents a year). Physicians’ assistants were used, and residents did not perform non-educational tasks (e.g. phlebotomy, transport). Service changes, including reducing external rotations to retain more juniors at the main training site and combining outpatient clinics from five to two, were also in place, and work organisation was changed by giving PGY-3 residents senior responsibility. The changes were successful in reducing hours (to 77 hours a week, significantly reduced from an average of 98 hours). However, there were marked differences in the perceptions of junior and senior residents of the effects of the changes. For example, the work satisfaction score for PGY-2 moved from 3.3 to 6.8 (on a 10 point scale, where 10 was most positive), while that for PGY-5 went from 9.5 to 2.8. A similar pattern was found for life-style and learning efficiency. For physical fatigue and sleep adequacy the PGY-5 scores did not change, but the PGY-2 scores showed improvement (from 2.8 to 7.5 for physical fatigue, from 3.0 to 7.5 for sleep adequacy). This implies that there are differences beyond attitudes, although these measures are also subjective.

Lin et al. (2007) surveyed 139 internal medicine residents (response rate 85%), and found that older residents in years 2 and 3 were more negative than year 1 interns. Respondents perceived negative

effects on communication, but overall were neutral on patient care, satisfaction with programme, and work-rest balance. (Lin et al. describe the perceived effect on patient care as negative, but the mean score given is actually near the mid-point of a five-point scale).

Coverdill et al. (2006) also found that faculty were more negative about effects on education and patient care. For example, only 12% of faculty agreed that restrictions improved the quality of surgical training, compared to 48% of residents. Conversely 92% of faculty and 56% of residents felt that the restrictions reduced surgical experience. Only 8% of faculty compared to 32% of residents felt that restrictions improved patient care, and similar proportions felt they enhanced residents' clinical decision making. Interestingly, Coverdill et al.'s analysis suggests that the opinions of older faculty were more similar to residents' than those of younger faculty on three items (relating to decreased faculty expectations of residents, effects on the number of errors in patient care, and patient care in general). Female residents were more likely to be positive about some items than male residents.

Hutter et al. (2006) in a study involving surveys and interviews (total n=116, overall response rate to surveys 61%) found that surgical attendings were more negative than residents, feeling that their education was worse, they knew patients less well and that resident cover was worse. Residents felt there was no change to their experience. Attendings also thought the education of interns would be adversely affected. However, there were changes in residents' working days, notably a significant increase in the operative experience of senior residents. Immerman et al. (2007) reported a survey of orthopaedic residents (n=976, response rate 30%) and programme directors (n=85, response rate 56%), finding junior residents to be more positive regarding the impact on education and patient care than seniors and programme directors, and overall agreement that quality of life was improved.

Dozois et al. (2009) compared the responses of attendings and residents who had started before and after the introduction of working hour restrictions (overall n=382, 57%). All felt that resident wellbeing had improved, but less than 33% of the sample overall felt that patient care improved. However, when considered by subgroup, differences were found. Far more of those who had started their programme after the introduction of restricted hours felt patients were safer (67% compared to 15% and 30% of attendings and residents who had started before). Similar patterns were found for perceptions of education, and of continuity of care.

Paediatric programme directors (n=26, 87%) surveyed by Henry et al. (2005) were more negative than fellows on their programmes (n=25). For example, 54% of directors felt that the quality of care decreased, compared with 23% of fellows, and there was a similar disparity found in perceptions of effects on education. The figures were closer for a question about continuity of care, with 77% of directors and 68% of fellows feeling it had decreased. One note of caution over this paper is the inclusion of bar charts which do not reflect the proportions reported in the text. Fortuna et al. (2009), in a later study of paediatric programme directors (n=53, no response rate available), also found that they were largely negative about the effects on continuity of care, education and the perceived satisfaction of attending doctors.

Zuckerman et al. (2005) also surveyed junior and senior surgical residents (n=48), and attending surgeons (n=39, response rate 100% for both). Senior residents were more negative about their

overall education than juniors (and in many cases less positive than attending surgeons), although junior residents did not feel their time in the operating room was positively affected.

Cull et al. (2006) found that paediatric residents thought the quality of patient care had improved slightly, but programme directors thought it had slightly worsened. Both residents and directors felt that resident wellbeing had improved.

Peabody (2006) compared responses of programme directors and chairs (n=94, 41%), and senior residents (n=59, 60%) before and after the 80-hour restriction, and found that while there were negative perceptions of the effects of the restrictions, these were less negative than opinions before the introduction – implying the reality was not as bad as the anticipation. As found in other studies, junior residents were less concerned than those whose training had bridged the changes.

Vallier et al. (2009) reported a study of orthopaedic residents (mean response rate 59%) and faculty (mean response rate 62%), conducted in eight residency programmes across two years (2004 and 2005). There were again different perceptions from the two groups, with junior residents feeling they worked too much in inpatient and outpatient care, while faculty felt the opposite. Senior residents' negative feelings, compared to junior residents, reduced in the second year of the study (two years after the introduction of the restrictions). However, faculty perceptions remained negative.

Surgical chief residents (n=122, 76%) and programme directors (n=110, 78%) surveyed by Jagannathan et al. (2009) largely believed the 80-hour restriction had compromised training (96% of respondents) and decreased experience (98% of respondents). Most felt there were negative effects on patient safety (although directors were more negative: 78% of residents compared to 96% of directors) and patients' access to quality care (87% of residents, 82% of directors). The majority felt additional restriction would further compromise these elements.

6.5 International comparisons

Only one study found has compared the attitudes of US and UK doctors. Jagsi and Surender (2004) reported on a study looking at US doctors following the introduction of the 80-hour week, and UK doctors following the introduction of New Deal, but before the first stage of WTR reduction. With 124 respondents (80% response rate) and 32 interviews, across two hospitals, they found few differences between the countries. Responses from both reported mixed feelings about the effects of restrictions on education – benefiting some forms of learning but hindering direct experience – and had concerns about continuity of care. Both groups also felt a large proportion of their time was spent on tasks with minimal educational value. Both reported improvements in personal lives, in fatigue and in wellbeing. Both groups felt fatigue remained a concern even after reductions, but it was a less important issue to the UK respondents than those in the US, and the UK respondents were less positive about further reductions in hours, implying that 48 hours was a minimum for many in the UK, whereas many in the USA felt a reduction below 80 hours was feasible and desirable. Organisational barriers to the effective management of WTR were identified in both countries.

6.6 Patient and public attitudes

Three studies were found which considered the perceptions of non-staff groups. Fletcher et al. (2008) conducted a questionnaire study of medical inpatients in three US hospitals (n=134, 66%). They found that patients under-estimated the hours doctors worked (a mean of 60 hours), but still felt they should work fewer hours (mean of 51). There was a mixed response to questioning about risk, with 45% feeling that tired doctors are riskier, while 39% felt that well-rested but inexperienced doctors are more likely to face problems. Perceived staff fatigue had a negative relationship with satisfaction with care.

Blum et al. (2010) conducted a telephone survey of 1,200 random members of the US public, finding a mean estimation of doctors' hours as 58 hours per week, with 67% of the sample estimating fewer than 80 hours. 85% said they would be anxious if a doctor had been working longer than 24 hour shifts, and 81% felt that shorter hours would lead to fewer errors.

Berg et al. (2011) reported data from 370 patients and accompanying persons arriving at a surgical centre (response rate 24.4%). 84% of these felt that doctors' weekly working hours should be restricted (68% thinking the limit should be 60 hours or less). 91% felt that a shift limit should be in place, with 77% thinking it should be 12 hours or less. 79% thought a surgeon would cancel a procedure if they were too tired.

Overall it seems the US public underestimate the hours their doctors work, and would prefer a limit lower than the ACGME's 80 hours (although interestingly above the 48 hours of the WTR). No studies looking at patient or public views of doctors' working hours in the UK were found.

6.7 Working time and professionalism

Finally, some studies raise a connection between working hours and professionalism.

Congliaro et al. (1993) found that both junior residents (n=79, 53%) and attendings (n=266, 60%) were uncertain about any beneficial effects of restrictions on house officers' attitudes to internal medicine, the quality of resident supervision and house-staff intellectual interest in challenging medical problems. However, both considered that a 'shift-work' mentality was developing among residents. Both groups agreed that residents had more spare time.

Ratanawongsa et al. (2006) report a survey of 189 medical residents (response rate 54%), asking about perceptions of the effects of restrictions on 12 aspects of professionalism. 45% felt that their professionalism was reduced, 32% that there was no change, and 19% that it improved. Negatives were attributed to a lack of time for communication, to the detriment of continuity of care, with a consequent lack of accountability for care. However there were improvements through being less fatigued and improvements in teamwork.

Griner et al.'s (2010) and Nuthalapaty et al.'s (2006) survey items about 'work ethic' could be seen as an aspect of professionalism, and faculty rated residents as lower on these measures following restrictions.

Reed et al. (2007) found that faculty (n=111, 72%) perceived residents' autonomy and professionalism (operationalised as variables including accountability to patients, and altruism) to have deteriorated. The majority did feel that residents' wellbeing had improved but that their residents' education (in terms of opportunities for didactic and experiential learning) had also deteriorated.

Kellogg et al. (2006) carried out ethnographic observation of resident activity leading to the introduction of a new system. They noted though that practical changes were not sufficient, and they needed to address the identity of residents to develop a 'new professionalism', and overcome resistance to new ways of working. The term 'new professionalism' was also used by Coverdill et al. (2010, 2011) who found that negative views of faculty were in part based on perceived conflict between restricted working hours and professional values. A lack of responsibility arising from reduced hours was also referred to by UK surgeons studied by Skipworth et al. (2008).

However, a three-month observational study of internal medicine and general surgery residents (total n= approximately 22), with 17 additional in-depth interviews, reported by Szymczak et al. (2010) found that at least some of the hypothesised detrimental effects on professionalism, that trainees may become 'clock watchers' or develop a 'shift work mentality' were not apparent, and that residents would exceed hours in a considered way, if they felt it was necessary. This suggests that core professional standards are adaptable and can be maintained despite changes to hours.

6.8 Summary

Research into attitudes, opinions and perceptions of working hour restrictions has adopted various approaches, with some robust, large-scale studies across large populations, and others presenting far smaller descriptive studies of local populations. Some papers lack methodological detail, and any overview must be aware that variability between studies exists. Much of the literature has come from the USA, and the transferability to the UK must be treated with caution given considerable differences in working hour limits – in total and in shifts. However there is consistency in several results, suggesting that findings can be treated as robust across different locations and populations.

Perceived levels of compliance are variable, but generally quite low. Much of the survey evidence portrays negative attitudes towards restrictions, around issues such as training opportunities and continuity of care. (Although many feel training opportunities are limited by restricted hours, they may also be resistant to extending the duration of training to compensate). Some positives are common though such as reducing trainee fatigue and improving quality of life. A number of studies also find no effects on a number of variables – sometimes this is taken as a negative result (the implication being that no improvement renders the changes pointless).

There are three main points of interest to take from these studies:

- Junior trainees are more accepting of changes than senior trainees and faculty, and identify fewer negatives in terms of education and patient care. While seniors may be seen to have more expert judgement in these issues, they are more adapted to the previous system, and may be consciously or unconsciously resistant to change.

- Studies comparing specialties have identified some inter-specialty differences, but these may be confounded by other local factors beyond the nature of the clinical care provided. Surgery appears to have been more studied, in the USA as well as the UK, but this may reflect political, rather than practical, concerns.
- Working hour restriction has been linked to professionalism, with the risk of doctors becoming 'clock-watchers' being linked to a loss of autonomy and a loss of professional responsibility. While incidental to most of the studies reported here (and one found no evidence such a change is occurring), that the concerns have been raised links the question of working time restriction to a wider debate about the changing nature of medicine.

These points all contribute to a final caveat in considering this literature. Many of the papers, even those in peer-reviewed journals, express a rhetorical bias. For example, Moalem et al. (2009) described 31% of respondents who did not see restrictions as a barrier as 'fewer than one third', although it is only 10% less than the 41% who found them a 'considerable or moderate' barrier. Tcharmtchi et al. (2010) combine 'no improvement' and 'some worsening' when reporting responses relating to patient safety and resident error rates, distinctly biasing results by including neutral responses with a negative one. This may illustrate a subtext of much of this literature, and the whole question of the effects of working time restriction: that medical work is not felt, by doctors, to be as susceptible to adverse effects as other activities.

The dominant finding from this literature is that opinions regarding restriction of working hours are negative. However there are also positive opinions about the impact on education and care, even among senior doctors, while the perceived effects on trainee doctors' wellbeing are near-universally positive.

7 Impact on educational opportunities

7.1 Perceptions of educational impact

Several surveys conducted in the UK have included questions asking respondents how they perceive the EWTD/WTR to have impacted on their training. Many of these have been commissioned or carried out by Royal Colleges, and have contained a number of items including perception of educational quality, exposure to cases, and opportunities to attend formal teaching. Overall, responses to these surveys have indicated negative perceptions – although the samples are self-selected, and not representative, so caution must be exercised in drawing any conclusions.

Data published by the Royal College of Surgeons of England (2010) stated that consultant surgeons in 2010 (n=503, no response rate given) reported that the number of lists conducted with a surgical trainee had decreased since 2009 (although no 2009 data was provided for that question), and the proportion of consultants reporting a decrease in their available time as a trainer rose slightly (from 49% in 2009 [n=363] to 54% in 2010 [n=503]). The proportion of surgical trainees reporting a decrease in their available time as a trainee also rose from 41% in 2009 (n=58) to 65% in 2010 (n=479). Data from a 2010 census reported by the Federation of the Royal College of Physicians (2011) showed that the majority of consultant respondents thought the quality of training had got worse following implementation of the EWTD (54.2% worse; 26.9% much worse), whilst only a very small minority thought it had got better (2.7%

The evidence in this section

Studies in this section fall into two groups: subjective perceptions of effects on educational impact, and objective measures of educational impact. No detailed reviews were identified in this area.

The former tend to have large sample sizes (n>100), but response rates vary, and many must be seen as of questionable quality and value, limited as they are by self-selecting samples, and the consequent risk of bias.

Those looking at objective measures on the other hand are generally of higher quality in terms of design, with retrospective audits of cases, although sample sizes vary. However, there are also specific methodological questions around the ways in which educational impact is operationalised. Specifically, there is a focus on frequencies – the numbers of procedures carried out, hours spent in teaching sessions – which may not reflect the depth of exposure or quality of learning. There are also concurrent changes to practice and the organisation of care which may confound effects of working time, and are often acknowledged, but not accounted for in results. Studies of changes in the patterns of exam results may be a more objective measure, but are to date only found in reference to American qualifications. Differences in the organisation of care, and the structure of medical training and assessment, may also limit the transferability of findings.

Key points in this section

1. Doctors' perceptions of the educational impact of restrictions are largely negative.
2. Effects on quantified educational experience, including caseload, are mixed, with some studies showing a reduction, others reporting no change.
3. Caseload may be maintained at the expense of other work (e.g. clinic attendance), and limit access for junior trainees in favour of senior trainees.
4. American studies of effects on examination results are mixed, some reporting improvements, others finding no change.
5. Most studies identify confounding factors (such as service redesign), meaning a simple causal effect of WTR cannot be assumed.

better; 0.3% much better), and 15.9% thought it was the same (3,777 of 5,126 respondents, from a population of 10,810 consultants, completed these items).

Results from a survey of UK ophthalmic trainees in October 2009 (n=189, response rate 27%) showed that 47.6% of trainees felt that the delivery of their training had been adversely affected (Ophthalmic Trainees Group 2009). Particular training issues included: missing surgical experience due to rest periods (22.5%); reduced exposure to managing emergencies (20.7%); reduced chances of repairing penetrating injuries (20.3%); missing clinical experience due to rest periods (18.5%); missing teaching sessions (11.7%); or other issues (6.3%), e.g. absence of teamwork, feelings of less support, loss of continuity of training due to shift changes.

A survey was conducted by the British Medical Association Junior Doctors Committee in December 2009-January 2010 with junior doctors across the UK (BMA Junior Doctors Committee 2010). The final response rate was 10.6% (1,567/14,754), representing approximately 5% of junior members. Over half of respondents (54.2%) reported that compliance with a maximum average 48-hour week had a negative effect on their training overall, 10.7% that it had a positive effect, and 35.2% that it had had no effect. Respondents who worked in research/academic medicine and hospital based medicine were more likely to report a negative effect (74.3% and 56.1% respectively); those in community health (61.5%) more likely to have reported no effect, and those in general practice (12.5%) a positive effect; however some categories had a very low number of respondents. Amongst hospital based specialties, respondents who worked in psychiatry and emergency medicine were most likely to have reported a positive effect, and respondents in neurosurgery, anaesthetics and surgery a negative effect. Almost half of all respondents (49.2%) reported having missed out on training opportunities since August 2009, with respondents in hospital based practice most likely (51.8%) and those in general practice (27.8%) least likely. Respondents in the hospital specialties of neurosurgery (80%), anaesthetics (66.1%) and obstetrics and gynaecology (62%) were most likely to report having missed out on training opportunities; those in psychiatry (77.9%) least likely. The most commonly reported missed training opportunities were lectures or training days (75.5% of cases), followed by observation/training supervision (65.6%) and opportunities to complete procedures/demonstrate skills necessary to evidence PDP competencies (63.1%). The most commonly reported reason for missing training opportunities was being required to fill long-term rota gaps/staff shortages (56.1% of cases), followed by the need to provide short-term cover for colleagues (41.4%), design of the rota or having to take compulsory time off due to WTR (28.5%), and the need to provide service provision or being too busy with clinical duties to take time out (14.1%).

Other studies have found negative perceptions of overall educational experience. Haycock et al. (2009) report a survey of gastroenterology trainees across the UK (n=249, 60%) which found that 31.4% felt their training was impaired, and 23% felt they would not gain competency in at least one required area during their training. Brunworth and Sindwani (2006) reported that 69% of otolaryngology faculty (n=185, response rate unknown) felt that the work hour restrictions had had a negative effect on resident training, compared to only 31% of residents (n=275, response rate unknown).

Elsewhere in Europe, Businger et al.'s (2010) survey of surgical departments in Switzerland, conducted a year after the 50-hour work-week limitation was introduced, found that the majority

(73-84%) of residents and consultants (n=405, 65.5%) reported that operative time and overall operating room experience were negatively affected by the work hour limitation, and there had been a negative effect on surgical training (62.8% of residents; 77.2% consultants). Only 8.1% of residents and 4.9% of consultants perceived the limitations as beneficial to training, although 39.8% of residents reported increased time for study and preparation, and a smaller proportion (17.9%) thought that overall knowledge had improved as a result of the limitation. Landrigan et al. (2008) reported, from their study of 220 paediatric residents (82% of sample, 44% of population), that overall ratings of educational experiences did not change significantly after implementation. Before implementation 22.4% of residents characterised their overall educational experience as poor or fair; 23.5% after implementation.

A national survey of general surgery residents (n=6,161, response rate \geq 95%), whose entire graduate education had taken place after implementation of the ACGME standards, found that 30% or less perceived their educational activity time to be 'Minimal' or 'Insufficient', with at least 70% of all respondents perceiving it to be 'Adequate' to 'Above Average'. Over 90% of respondents considered their faculty supervision to be adequate or better (Borman et al. 2011).

One study (Balmer et al. 2007) looked at the extent to which a clinic being rescheduled to meet restrictions may have disrupted the longitudinal learning relationship between residents and a continuity clinic preceptor. Observations were carried out at one clinic (100 hours over five months) as well as two semi-structured interviews with third-year residents (n=10) and one with continuity clinic preceptors (n=10). There was a difference in how the change was perceived. Residents felt it benefited their learning through exposing them to different preceptors with different practice styles, as well as reducing fatigue. Preceptors, however, felt it frustrated their efforts to evaluate residents' progress over time, and be learner-centred teachers and effective mentors.

7.2 Impact of working hour restrictions on caseload

One indicator of the effects of working time restriction on educational experience which has been studied is the number of cases seen by doctors. These studies have been in craft specialties (surgery, anaesthesia, obstetrics and gynaecology) where the number of procedures can be easily quantified. No studies were found presenting comparable data for other specialties.

Sadaba and Urso (2011) conducted a review of literature on the impact of duty-hour restrictions on trainees' exposure to surgical procedures, all studies being from the USA. They concluded that whilst most studies revealed that the USA working-hour restrictions had resulted in a decrease in the number of cases performed by trainees, some did not. They also observed from the literature that numbers performed by junior residents appeared to have reduced more, with surgical workload shifting towards the seniors.

7.2.1 UK and other European studies

Anaesthesia

Underwood and McIndoe (2005, 2009) report two studies of data from operating theatres in a teaching hospital in the south-west of England. The first study examined data on over 50,000 cases

across three time periods: 1996-97 (to capture the introduction of the specialist registrar grade in 1996), 2001 (to capture any influence of the New Deal in 2000) and 2004 (the first wave of WTR, with a 13 hour maximum shift duration and maximum 58-hour working week). The caseload of senior house officers and specialist registrars reduced by 20% and 21% respectively, whereas that of consultants rose. This was particularly true during daytime. The later study compared data for 1997 and 2008 (the second wave of WTR in 2007, with a reduction to a 56 hour week). Average case numbers increased for senior registrars, including an increase in emergency workload and evening and night theatre cases, while those for pre-fellowship registrars (less than two years in a specialty training post) decreased slightly. Underwood and McIndoe also report on the extent of supervision in theatre. The 2005 paper found that direct supervision of trainees (i.e. in theatre with a consultant or, for SHOs, with a specialist registrar) increased during the period of study (32% to 37% to 47%) and continued in the period covered by the second paper; registrars and post-fellowship senior registrars (with more than two years in a specialty training post) were supervised directly by consultants in 49% and 39% of cases respectively. This raises the point that quantity (raw caseload) and quality (supervised caseload) of educational experiences may be different things.

Sim et al. (2004) performed logbook and list analyses for trainee anaesthetists for two ten-week periods (between August and October 2002 and January and March 2003) to examine the effects of the change from a partial to a full shift system. Results from logbooks showed an 18% decrease in the number of cases led by specialist registrars (n=4) and 22% by senior house officers (n=5). Information from departmental records showed an 11% decrease in the number of weekly training lists for specialist registrars (n=13) and 14% for senior house officers (n=12). Implications regarding fatigue, good handover and record keeping for continuity of care were noted e.g. being tired at the end of a long on-call period may have adverse effects on handover. Searle and Lyons (2008) examined one obstetric department's audit information for the years 1998 to 2006 and found that the mean number of obstetric general anaesthetics given per trainee (specialist registrars) had fallen from four in 1998 to one in 2006.

Three studies were found in the subspecialty of paediatric anaesthesia. A study by White et al. (2005) looked at the number of operating lists undertaken by specialist registrars (n=62). The study compared lists from two six-month periods, one before the 2004 phase of WTR (24-hour partial shift system, working 1:8 nights, 60 hours rostered per week) and one after (full shifts, 1:9 nights, 56 hours per week). The mean number of elective lists decreased by 13%, from 24 to 21 lists per SpR per month, but the number of specialist lists performed remained unchanged. The authors suggest this may have been because specialist lists were considered to offer better training opportunities and were relatively protected. Also, two additional posts had been created, resulting in a larger number of trainees, which may have minimised the effect of the WTR. The significance of the impact of the WTR for clinical practice was not measured and was deemed to be unclear, although the issue of formal support and/or supervision for new, less experienced consultants was raised.

A study by Fernandez and Williams (2009) consisted of a retrospective analysis of theatre logbook data from 62 specialist registrars who had undertaken a twelve-month period of advanced training in paediatric anaesthesia between 2000 and 2007, comparing those who had worked before May 2004 (n=30) with those who worked afterwards (n=32). This date involved a change from a 60 hour per week partial shift system to a 56-hour week and full shift rota. They found a significant decrease of

24% in the mean total number of cases performed by SpRs per year (from 441 to 336 cases), particularly in the group of children under one month of age. There was also a reduction in the mean number, and proportion, of emergency cases. While the authors comment that they have no direct evidence that this has any impact on training or patient care, this group of SpRs did not meet the Royal College of Anaesthetists (RCOA) recommended minimum caseload for the advanced training period or the minimum number of cases in the under one-year age group.

Naik et al. (2010) conducted a retrospective review of paediatric anaesthesia trainees' paper logbooks from 1997 to 2010 (n=104/220 logbooks, the remainder being incomplete or unavailable). They found a decline of almost 25% in the total number of paediatric cases undertaken by trainees since 2000. Initiatives were undertaken to improve trainees' experience, including the opportunity to spend time in the paediatric critical care unit, out of programme training in other UK centres or abroad, and the use of simulation training.

Al-Rawi and Spargo (2009) also examined logbooks submitted at trainees' annual Record of In-Training Assessment (RITA), and compared caseload and supervision levels before (n=40) and after (n=79) implementation of EWTD compliant rotas (1999 and 2006). In contrast to those described above, this study found no difference in total caseload, obstetric caseload or supervision levels between groups, although out-of-hours caseload was greater in the earlier group.

Surgery

Several UK studies have looked at trainees' surgical exposure, the majority reporting a decrease in exposure following working time restrictions.

Ngan et al. (2009) conducted a retrospective analysis of a colorectal cancer database in one hospital in England to examine the percentage of surgery cases performed by trainees per year over a ten year period which encompassed changes up to and including the 56 hour stage of WTR introduction. Over the ten years there was an almost 50% reduction in the proportion of colorectal cancer resections performed by trainees, from 42% in 1998 to 17% in 2007 (the mean number of cases performed by a trainee before 2001 was 34 (95% CI 31-37); after 2001 it was 19 (95% CI 17-21).

Wilson et al. (2010) found a decrease between 2004 and 2008 in the proportion of procedures performed by trainees in orthopaedic surgery - from 38% to 17% of cases. A retrospective single centre study (Blencowe et al. 2011) looked at theatre data for elective and emergency general surgical operations (excluding orthopaedic, urological, maxillofacial and cardiothoracic cases) at different time points: 1996, 2001, 2004 and 2009. This showed a decrease in the overall proportion of both elective and emergency operating) performed by SHOs and SpRs, with a corresponding increase in cases performed by consultants. There was a reduction in the proportion of appendectomies performed by senior house officers (72.2% in 1996; 3.8% in 2009), and by 2009 appendectomies and abscess drainage were the only emergency procedures they performed. For SpRs, the proportion of emergency operating performed remained constant, but elective operating reduced from 34.6% to 15.7%. In both elective and emergency work, supervision of both groups of trainees increased between 1996 and 2009 (for SpRs from 5.1% of total caseload to 12.4% supervised

by a consultant; for SHOs from 17.2% to 46.8% supervised by a consultant or SpR), suggesting that consultants are more available for training, with potential benefits for patient care.

Blencowe et al. (2011) suggested protected theatre sessions may be required for trainees, to balance operative training and ward based duties; educational strategies such as modules to learn component parts of operative procedures may help the stepwise acquisition of technical skills, as well as simulation and web-based materials.

Moss et al. (2011) surveyed trainees (n=104, response rate 64.3%) and consultants (n=66, 66.7%) in obstetrics and gynaecology about the barriers to surgical training and potential solutions. They identified concerns that the WTR had led to a substantial reduction in daytime working and consequently reductions in theatre attendance, as demonstrated by 28.3% of trainees reporting only being present at a list with a major procedure once a month or less. At the same time trainees reported that staff shortages meant being removed from theatre to cover essential ward services. Trainees based in hospitals with fewer than 3,999 deliveries per year were able to attend theatre more regularly. Trainees attached to consultants who did not perform major gynaecological procedures themselves were significantly less likely to attend theatre, or lists containing major cases. Potential solutions popular with trainees and consultants were attachment to a 'surgical trainer' (a consultant with particular teaching aptitude and skills) and the introduction of training lists.

Kamat et al. (2009) suggested that maintaining operative curriculum requirements was at the expense of clinic attendance. They examined prospective operative data and clinic attendance data in 2007 and 2008, to cover a change in work patterns from non-resident 1-in-7 on-call (72 hour compliant) to 1-in-8 full shift (56 hour compliant). They found a significant reduction in the number of trainee-involved cases during working hours, and from August 2008 mandatory non-specialist clinic attendance was reduced by 85% to maintain the required minimum number of operative cases performed by trainees (ST3 to ST8) per year.

One study compared the working hours, in January/February 2009, of orthopaedic specialist registrars in the Republic of Ireland and North West England. (The Republic of Ireland did not have a phased reduction in working hours to implement the EWTD, but moved directly to 48 hours in August 2009). This found that the Irish doctors worked significantly more hours per week (72 vs. 51.5), did more trauma operative lists and more cases in total per six month period (Banks et al. 2010).

One study found reported increased participation in operations after the restrictions. Lim and Tsui (2006) examined data from a cardiac surgical database in one UK hospital and found a marginal increase in the proportion of operations being performed by trainees in the year after the introduction of the 58 hour WTR compliant rota in 2004, from 39% (626/1587) to 40% (695/1725). (This involved a move to a full-shift system and a reduction from approximately 16 to 11 days per month allocated to theatre for trainees). The three most influential predictors for surgery being performed by a trainee were (in descending order of influence) the consultant in charge, the procedure performed, and the increasing seniority of the trainee. There were no differences in operative risk. The authors noted, as well as a strong commitment to training, the introduction of a

'team approach' to surgical training; however suggested that this approach may not be suitable for rotations that involve a large number of different hospitals.

7.2.2 *American studies*

Several US studies also show decreases in operative experience, although there is conflicting evidence, and several authors comment that it may take longer than the time span of their studies to fully assess the impact of the work-hour restrictions. Questions are also raised regarding the quantity of procedures completed versus the quality of the learning experiences they constitute.

An early retrospective study (Hassett et al. 2002) was undertaken after the introduction of the New York State Health Code. This looked at five years experience in a surgical programme when changes had been made to the programme, including strict start/stop working hours for clinical contact; modification of clinical assignments and prioritisation of procedures, transfer of some clinical procedures to nurse practitioners, physician assistants and registered nurse first assistants (particularly since 1998). Working hour compliance was greater than 95%. There was no significant difference in the procedural activity of residents.

Barden et al. (2002) reported on a general surgery residency programme where an 80-hour work week was introduced in January 1998, along with the addition of a night float resident at the junior and PGY-3 levels, a decrease in ICU call frequency from every two to every three days, and creation of weekend cross-coverage for general surgery and vascular services, providing residents with two 48-hour breaks per month. Data for the two years before and after implementation showed a significant increase in the total number of cases performed by chief residents. Survey data from residents (n=29, response rate 73%) and faculty (n=8, response rate not given) showed that the majority (85%) of the residents reported an overall improvement in quality of life, but both residents and faculty perceived changes to have negatively impacted on a number of elements of patient care.

Several studies have reported reduced operative experience of surgical residents after the introduction of the 80-hour working week. For example, Feanny et al. (2005) found a shift in the type of surgery completed. They compared the two-year operative experience in emergency abdominal procedures of postgraduate year 4 and 5 (final-year) residents before and after the ACGME duty hour restriction. Although there was no difference between groups in the mean number of procedures performed as the primary surgeon, there was a 40% decrease in technically advanced procedures, and a 44% increase in basic procedures which may previously have been delegated to more junior members of the team. There is therefore a potential knock-on effect on the juniors' operative experience. There was also a 54% decrease in the operative volume as first assistant, potentially affecting the opportunity to develop operative independence and technical self-confidence. Operative continuity of care decreased from 60% to 26% of cases.

Jarman et al. (2004) looked at the number of missed surgical procedures recorded by surgical residents on post-call days from 1 September 2002 to 31 March 2004 (spanning implementation of a night rotation in April 2003). This found that, before implementation of the night rotation, residents were predicted to miss an average of 202 operations over four years; the projected loss after implementation was 107 over four years.

A study in a two-person per year orthopaedic training programme compared the operative case experiences of PGY-2 and PGY-3 residents in the academic year before and after implementation using ACGME case logs (Weatherby et al. 2007). It was found that they performed 21.5% fewer cases between the two years, and the average number of cases per rotation decreased by 20.44%. Connors et al. (2009) looked at the operative logs of 37 cardiothoracic surgery residents at three training institutions before and after the 80-hour restriction was introduced (graduating in 1999-2002 or 2003-2007). The overall volume of thoracic surgery cases was not significantly different after the change (the number of cases seen was lower during PGY-1 but increased in PGY-2 and PGY-3) but the number of cardiac cases seen by each year of training was substantially lower. As a result, overall total cases were lower in all years of residency.

Several studies have been undertaken in general surgery. Damadi et al. (2007) compared the operative experience of chief residents in one institution before and after duty hour restrictions (n=6 before, n=3 afterwards). They found an overall decrease of nearly 20% in operative volume after work-hour restrictions. There was no change in total surgical activity by the faculty over the same period. Kairys et al. (2008) examined ACGME resident reports for general surgery residents from the academic years 1992-93 to 2005-06. They showed that the total number of major operations reported by residents as surgeon decreased significantly between 2001-02 and 2005-06 (a 2.3% decrease from 930 to 909). However the authors caution against attributing this solely to the impact of duty hour restrictions, and it being too early to assess impact for undertaking the entirety of resident training under these restrictions.

A later study by Watson et al. (2010) compared data on surgical procedure codes logged by PGY-5 general surgery residents for 15 years before and five years after 2003. Despite an increase in total surgery cases over this time, there was a statistically significant decrease in the operative experience of categorical surgical residents following the restrictions.

Other studies have found a decrease in some of the different types of experience relating to residents' role in operations. Christmas et al. (2009) found a significant decrease in the number of total chief residents' cases (n=6 before reduction; n=16 afterwards). Total teaching assistant cases increased but also failed to reach significance. Picarella et al. (2011) examined data logged on the ACGME website for residents completing training at one institution from 2002 to 2008 (n=31). They found a significant decrease in the total number of operative procedures performed for 'first assistant' residents only, whilst the number in which residents functioned as the primary (chief or junior) surgeon or 'teaching assistant' remained constant. This resulted in a significant decrease in the total number of procedures per resident between 2002 and 2008.

While the preceding studies suggest the effect anticipated by many – that restricted hours would reduce exposure – had emerged, several studies have suggested otherwise, showing no significant change in operative volume. Others have looked at different subspecialties and found variable patterns.

For example, data compiled retrospectively from ACGME logs and operating room records for 2002 and 2003, found no decrease in operative experience overall, although PGY-5 residents did have statistically fewer cases after working-hour restrictions which may have represented shifting of post-

call afternoon cases to other residents (McElearney 2005). Another study by Tran et al. (2006) examined data on operative cases in general surgery performed by residents, over a longer period from 2000 to 2004. There was no change at PGY-4 and PGY-5 levels, a trend towards an increase at PGY-1 and PGY-2 level and a decrease at PGY-3 level, but changes were not significant.

A report by the ACGME Residency Review Committee-Surgery (Bland et al. 2005) showed no significant change in overall surgical experience for major procedures in the first year following the introduction of the ACGME limit. Similarly Malangoni et al. (2005) found the number of operations performed by senior residents in trauma and emergency surgery did not change, although there was a shift in the median number of emergency surgery cases to more senior residents. Short et al. (2006) found no significant difference in the total numbers of obstetrics and gynaecology cases pre and post restriction (n=17 residents pre-, n=18 post-), although the total number of obstetric cases per resident did decline.

A comparison of residents graduating in 2003 and 2007 in two institutions, one academic and one university-based, also found little impact on the number of gynaecologic surgeries performed by residents (Occhino et al. 2008). A later national study (Smith 2010) examining data for this specialty spanning the years 1997 to 2008 (projected data for 2008), and reporting descriptive statistics and trends, also found little change in the reported median resident experience in core procedures. The author also points to other contextual factors, such as a national trend away from the use of certain procedures, and unknown effects of e.g. increased efficiency and altered rotation structures such as night-float systems.

A study that also covered the second year after the formal 2003 implementation, comparing surgical case logs of 35 second to fifth year orthopaedic residents at a single university-based programme, found no significant difference in the number of surgical procedures logged by residents for the two years before and after implementation for any level of residency training (Pappas & Teague 2007).

A comparison of the number of elective cases covered by general surgery residents in one institution in July 2002-June 2003 and July 2004-June 2005 showed a non-significant reduction in the proportion of cases covered by residents (Shin et al. 2008). Shin et al. (2010) extended the study to include July 2006-June 2007, and found case coverage was the same or better in the latest time period overall, and for each resident level. An appropriate level resident was available for senior level cases similarly during all periods, and junior and intermediate level cases were more often covered by an appropriate level resident. One adjustment that had been made in July 2003 was the addition of another PGY-3 resident to the team.

In contrast, however, another study in general surgery (Hope et al. 2011), which reviewed cases for 2002-03 and 2008-09 found that before the 80-hour workweek 85% of cases were covered by residents and 15% uncovered, whilst in the later period 60% were covered and 40% uncovered. This was considered to have implications, for example, for the workload of attending physicians, staffing, and residents' prioritisation of cases to be involved in.

Spencer and Teitelbaum (2005) found in paediatric surgery, however, that the lack of change in the number of operative cases performed by senior and junior residents (n=47 residents pre-

implementation; n=44 post-implementation) may have been at the expense of outpatient clinic experience, as residents' participation in outpatient clinics was significantly decreased (from 66% to 17% of clinics covered, $p < 0.005$). A similar result was found in Ladd's (2006) national US survey of paediatric surgery first and second year fellows (n=40, 74% response rate), 31% of whom reported loss of outpatient clinic participation. This study did not include quantitative assessment of operative case volume, but through qualitative reporting 80% of respondents noted no impact on their operative volume, although clinical education was felt to be impacted by 44% of respondents, by reducing opportunities for elective, off-service rotations in related surgical disciplines. However, at the time of the survey (March 2005), less than half of the respondents felt compliant with the guidelines, although 95% reported that their programme made concerted efforts to comply.

A later study, comparing operative logs for 2002-03 to 2007-08, found no change in total operative volume performed as surgeon for graduating fellows in paediatric surgery (Simien et al. 2011). Another study by Simien et al. (2010), comparing operative logs for general surgery, urology and plastic surgery over the same period, showed no changes in operative volume for plastic surgery, an increase for urology programmes, with a decrease for some categories of general surgery (e.g. vascular and thoracic) and an increase for others. A study looking at the particular subspecialty of vascular surgery, comparing operative logs for 2002-03 to 2006-07, found an increase in total major procedures as a surgeon for graduating fellows (Simien et al. 2011).

Bruce et al. (2010) compared operative logs of surgical residents who had graduated in the three years prior to the work-hour restriction implementation (2001, 2002, 2003, n=17 residents) with those of residents graduating in 2008 and 2009, whose entire residency was undertaken after implementation (n=12 residents). Operative volumes in 13 of the 19 categories were not significantly affected by the implementation of the 80-hour working week. Four showed a significant decrease ($p < 0.05$), although they were still within the ACGME Resident Review Committee (RRC) minimum requirements. One (laparoscopic-basic) showed a significant increase in operative volume.

Other studies have found an increase in operative volume for residents. De Virgilio et al.'s (2006) comparison of operative volume for residents at a trauma centre in the periods July 1998-June 2003 and July 2003-June 2005 found that mean resident total major case volumes increased significantly in the second period (from 831 to 1,156, $p < 0.0001$), although chief resident case volume was unchanged. Froelich et al. (2009) observed a slight increase in the average number of cases performed by orthopaedic surgery residents each year after implementation, but this was not statistically significant.

Baskies et al. (2008) examined operative logs of Postgraduate Year (PGY) 2-5 residents in orthopaedic surgery, and found an increase in operative volume of an average of 46.6 (363.6 to 410.2) cases per year for the 2002-2006 cohort compared to the 2000-2002 cohort, although the difference was significant for PGY-5 residents only (mean increase of 73.6) when analysed by year of training. It was suggested that this may have been because junior residents no longer stayed on-site to participate in operative cases on days following a night of on-call, as they often had done before. This may thus require more senior residents to assume increased operative responsibilities (and possibly reallocate time from other daily responsibilities e.g. clinic cover, and personal and study time).

Examining the impact of the 30-hour work limit, Izu et al. (2007) reported an increase in the participation of one centre's general surgery residents in the total number of operations, from 35% (47/134) in April 2003 to 45% (49/109) in April 2005, and from 37% (11/30) to 44% (20/45) of those beginning after noon. However, this comparison involved only two residents. In a survey administered as part of this study in September 2006, also with a small sample size (n=41), 23 (56%) residents reported missing operations each month due to the 30-hour restriction. Thirty-six (88%) reported that operating on patients whom they had evaluated provided a better educational experience, and preferred to do this rather than sign the operation out to someone else. Thirty-four (83%) reported occasions when this would have required an additional one to four hours work, leading the authors to suggest one exception per month to the 30-hour restriction.

Ferguson et al. (2005) found that it was possible to maintain operative volume through implementing a number of changes including physician extenders, changed call schedules, and a night float rotation, but there was no clear relationship between the types of changes and case volume. They concluded that changes need to be individualised to meet the needs of specific rotations.

7.3 Factors confounding changes in caseload

Caseload is a temptingly simple metric to consider changes in the education of trainees. While other indicators may be subjective, or vary with the environment, the numbers of procedures carried out, or patients seen, are intuitively objective and robust indicators of experience. However, there are other areas that must be considered – concurrent changes which may explain changes in caseload, the educational value of a mix of experiences in training, and the quantity of procedures conducted, against the quality of those educational experiences.

The studies of anaesthetists' caseload by Underwood and McIndoe (2005, 2009) and Sim et al. (2004) did not examine other activity, such as intensive care, ward and clinic work, research and administration which are also important parts of the training of anaesthetists.

Several of the studies reporting a reduction in procedures placed this within a wider context, for example where there have been structural changes to training, changes in team structure and functioning, and changes in the numbers of trainees (e.g. Blencowe et al. 2011). Searle and Lyons (2008) noted that the reduction in the number of obstetric general anaesthetics given per trainee reflected both changing trends in the delivery of anaesthesia for caesarean section and an increase in trainee numbers between 1998 and 2006 (nearly doubling between 2000 and 2004) as well as the changes in working hours. Wilson et al. (2010) linked their findings of a reduction in procedures to effects of Payment by Results (trainees took significantly longer to perform procedures than consultants), the 18 Week Pathway, and some suitable training cases being sent by primary care trusts to the independent sector, as well as effects of working time restrictions and shift work. Ngan et al. (2009) point out that the reduction they identified coincided with increasing sub-specialisation in surgery and the introduction of multidisciplinary teams for cancer.

In the UK, policy-driven changes such as new training programmes and changes in training numbers, a required decrease in the number of procedures carried out between 1800h and 0800h and latterly the CPOD restriction on night-time operating, and the 4-hour waiting times in acute receiving units

may all have had an effect. Involvement of a 'Hospital at Night' team is also a possible confound. Finally, clinical developments such as less invasive techniques, and the medical treatment of previously surgical cases, may have affected caseloads.

In the USA, Bruce et al. (2010) highlighted confounding factors in addition to the work-hour restrictions, such as the deletion of resident coverage for one major trauma centre, an increase in non-operative management of abdominal injuries, the opening of a specialist heart hospital where the residents were not involved, and a move of some plastic surgery cases to outpatient facilities limiting resident access. A night float call system had been introduced which, with other arrangements, allowed residents to be free from call on weekdays, enabling them to participate fully in clinics, surgeries and conferences occurring Monday to Friday.

Picarella et al. (2011) observed that procedural volume in which a resident is the operating surgeon is not the only important variable, as time spent observing and first assisting a senior performing a complex procedure, and the overall educational value of real-time experience in the operating room, are also important to overall surgical training. Several of the studies discussed have noted that seniors' experience may be maintained at the expense of juniors.

Finally, Watson et al. (2010) identified possible inaccuracies in self-reporting of cases, and different logging systems having been used in the time periods they compared. There is a risk therefore that comparisons made are not always like-for-like.

7.4 Other educational opportunities

Several studies have examined the impact of working hour restrictions on access to medical education and training other than case volume, for example attendance at outpatient clinics and formal teaching. The majority of these have been American studies.

Working time restriction has often resulted in the on-call general surgery junior doctor regularly missing consultant-led post-take ward rounds and the educational opportunities these provide. A prospective observational study of consecutive admissions to a general surgery department over a four-week period in 2009 found that, for 52 patients admitted by seven general surgery juniors (foundation year 2, core surgical training years 1 and 2), fourteen diagnoses (27%) were changed (including two 'major' diagnostic changes), and further investigations ordered for 18 patients (35%) on the post-take ward round. However, no comparative data from before introduction of the WTR were given (Bhangu & Hartshorne 2011).

Du Rand and Lewis (2009) report an online national survey of UK respiratory trainees (n=224, response rate 48%), which found that 46% of respondents missed at least at least one bronchoscopy list per month.

In the USA, Gelfand et al.'s (2004) survey of 37 surgery residents found that formal in-hospital education time (e.g. clinical conferences) was reduced after implementation of the ACGME guidelines (4.8 to 2.5 hours per week), whilst operating room hours, clinic time and duration of rounds did not show a significant decrease. However, residents were still working over 80 hours per

week (reduced from 100.7 to 82.6). Gopal et al. (2005) also reported that surgery residents in one university-based department reported attending fewer educational sessions after ACGME.

Kort et al. (2004) in their study of surgical residents found that residents perceived a reduction in caseload and a negative effect on their relations with attendings. However there was no significant change in perceptions of ability to attend teaching conferences, study outside work or pursue clinical or basic research. Continuity and safety of care were perceived to be negatively affected.

Sneider et al. (2009) found that similar proportions of surgical programme directors and co-ordinators who responded to a survey (n=17, 85%) felt that changes had positive (25%) or negative (31%) effects on education. They also reported no change in exam pass rates, and some changes in delivery of teaching (such as an increase in simulation, although didactic teaching was still the most common method).

Moalem et al. (2009) present data from a web-based survey of 599 resident and associate members of the American College of Surgeons. Questions concerned barriers to education presented by working hour restrictions, and ideal hours. 41% identified the restrictions as a considerable or moderate barrier to education; 27% a minor barrier, while 31% did not feel they acted as a barrier. Free text responses expressed concerns about operative time and continuity of care.

Namdari et al. (2010) identified an impact of duty-hour restrictions on numbers of publications by residents. Their comparison of the number of publications by orthopaedic surgery residents in one institution before (1995-1996) and after (2008-2009) restrictions, conducted through PubMed literature search, identified a greater probability of peer review authorship after the restrictions than before, for any given resident year. This applied to total articles, clinical articles, case reports, and reviews; there was also an increased rate of publications with the resident as first author.

Finally, Lindquist et al. (2010) found consequences for junior medical students' experience during clinical rotations following working hour restrictions. Patient logs (self-reported by students) for the periods 2002-2004 and 2005-2007 were compared, and showed a drop from 21 to 12 in the mean number of patients seen per student on their junior medicine clerkship ($p < 0.001$). Students also encountered a different mix of patient diagnoses in the two study periods – with fewer students from 2005-2007 helping manage patients with chest pain, pancreatitis, pneumonia, gastroenteritis or cellulitis, whilst seeing more patients with abdominal pain, anaemia, mental status changes, failure to thrive and endocrine disorders. The implementation of a hospitalist service, with an increase in the number of hospitalists to take over the care of patients not covered by residents, was reported as a concurrent factor in addition to the reduction in resident duty hours. Also, 2004 guidelines from the medical school accrediting agency (the Liaison Committee on Medical Education or LCME) recommend that, in general, medical students should not be required to work longer hours than residents.

7.5 Teaching time

A further impact of working hour restrictions identified in some studies has been on time available for teaching (by both consultants/attendings and by specialty trainees/residents), thus potentially affecting the education and training of more junior trainees and medical students.

Several studies have looked at the effects of working time restriction on postgraduate trainees' contribution to teaching, from the perspective of junior trainees or medical students.

Jagsi et al. (2005) found minimal effects from a pre- and post-restriction questionnaire with medical students on clerkships in two hospitals in 2003 (n=129, response rate 98%) and 2004 (n=112, response rate 93%). Only 41% of students felt that residents' hours were restricted in 2004 – an increase from 2003, but still low considering that restrictions had been introduced. The 2004 sample also felt that residents' availability was higher, which seems counterintuitive, but there may have been reorganisation of care which meant residents were working more concentrated daytime hours. Fewer students felt they had witnessed suboptimal care by residents in 2004, although a higher proportion of those instances were attributed to working hours.

Nixon et al. (2007) compared the quantity and quality of weekly teaching that students received from residents in three specialties (internal medicine, general surgery and paediatrics) in 2001 and 2005. They found a marginal mean increase in the number of hours of teaching received (from 10.2 hours per week in 2001 to 11.8 in 2005), and no significant difference in quality. Students also reported that they worked fewer hours in their clerkships, although only at an average of 1.5 hours per week, with surgical clerkship reporting the largest reduction at 4.8 hours per week.

However, in contrast to this, Feanny et al. (2005) found a 42% reduction in the number of cases in which the resident acted as teaching assistant during emergency abdominal procedures, between two groups of residents, one graduating just before implementation and one two years after. When only major abdominal trauma procedures were considered, there was an 82% decrease. Zahn et al. (2007) also found that residents were less involved in teaching following duty hour restriction.

Medical students were also mostly negative about the effects of restrictions in a survey by White et al. (2006) administered to students on different clerkships (response rates between 50% and 100% depending on clerkship). Changes on items including the accessibility of faculty, teaching quality, feedback quality and time in unproductive activities, were mostly negative but varied between the clerkships and some were positive. White et al. conclude that the extent of programmes' preparation for change, and so the adaptation of the clerkship, affected perceptions. They report that one programme improved in the second year (although data is not presented) because further changes to the programme were made.

Brasher et al. (2005) asked medical students about their perceptions of residency teaching on a third-year eight-week surgery clerkship before and after implementation of duty hour restrictions. After duty hour restrictions students made significantly more negative comments about teaching activities and residents as supervisor and teacher. Positive comments about bedside teaching also decreased. However comments about the resident as a person (e.g. supportive, helpful, friendly, caring) increased. There was no significant difference in other aspects of resident teaching such as residents'

availability, operating room teaching, commitment to teaching and concern for student learning. The implication was that residents needed to be sufficiently prepared to capitalise on 'teachable moments' and supported in incorporating student learning activities into their daily work schedule.

In a national US survey of paediatric surgery first and second year fellows (Ladd 2006), over 50% of respondents (total n=40, response rate 74%), reported that time available for instruction of subordinate residents and medical students was reduced. However, analysis of operative logs from 1997 to 2005 of all general surgery residents in one institution showed the number of teaching assistant cases to be unaffected by the work-hour changes (Durkin et al. 2008).

Mazotti et al. (2009) found, in a survey of internal medicine residents (n=125, response rate 76%), that 24% of residents reported spending less time teaching, and these residents also reported less frequent emotional exhaustion and greater satisfaction with the quality of patient care they provided.

Attending doctors' perception of the time available for teaching residents was among the effects considered in a survey of family medicine faculty members (Choby & Passmore 2007) from 67 ACGME-accredited residencies, carried out in November 2004-March 2005 (n=368, response rate 55%). Almost two-thirds (65%) of respondents disagreed or strongly disagreed that there was more time for teaching since duty hour restrictions. Only 3% agreed or strongly agreed, and 32% were neutral. 36% of trauma surgeons responding to a survey (n=303, 34%) reported by Byrnes et al. (2006) indicated that their interest and participation in resident education had somewhat or significantly decreased since work-hour restrictions were implemented, although over half (56.3%) reported that it had not changed.

One study looked at faculty members' perceptions of clerkship learning. Kogan et al. (2006) found that 69.7% of their sample of 96 medical directors (response rate 84%) disagreed that restrictions had a positive effect on residents' educational experience. Opinion was split on whether clerkships should have the same restriction as residents.

7.6 Examination scores

Some American studies have looked at examination scores before and after working time restriction. To date, no European studies have presented similar data.

Hassett et al.'s (2002) study following the introduction of the New York State Health Code restrictions found that the first-time pass rate on the qualifying examination of the American Board of Surgery rose from 77% (between 1991 and 1995) to 90% (between 1996 and 2001).

Durkin et al. (2008) report a comparison of general surgery residents' performance on two exams from 1997 to 2005: the American Board of Surgery In-Training Examination (ABSITE; taken annually during residency) and the American Board of Surgery Qualifying Examination (ABSQE; taken within 6 months of graduation). ABSITE scores improved significantly after the restriction of work hours in both basic science and total score. While this was possibly due to work-hour restrictions leading to greater study time outside of work, clinical management scores were not affected. A positive correlation was found though between the number of cases performed during residency and the

clinical management ABSITE scores (although not ABSQE scores). The number of major cases recorded by graduating residents did not reduce significantly between the two years. Barden et al. (2002) found a significant increase in mean overall ABSITE composite percentile scores after institution of a strict 80-hour work week for surgical residents. Within this overall increase, there was a significant improvement in scores for junior residents, whilst there was no significant increase for senior residents.

Froelich et al. (2009) found no differences in residents' orthopaedic in-training examination (OITE) scores for 2000 to 2007. Similarly, analysis of annual Otolaryngology Training Examination (OTE) scores recorded from 2000 to 2007 for the four years preceding and following working hours restriction (Shonka et al. 2009) demonstrated no significant difference in scores between the two periods. Graduating residents' operative experiences also showed no significant difference.

7.7 Summary

Studies on the impact of WTR on education generally demonstrate negative effects on subjective measures including overall training experience, available time for training, available time for teaching of students and ability to assess trainees. However these effects are not universal and a proportion of respondents in studies on impact on education typically also report that they observed no change.

Some positive effects were reported. Reduction in fatigue was noted as a benefit of reduced working hours in one study. Restructuring of services due to WTR may also offer benefits for learning, such as exposure to different practice types/preceptors (Balmer et al. 2007). Interestingly, two USA-based study reported improvements in surgery exam scores after duty hour restrictions (Hassett et al. 2002, Durkin et al. 2008), although this effect was not found in two other studies, one in orthopaedics and one in otolaryngology.

There may be a knock-on effect of restrictions through training grades. Junior trainees' experience may suffer in order to give seniors more experience. This means that senior trainees may be able to take on fewer advanced surgical procedures as they are still performing the basic procedures they did not have the opportunities to practice as juniors. This may increase seniors' workload, but also risks their having less advanced experience at the end of training. However, as with much of this literature review, several studies (particularly from the UK) have issues with low response rates. As many are USA-originated studies the limited generalisability to UK medical education should be borne in mind. Several have also been conducted shortly after restrictions have been introduced, reducing the time for systems to settle, and initial teething problems to be overcome.

Evidence looking at caseload indicates that restriction of working hours is typically associated with lower case exposure, which is taken by many to indicate a lowering of educational experience, and so lowered standards of expertise. However, while practice is an important component of the development of expertise, focusing on operative surgical training means only focusing on one aspect of training, and does not address other aspects of training which may be affected by working time restrictions. It is an aspect that is relatively easy to measure, which may explain the wealth of literature in this area, but may also be a warning against placing too much value on it. In addition, a

focus on caseload biases findings towards craft specialties which lend themselves such a metric. The review did not find any studies looking at analogous indicators in other specialties.

Some authors have suggested that comparison of surgical case logs may not be reliable due to, for example, increased pressure/improved or variable diligence in documenting cases (Froelich et al. 2009) or inaccuracies in recording (Bruce et al. 2010). Furthermore, exposure may be reduced by separate changes to service delivery, such the movement of some procedures to outpatient services (Bruce et al. 2010). Caseload indices do not account for other important characteristics that trainees need to acquire that may not be as easily measured, such as accountability, technical skill and/or clinical decision-making (Froelich et al. 2009); patient care and surgical decision making (Shin et al. 2010); communication, knowledge and clinical judgement (Blencowe et al. 2011). As often stated, quantity is not the same as quality, and nor does it necessarily equate to competence. The amount of experience, or instances of a particular procedure required to develop expertise is not known, and cannot be generalisably quantified as individuals' aptitude may vary, but not have a bearing on their ultimate ability. Fewer, better supervised cases may be more educationally valuable, as well as safer, than a higher number of cases without a senior being present.

Finally, most studies identify confounding factors (such as service redesign), meaning a simple causal effect of WTR cannot be assumed.

8 Impact of work hour restrictions on patient care, patient safety and clinical outcomes

This section first looks at surveys and qualitative studies which have assessed perceptions of the impact of resident work hour restrictions on patient care, patient safety and clinical outcomes, and then moves on to discuss studies with more objective indicators of patient outcomes.

8.1 Perceptions of impact on patient care and patient safety

8.1.1 UK and other European studies

Surveys of consultant surgeons and surgeons in training, regarding the EWTR, were conducted by the Royal College of Surgeons of England (2010). Data were collected in September 2009 (total n=901; 363 consultants, 58 surgeons in training) and July 2010 (n=982; 503 consultants, 479 surgeons in training, response rates not known). Respondents were from England, Wales and Northern Ireland. Just over half of consultants and over a third of trainees felt that compliance with the 48-hour working week had been achieved at the expense of patient safety, with little or no difference between responses for 2009 and 2010 (consultants: 52% 2009, 56% 2010; surgical trainees: 38% 2009, 38% 2010). An increasing majority thought the quality of care a patient receives had worsened due to the Directive (consultants: 72% 2009, 80% 2010; surgical trainees: 59% 2009, 66% 2010). An increasing minority of consultants and trainees reported that adequate time had been allocated for handovers (consultants: 37% 2009, 41% 2010; surgical trainees: 29% 2009, 37% 2010) and a minority of consultants reported that they did not have the opportunity to be involved in all stages of patient care for individual patients, although this had increased in 2010 (18% 2009, 26% 2010) (Royal College of Surgeons, 2010).

A UK national telephone questionnaire survey of 83 (from 91 eligible hospitals) first on-call doctors for ENT (Biswas et al. 2009), carried out during the period of 56 hour restriction, found that 74% of respondents were cross-covering specialties during night shifts, with 10% covering four or more specialties. Night-time ENT care was often provided by junior doctors with little experience of the specialty – 68% reported having no ENT experience and 42% did not feel comfortable managing

The evidence in this section

Studies in this section fall into two main groups: studies of doctors' perceptions of effects on patient care which are largely surveys of staff, and studies of objective patient outcomes from audits of cases and standardised outcome measures used in clinical governance processes.

The former group consists of mainly large-scale studies (sample sizes of several hundred, although with varying response rates), but their value is limited by their being open to biases in sampling and reporting, and not being linked to objective data.

The latter group, including studies of continuity of care and medical error, are generally of a higher quality, as measures are more robust and stringently collected. There remain however issues of unaddressed confounds in changes in clinical practice and the design of work, and the problem that there is often a relatively short time period between a change in hours and data being collected (e.g. in the year following a change), meaning that effects of reductions may be confounded by the simple fact of the change.

Key points in this section

1. There is some concern that restrictions have consequences for patient care, particularly by limiting continuity of care.
2. There is limited objective evidence of effects on patient safety and findings are mixed.
3. Evidence on clinical outcomes is mixed and confounded with other factors.

common ENT emergencies as the first doctor on call – and 88% of second-on-call doctors were reported to be non-resident. The authors suggested a need for a mandatory induction course for all doctors covering ENT; courses were provided in 51% of these hospitals, although they were of varying duration.

Businger et al. (2010) conducted a study in Switzerland, a year after the introduction of a 50-hour workweek, involving a survey of surgical residents and surgical consultants. This found that 43% of residents and 70.1% of consultants (n=221 and 184 respectively, overall response rate 65.5%) considered that the workweek limitation had had a negative effect on the quality of patient care. Similarly, 48.8% of residents and 72.8% of consultants reported that continuity of patient care had decreased. A minority of both groups considered that the number of patient care errors had decreased (23.5% of residents, 8.7% of consultants, $p < .001$).

8.1.2 American studies

Results of a survey mailed to all members of the American Association for the Surgery of Trauma (Byrnes et al. 2006; n=303, response rate 34%) showed that 47% of respondents indicated that the care of injured patients had not changed since resident work-hour restrictions were implemented, although 37% indicated that it had somewhat decreased, and 8% that it had significantly decreased. This was partly related to discontinuity of care associated with shift changes. Just under a third (31.3%) of respondents indicated that patient care had been compromised every few days as a result of resident shift changes or discontinuity of care. Smaller minorities considered that it had been compromised weekly (16.5%), on a daily basis (13.6%), or never (7.8%). Kupferman and Lian (2005) reported on a survey sent to residency programme directors of otolaryngology-head and neck programmes in the USA (n=31, 30%) which showed that 84% of the respondents did not believe the limitations on duty hours improved patient care, and 81% believed they had negatively impacted resident training experience. In a survey of otolaryngology faculty and residents distributed electronically to all 102 ACGME-accredited otolaryngology residency programmes, 61% of respondents (n=460, response rate unknown) did not consider that the work hour restrictions had had a negative effect on patient care, whilst 33% thought they had (Brunworth & Sindwani 2006).

Participants in four focus groups of internal medicine residents at one hospital (n=26 participants from the first three years of residency), held six to seven months after the 80-hour work week implementation, perceived that restricted work hours diminished the continuity of patient care and increased the likelihood of medical errors, such as those resulting from delayed follow-up of diagnostic tests, frequent handoffs, long stretches of cross-coverage and rushed patient evaluations (Lin et al. 2006). Whilst in favour of work hour restrictions, they reported a conflict between compliance and non-compliance if these were felt to compromise patient care. Respondents (particularly interns) also reported finding it difficult to attend conferences, although they did have more time to read and think about their patients and pursue educational opportunities such as research projects; residents reported finding fewer opportunities to teach interns and medical students.

Myers et al. (2006) report a 2005 survey of internal medicine and general surgery residents who trained both before and after work hours reform at six residency programmes (3 internal medicine, 3

surgery) at five academic medical centres in the USA (n=159, response rate 80%). They found that residents reported that fatigue-related errors decreased slightly, but those related to reduced continuity of care significantly increased, suggesting that the former may have been replaced by the latter. Respondents also reported somewhat decreased opportunities for formal education, bedside learning, and procedures; however they (particularly surgical trainees) did report improvements in quality of life and reduced burnout.

In a survey of convenience samples of residents from three surgical specialties (general surgery, obstetrics/gynaecology, otolaryngology), conducted in early 2004 (n=156, response rate 94.5%), 89% indicated by subjective impression that the quality of patient care was either unchanged (63%) or worse (26%) due to work-hour restrictions (p=0.003), with only 12% feeling it had improved. Those trainees already regulated by work-hour restrictions (under New York State 405 Regulations) were more likely than those recently under work-hour restrictions to report unchanged or worse quality of care. Overall, respondents perceived improvement in some types of error, with fewer fatigue-related errors and errors that involved cognitive capacity (e.g. medication, judgement and manual technique) (Biller et al. 2006). However, as in Myers et al.'s (2006) study, more errors were perceived to be related to continuity of care (e.g. miscommunication and cross-coverage availability).

Choby et al. (2007) reported that 44% of family medicine faculty members responding to a survey (November 2004-March 2005; n=368, response rate 55%) either disagreed or strongly disagreed that patient care had been positively affected by duty hour restrictions, although over a third (37%) were neutral. Just over half (51%) were neutral regarding whether patient safety had been improved, but 31% disagreed or strongly disagreed that it had been improved.

The following studies have used more objective methods to examine the impact of working hour restrictions on quality and continuity of patient care, patient safety and patient outcomes.

8.2 Objective evidence of impact on patient care and patient safety

8.2.1 UK and other European studies

Several studies have examined quality and continuity of patient care in view of working time restrictions, some arising from concern from smaller specialties.

Ramsey et al. (2007) studied 75 consecutive patients requiring inpatient surgery, and analysed 72 patient pro formas, to assess the effect of the EWTD on continuity of care (viewed as the ongoing relationship between a patient and a single practitioner) in a maxillofacial setting. The pro formas recorded all direct clinical contact and the grade of staff involved. They found that a consultant was in attendance in 83% of all points of clinical contact (suggesting delivery of a consultant-led service in this unit); however the SpRs working an on-call rota within the constraints of the then-current WTR were present throughout the treatment care pathway in only 42% of cases, and SHOs on a full shift pattern in only 33% of cases. The authors suggest this highlights the need for excellent patient handover. There was no patient continuity data pre-EWTD for comparison, but the authors suggested their data could serve as a benchmark for additional research in this area as hours were further reduced (Ramsey et al. 2007). A later study (Maxwell et al. 2010) in a regional neurosurgical

unit examined case notes for 50 emergency and 50 elective admissions, randomly selected from four months before and after implementation of a 48-hour WTR compliant senior trainee (resident) roster, operating a full-shift system with a day off before and after a night on call. Each of the total 200 episodes was objectively scored for continuity of care from the operating surgeon. In elective cases there was no before/after difference in the number of residents consenting and then operating on patients, however there was a significant reduction in the number of operating residents subsequently following up their operative cases (80% vs 20%, $p < 0.0001$). In emergency cases there was a reduction in the number of residents admitting and operating on the patient (76% vs. 62%, $p < 0.05$) and in the number both consenting and operating on the same patient (88% vs. 76%, $p < 0.01$), suggesting that emergency patients were receiving reduced continuity of perioperative care. A review of working patterns for 13 weeks prior to, and 13 weeks following, 1st August 2009 found that the proportion of available operating sessions attended by residents reduced from 79% to 63%; of the outpatient clinics available, the proportion attended reduced from 72% to 60%.

A conference paper presented by Tompsett et al. (2010) on a study undertaken in one obstetric department showed that 48-hour WTR compliant rotas did not significantly impact on anaesthetic response time, although maintaining this did impact on anaesthetic cover in the main hospital.

Objective data were gathered in a study by Cappuccio et al. (2009) in order to examine the effects of the 48-hour work week on patient safety, and on doctors' work-sleep patterns. This was a single-blind intervention study carried out over a 12-week period in one hospital. Foundation Year 2 doctors on medical wards who were working either an intervention schedule of <48 hours per week ($n=9$) or the then-compliant <56 scheduled hours ($n=10$) were studied. Doctors on the intervention schedule worked three sequential shifts to allow for morning-evening-night adaption and acclimatisation to night-working, had fewer night shifts, and were given written advice on sleep hygiene and the importance of naps. Work hours and sleep duration were recorded daily, and rates of medical errors for wards with the two schedules were compared. Average scheduled work hours were 43.2 on the intervention schedule and 52.4 on the traditional schedule, and there was a non-significant trend for increased total sleep time per day (7.26 vs. 6.75 hours). During a total of 4,782 patient-days with 481 admissions, 32.7% fewer total medical errors occurred during the intervention rota than during the traditional rota, including 82.6% fewer intercepted, and 31.4% fewer non-intercepted, potential adverse events. This study indicated that a 48-hour week along with targeted efforts to improve sleep hygiene improves patient safety; however interview data showed that most doctors on this intervention schedule felt their educational opportunities were compromised.

8.2.2 *American studies*

Meta-analyses by Baldwin et al. (2011) and Fletcher et al. (2011) found that mortality rates improved following the ACGME 80-hour restriction. The latter found that other patient outcomes varied, and that resident wellbeing improved. Earlier reviews by Fletcher et al. (2004, 2005), looking at earlier periods of literature, had not established clear effects.

In order to identify whether work limits affected clinic continuity, the records of paediatric residents at one medical university were reviewed for the first half of the academic year before ($n=44$ residents) and after regulation ($n=45$ residents) (McBurney et al. 2008). This weekday, daytime only,

continuity clinic generally accepted patients from birth to nineteen years old, who were seen by an assigned resident (present half a day a week throughout three years of training; every two weeks for medicine-paediatric residents) for health maintenance and acute care. Mean continuity reduced slightly, from 54% to 53%, but this was not statistically significant. For well-child only care, the overall mean continuity reduced from 78% to 73%, with a trend towards statistical significance ($p=0.07$). In both cases, interns had least continuity. Only short periods were reviewed for this study; this was due to a change in the computerised billing and appointments records.

An early American study (Poulose et al. 2005) examined the impact on patient safety of resident work hour limits implemented through Code 405 in New York State (1989). The study involved analysis of data on standardised surgical Patient Safety Indicators for a mean of 2.6 million New York discharges between 1995 and 2001, and comparing pre- and post-implementation in New York teaching hospitals, with non-teaching hospitals in New York and teaching hospitals in California as two control groups. There were significant increases in rates of accidental puncture or laceration and postoperative pulmonary embolus or deep vein thrombosis in the New York teaching hospitals but not in the control group hospitals, and no changes in other safety measures (foreign body left during procedure; iatrogenic pneumothorax; postoperative wound dehiscence). Results may have been affected by the employment of more physician extenders in New York teaching hospitals to compensate for reduced resident working hours.

Prior to the introduction of the 80-hour per week duty hour restrictions, Landrigan et al. (2004) compared rates of serious medical errors made by interns working to a traditional shift schedule (with every other shift being 24 hours or more, an “every third night” call schedule) with those made by interns working to an intervention schedule, designed to improve interns’ sleep, that reduced consecutive working hours to approximately 16 hours, and the number of hours worked per week to a maximum of 63. The study took place in the medical intensive care unit and coronary care unit of a large academic hospital. Interns were randomly assigned to schedules. Over 2,203 patient-days, interns on the traditional schedule made 35.9% more serious medical errors than those on the intervention schedule, including 56.6% more non-intercepted serious errors. They also made a 22% higher rate of serious errors on the critical care units, 20.8% more serious medication errors and 5.6% times as many serious diagnostic errors. Most errors were either intercepted or did not result in clinically detectable harm to the patient. However, there may be other issues relevant to schedule design beyond shortening working hours, such as interrupted sleep patterns, increase in providers’ workload or numbers of handovers, which have potential to lead to an increase in error. A conference abstract by Manjunath et al. (2010) reported on a review of handover data for urology patients admitted over sixty consecutive days in one district general hospital, and of critical incident data, after introduction of the 48-hour week. Out-of-hours admissions were managed by Hospital at Night teams and subsequently handed over. Face-to-face handovers were found to be infrequent. Although no critical incidents resulting in serious harm to a patient were recorded, there were several near misses.

Mycyk (2005) compared adverse drug events (ADEs) in the six months after implementation of the work hour limit and the same six months in the previous year in a 750-bed academic tertiary care hospital, where resident physicians provided direct care under the supervision of faculty attending physicians. They found no significant differences between the study periods in any of the measure

variables (number of confirmed ADEs, number of ADEs per 1,000 patient days, and number of preventable ADEs).

Rosen et al. (2009) examined changes in patient safety events in more versus less teaching intensive hospitals before (2000-2003) and after (2003-2005) duty hour reform, and found no overall systematic impact on patient safety indicator (PSI) rates.

8.3 Objective evidence on clinical outcomes

Studies of the data on patient outcomes, such as morbidity and mortality, before and after implementation of working hour restrictions have shown mixed results.

8.3.1 UK studies

Hellawell et al. (2005) raised a concern about adequate cover on call for medical and surgical subspecialties after the 58-hour limit for doctors in training was introduced in 2004 as the first stage of the WTR. They noted that as a result of the restriction in junior doctors' hours the care of acute subspecialty patients had shifted to general surgical teams in many smaller trusts. They prospectively monitored all patients (n=73) admitted acutely with renal colic over a continuous 12-month period in one district general hospital and found that the management of patients was associated with considerable morbidity due to lack of on-call urology cover, with reliance on junior trainees from general surgical teams, and delayed urological review (overall 1.4 days, 0.95 days for weekday admissions and 1.82 days for weekend admissions). This was an early study, prior to full implementation of the WTR, which raised implications for staffing, including the potential further contribution of subspecialty nurses, and the number of urology specialist registrars required to provide adequate on-call cover.

A retrospective observational study (McIntyre et al. 2010) conducted in a single district general hospital, in which data were gathered on all non-elective medical admissions during the 12 months before and after the 2007 restrictions found no impact on the standard of patient care (as measured by in-hospital mortality and length of stay).

However, a survey of indicators in the North West of England found that several indicators of patient outcomes (hospital standardised mortality ratio, average length of stay and standardised readmission rate) continued to follow the same trends of improvement following the introduction of the 2009 WTR as they had in the preceding year (Collum et al. 2010).

8.3.2 American studies

A very early single-centre study, following implementation of the New York State Code 405 regulations restricting residents' working hours (enacted 1989), conducted in the general medical service of an urban teaching hospital, found a significant increase in resident delays in ordering diagnostic tests and in patients suffering at least one medical complication, but no significant increase in outcomes such as in-hospital mortality, transfers to intensive care units or length of stay (Laine et al. 1993). A study by Howard et al. (2004) to identify any effects on patient mortality compared inpatient discharge files for 1988 and 1991, for patients with a principal diagnosis of

congestive heart failure, acute myocardial infarction or pneumonia, from state-wide teaching and non-teaching acute care hospitals (with patients from non-teaching hospitals, unaffected by Code 405, as controls). It found an almost identical beneficial trend towards lower mortality over time between teaching and non-teaching hospitals, suggesting no positive or negative effects of limiting residents' working hours. It was not known, however, whether there was any lack of compliance.

A later study (Shetty & Bhattacharya 2007) undertaken to determine whether work-hour regulations were associated with changes in mortality in hospitalised patients examined mortality rates for patients admitted to teaching service hospitals for medical diagnoses (n=1,268,738) and surgical diagnoses (n=243,207) between January 2001 and December 2004 and compared the periods before and after July 2003. Non-teaching service patients were used as a control group. The work hour regulations were associated with decreased short-term mortality among the medical patients in teaching hospitals, but there were no statistically significant changes among surgical patients.

Two other, complementary, studies also looked at mortality rates in both medicine and surgery. An observational study was carried out of all medical and surgical patients (n=318,636) admitted to 131 short-term acute-care Veterans Affairs hospitals using interrupted time series analysis with data from 1st July 2000 to 30th June 2005. The patients all had principal diagnoses of acute myocardial infarction, congestive heart failure, gastrointestinal bleeding or stroke, or a diagnosis related to general, orthopaedic or vascular surgery. In the first year after the reforms no significant relative changes in mortality (within 30 days of admission to hospital) were observed for either medical or surgical patients. In the second year, there was a significant decrease in the odds of mortality in more teaching-intensive hospitals for medical patients only (Volpp et al. 2007a). A complementary study of all Medicare patients (n=8,529,595) with the same principal diagnoses in US non-federal, short-term, acute care general hospitals (n=3,321) found no significant relative increases or decreases in the odds of mortality for more versus less teaching-intensive hospitals in medical or surgical patients in either of the first two years after implementation (Volpp et al. 2007b). Neither study, however, had information on actual hours worked at each hospital.

A retrospective analysis of 1,003 consecutive patients with acute coronary syndrome admitted to one hospital between July 2002 and June 2004 (n=572 pre duty hour changes, n=431 after) found improved adherence to evidence-based guidelines for acute coronary care syndrome at time of discharge, continuing at six months following discharge. Length of stay decreased from 3.1 to 2.8 days (p=0.02). There was no significant difference in in-hospital or unadjusted six-month adverse events, and no difference in in-hospital mortality (although there was a trend towards improvement in risk-adjusted in-hospital mortality), but there was a decrease in unadjusted, and significant decrease in risk-adjusted, six-month mortality. The authors note that it is difficult to control for temporal changes in cardiac care over a two-year period, such as advancements in medical research and technology; there were also other innovations such as a quality improvement programme regarding evidence-based guidelines in July 2002, and the introduction of a day-float system, as well as reduction in work hours (Bhavsar et al. 2007). No difference in mortality or stroke-associated complications were found for hospitalised patients with acute ischemic stroke in a study comparing data from almost 1,000 hospitals for periods before and after implementation of the work hour restrictions (data from 2000 through 2005; Alshekhlee et al. 2009).

In a study by Horwitz et al. (2007), outcomes including intensive care utilisation, length of stay, discharge disposition, 30-day readmission rate to the study institution, pharmacist interventions to prevent error, drug-drug interactions and in-hospital death, were measured in a retrospective cohort study in one urban academic medical centre of 14,260 consecutive patients discharged from the teaching service and 6,664 from the non-teaching service between 1st July 2002 and 30th June 2004. The teaching service had significant improvements in three outcomes versus the non-teaching service: the rate of intensive care unit utilisation decreased, the rate of discharge to home or rehabilitation facility improved and, with the greatest significance, pharmacist interventions to prevent error were reduced.

Trauma patient morbidity and mortality were reviewed at a busy trauma centre in Los Angeles County to assess patient outcomes before (July 1998-June 2003) and after (July 2003-June 2005) implementation of the 80-hour workweek, and no change was found in these two periods (de Virgilio et al. 2006). Another single trauma service study compared data on patients admitted in the 11 months before and 11 months after the introduction of a rotating night-float system in 2002 (total n=2,826 patients) (Schenarts et al. 2005). Work hours decreased from an estimated 100-105 hours per week to a mean of 78.4 per week, although estimates may not have been accurate. Limitation of work hours had no effect on length of hospital or ICU stay, ventilator days, mortality, the total number of complications nor the distribution of complications determined to be preventable or potentially preventable. A later study (Salim et al. 2007) comparing death and complication rates for adult trauma patients admitted to one institution during the two years before and after the 80-hour work week found no significant difference in the total and preventable death rates. There was a doubling of the number of missed injuries, although this did not reach statistical significance, and a significantly higher total complication rate, preventable complication rate and non-preventable complication rate. With no simultaneous change in mortality the authors suggest the increased complication rates may have been a transient phenomenon, or a result of other factors not studied.

A national retrospective study of data collected for 2001-2002 (n=250,957 patients) and 2004-2005 (n=241,216 patients) found a decrease in the overall mortality rate (4.64% to 4.46%, p<0.0001) (Morrison et al. 2009). There were differences in academic and non-academic institutions, with a decrease in university hospitals (5.16% to 5.03%, p=0.03) and an increase in non-teaching hospitals (3.37% to 3.85%, p<0.001). Overall values for secondary outcomes (length of mechanical ventilation, length of ICU stay, length of total hospitalisation) were slightly lower during the period after implementation. The authors comment that whilst the study data are statistically significant, the differences are unlikely to be clinically important. A strength of the study is its large sample size representing over 400 hospitals, however it did not allow for subgroup analysis of surgical subspecialties that may have been involved, and there may have been confounding changes in the field of surgery over the four years of the study, such as other hospital policies, advances in surgical and ICU monitoring techniques, and changing patient populations.

Data from the perinatal database at one institution on sentinel events, medication errors, maternal and neonatal outcomes, and decision making were compared for a year before and after reduction in working hours (implemented in 2002) to measure the effect on the quality of obstetric and gynaecological care (Bailit & Blanchard 2004). There was a significant decrease in postpartum haemorrhage and neonatal resuscitations but no significant difference in other outcomes; policy

changes for treatment may have affected the number of resuscitations. There were insufficient prescribing errors to enable comparison and too few incidents to determine statistical difference between the two years, although it was noted that these may have been under-reported.

An early study was conducted in general and vascular surgery at one institution that implemented a limited work hours schedule from October 2002 (Kaafarani et al. 2005). They compared the rate of postoperative morbidity and mortality in the year before and year after the new schedule, and found no significant differences in observed to expected ratios of mortality or morbidity over the two periods, however this may have been partly due to an increase in attending surgeon involvement in the operating room.

A retrospective review of patient medical records was undertaken for 2,470 patients who had undergone laparoscopic cholecystectomy in the three years before (n=1,353) and after the work hour restrictions (n=1,117) in a major teaching hospital, to compare mortality and morbidity in these two periods (Yaghoubian et al. 2008). The incidence of bile duct injury decreased in the second period (1% to 0.4%, p=0.04) as did total complications (5% to 2%, p<0.001). Mortality was unchanged. The results may have been partly due to an increase in attending surgeon hours.

A database review of patients treated for hip fracture in resident teaching and non-teaching hospitals before (2001-2002) and after duty-hour reform (2004-2005) found an association between duty-hour changes and an accelerated rate of increasing patient morbidity following treatment of hip fractures in teaching institutions; however, this does not imply causality. There was no association with an increase in mortality (Browne et al. 2009). A study in otolaryngology included a review of the benchmark standard patient data for a hospital associated with an otolaryngology residency programme. This found no difference in 30-day hospital readmission rates, hospital mortality index or length of stay before and after work hour restriction; however, there was evidence of some violation of the work hour regulations during 2003 to 2007, particularly in the first year of implementation. The minimum of ten hours off between shifts was most frequently violated (91% of total violations) although a change in the logging system in 2007 may have affected these results (Shonka et al. 2009).

Some studies did find an improvement in mortality rates. Gopaldas et al. (2009) report a study involving a review of patients who underwent cardiac operations in an institution for veterans between 1997 and the end of June 2003 (n=777) and from July 2003 to end 2007 (n=785). Post ACGME reform patients had a significantly lower 30-day mortality rate (1.8% vs 3.9%, p=0.01) and a slightly lower six-month mortality rate (4.5% vs 6.3%, p=0.12) than pre-reform patients. Potential reasons suggested for this included improved resident performance, increased knowledge amongst residents with more time to study, the use of physician extenders, the possibility of greater faculty involvement following the reforms, and advances in critical care management. As the veteran population was largely male, the results could not be generalised to female patients. A separate study (Golpaldas et al. 2010) of patient outcomes following coronary artery bypass grafting (with pre- and post-implementation groups, from 1998 to end 2007) found a statistically significant decrease in in-hospital mortality rate after the reforms (2.89% to 2.34%, p<0.001) for teaching hospitals, but this was not significantly different from that in non-teaching hospitals. Implementation of work hour regulations was, however, associated with a higher risk of in-hospital complications in teaching

hospitals, whilst there was a reduced risk in non-teaching hospitals, and the difference between hospital types was highly significant ($p < 0.0001$). The timeframe of these two studies, which included four years post reform, potentially compensated for any instability in the early period after reform.

Privette et al. (2009) conducted a retrospective observational cohort analysis of data on patient care for 30 days after admission or surgical intervention for two years prior to duty hour restrictions (July 2001-June 2003) and two years post-restriction (July 2005-June 2007) (total $n=14,610$ patients). This found a significant reduction in the percentage of provider-related complications and a significant reduction in mortality rate. The number of clinical care hours provided by attending surgeons also increased significantly post-restriction. A retrospective cohort study (Prasad et al. 2009) comparing mortality trends before and after 1st July 2003 (data reviewed from 1st July 2001 to 30th June 2005) for patients admitted to 104 intensive care units at 40 hospitals (including academic hospitals, community hospitals with residents and non-teaching hospitals) found that risk-adjusted mortality trends improved in all types of hospital, and that there were no significant differences in mortality trends between hospitals of different teaching intensities. Data on compliance were not available, nor was any information on whether there were any changes to admission policies or resident case loads. Other interventions that may have coincided with the reform could not be accounted for in the study.

8.4 Summary

Evidence on the perceived impact of working time restriction on patient care indicates that doctors generally regard the implementation of restrictions as detrimental to the quality of patient care, continuity of patient care, and patient safety. Two studies suggested there were some trade-offs with respect to medical errors, with a reduction in fatigue-related errors but an increase in errors related to continuity of care. Other studies found no differences.

Many studies did not detect a significant difference in patient mortality and clinical outcome figures before and after the introduction of working time restrictions (although the majority of the studies were USA-based). Positive outcomes were found, including decreased mortality, improved adherence to evidence-based guidelines, reduction in the rate of intensive care utilisation, improvement in rate of discharge to home or rehabilitation, and reduction in pharmacist interventions to prevent error. Negative outcomes were also found, including higher morbidity and delayed clinical review, higher risk of in-hospital complications and increases in delays ordering diagnostic tests. Several studies found that continuity of care is affected by reduced working hours, and that consequently effective handover is of increased importance.

Several studies noted limitations when comparing patient care, patient safety and patient outcomes before and after implementation of work hour restrictions. For example, some studies were undertaken very soon (e.g. six months) after the implementation of work hour restrictions and new schedules, so changes may not have fully bedded in. Furthermore, several studies note that compliance data was not collected, and so any changes may not have corresponded to a reduction in hours worked. The specific approach to implementation of restrictions in a given setting may also confound any conclusions from observed changes. As is pointed out throughout this review, applying

findings from the USA to the UK is particularly problematic, as trends observed around an 80-hour working week may not generalise to a 48-hour working week.

Confounds including changes in clinical practice and work organisation, including cross-cover between specialties, mean the effects of hours per se may not be transparent. Other variables may also have an effect:

“...teaching hospitals are complex healthcare delivery systems and it is unlikely that a single factor alone would result in alterations to patient outcome. In addition to resident fatigue, factors such as resident knowledge base, junior resident supervision, resource availability, and ancillary support staff also need to be considered.”
(Schenarts et al. 2005 p.149)

Long-term analysis of trends, accounting for seasonal variation, and controlling for patient and doctor variables would be necessary to identify any effect of one particular variable. Such a study may not be cost-effective, or even feasible.

Finally, cross-cover between specialties in which doctors have limited experience is a concern, but no studies were found that had linked this to patient safety issues.

9 Interventions and Solutions

This section describes a number of studies looking at different approaches to changing practice and education in response to restricted working hours.

Overviews of the different types of approach are given in a number of papers, dating back to a 1991 report of efforts to adapt to limitations in San Francisco (Foster & Selzer 1991). Some have looked at interventions in different specialties (surgery: Chandra 2004, Gordon et al. 2006; orthopaedics: Kusuma et al. 2006; family medicine: Peterson et al. 2006), but all have covered a similar range of approaches. Early UK data collected by the Royal College of Physicians (Mather 1998), considering ways of adapting to the New Deal reductions in hours, identified twice-daily consultant rounds, and the use of nurse consultants and staff grade doctors to take up care responsibilities.

Interventions are unavoidably specific to particular locations, meaning that details may not translate directly to other settings, but general approaches may be transferrable. This review has identified three main approaches to dealing with restricted working time:

- re-organisation of services, rotas and shifts;
- redistribution of trainee doctors' workload to other professionals;
- use of technology to optimise available time.

The evidence in this section

Studies in this section are of variable quality. Intervention studies (on work design, clinical roles, rotas, or technology) tend to be descriptive and do not always evaluate impact in terms of subjective or objective measures. Furthermore, not all studies provide full details of interventions or evaluations.

Additionally, because interventions are located in particular organisational contexts, even the stronger studies in methodological terms may not automatically translate to different contexts. Differences in national or even local healthcare organisation mean that the process by which a rota change is implemented in one setting may not immediately transfer to another. The relevance of these findings should therefore be considered in terms of the particular circumstances to which they may be transferred.

Key points in this section

1. Interventions may address service delivery, work structure or workload, through redesign of service or rotas, redistribution of workload, or technological interventions.
2. Evidence suggests many doctors are averse to shift systems, but carefully considered redesign of service and rotas can improve access to training opportunities.
3. Successful redesign is that which has an awareness of current practice and works around factors like peak admission times, and the current activity of junior doctors.
4. New roles or workload distribution can be successful, but should be developed through negotiation rather than imposed, and the risks of deskilling junior doctors should be considered.
5. Night working may benefit from specific approaches, such as Hospital at Night and night float, but evidence is somewhat mixed, and success is likely to rely on sensitivity to local needs and staff consultation.
6. Technological advances may help to meet some educational and service needs. Again, these must be developed and implemented according to local needs, and alongside appropriate training.

9.1 Development of service changes

Some studies have described changes based on observation or audit of current practices. For example, Dassinger et al. (2008) audited a single surgical trainee's activity and movement around a hospital, finding he spent 38.2% of his time in the operating room, and 15.4% in educational activities (classroom and ward-based teaching). However he spent 12.3% of his time travelling around the hospital site, and 11.7% in communication (including telephone, email and answering pages). They found that tasks took 1-5 minutes, and suggest that redesign should aim to improve efficiency. They suggest that as the largest proportion of time was spent in the operating room, attention on redesign should focus there, but the implication is that with 25% of time being spent on travel and communication, improving efficiency in those areas would free time for education and care. They also found that the resident underestimated the time he spent on different activities, implying that objective measures should be used to assess requirements for redesign.

Wasson et al. (2006) looked at a group of surgical trainees, auditing the learning opportunities available to senior house officers in theatre in March 2005, ahead of the WTR and other changes. They found that through simple changes to timetables, attendance at theatre increased from 30% to 46% of theatre sessions, with participation increasing from 27% to 48%. The problems identified, and addressed in the redesign, were that there were too many SHOs timetabled to cover clinics, and that SHOs could miss theatre sessions because the rota did not account for on calls, or allow trainees to cover theatre if another was absent. Many theatre sessions were simply not included in the SHOs' timetable. The redesign focused on allocating SHOs to theatre lists based on the actual case mix week-by-week, taking account of the on-call rota and trainee absences. This meant that trainees would attend more theatre sessions most appropriate for education.

Mason et al. (2006) report a study that identified benefits of changes to an out-of-hours psychiatric service, covering two sites, by monitoring on-call activity on those shifts (1700 to 0900 on weeknights, and throughout weekends). They found that a junior on-call doctor received 23 calls after midnight, and conducted a total of 25 assessments during a shift. The introduction of an overnight crisis team reduced the number of assessments SHOs were required to do by 68% to six, and having a nurse screen calls reduced calls about inpatients by 60% to 10. The study also identified further potential changes in the way cases were dealt with that would further reduce workload, such as developing nurse-led prescribing for rapid sedation (one fifth of the doctor's calls were to prescribe sedation), and finding alternatives to seclusion. The changes also increased the doctors' total (and continuous) rest, from 8 hours (4 continuous) to 12 hours (9 continuous) per weeknight, and from 7 hours per 24 (5 continuous) to 11 hours (9 continuous) at weekends.

In the USA a similar approach by Ogden et al. (2006) reported an audit of admission times to hospital, with the intent of improving a rota that had been introduced to meet the 80-hour limit, but had in fact led to complaints from residents, and duties being unperformed. The response, including a longer on call mapped to the peak admission period between noon and 8pm, and out-of-hours admissions being dealt with by 'hospitalists' (analogous to staff grade or trust doctors in the UK), meant that residents could work together during on-call and post-call days, and also improved attendance at educational activities. They also introduced a two-resident night-float system (see below) to manage daytime admissions into the night – the daytime on-call doctors had to hand over

to the night float. Subjective responses indicated improvements in perceptions of education, care and the residents' personal lives.

9.2 Rota changes

Working hours and maximum shift lengths are lower under the WTR in the UK than under restrictions in the USA. Under the WTR, trainee doctors in the UK are limited to a maximum 13-hour shift, followed by a minimum break of 11 hours. The ACGME restrictions specify a 24-hour limit to consecutive in-house call shifts (with a 6-hour extension for continuity of care and educational objectives).

Guidance on rota design stresses that there is no 'one size fits all' solution (RCS 2008, National Workforce Projects 2009), nor should rotas be set in stone (Horrocks & Pounder 2006). Reviews by Levine et al. (2010) and Reed et al. (2010) looked at the effects of shift length, suggesting that shorter shifts are not detrimental to education, and can be beneficial to residents, but with concerns about the rigour and generalisability of the published findings. Reed et al. (2010) concluded that while most studies supported reducing shift length, they did not offer sufficient evidence to define optimal shift duration.

Cappuccio et al. (2009) suggested that circadian rhythms should be taken into account in redesign of work schedules. This may be achieved by rotating through evening shifts before night shifts, rather than making an abrupt change from day to night. They reported positive benefits from the introduction of the use of naps before night work to help this adjustment. The studies by Smith et al. (2006), Tucker et al. (2010) and Brown et al. (2010) described in the earlier section on fatigue illustrate how consecutive night shifts can be detrimental.

9.2.1 UK studies

Cass et al. (2003) describe changes to the structure of rotas, including a move from partial shifts to a full night shift, reducing the number of doctors and tiers of cover at night, and increasing cross-specialty cover. SHOs were removed from night duties but provided cover from 2030h to 2200h. Non-medical roles were also developed, including clinicians' assistants to take on administrative tasks, and non-medical prescribing. They found a substantial increase in compliance with the New Deal, with a reduction in workload.

Rawnsley et al. (2004) found no effects of the introduction in 2001 of a full shift system, in terms of trainees' access to education (albeit with a sample of only eight). They also found that while some nurses were unsure of who was on call and felt there were fewer junior doctors available, they felt continuity and quality of care were unchanged.

Tait et al. (2008) conducted a telephone survey of UK neurosurgical units in April 2007, to identify emergency cover arrangements, and preferences for providing cover. Of 33 rotas, 22 worked a 24 hour on-call system, nine worked a partial shift system and two worked hybrids of both. Twenty-one of the on-calls were officially non-resident, although 12 did not manage to go home overnight. Twenty-two of the registrar respondents had worked both systems, and preferred the traditional on call, for reasons of patient care, educational exposure and work life balance.

Garvin et al. (2008) describe a pilot EWTD compliant rota in Ireland, which involved trainees concentrating on emergencies and a surgical assessment unit, rather than working with their consultant 'firm'. The rota was designed to achieve an average of 53.6 hours (compliant at the 2004 level). The rota did not achieve this in self-reported hours, which indicated that they were working an average 58.1 hours. A majority of participant SHOs felt that it did not benefit continuity of care, and 81% felt that care deteriorated. Educational opportunities were also limited, and teams felt that there was more work for other members to cover.

Chowdhury and Goodfellow (2011) presented results of a survey of Foundation Programme doctors in medical and surgical directorates (n=54, response rate 83%) concerning the contribution of night and weekend shifts to their exposure in areas of acute management of patients. The majority of respondents (88%) thought that working nights and weekends was of benefit to training, and over 65% thought that 50-75% of their acute management and vital clinical skills were acquired during these shifts. A conference paper by Roy and Steger (2011) described a move *from* a full shift pattern to a non-resident on-call rota for surgeons, and found that it improved educational opportunities, with no apparent negative consequences.

9.2.2 American studies

In the USA Mathis et al. (2006) described a change to a ward team structure to aid 80-hour compliance. From four teams, each consisting of an attending, a resident team leader and 3-4 interns, they moved to two larger teams with two residents and four interns, which functioned as half-teams under a single attending. These half-teams alternated on-calls, meaning admissions were distributed more evenly, but post-admission management, including ward rounds, was done as a whole team. The intention was to improve continuity of care. Both faculty and residents were neutral about the new system's effect on patient care, but residents felt it had a slightly detrimental effect on education.

Auger et al. (2010) compared the responses of interns rotating through two paediatric teams in the same hospital – one meeting the 2003 ACGME limit, the other meeting the 2008 IOM-proposed hours. While a more powerful design than many studies, containing some control as participants worked both rotas in the same department, there were only 11 participants, meaning the study had low statistical power. Nonetheless, there were trends indicating the further reduction may be problematic – only 40% of those working the new schedule rated continuity of care as excellent (compared to 100% under the earlier hours). Only 20% of interns, and none of the attendings, felt the quality and amount of education was 'very good' or 'excellent' (compared to 40% of interns, and 75% of attendings under the previous schedule).

Arora et al. (2008) suggested that any further limitation of duty hours needs to take into account limits on workload as well as on hours worked. In their prospective cohort study (1 July 2003-24 June 2005) of medical interns working a traditional extended-shift model, increased workload, as measured by the number of new admissions on-call and the number of previously admitted patients remaining on the service, was associated with more sleep loss, increased shift duration, and a lower likelihood of participation in educational activities.

9.2.3 Night Float

Foster and Selzer (1991) assembled a 'prototypical' call schedule from a survey of 26 obstetrics and gynaecology programme directors who had instigated changes following the New York Code 405 80-hour restriction. They concluded that a 'night float' system was essential for a successful schedule.

The night float is a particular approach to managing rotas overnight which has gained popularity in the USA and as such been the subject of several studies. It is defined by the ACGME as a "Rotation or educational experience designed to either eliminate in-house call or to assist other residents during the night. Residents assigned to night float are assigned on-site duty during evening/night shifts and are responsible for admitting or cross-covering patients until morning and do not have daytime assignments. Rotation must have an educational focus" (ACGME 2011). It is therefore essentially a night shift which ensures an easy transition from day to night and ensures day staff are not kept behind admitting or following up patients admitted in the day. The night float may be a single doctor, or a team. Goldstein et al. (2004) found overall benefits for doctors and their families (in terms of fatigue, availability for family events), and nurses (availability of physicians, communication, and ease of nursing duties). Faculty felt there were negative consequences for patient care.

Schneider et al. (2007) evaluated a residency programme which had been adapted for compliance, and included a night float system alongside physician assistants and other elements. Perceptions of caseload, continuity, teaching and supervision, and quality of life remained constant or improved, and patient outcomes showed no change.

On the other hand, there have been negative findings regarding night float systems. Akl et al. (2006) found the majority of residents, attendings and nurses had negative attitudes to the night float (attendings were more negative than residents, who were in turn more negative than nurses). Kelly and Senkowski (2009) found that a night float led to reduced operative experience (based on case logs) compared to a traditional rotating on-call schedule. Luks et al. (2010) found that medical residents had negative views of night float in terms of its education impact.

Roses et al. (2009) describe a move from a night float system to a rotating on-call system. There were no substantial differences on objective measures including ABSITE scores (although there were more violations of the 80-hour limit with the shift system, the prevalence was still low at 3%), but subjective measures of morale were improved.

Wong et al. (2004) and Roey (2006) both describe positive responses to 'day float' rotations in medical departments (essentially the same principal as a night float, but managing admissions into the day shift). Both found the day float reduced working hours, and was felt to be educationally beneficial. Wong (2004) used a descriptive survey (n=13, 100%) following the introduction of the day float and found positive responses to questions about education (e.g. 'I had adequate time to prepare for resident report'), delivery of care (e.g. 'Rounding with the post call team made them more efficient'), and an overall item ('I believe this rotation is a good addition to the program'). Roey (2006) compared responses from cohorts before (n=39, 91%) and after (n=38, 86%) the introduction of a day float, and found significant improvements on items regarding autonomy, teaching by attendings and completing patient care responsibilities. A repeated measures subgroup analysis

suggested only the first of these was significant for those who had worked under both systems, but that test may have been underpowered (n=11).

9.3 Hospital at Night

The Hospital at Night programme was a specific initiative developed in the UK (www.healthcareworkforce.nhs.uk), which aimed to reconfigure services to provide safe care targeted at clinical need out of hours. It has since been adopted across the UK as an effective way of delivering efficient care at night, albeit with critics. Fernandes et al. (2008) described Hospital at Night as a transferrable approach, suitable for meeting EWTD requirements in Greece.

Hospital at Night is a team-based approach aimed at configuring care specifically for out-of-hours services, when fewer staff may be necessary to deliver effective care, but those staff should be appropriately skilled. Among its goals was reduction in the time junior doctors spent working at night, both for reasons of patient safety and to improve their access to educational opportunities in the daytime. The programme was piloted in eight sites in 2004 (Department of Health 2005) and subsequently rolled out further, with data suggesting it had positive consequences for patient safety, clinical outcomes and productivity (Skills for Health/ Workforce Projects Team 2008).

There has been little published work explicitly on the Hospital at Night programme, although it has also been a component of changes in other studies.

Jones et al. (2004) describe a strategic approach in response to the 2004 phase of WTR introduction, building on changes made for New Deal. A Hospital at Night team was a significant component of this approach, but they stress the importance of having effective evening and weekend working (such as a 'twilight shift' to cover the transition to the night team). They reported that care was maintained, training opportunities were available with reduced workload, and there was a cost effective reduction in the need for locums.

Aspinall et al. (2006) questioned the educational value of Hospital at Night for surgical trainees following observation of trainee activity during a five-week Hospital at Night rotation. They found that trainees spent 41% of their time on 'appropriate' surgical tasks (e.g. reviews and referrals), but a large amount of time on non-specialist tasks (e.g. writing up fluids). The lack of theatre opportunities in particular at night was seen to make the surgical Hospital at Night of less value for trainees. However Aspinall et al. raise the potential risk of a consultant delivered service at night removing a trainer from daytime shifts.

A conference abstract by Reddy-Kolana et al. (2007) reports on a study looking at the effects of a surgical Hospital at Night team on maxillofacial admissions. They hypothesised that overnight admissions would increase as patients would have to wait for specialty review, and found a small increase from 15 in the three months before its introduction, to 19 in the three months afterwards, although the data are too limited to infer a causal relationship.

Beckett et al. (2009) conducted an observational study before and after the implementation of Hospital at Night in one hospital. They reviewed different elements of 219 care episodes before its introduction and 216 afterwards. They found no change in response time, and that previously

existing inter-specialty variations in response time were removed. There tended to be more senior review of patients, and a reduction in adverse outcomes. No adverse effects were found.

Gallagher et al. (2009) looked at trainees' achievement of competencies during a Hospital at Night rotation. They looked at a database of requests made to a team in one hospital, and compared it to competencies required for Foundation Programme trainees. They found that for most FP competencies there were several opportunities per week (for example 54 blood investigations, 107 IV access, 3 deaths). Only 'enteral nutrition problem' (as coded on the call database), which maps to the 'insert nasogastric tube' competency, provided less than one opportunity per week, but still presented four in total. Gallagher et al. conclude that the Hospital at Night programme does not hinder educational opportunities in terms of the competencies required for assessment.

Findlay et al. (2011) looked at changes in workload, care, and mortality and morbidity across surgical specialties following the introduction of surgical Hospital at Night in one hospital, where a medical Hospital at Night was already in place. It involved a nurse practitioner and clinical support worker working with surgical trainees (Foundation Year 2 and Core Surgical trainees). There was an increase in ward activity (direct admissions, reviews and prescriptions), and a reduction in time from referral to review in the emergency department. There was no change in mortality or morbidity.

9.4 Redistribution of workload

Several interventions have looked at ways of increasing the efficiency of trainee doctors' working time by changing the distribution of workload among medical and non-medical staff. Some involve new team structures (of which Hospital at Night would be an example), others the introduction or development of non-medical roles to perform tasks that doctors would otherwise have to perform. These roles include nursing and other professional and non-professional roles. Pezzi et al. (2009) surveyed the use of such 'physician extenders' in surgery residency programmes in the USA, and found a majority of programmes used them to some extent, with a mean of 5.3 physician extenders per programme in 2003, an increase from two per programme in 2002. A number of studies, in the UK and the USA, have identified improvements in trainee working time through the introduction of non-medical roles, with no reported adverse effects on patient safety or patient care. The majority of these examples involve extended or advanced nursing roles. To establish the impact such roles can have, Block and Norton (2008) calculated the extent to which nursing staff compensated for reduced resident hours, and concluded that on average, one full-time nurse was hired for each 5.5 residents.

In the UK, the examples of change described by Mason et al. (2006) and Cass et al. (2003, see pp.90-92 above) included nurse practitioners taking on some of the work within a team structure. Carberry (2006) describes the development of Hospital Emergency Care Teams, which used critical care nurses in advanced assessment roles previously undertaken by junior doctors. Dartey et al. (2010) provide an example of a nurse practitioner conducting preoperative assessment and gaining consent for elective procedures in obstetrics and gynaecology. This freed trainee time, and had no adverse effects.

Herbertson et al. (2007) give an example of the development in 2000-2001 of 'Clinical Support Workers' (CSWs) – auxiliary nurses or support workers specifically trained to carry out cannulation

and venepuncture. This led to junior doctors carrying out fewer such procedures (around one third of the number before the CSWs were introduced), with no apparent detriment to patient care – over 98% of the procedures performed by the CSWs were successful (although comparative data for the doctors' success rate is not given). They do not report any adverse effects on doctors' training, but do recognise the risk of deskilling junior doctors.

Some roles are not extended or specialised nursing roles, but new roles, which may be clinical, or technical. Kneebone et al. (2006) describe the development of a new role, the perioperative specialist practitioner (PSP), in a UK surgical department, designed specifically in response to the working time regulations. They conducted 124 interviews with participants in the training course, although only brief analysis is presented. They report successful implementation of the new role. Interestingly, they identify the emergence of a new professional identity among the PSPs, and some resistance from existing professionals, related to the risk of blurring professional boundaries with such a para-medical role.

In the USA, findings following such initiatives have been generally positive. Lundberg et al. (2006) found nurse practitioners an effective and safe solution to working hours limitations in general medicine. Christmas et al. (2005) found that the addition of nurse practitioners to a trauma team improved resident working hours, and reduced the average time spent in the department by patients, without adversely affecting care. Kendrick (2006) also found that Trauma Nurse Specialists, credentialed with particular skills, were able to perform basic procedures previously carried out by surgical residents, to the extent of 10.6 hours per week saved from residents' working hours. There were no differences in patients' time in department or safety metrics between the nurse specialists and residents. Holleman et al. (2010) found that calls to paediatric neurosurgical residents decreased with the addition of nurse practitioners to a programme, while patient safety sentinel events remained stable. Doctors, nurses and other healthcare practitioners reported greater satisfaction with service availability, responsiveness and "assessment of patient clinical satisfaction".

Advanced nursing roles can enhance medical staffing. Lemoine et al. (2010) report in a conference abstract that the addition of a second, non-traditional, team consisting of an attending physician and a nurse practitioner, to a paediatric intensive care unit alongside a traditional team allowed care to be maintained, while reducing the number of duty-hour violations.

Podnos et al. (2003) describe how health technicians were used to free resident time for direct patient care. Tasks covered a range of administrative, technical and patient care activities, including checking patients in, retrieving notes, changing dressings and phlebotomy. Podnos et al. found that each technician performed an average of 20.25 tasks per day, with benefits for residents including an increase in theatre time from 3.3 to 9.8 hours per week.

In the USA, 'physician assistants' are commonplace (the role is being developed in the UK – Roberts et al. [2004] describe an early evaluation of trainee doctors' views – but has yet to gain much traction). Mathur et al. (2005) describe the use of physician assistants to supplement residents in paediatric intensive care. A positive role in support and continuity of care provision was found, but there was some confusion among physician assistants about their status, and a high turnover of staff in that role. Buch et al. (2008) also raised the question of relative status of what they term 'non-

physician practitioners' (NPPs – a mixture of nurse practitioners and physician assistants) in a surgical residency programme. They found that residents experienced benefits in their own workload, but that tellingly, more NPPs than residents felt that the NPPs contributed to the physicians' education, and that NPPs provided more continuity of care. This may reflect their different perceptions of the NPPs' position in the hierarchy – 75% of NPPs felt they worked at senior resident level, compared to 90% of residents who felt they were at the intern level.

Some cases were identified where doctors have been used to provide cover or allow workload to be distributed from trainees. Wilson et al. (2005) considered the use of research fellows on hybrid rotas to provide surgical night cover at SHO level. This was felt to benefit surgical trainees by exposing them to more educational opportunities in daytime shifts, as well as maintaining clinical practice for the research fellows. Prince et al. (2010) highlighted the risk of reduced senior care in remote and rural hospitals in the UK and proposed the use of appropriately skilled general practitioners to provide medical on-call cover. The resultant role would provide an interface between primary and secondary care, and a broader base of expertise for acute medical cover in hospitals.

Thomson et al. (2005) described a strategic approach to expanding the clinical workforce through the use of international doctors recruited through an international training partnership. This allowed service demands to be covered while maintaining educational value for overseas doctors. The changes to UK immigration law which came into operation in 2009, imposing additional restrictions on overseas doctors entering the UK, may limit the value of such an approach today.

In the USA, Nwomeh et al. (2006) looked at the effects of changing the requirement for a surgeon to be present in trauma cases, with an on-call physician providing cover. Medical residents subsequently gained more acute experience, and surgical residents were able to gain more focused education. There were no adverse effects on mortality, and while length of stay in the trauma room was increased, the use of abdominal CT scans decreased with medical cover (implying less time and discomfort for the patient during diagnosis).

9.5 Technological changes

Some studies have described interventions using technology to support compliance with restricted hours, changes in working patterns, or education. These include two areas which have a lot of potential for adapting the delivery of education to limited working hours: the use of online teaching materials (e-learning), and simulation. Both of these areas have been well studied, and large literatures exist (see for example Ellaway & Masters, 2008, for e-learning; McGaghie et al. 2010, for simulation). While many papers in our initial search mentioned restricted working hours as the context of their study, few satisfied the inclusion criterion of direct application to working time.

Some studies though did directly refer to ways of using e-learning or simulation to organise education around restricted working hours. DaJusta et al. (2008) described an e-learning system for paediatric oncology, and Carley and Mackaway-Jones (2007) described a virtual learning course in emergency medicine for Foundation Year 2 doctors, both of which allowed core knowledge to be presented outside shift patterns, and so meant that teaching did not impose on service delivery.

Simulation provides a similar opportunity for practical skills to be developed away from service delivery. Two studies described how simulation was used to increase the flexibility of practical skills learning. Naughton et al. (2011) compared the performance on an endovascular skills simulator of doctors working day and night shifts. While the performance of those on a night shift took longer to plateau, the conclusion is that out-of-hours simulation was an effective means of developing basic skills. Russo and Tsuda (2011) on the other hand describe the use of a take-home box laparoscopic simulator, meaning that the trainees could effectively follow an e-learning curriculum for motor skills, in the same way as they may for knowledge-based learning.

Other examples of technological interventions included the use of electronic records to make handovers quicker and more efficient. Carberry (2006) looked at the use of handheld computers by multidisciplinary teams and similarly found that the use of the devices for generating reports was useful in rounds, and that access to the wider medical history was beneficial for care. Kochendorfer et al. (2010) found that a 'rounding report' generated from an electronic medical record saved time for staff at handovers and on rounds, was felt to improve safety and was overall more satisfying. Van Eaton et al. (2010) found with a similar approach that time was saved without adverse effects on safety.

Achuthan et al. (2006) looked at the use of an electronic logbook for surgery, which would populate a regional database allowing caseloads to be monitored. However comparison with other data sources found that 12.5% of entries were incorrect in some way, suggesting the electronic system was, at that point at least, not sufficiently reliable.

Goldstein et al. (2009) describe a means of enhancing compliance with the ACGME limits using an automated system facilitated by text messaging. Initially implemented such that residents would text the system when they entered and left the hospital, incomplete data led to an automated reminder service being implemented, whereby the system would text doctors when they were due to start work, reminding them to confirm their time on and off. A survey after eight weeks found residents' ratings of their ability to be compliant with the ACGME restrictions increased from 47% to 75%. 96% of the residents involved felt the text system was easier to use than previous systems of monitoring hours. Despite this, the system seems quite cumbersome and, as the authors acknowledge, requires both honesty and accuracy on the part of the doctors. Landesman et al. (2010) describe the utility of electronic time sheets for monitoring, over paper-based approaches.

The iBleep is an approach developed as part of the Hospital at Night programme (<http://www.healthcareworkforce.nhs.uk/ibleep/>) and is now a commercial enterprise (www.ibleep.net). It uses personal digital assistants/smartphones to provide an intelligent approach to bleeping doctors (and now other staff) – by providing more information on the screen than would be possible with a traditional bleep or over the telephone, it means the doctor can more easily prioritise work and spend less time travelling around the hospital or waiting to speak to appropriate nursing staff. However, only one published study on the iBleep was found in this review, and Liang et al. (2011) report that its implementation in a New Zealand hospital failed because doctors and nurses did not like the system. Reasons included a lack of trust in management intentions, a feeling too much time was spent at a computer, and the advantages of the system over a traditional pager not being recognised or used. The implication is that technological solutions, like those of work design or

workforce, need to be adapted to the local circumstances and not implemented without care and engagement with staff.

Finally, while a conference abstract by Ahlstrom et al. (2011) describes software-based scheduling for the ACGME rules as something of a novelty, electronic rota design has been a core part of the NHS systems in the UK since the introduction of the New Deal. The Doctors Rota System (DRS) was developed specifically for the NHS (<http://www.drusers.nhs.uk/>) and current versions are used across much of the NHS today (although private sector systems are also in use).

9.6 Other approaches

Some other approaches, which do not clearly fall into the categories above, were identified. These mainly relate to changes in organisation which do not involve changing rotas per se. For example, Kuo et al. (2004) described an intervention involving a slight change in the timing of a clinic which was moved from the afternoon to the evening. This was easier to deliver within the ACGME limit, and increased resident satisfaction while maintaining education and patient care. Balmer et al. (2007) also found that movement of a clinic could address working hour restriction, although their focus was on the educational relationship with a preceptor (see Section 7: Educational impact).

Several papers have looked at rescheduling formal, didactic education. Nguyen et al. (2006) looked at enhancing the didactic teaching programme received by surgical residents, in order to gain more benefit from the time available. A structured reading programme from a surgical textbook, coupled with problem-based learning sessions, were found to improve examination results compared to the previous year's cohort. However, this was true only of two of the years studied (PGY-4 and PGY-5, PGY-3 showed a 9% decrease). Numbers were small (n=55 across all years), and there was no control or matching between years. Fields et al. (2009) found that small group teaching out of hours was well received by residents, although they do not provide any data regarding educational impact. Lim et al. (2005) found that moving a didactic session in a medical ICU, from an hour in the middle of the day to half an hour at 8am, improved performance on an end-of-rotation examination.

Frankel et al. (2006) looked at the impact of a targeted intervention on readmission rates to a surgical intensive care unit, which had risen following initial changes to rotas to comply with the ACGME restrictions. The targeted intervention involved a focused transfer telephone call, charted care summary and discharge check-up, as patients were transferred back to wards. The readmission rate returned to the level it had been before the initial rota change (1.4% and 1.2%, compared to 3% after the initial change), with the implication that improved handover on discharge from the unit improved care.

Haliasos et al. (2010) describe the use of a new referral algorithm to make out-of-hours referrals to an on-call registrar more efficient, so allowing an on-call system to be maintained in neurosurgery, while decreasing the number of calls by 45% and increasing the average maximum uninterrupted sleep by over 1.5 hours.

9.7 Summary

There are three main approaches to implementing, compensating for, or mitigating reduction in trainee working hours:

- Restructuring work, through the use of shifts, changes in rotas, and the design of services.
- The redistribution of work from trainees to other staff – mainly involving non-medical roles (particularly extended nursing roles), but also redistribution of workload to other doctors.
- The use of technology to support changes, through assisting rota design, allowing flexibility in education, and supporting working hour compliance.

All of these are used, with different reception from the trainee staff involved. Freiburg et al. (2011) conducted a survey asking respondents to rate different approaches to achieving working hour compliance. This was distributed to the membership of the Resident and Associate Society of the American College of Surgeons, and 599 responses received (a response rate of 9.7%). IT-based solutions (including electronic records and digital imaging) were the most favoured, followed by the use of non-medical staff. Recruiting more residents was also favoured, but recruiting fellows was lowly rated, as was shift working. Findings from many of the papers reviewed would appear to accord with this ranking.

In practice, these may all be used as part of a new system, but some studies have shown that redistribution of workload, for example, has the potential to improve compliance without more complex restructuring of rotas and shifts. In addition, interventions are likely to be most effective when they are developed in response to specific local service demands and consideration of current practice and trainee activity, and with the collaboration and cooperation of the staff involved.

There is no 'one size fits all' solution to rota design, nor should rotas be set in stone, rather they should be adapted to specific circumstances, and open to revision. People's circadian rhythms should be taken into account in rota design, e.g. by rotating through evening shifts before night shifts, rather than an abrupt change from day to night. Although many doctors are averse to shift systems and there is some evidence of negative reception to rota changes, carefully considered redesign of service and rotas can improve access to training opportunities.

Night working may benefit from specific approaches, such as Hospital at Night and night float, but evidence is somewhat mixed, and success is likely to rely on sensitivity to local needs and staff consultation.

New roles or workload distribution can be a successful and safe approach to compliance with working hour restrictions, but should be developed through negotiation rather than imposed. Furthermore, the risks of deskilling junior doctors should be considered and concerns regarding the blurring of professional boundaries should be addressed.

Technological advances may help to meet some educational and service needs, but these should be developed and implemented according to local needs, and alongside appropriate training.

Many of these studies, perhaps more than in other sections of this review, are situated in their specific circumstances, and so results will be subject to any number of situational confounds. This is unavoidable with many organisational interventions where controlled studies are not possible. Small and biased samples are also a risk to the generalisability of any observations.

It is important to note that changes are not made in isolation, and many of the examples in this section have included more than one intervention (e.g. Hospital at Night programmes often involve development of non-medical roles and rota changes).

10 Discussion

This report has reviewed a large body of work considering different elements relevant to the restriction of working hours, and the impact of that restriction on medical education and training. Much of the research comes from the USA, where restriction to an 80-hour working week has been in place in New York State since 1989, and nationwide since 2003. In the UK, despite the New Deal for junior doctors being implemented in 1991, there has been far less work published. While some leads may be taken from the American literature, the extent to which findings relating to the 80-hour limit can be translated to the 48-hour European limit is questionable.

There is a strand of rhetoric in some of the literature, not limited to commentaries and editorials, which presents the changes in duty hours as a threat or a loss (with references to grief, and something coming to an end), which raise the suspicion that at least some of the assertions of loss of quality in training and care may be post hoc rationalisations of this mourning of change. On the face of it this may be of interest psychologically, or sociologically, but may be less directly relevant for the development of policy (although antagonism to policy can hinder its successful implementation). However, these changes are also couched in terms of a 'new professionalism' (e.g. Van Eaton et al. 2005, Coverdill et al. 2010), which carries with it the implication that the standards which the medical profession sets itself (and so implicitly those which the regulator should be setting) may be changing. There has been some evidence that behaviour is not changing, but it may be worth looking more deeply into how time management and doctors' attitudes to work and non-work may be changing.

The literature is broad and complex, but some overall key findings have been identified, and are detailed below.

Key findings: Fatigue and wellbeing

The physiological and cognitive effects of fatigue are unquestionable, and are indicated by a large amount of rigorous research. The methodologies in this area, and the variables they consider, tend to be more robust and less problematic than some of the other areas.

- Fatigue is likely to arise from long shifts or long periods of work.
- Negative effects of fatigue are identified on indicators including subjective and objective stress, with consequences for doctors' health, such as the development of cardiovascular problems.
- Fatigue is associated with adverse effects on cognitive and psychomotor skills, such as working memory capacity, attentional issues, and performance on simulator tasks.
 - Fatigue has demonstrated negative consequences for personal safety, such as the occurrence of needlestick injuries and sleepiness and increased risk of accidents while driving after long shifts.
 - There are therefore potential consequences for patient safety, such as increased clinical errors and diagnostic mistakes.

- There is some evidence that doctors not recognise the potential effects and dangers of fatigue for their practice. Education about the consequences of insufficient sleep may be needed to inform about the risks of fatigue and how it may be managed and risks avoided, and to change organisational cultures where long hours are accepted. Organisational strategies may be needed to improve sleep quality and reduce stress. Short naps may be an effective countermeasure to fatigue and its consequences.
- A reduction in working hours alone may not decrease fatigue, which is also affected by different work schedules (e.g. number of consecutive days or nights worked, lengths of intervals between shifts). Effects of fatigue have been found to be more pronounced after night shifts than after day shifts.
- Nonetheless, the reduction in working hours, in conjunction with consideration of work patterns, can contribute to a decrease in fatigue, improve quality of life, and may impact on burnout.

Key findings: Perceptions and attitudes

- Doctors' attitudes towards restrictions are often negative, although studies have found mixed results.
- Junior doctors are often more positive about restricted hours – in terms of the effects on education and patient care as well as their quality of life – than senior trainees and clinical faculty.
- Working hour restriction may be linked to a changing professionalism among younger doctors, but there is no objective evidence that any detrimental changes are occurring. Older doctors' attitudes may reflect their embeddedness in the previous structure of work; they are more adapted to the previous system, and may be consciously or unconsciously resistant to change.

Key findings: Impact on educational opportunities

- Doctors' perceptions of the educational impact of restrictions are largely negative, although some positive effects are reported.
- There is evidence that restricted working hours need not present obstacles to medical education, and need not have adverse effects on patient safety, despite negative perceptions.
- Studies of educational impact focus on quantity, in terms of the number of cases seen, rather than quality of experience.
 - Concentration on easily quantified indicators such as caseload may disguise effects (positive or negative) on other aspects of education and practice which are not as easily measured. It also contains a bias towards craft

specialties which lend themselves to such metrics. No studies were found that reported comparable effects on cases seen in non-craft specialties.

- They generally identify a reduction in exposure with the introduction of working time restrictions, but many also identify confounding changes to service delivery meaning hours alone cannot be seen as responsible.
- There is some evidence that caseload may be being maintained at the expense of other activity, e.g. clinic attendance. Other educational indicators show little change.
- There may be a knock-on effect of restrictions through training grades. Junior trainees' experience may suffer in order to give seniors more experience. This means that senior trainees may be able to take on fewer advanced surgical procedures as they are still performing the basic procedures they did not have the opportunities to practice as juniors. This may increase seniors' workload, but also risks their having less advanced experience at the end of training.

Key findings: Impact on patient care, patient safety and clinical outcomes

- There is limited objective support for clinicians' fears and perceptions of negative effects of working time restrictions on patient care.
- Studies looking at indicators of patient care and patient outcomes are limited and confounded by other factors, and the findings are mixed.
 - Many studies did not detect a significant difference in mortality or clinical outcomes before and after working time restrictions.
 - Some studies reported positive outcomes, including: decreased mortality, improved adherence to evidence-based guidelines, reduction in the rate of intensive care utilisation, improvement in the rate of discharge to home or rehabilitation, and a decrease in pharmacist interventions to prevent errors.
 - Some studies reported negative outcomes, including: higher morbidity, delayed clinical review, higher risk of in-hospital complications, and increased delays ordering diagnostic tests.
- A UK study of patient outcomes found a trend of improvement spanning the introduction of the WTR, suggesting they are not a primary influence.
- Several studies have found that continuity of care is affected by reduced working hours, and that consequently effective handover is of increased importance.
- Cross-cover between specialties in which doctors have limited experience is a concern, but no studies were found linking this to patient safety issues.

Key findings: Interventions and solutions

- A number of strategies for adjusting service and education to meet restricted hours have been reported. These include the redesign of working hours (shifts and rotas, including specific initiatives for night-time services), the redistribution of trainee workload to other professionals (usually nurses or other groups, although sometimes other doctors), and the use of technology to improve monitoring and time management, or to facilitate more flexible learning.
- There is no 'one size fits all' solution to rota design, nor should rotas be set in stone, rather they should be adapted to specific circumstances, and open to revision.
 - Interventions are likely to be most effective when they are developed from the specific local service demands, and with the collaboration and cooperation of the staff involved.
 - People's circadian rhythms should be taken into account in rota design, e.g. by rotating through evening shifts before night shifts, rather than an abrupt change from day to night.
 - Shorter shifts do not seem to be detrimental to education and can be beneficial to residents.
- There are general guidelines for best practice in things that should be avoided:
 - A full shift system with blocks of seven nights has been linked to increased stress and fatigue, and found to be less manageable on a personal level compared to blocks of three or four nights.
 - Long sequences of daytime work – such as seven long shifts in a row - should also be avoided; with a recommended maximum of four.

10.1 Metrics and indicators of impact

The studies in this review have identified a number of measures that may provide indicators of any effects of working time restrictions. These are summarised in table 3, but it should be remembered that any measures should be situated in their specific locality, and even objective measures (such as hospital standardised mortality rate) will be subject to confounding factors. Any retrospective study of effects would therefore be of uncertain reliability, and even a prospective study would need to be alert to any circumstantial confounds. In UK medical education the changes of the past decade, and the on-going changes in the NHS, mean that working time should not be seen as an isolated factor. The same is true for educational outcomes (whether caseload and operative experience, or exam results).

Table 3. Summary of potential indicators, with pros and cons

Type of indicator	Pros	Cons
Patient outcomes		
Mortality rates	Objective data. Standardised calculations. Recorded for other purposes.	Subject to all organisational confounds. 'Near misses' may not be recorded. Not all errors may be recorded.
Average length of stay		
Sentinel events / Serious untoward incidents		
Error rates (including medication/diagnostic errors)		
Patient feedback		
Patient complaints	Direct reflection of care.	May be low frequency. Will be variable with specialty.
Educational outcomes		
Audits	Objective data. Easily recordable. Face validity for educational experience.	Logbooks may be more suitable for craft specialties. Depends on reliability of completion – even automated systems may not be reliable. Subject to confounds in service reorganisation and clinical/technical developments. Does not capture quality of experience. Only focus on one aspect of training.
Logbooks		
Clinic attendance		
Exam scores/pass rates		
Attendance at formal/didactic teaching		
Personal outcomes		
General Health Questionnaire	Validated scales are available.	May not have obvious direct utility.
Maslach Burnout Inventory		
Sleepiness and wellbeing scales		
Sickness/absence rates	Routinely recorded data.	Link to working hours may be tenuous. Ethical issues.
Attitudinal measures		
Surveys	May highlight issues of concern among trainees or educators.	May be simply a record of biases or prejudices.

11 Conclusion

The balance of evidence appears to be that while working time restriction is neutral or beneficial in terms of its effects on medical education, patient care and patient safety, attitudes towards it still tend to be negative. This may change in time, and the fact that younger trainees are more positive than their seniors suggests there may be a generational shift.

Successful interventions, whether they involve the redesign of a service, the introduction of new rotas or shift systems, or distribution of workload outside the medical workforce seem to be those which respond to the particular requirements of a given clinical context, by reviewing that context and designing the intervention around its specifics. A successful change in service design or practice in one organisation may not simply transfer to another, even if both are working within the same restrictions.

The review was designed to focus on the effects of working time restrictions, rather than to identify or specify best practice. While an overall picture of attitudes and effects can be abstracted from such a broad literature, there are too many confounds (of which the difference in the USA and UK restrictions is only the most obvious) to confidently state what best practice should be, and any intended transfer of knowledge should consider carefully how the context may vary.

11.1 Future research

Any future research into the effects of the working time regulations would need to be aware of local circumstances, and the possible confounding effects on any measures used. Focusing research questions on the effects of the WTR per se may not be realistic, if conclusions are to be valid. Nonetheless, focused research questions can be identified which are of interest and relevance:

- perceptions of work and non-work in establishing what aspects of practice and education should fall within working time restrictions;
- attitudes towards time management, including their relationship with professionalism and professional identity;
- audit of caseload against rota organisation, to see how specific approaches to work organisation affect workload;
- consideration of how attitudes and workload vary between specialties.

12 References

- Abraham, T., Freitas, M., Frangos, S., Frankel, H.L., & Rabinovici, R. (2006). Are resident work-hour limitations beneficial to the trauma profession? *American Surgeon*, 72(1), 35-41.
- ACGME (2011). Glossary of terms, June 28, 2011. Available at: http://www.acgme.org/acwebsite/about/ab_acgmeglossary.pdf [Accessed 1 July 2012].
- Achuthan, R., Grover, K., & MacFie, J. (2006). A critical evaluation of the electronic surgical logbook. *BMC Medical Education*, 6, 15.
- Ahlstrom, T., Vajracharya S., V., & Govind, N. (2011). Balancing hospitalist productivity and satisfaction with patient care continuity utilizing software-based scheduling. *Journal of Hospital Medicine, Conference*, 6 (4)suppl.2, S97-S98.
- Ahmed, M., Lund, T., & Morris, A. (2009). A Compendium of Solutions for Implementing the Working Time Directive for Doctors in Training from August 2009. Available at: <http://www.healthcareworkforce.nhs.uk/compendium/> [Accessed 1 July 2012].
- Akl, E.A., Bais, A., Rich, E., Izzo, J., Grant, B.J. B., & Schunemann, H.J. (2006). Brief report: Internal medicine residents', attendings', and nurses' perceptions of the night float system. *Journal of General Internal Medicine*, 21(5), 494-497.
- Albert, W., Freitag, M., & Ludwig, K. (1998). [The employment schedule act--effects on the young surgeon]. *Langenbecks Archiv fur Chirurgie - Supplement - Kongressband*, 115, 806-812.
- Al-Rawi, S., & Spargo, P. (2009). A retrospective study of anaesthetic caseload of Specialist Registrars following the introduction of new working patterns in the Wessex region. *Anaesthesia*, 64(3), 297-300.
- Alshekhlee, A., Walbert, T., DeGeorgia, M., Preston, D.C., & Furlan, A.J. (2009). The impact of Accreditation Council for Graduate Medical Education duty hours, the July phenomenon, and hospital teaching status on stroke outcomes. *Journal of Stroke & Cerebrovascular Diseases*, 18(3), 232-238.
- Arndt, J.T., Owens, J., Crouch, M., Stahl, J., & Carskadon, M.A. (2005). Neurobehavioral performance of residents after heavy night call vs after alcohol ingestion. *JAMA*, 294(9), 1025-1033.
- Arora, V., Dunphy, C., Chang, V.Y., Ahmad, F., Humphrey, H.J., & Meltzer, D. (2006). The effects of on-duty napping on intern sleep time and fatigue. *Annals of Internal Medicine*, 144(11), 792-798.
- Arora, V.M., Georgitis, E., Siddique, J., Vekhter, B., Woodruff, J.N., Humphrey, H.J., et al. (2008). Association of workload of on-call medical interns with on-call sleep duration, shift duration, and participation in educational activities. *JAMA*, 300(10), 1146-1153.
- Arora, V.M., Georgitis, E., Woodruff, J.N., Humphrey, H.J., & Meltzer, D. (2007). Improving sleep hygiene of medical interns: can the sleep, alertness, and fatigue education in residency program help? *Archives of Internal Medicine*, 167(16), 1738-1744.
- Aspinall, S.R., Bradburn, D.M., & Mills, S.J. (2006). Hospital at night and the surgical middle grade: An observational study from a district general hospital. *Annals of the Royal College of Surgeons of England* 88(Suppl):24-26.

- Auger, K.A., Sieplinga, K.R., Simmons, J.M., & Gonzalez del Rey, J.A. (2010). Educational Implications and Sleep and Fatigue Implications of the 2008 Proposed Work Hour Regulations: Pilot Studies [Conference abstract]. *Academic Pediatrics*, 10, e5.
- Ayas, N.T., Barger, L.K., Cade, B.E., Hashimoto, D.M., Rosner, B., Cronin, J.W., et al. (2006). Extended work duration and the risk of self-reported percutaneous injuries in interns. *JAMA*, 296(9), 1055-62.
- Bailit, J.L., & Blanchard, M.H. (2004). The effect of house staff working hours on the quality of obstetric and gynecologic care. *Obstetrics & Gynecology*, 103(4), 613-616.
- Bailit, J.L., Weisberger, A., & Knotek, J. (2005). Resident job satisfaction and quality of life before and after work hour reform. *Journal of Reproductive Medicine*, 50(9), 649-652.
- Baldwin, K., Namdari, S., Donegan, D., Kamath, A. F., & Mehta, S. (2011). Early effects of resident work-hour restrictions on patient safety: a systematic review and plea for improved studies. *Journal of Bone & Joint Surgery - American Volume*, 93(2), e5.
- Balmer, D., Ruzek, S., Ludwig, S., & Giardino, A. (2007). Pediatric residents' and continuity clinic preceptors' perceptions of the effects of restricted work hours on their learning relationship. *Ambulatory Pediatrics*, 7(5), 348-353.
- Banks, L.N., Cashman, J., Mohil, R., Morris, S., & McElwain, J.P. (2010). Irish (Republic) versus British (North West) orthopaedic trainees: what are the differences? *Surgeon Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 8(5), 259-261.
- Barden, C.B., Specht, M.C., McCarter, M.D., Daly, J.M., & Fahey, T.J., 3rd. (2002). Effects of limited work hours on surgical training. *Journal of the American College of Surgeons*, 195(4), 531-538.
- Barger, L.K., Cade, B.E., Ayas, N.T., et al. (2005) Extended work shifts and the risk of motor vehicle crashes among interns. *New England Journal of Medicine*, 352:125-134.
- Barger, L.K., Ayas, N.T., Cade, B.E., Cronin, J.W., Rosner, B., Speizer, F.E., et al. (2006) Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. *PLOS Medicine*, 3(12), e487.
- Barone, J.E., & Ivy, M.E. (2004). Resident work hours: the five stages of grief. *Academic Medicine*, 79(5), 379-380.
- Barrack, R.L., Miller, L.S., Sotile, W.M., Sotile, M.O., & Rubash, H.E. (2006). Effect of duty hour standards on burnout among orthopaedic surgery residents. *Clinical Orthopaedics & Related Research*, 449, 134-137.
- Baskies, M.A., Ruchelsman, D.E., Capeci, C.M., Zuckerman, J.D., & Egol, K.A. (2008). Operative experience in an orthopaedic surgery residency program: the effect of work-hour restrictions. *Journal of Bone & Joint Surgery - American Volume*, 90(4), 924-927.
- Beckett, D.J., Gordon, C.F., Paterson, R., Chalkley, S., Stewart, C., Jones, M.C., et al. (2009). Improvement in out-of-hours outcomes following the implementation of Hospital at Night. *QJM: An International Journal of Medicine*, 102(8), 539-546.
- Benes, V. (2006). The European Working Time Directive and the effects on training of surgical specialists (doctors in training): a position paper of the surgical disciplines of the countries of the EU. *Acta Neurochirurgica*, 148(11), 1227-1233.
- Berios, I., Surani, S., & Simmons, M. (2009). Assessing reaction time among emergency medicine residents working different shift hours. *Annals of Emergency Medicine*, 54(3 Suppl 1), S35.

- Bhangu, A., & Hartshorne, G. (2011). Ward rounds: missed learning opportunities in diagnostic changes? *The Clinical Teacher*, 8(1), 17-21.
- Bhavsar, J., Montgomery, D., Li, J., Kline-Rogers, E., Saab, F., Motivala, A., et al. (2007). Impact of duty hours restrictions on quality of care and clinical outcomes. *American Journal of Medicine*, 120(11), 968-974.
- Biller, C.K., Antonacci, A.C., Pelletier, S., Homel, P., Spann, C., Cunningham, M.J., et al. (2006). The 80-Hour Work Guidelines and Resident Survey Perceptions of Quality. *Journal of Surgical Research*, 135(2), 275-281.
- Biswas, D., Rafferty, A., & Jassar, P. (2009). Night emergency cover for ENT in England: a national survey. *Journal of Laryngology & Otology*, 123(8), 899-902.
- Bland, K.I., Stoll, D.A., Richardson, J.D., & Britt, L.D. (2005). Brief communication of the Residency Review Committee-Surgery (RRC-S) on residents' surgical volume in general surgery. *American Journal of Surgery*, 190(3), 345-350.
- Blencowe, N.S., Parsons, B.A., & Hollowood, A.D. (2011). Effects of changing work patterns on general surgical training over the last decade. *Postgraduate Medical Journal*, 87, 795-799.
- Block, A.E., & Norton, D.M. (2008). Nurse labor effects of residency work hour limits. *Nursing Economics*, 26(6), 368-373.
- Blum, A.B., Shea, S., Czeisler, C.A., Landrigan, C.P., & Leape, L. (2011). Implementing the 2009 Institute of Medicine recommendations on resident physician work hours, supervision, and safety. *Nature and Science of Sleep*, 3, 47-85.
- Blum, A.B., Raiszadeh, F., Shea, S., Mermin, D., Lurie, P., Landrigan, C.P., et al. (2010). US public opinion regarding proposed limits on resident physician work hours. *BMC Medicine*, 8, 33.
- BMA Junior Doctors Committee (2010) Maintaining the Quality of Training in the Craft Specialties: Managing EWTD Implementation. London: British Medical Association.
- Borman, K.R., Biester, T.W., Jones, A.T., & Shea, J.A. (2011). Sleep, supervision, education and service: Views of junior and senior residents. *Journal of Surgical Education*, 68(6), 495-501.
- Bowhay, A.R. (2008). An investigation into how the European Working Time Directive has affected anaesthetic training. *BMC Medical Education*, 8, 41.
- Brandenberger, J., Kahol, K., Feinstein, A.J., Ashby, A., Smith, M., & Ferrara, J.J. (2010). Effects of duty hours and time of day on surgery resident proficiency. *American Journal of Surgery*, 200(6), 814-818.
- Brasher, A.E., Chowdhry, S., Hauge, L.S., & Prinz, R.A. (2005). Medical students' perceptions of resident teaching: have duty hours regulations had an impact? *Annals of Surgery*, 242(4), 548-553.
- Brennan, P. A., & McCaul, J. A. Association of Surgeons of Great Britain & Ireland, & Association of Surgeons in Training. (2007). The future of academic surgery - a consensus conference held at the Royal College of Surgeons of England, 2 September 2005. *British Journal of Oral & Maxillofacial Surgery*, 45(6), 488-489.
- Brion, L. P., Neu, J., Adamkin, D., Bancalari, A., Cummings, J., Guttentag, S., Juul, S., et al. (2009). Resident Duty Hour Restrictions: Is Less Really More? *Journal of Pediatrics*, 154(5), 631-632.

- British Orthopaedic Trainees Association (2009). BOTA position statement on the European Working Time Directive and training in trauma and orthopaedic surgery – January 2009. Available at: <http://www.bota.org.uk/uploads/cms/00178/BOTA%20EWTD%20Statement.pdf> [Accessed 26 January 2012].
- Brown, M., Tucker, P., Rapport, F., Hutchings, H., Dahlgren, A., Davies, G., et al. (2010). The impact of shift patterns on junior doctors' perceptions of fatigue, training, work/life balance and the role of social support. *Quality & Safety in Health Care*, 19(6), e36.
- Browne, J.A., Cook C., Olson, S.A., & Bolognesi, M.P. (2009). Resident duty-hour reform associated with increased morbidity following hip fracture. *Journal of Bone and Joint Surgery Series A*, 91(9), 2079-2085.
- Bruce, P.J., Helmer, S.D., Osland, J.S., & Ammar, A.D. (2010). Operative volume in the new era: a comparison of resident operative volume before and after implementation of 80-hour work week restrictions. *Journal of Surgical Education*, 67(6), 412-416.
- Brunworth, J.D., & Sindwani, R. (2006). Impact of duty hour restrictions on otolaryngology training: divergent resident and faculty perspectives. *The Laryngoscope*, 116(7), 1127-1130.
- Buch, K.E., Genovese, M.Y., Conigliaro, J.L., Nguyen, S.Q., Byrn, J.C., Novembre, C.L., et al. (2008). Non-physician practitioners' overall enhancement to a surgical resident's experience. *Journal of Surgical Education*, 65(1), 50-53.
- Businger, A., Guller, U., & Oertli, D. (2010). Effect of the 50-hour workweek limitation on training of surgical residents in Switzerland. *Archives of Surgery*, 145(6), 558-563.
- Buysse, D.J., Barzansky, B., Dinges, D., Hogan, E., Hunt, C.E., Owens, J., Rosekind, M., et al. (2003). Sleep, fatigue, and medical training: setting an agenda for optimal learning and patient care. *Sleep*, 26(2), 218-225.
- Byrnes, M.C., Narciso, V.C., Brantley, L., Helmer, S.D., & Smith, R.S. (2006). Impact of resident work-hour restrictions on trauma care. *American Journal of Surgery*, 191(3), 338-343.
- Caldicott, C.V., & Holsapple, J.W. (2008). Training for fitness: reconsidering the 80-hour work week. *Perspectives in Biology & Medicine*, 51(1), 134-143.
- Campbell, J., Prochazka, A.V., Yamashita, T., & Gopal, R. (2010). Predictors of persistent burnout in internal medicine residents: a prospective cohort study. *Academic Medicine*, 85(10), 1630-1634.
- Canter, R. (2011). Impact of reduced working time on surgical training in the United Kingdom and Ireland. *Surgeon Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 9 Suppl 1, S6-7.
- Cappuccio, F.P., Bakewell, A., Taggart, F.M., Ward, G., Ji, C., Sullivan, J.P., et al. (2009). Implementing a 48 h EWTD-compliant rota for junior doctors in the UK does not compromise patients' safety: assessor-blind pilot comparison. *QJM: An International Journal of Medicine*, 102(4), 271-282.
- Carberry, M. (2006). Hospital emergency care teams: our solution to out of hours emergency care. *Nursing in Critical Care*, 11(4), 177-187.
- Carley, S., & Mackaway-Jones, K. (2007). Developing a virtual learning course in emergency medicine for F2 doctors. *Emergency Medicine Journal*, 24(8), 525-528.
- Carpenter, R.O., Austin, M.T., Tarpley, J.L., Griffin, M.R., & Lomis, K.D. (2006). Work-hour restrictions as an ethical dilemma for residents. *American Journal of Surgery*, 191(4), 527-532.

- Carpenter, R.O., Spooner, J., Arbogast, P.G., Tarpley, J.L., Griffin, M.R., & Lomis, K.D. (2006). Work hours restrictions as an ethical dilemma for residents: a descriptive survey of violation types and frequency. *Current Surgery*, 63(6), 448-455.
- Cass, H.D., Smith, I., Unthank, C., Starling, C., & Collins, J.E. (2003). Improving compliance with requirements on junior doctors' hours. [Erratum appears in *BMJ*.2003 Sep 13;327(7415):586]. *BMJ*, 327(7409), 270-273.
- Chandra, R.K. (2004). The resident 80-hour work week: how has it affected surgical specialties? *The Laryngoscope*, 114(8), 1394-1398.
- Charap, M. (2004). Reducing Resident Work Hours: Unproven Assumptions and Unforeseen Outcomes. *Annals of Internal Medicine*, 140(10), 814-815.
- Chen, I., Vorona, R., Chiu, R., & Ware, J.C. (2008). A survey of subjective sleepiness and consequences in attending physicians. *Behavioral Sleep Medicine*, 6(1), 1-15.
- Choby, B., & Passmore, C. (2007). Faculty perceptions of the ACGME resident duty hour regulations in family medicine. *Family Medicine*, 39(6), 392-398.
- Choi, D., Dickey, J., Wessel, K., & Girard, D.E. (2006). The impact of the implementation of work hour requirements on residents' career satisfaction, attitudes and emotions. *BMC Medical Education*, 6, 53.
- Chowdury, F. & Goodfellow, P.B. (2011)The effect of European Working Time Directive on the education and development of junior doctors. Poster Presentation at AMEE conference, Vienna, Austria, 27-31 August 2011.
- Christmas, A.B., Brintzenhoff, R.A., Sing, R.F., Schmelzer, T.M., Bolton, S.D., Miles, W.S., et al. (2009). Resident work hour restrictions impact chief resident operative experience. *American Surgeon*, 75(11), 1065-1068.
- Christmas, A.B., Reynolds, J., Hodges, S., Franklin, G.A., Miller, F.B., Richardson, J.D., et al. (2005). Physician extenders impact trauma systems. *Journal of Trauma-Injury Infection & Critical Care*, 58(5), 917-920.
- Chung, R., Ahmed, N., & Chen, P. (2004). Meeting the 80-hour work week requirement: what did we cut? *Current Surgery*, 61(6), 609-611.
- Cockerham, W.T., Cofer, J.B., Lewis, P.L., Scroggins, C.M., & Burns, R.P. (2004). Resident work hours: can we meet the ACGME requirements? *American Surgeon*, 70(8), 687-690.
- Collins, J.P. (2011). International consensus statement on surgical education and training in an era of reduced working hours. *Surgeon, Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 9 Suppl 1, S3-5.
- Collum, J., Harrop, J., Stokes, M., & Kendall, D. (2010). Patient safety and quality of care continue to improve in NHS North West following early implementation of the European Working Time Directive. *QJM: An International Journal of Medicine*, 103, 929-940.
- Conigliaro, J., Frishman, W.H., Lazar, E.J., & Croen, L. (1993). Internal medicine housestaff and attending physician perceptions of the impact of the New York State Section 405 regulations on working conditions and supervision of residents in two training programs. *Journal of General Internal Medicine*, 8(9), 502-507.

- Connors, R.C., Doty, J.R., Bull, D.A., May, H.T., Fullerton, D.A., & Robbins, R.C. (2009). Effect of work-hour restriction on operative experience in cardiothoracic surgical residency training. *Journal of Thoracic & Cardiovascular Surgery*, 137(3), 710-713.
- Coverdill, J.E., Adrales, G.L., Finlay, W., Mellinger, J.D., Anderson, K.D., Bonnell, B.W., et al. (2006). How surgical faculty and residents assess the first year of the Accreditation Council for Graduate Medical Education duty-hour restrictions: results of a multi-institutional study. *American Journal of Surgery*, 191(1), 11-16.
- Coverdill, J.E., Carbonell, A.M., Cogbill, T.H., Fryer, J., Fuhrman, G.M., Harold, K.L., Hiatt, J.R., et al. (2011). Professional values, value conflicts, and assessments of the duty-hour restrictions after six years: A multi-institutional study of surgical faculty and residents. *American Journal of Surgery*, 201(1), 16-23.
- Coverdill, J.E., Carbonell, A.M., Fryer, J., Fuhrman, G.M., Harold, K.L., Hiatt, J.R., et al. (2010). A new professionalism? Surgical residents, duty hours restrictions, and shift transitions. *Academic Medicine*, 85(10 Suppl), S72-75.
- Cull, W.L., Mulvey, H.J., Jewett, E.A., Zalneraitis, E.L., Allen, C.E., & Pan, R.J. (2006). Pediatric residency duty hours before and after limitations. *Pediatrics*, 118(6), e1805-1811.
- Czeisler, C.A. (2009). Medical and genetic differences in the adverse impact of sleep loss on performance: ethical considerations for the medical profession. *Transactions of the American Clinical & Climatological Association*, 120, 249-285.
- DaJusta, D.G., Mueller, T.J., & Barone, J.G. (2008). Accreditation Council for Graduate Medical Education competency-based on-line computer course in pediatric oncology for urology residents. *Urology*, 71(5), 818-820.
- Damadi, A., Davis, A.T., Saxe, A., & Apeltgren, K. (2007). ACGME duty-hour restrictions decrease resident operative volume: a 5-year comparison at an ACGME-accredited university general surgery residency. *Journal of Surgical Education*, 64(5), 256-259.
- Dartey, W., Borase, H., Organ, A., Evans, T., & Fox, R. (2010). Preoperative assessment and consent for surgery: a role for the gynaecology nurse-practitioner. *Journal of Obstetrics & Gynaecology*, 30(2), 166-170.
- Dassinger, M.S,3rd., Eubanks, J.W,3rd., & Langham, M.R.Jr. (2008). Full work analysis of resident work hours. *Journal of Surgical Research*, 147(2), 178-181.
- Davies, H., Clarke, J., Farrell, K., & Voelkin, C. (2007). Impact of the European Working Time Directive (EWTD) on Postgraduate Medical Education. Executive Summary of the scoping phase of project. Available at: http://www.healthcareworkforce.nhs.uk/index.php?option=com_docman&task=doc_download&gid=2043&Itemid=697 [Accessed 1 July 2012].
- de Virgilio, C., Yaghoubian, A., Lewis, R.J., Stabile, B.E., & Putnam, B.A. (2006). The 80-hour resident workweek does not adversely affect patient outcomes or resident education. *Current Surgery*, 63(6), 435-439.
- Dean, B., & Pereira, E. (2011). Surgeons and training time. *BMJ Careers*, doi:10.1136/bmj.d6724.
- Deitmer, T. (2004). [Influence of working time regulations on the organisation and quality of clinical workflow]. *Zeitschrift fur Arztliche Fortbildung und Qualitätssicherung*, 98(3), 210-213.

- Department of Health (2005). The implementation and impact of Hospital at Night pilot projects: An evaluation report. London: Department of Health.
- Dozois, E.J., Holubar, S.D., Tsikitis, V.L., Malireddy, K., Cima, R.R., Fairley, D.R., et al. (2009). Perceived Impact of the 80-Hour Workweek: Five Years Later. *Journal of Surgical Research*, 156(1), 3-15.
- Drolet, B.C., Spalluto, L.B., & Fischer, S.A. (2010). Residents' perspectives on ACGME regulation of supervision and duty hours - a national survey. *New England Journal of Medicine*, 363(23), e34.
- Du Rand, I.A., & Lewis, R.A. (2009). BTS bronchoscopy training survey 2009. *Thorax*, 64 (Conference), A164-A165.
- Durkin, E.T., McDonald, R., Munoz, A., & Mahvi, D. (2008). The impact of work hour restrictions on surgical resident education. *Journal of Surgical Education*, 65(1), 54-60.
- Dusmet, M., Reymond, M., & Merlini, M. (1993). [The 60 hour week in surgery: possible or impossible?]. *Helvetica Chirurgica Acta*, 59(5-6), 855-860.
- Ellaway, R., & Masters, K. (2008). AMEE Guide 32: e-Learning in medical education Part 1: Learning, teaching and assessment. *Medical Teacher* 30(5), 455-473.
- Ellman, P.I., Kron, I.L., Alvis, J.S., Tache-Leon, C., Maxey, T.S., Reece, T.B., et al. (2005). Acute sleep deprivation in the thoracic surgical resident does not affect operative outcomes. *Annals of Thoracic Surgery*, 80(1), 60-64.
- Ellman, P.I., Law, M.G., Tache-Leon, C., Reece, T.B., Maxey, T.S., Peeler, B.B., et al. (2004). Sleep deprivation does not affect operative results in cardiac surgery. *Annals of Thoracic Surgery*, 78(3), 906-911.
- Espey, E., Ogburn, T., & Puscheck, E. (2007). Impact of duty hour limitations on resident and student education in obstetrics and gynecology. *Journal of Reproductive Medicine*, 52(5), 345-348.
- Feanny, M.A., Scott, B.G., Mattox, K.L., & Hirshberg, A. (2005). Impact of the 80-hour work week on resident emergency operative experience. *American Journal of Surgery*, 190(6), 947-949.
- Federation of the Royal Colleges of Physicians of the UK. (2011). Census of consultant physicians and medical registrars in the UK, 2010: data and commentary. London: Royal College of Physicians. Available at: <http://www.rcplondon.ac.uk/sites/default/files/census-2010.pdf> [Accessed 1 July 2012].
- Ferguson, C.M., Kellogg, K.C., Hutter, M.M., & Warshaw, A.L. (2005). Effect of work-hour reforms on operative case volume of surgical residents. *Current Surgery*, 62(5), 535-538.
- Fernandes, C., & Raptis, D.A. (2008). The "hospital at night" medical cover in the UK. *Archives of Hellenic Medicine*, 25(2), 221-223.
- Fernandez, E., & Williams, D.G. (2009). Training and the European Working Time Directive: a 7 year review of paediatric anaesthetic trainee caseload data. *British Journal of Anaesthesia*, 103(4), 566-569.
- Fields, R.C., Bowman, M.C., Freeman, B.D., & Klingensmith, M.E. (2009). Implementation of an "after hours" resident educational program in a general surgery residency: a paradigm for increasing formal didactic training outside of the hospital setting in the era of the 80-hour workweek. *Journal of Surgical Education*, 66(6), 340-343.

- Findlay, J., Boulton, C., Forward, D., & Moran, C. (2011). 'Hospital-at-Night' expedites review of trauma patients without affecting outcome from hip fracture. *Journal of Perioperative Practice*, 21(10), 346-51.
- Fischer, J.E. (2004). Continuity of care: a casualty of the 80-hour work week. *Academic Medicine*, 79(5), 381-383.
- Fisman, D.N., Harris, A.D., Rubin, M., Sorock, G.S., & Mittleman, M.A. (2007). Fatigue increases the risk of injury from sharp devices in medical trainees: results from a case-crossover study. *Infection Control & Hospital Epidemiology*, 28(1), 10-17.
- Fletcher, K. E., Davis, S. Q., Underwood, W., Mangrulkar, R. S., McMahon, L. F. Jr., & Saint, S. (2004). Systematic review: effects of resident work hours on patient safety. *Annals of Internal Medicine*, 141(11), 851-857.
- Fletcher, K.E., Parekh, V., Halasyamani, L., Kaufman, S.R., Schapira, M., Ertl, K., & Saint, S. (2008). Work hour rules and contributors to patient care mistakes: A focus group study with internal medicine residents. *Journal of Hospital Medicine*, 3(3), 228-237.
- Fletcher, K. E., Reed, D.A., & Arora, V.M. (2011). Patient safety, resident education and resident well-being following implementation of the 2003 ACGME duty hour rules. *Journal of General Internal Medicine*, 26(8), 907-919.
- Fletcher, K.E., Saint, S., & Mangrulkar, R.S. (2005). Balancing continuity of care with residents' limited work hours: defining the implications. *Academic Medicine*, 80(1), 39-43.
- Fletcher, K.E., Wiest, F.C., Halasyamani, L., Lin, J., Nelson, V., Kaufman, S.R., et al. (2008). How do hospitalized patients feel about resident work hours, fatigue, and discontinuity of care? *Journal of General Internal Medicine*, 23(5), 623-628.
- Fortuna, R.J., Paffrey, J.S., Shelov S.P., & Samuels R.C. (2009). Paediatric experiences with work-hour limitations. *Journal of Evaluation in Clinical Practice*, 15(1), 116-120.
- Foster, J.H.W., & Selzer, V.L. (1991). Accommodating to restrictions on residents' working hours. *Academic Medicine*, 66(2), 94-97.
- Frankel, H.L., Foley, A., Norway, C., & Kaplan, L. (2006). Amelioration of increased intensive care unit service readmission rate after implementation of work-hour restrictions. *Journal of Trauma Injury, Infection and Critical Care*, 61(1), 116-121.
- Freiburg, C., James, T., Ashikaga, T., Moalem, J., & Cherr, G. (2011). Strategies to accommodate resident work-hour restrictions: impact on surgical education. *Journal of Surgical Education*, 68(5), 387-392.
- Friesen, L.D., Vidyarthi, A.R., Baron, R.B., & Katz, P.P. (2008). Factors associated with intern fatigue. *Journal of General Internal Medicine*, 23(12), 1981-1986.
- Froelich, J., Milbrandt, J.C., & Allan, D.G. (2009). Impact of the 80-hour workweek on surgical exposure and national in-training examination scores in an orthopedic residency program. *Journal of Surgical Education*, 66(2), 85-88.
- Gallagher, P., McLean, P., Campbell, R., Gallacher, S., & Kennon, B. (2009). Medical training and the hospital at night: an oxymoron? *Medical Education* 43(11),1056–1061.
- Gander, P., Millar, M., Webster, C., & Merry, A. (2008). Sleep loss and performance of anaesthesia trainees and specialists. *Chronobiology International*, 25(6), 1077-1091.

- Gander, P., Purnell, H., Garden, A., & Woodward, A. (2007). Work patterns and fatigue-related risk among junior doctors. *Occupational & Environmental Medicine*, 64(11), 733-738.
- Gander, P.H., Merry, A., Millar, M.M., & Weller, J. (2000). Hours of work and fatigue-related error: a survey of New Zealand anaesthetists. *Anaesthesia & Intensive Care*, 28(2), 178-183.
- Garvin, J.T., McLaughlin, R., & Kerin, M.J. (2008). A pilot project of European Working Time Directive compliant rosters in a university teaching hospital. *Surgeon: Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 6(2), 88-93.
- Gelfand, D.V., Podnos, Y.D., Carmichael, J.C., Saltzman, D.J., Wilson, S.E., & Williams, R.A. (2004). Effect of the 80-hour workweek on resident burnout. *Archives of Surgery*, 139(9), 933-938.
- Giles, E., Hansen, R., Barclay, A.R., Burt, A., Sullivan, P.B., & Beattie, R.M. (2011). EWTD: Incompatible with subspecialty training? *Gut, Conference*, 60, A119-A120.
- Giles, J. A. (2010). Surgical training and the European Working Time Directive: The role of informal workplace learning. *International Journal of Surgery*, 8(3), 179-180.
- Goddard, A.F. (2011). Progress on the European Working Time Directive (EWTD) and New Deal negotiations. *Clinical Medicine*, 11(5), 420-421.
- Goddard, A.F., Hodgson, H., & Newbery, N. (2010). Impact of EWTD on patient:doctor ratios and working practices for junior doctors in England and Wales 2009. *Clinical Medicine*, 10(4), 330-335.
- Gohar, A., Adams, A., Gertner, E., Sackett-Lundeen, L., Heitz, R., Engle, R., et al. (2009). Working memory capacity is decreased in sleep-deprived internal medicine residents. *Journal of Clinical Sleep Medicine*, 5(3), 191-197.
- Goitein, L., Shanafelt, T.D., Nathens, A.B., & Curtis, J.R. (2008). Effects of resident work hour limitations on faculty professional lives. *Journal of General Internal Medicine*, 23(7), 1077-1083.
- Goitein, L., Shanafelt, T.D., Wipf, J.E., Slatore, C.G., & Back, A.L. (2005). The effects of work-hour limitations on resident well-being, patient care, and education in an internal medicine residency program. *Archives of Internal Medicine*, 165(22), 2601-2606.
- Goldstein, E.B., Savel, R.H., Chorost, M.I., Borgen, P.I., & Cunningham, J. (2009). Use of text messaging to enhance compliance with the Accreditation Council for Graduate Medical Education resident duty hour requirements. *Journal of Surgical Education*, 66(6), 379-382.
- Goldstein, M.J., Kim, E., Widmann, W.D., & Hardy, M.A. (2004). A 360 degree evaluation of a night-float system for general surgery: A response to mandated work-hours reduction. *Current Surgery*, 61(5), 445-451.
- Golub, J.S., Weiss, P.S., Ramesh, A.K., Ossoff, R.H., & Johns, M.M.3rd. (2007). Burnout in residents of otolaryngology-head and neck surgery: a national inquiry into the health of residency training. *Academic Medicine*, 82(6), 596-601.
- Gopal, R., Glasheen, J.J., Miyoshi, T.J., & Prochazka, A.V. (2005). Burnout and internal medicine resident work-hour restrictions. *Archives of Internal Medicine*, 165(22), 2595-2600.
- Gopal, R.K., Carreira, F., Baker, W.A., Glasheen, J.J., Crane, L.A., Miyoshi, T.J., et al. (2007). Internal medicine residents reject "longer and gentler" training. *Journal of General Internal Medicine*, 22(1), 102-106.

- Gopaldas, R.R., Chu, D., Dao, T.K., Huh, J., Lemaire, S.A., Coselli, J.S., et al. (2010). Impact of ACGME work-hour restrictions on the outcomes of coronary artery bypass grafting in a cohort of 600,000 patients. *Journal of Surgical Research*, 163(2), 201-209.
- Gopaldas, R.R., Huh, J., Bakaeen, F.G., Wang, X.L., Coselli, J.S., LeMaire, S.A., et al. (2009). The impact of resident work-hour restrictions on outcomes of cardiac operations. *Journal of Surgical Research*, 157(2), 268-274.
- Gordon, C.R., Axelrad, A., Alexander, J.B., Dellinger, R.P., & Ross, S.E. (2006). Care of critically ill surgical patients using the 80-hour Accreditation Council of Graduate Medical Education work-week guidelines: a survey of current strategies. *American Surgeon*, 72(6), 497-499.
- Gough, I.R. (2011). The impact of reduced working hours on surgical training in Australia and New Zealand. *Surgeon: Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 9 Suppl 1, S8-9.
- Grady, M.S., Batjer, H.H., & Dacey, R.G. (2009). Resident duty hour regulation and patient safety: establishing a balance between concerns about resident fatigue and adequate training in neurosurgery. *Journal of Neurosurgery*, 110(5), 828-836.
- Grantcharov, T.P., Bardram, L., Funch-Jensen P., & Rosenberg, J. (2001). Laparoscopic performance after one night on call in a surgical department: prospective study. *British Medical Journal*, 323, 1222-3.
- Griner, D., Menon, R.P., Kotwall, C.A., Clancy, T.V., & Hope, W.W. (2010). The eighty-hour workweek: surgical attendings' perspectives. *Journal of Surgical Education*, 67(1), 25-31.
- Haig, A., & Dozier, M. (2003). BEME Guide No 3: Systematic searching for evidence in medical education - Part 1: Sources of information. *Medical Teacher*, 25(4), 352-363.
- Haliasos, N., Prezerakos, G., Akram, H., Shaw, S., & Brecknell, J.E. (2010). An algorithm to permit the safe, EWTD and new deal compliant preservation of the registrar on-call system: A 1 year prospective study. *British Journal of Neurosurgery, Conference*, 24(2), 109-110.
- Haro-Garcia, L., Sanchez-Roman, R., Juarez-Perez, C.A., & Larios-Diaz, E. (2007). [Medical justification of the eight-hour shift work]. *Revista Medica del Instituto Mexicano del Seguro Social*, 45(2), 191-197.
- Harrison, R., & Allen, E. (2006). Teaching internal medicine residents in the new era. Inpatient attending with duty-hour regulations. *Journal of General Internal Medicine*, 21(5), 447-452.
- Hassett, J.M., Nawotniak, R., Cumiskey, D., Berger, R., Posner, A., Seibel, R., et al. (2002). Maintaining outcomes in a surgical residency while complying with resident working hour regulations. *Surgery*, 132(4), 635-639.
- Haycock, A. V., Flanagan, P., Ignjatovic, A., Kendrick, S., Mead, R., Mizen, P., Mottershead, M., et al. (2009). Gastroenterology training in 2008: Results from the TIG/BSG national training survey. *Gut, Conference*, 58, A11-A12.
- Hellawell, G.O., Kahn, L., & Mumtaz, F. (2005). The European Working Time Directive: implications for subspecialty acute care. *International Journal of Clinical Practice*, 59(5), 508-510.
- Heller, F.R. (2008). Restriction of duty hours for residents in internal medicine: a question of quality of life but what about education and patient safety? *Acta Clinica Belgica*, 63(6), 363-371.

- Henry, M., Silverman, B., & Moss, R. (2005). The impact of the 80-hour workweek on pediatric surgical training: an Association of Pediatric Surgery Program Directors-sponsored study. *Journal of Pediatric Surgery*, 40, 60-68.
- Herbertson, R., Blundell, A., & Bowman, C. (2007). The role of Clinical Support Workers in reducing junior doctors' hours and improving quality of patient care. *Journal of Evaluation in Clinical Practice*, 13(3), 449-452.
- Higginson, J.D. (2009). Perspective: limiting resident work hours is a moral concern. *Academic Medicine*, 84(3), 310-314.
- Holleman, J., Johnson, A., & Frim, D.M. (2010). The impact of a 'resident replacement' nurse practitioner on an academic pediatric neurosurgical service. *Pediatric Neurosurgery*, 46(3), 177-181.
- Holzman, I.R., & Barnett, S.H. (2000). The Bell Commission: ethical implications for the training of physicians. *Mount Sinai Journal of Medicine*, 67(2), 136-139.
- Hope, W.W., Griner, D., Van Vliet, D., Menon, R.P., Kotwall, C.A., & Clancy, T.V. (2011). Resident case coverage in the era of the 80-hour workweek. *Journal of Surgical Education*, 68(3), 209-212.
- Horrocks, N., & Pounder, R. (2006). *Designing safer rotas for junior doctors in the 48-hour week*. London: Royal College of Physicians.
- Horrocks, N., & Pounder, R. (2006). Working the night shift: preparation, survival and recovery- a guide for junior doctors. *Clinical Medicine*, 6(1), 61-67.
- Horwitz, L.I., Kosiborod, M., Lin, Z., & Krumholz, H.M. (2007). Changes in outcomes for internal medicine inpatients after work-hour regulations. *Annals of Internal Medicine*, 147(2), 97-103.
- Howard, D.L., Silber, J.H., & Jobes, D.R. (2004). Do regulations limiting residents' work hours affect patient mortality? [Erratum appears in *J Gen Intern Med*. 2004 Feb;19(2):204 Note: Silber, Jeffrey H [corrected to Silber, Jeffrey H]]. *Journal of General Internal Medicine*, 19(1), 1-7.
- Hutter, M.M., Kellogg, K.C., Ferguson, C.M., Abbott, W.M., & Warshaw, A.L. (2006). The impact of the 80-hour resident workweek on surgical residents and attending surgeons. *Annals of Surgery*, 243(6), 864-871.
- Immerman, I., Kubiak, E.N., & Zuckerman, J.D. (2007). Resident work-hour rules: a survey of residents' and program directors' opinions and attitudes. *American Journal of Orthopedics*, 36(12), E172-179.
- IOM (2008) *Resident Duty Hours: Enhancing Sleep, Supervision, and Safety*. Available at: <http://www.iom.edu/Reports/2008/Resident-Duty-Hours-Enhancing-Sleep-Supervision-and-Safety.aspx> [Accessed 21 January 2012].
- Izu, B.S., Johnson, R.M., Termuhlen, P.M., & Little, A.G. (2007). Effect of the 30-hour work limit on resident experience and education. *Journal of Surgical Education*, 64(6), 361-364.
- Jagannathan, J., Vates, G.E., Pouratian, N., Sheehan, J.P., Patrie, J., Grady, M.S., et al. (2009). Impact of the Accreditation Council for Graduate Medical Education work-hour regulations on neurosurgical resident education and productivity. *Journal of Neurosurgery*, 110(5), 820-827.
- Jagsi, R., & Surender, R. (2004). Regulation of junior doctors' work hours: an analysis of British and American doctors' experiences and attitudes. *Social Science & Medicine*, 58(11), 2181-2191.
- Jagsi, R., Shapiro, J., & Weinstein, D.F. (2005). Perceived impact of resident work hour limitations on medical student clerkships: a survey study. *Academic Medicine*, 80(8), 752-757.

- Jagsi, R., Shapiro, J., Weissman, J.S., Dorer, D.J., & Weinstein, D.F. (2006). The educational impact of ACGME limits on resident and fellow duty hours: a pre-post survey study. *Academic Medicine*, 81(12), 1059-1068.
- Jagsi, R., Weinstein, D.F., Shapiro, J., Kitch, B.T., Dorer, D., & Weissman, J.S. (2008). The Accreditation Council for Graduate Medical Education's limits on residents' work hours and patient safety. A study of resident experiences and perceptions before and after hours reductions. *Archives of Internal Medicine*, 168(5), 493-500.
- Jakubowicz, D.M., Price, E.M., Glassman, H.J., Gallagher, A.J. G., Mandava, N., Ralph, W.P., et al. (2005). Effects of a twenty-four hour call period on resident performance during simulated endoscopic sinus surgery in an Accreditation Council for Graduate Medical Education-compliant training program. *The Laryngoscope*, 115(1), 143-146.
- Jamal, M.H., Rousseau, M.C., Hanna, W.C., Doi, S.A.R., Meterissian, S., & Snell, L. (2011). Effect of the ACGME duty hours restrictions on surgical residents and faculty: a systematic review. *Academic Medicine*, 86(1), 34-42.
- Jarman, B.T., Miller, M.R., Brown, R.S., Armen, S.B., Bozaan, A.G., Ho, G.T., et al. (2004). The 80-hour work week: will we have less-experienced graduating surgeons? *Current Surgery*, 61(6), 612-615.
- Jha, A.K., Duncan, B.W., Bates, D.W. (2001). Fatigue, sleepiness, and medical errors. In K.G. Shojania, B.W. Duncan, K.M. McDonald, R.M. Wachter (eds) *Making Health Care Safer: A Critical Analysis of Patient Safety Practices*. Rockville MD: Agency for Healthcare Research and Quality, pp519-532.
- Jones, A.M., & Jones, K.B. (2007). The 88-hour family: effects of the 80-hour work week on marriage and childbirth in a surgical residency. *Iowa Orthopaedic Journal*, 27, 128-133.
- Jones, G.J., Vanderpump, M.P.J., Easton, M., Baker, D.M., Ball, C., Leenane, M., et al. (2004). Achieving compliance with the European Working Time Directive in a large teaching hospital: a strategic approach. *Clinical Medicine*, 4(5), 427-430.
- Kaafarani, H.M. A., Itani, K.M. F., Petersen, L.A., Thornby, J., & Berger, D.H. (2005). Does resident hours reduction have an impact on surgical outcomes? *Journal of Surgical Research*, 126(2), 167-171.
- Kairys, J.C., McGuire, K., Crawford, A.G., & Yeo, C.J. (2008). Cumulative Operative Experience Is Decreasing During General Surgery Residency: A Worrisome Trend for Surgical Trainees? *Journal of the American College of Surgeons*, 206(5), 804-811.
- Kamat, A.A., Farooqi, N.A., & Carroll, T.A. (2009). A study of the impact of the European Working Time Directive on neurosurgical training: A quantitative assessment of reduction in trainee operative numbers, clinic attendances and ward rounds. *British Journal of Neurosurgery*, 23, Conference (2), 130-131.
- Kashner, T.M., Henley, S.S., Golden, R.M., Byrne, J.M., Keitz, S.A., Cannon, G.W., et al. (2010). Studying the effects of ACGME duty hours limits on resident satisfaction: results from VA learners' perceptions survey. *Academic Medicine*, 85(7), 1130-1139.
- Kellogg, K.C., Breen, E., Ferzoco, S.J., Zinner, M.J., & Ashley, S.W. (2006). Resistance to change in surgical residency: an ethnographic study of work hours reform. *Journal of the American College of Surgeons*, 202(4), 630-636.

- Kelly, B.D., Curtin, P.D., & Corcoran, M. (2011). The effects of the European Working Time Directive on surgical training: the basic surgical trainee's perspective. *Irish Journal of Medical Science*, 180(2), 435-437.
- Kelly, D.J., & Gale C.P. (2008). 2007 BJCA survey of cardiology trainees. *British Journal of Cardiology*, 15(3), 134-136.
- Kelly, R.J.Jr., & Senkowski, C.K. (2009). Effect of the night float system on operative case volume for senior surgical residents. *Journal of Surgical Education*, 66(6), 314-318.
- Kendrick, A.S., Ciraulo, D.L., Radeker, T.S., Lewis, P.L., Richart, C.M., Maxwell, R.A., et al. (2006). Trauma nurse specialists' performance of advanced skills positively impacts surgical residency time constraints. *American Surgeon*, 72(3), 224-227.
- Kienzle, H.F. (1998). [The employment schedule act: temporal and economic limits]. *Langenbecks Archiv fur Chirurgie - Supplement - Kongressband*, 115, 795-798.
- Kiernan, M., Civetta, J., Bartus, C., & Walsh, S. (2006). 24 hours on-call and acute fatigue no longer worsen resident mood under the 80-hour work week regulations. *Current Surgery*, 63(3), 237-241.
- Kim, H., & Wiedermann, B. (2011). Have Accreditation Council for Graduate Medical Education duty hour limits made a difference? A re-examination of resident sleep, mental health, education, and safety seven years later. *Journal of Investigative Medicine, Conference* 59(3), 630-631.
- Kneebone, R., Nestel, D., Chrzanowska, J., Barnet, A.E., Younger, J., Burgess, A., et al. (2006). The perioperative specialist practitioner: developing and evaluating a new surgical role. *Quality & Safety in Health Care*, 15(5), 354-358.
- Kochendorfer, K.M., Morris, L.E., Kruse, R.L., Ge, B.G., & Mehr, D.R. (2010). Attending and resident physician perceptions of an EMR-generated rounding report for adult inpatient services. *Family Medicine*, 42(5), 343-349.
- Kogan, J.R., Pinto-Powell, R., Brown, L.A., Hemmer, P., Bellini, L.M., & Peltier, D. (2006). The impact of resident duty hours reform on the internal medicine core clerkship: results from the clerkship directors in internal medicine survey. *Academic Medicine*, 81(12), 1038-1044.
- Kohen-Raz, R., Himmelfarb, M., Tzur, S., Kohen-Raz, A., & Shub, Y. (1996). An initial evaluation of work fatigue and circadian changes as assessed by multiplate posturography. *Perceptual & Motor Skills*, 82(2), 547-557.
- Kort, K.C., Pavone, L.A., Jensen, E., Haque, E., Newman, N., & Kittur, D. (2004). Resident perceptions of the impact of work-hour restrictions on health care delivery and surgical education: time for transformational change. *Surgery*, 136(4), 861-871.
- Kuo, A.K., Ma, C.T., & Kamei, R.K. (2004). Evening continuity clinic: preserving primary care education in the face of duty hour limitations? *Ambulatory Pediatrics*, 4(4), 332-335.
- Kupferman, T.A., & Lian, T.S. (2005). Implementation of duty hour standards in otolaryngology-head and neck surgery residency training. *Otolaryngology - Head & Neck Surgery*, 132(6), 819-822.
- Kusuma, S.K., Mehta, S., Sirkin, M., Yates, A.J., Miclau, T., Templeton, K.J., et al. (2006). Measuring the attitudes and impact of the eighty-hour workweek rules on orthopaedic surgery residents. *Journal of Bone & Joint Surgery - American Volume*, 88-A(3), 679-685.
- Ladd, A.P. (2006). Pediatric surgery fellowship compliance to the 80-hour work week. *Journal of Pediatric Surgery*, 41(4), 687-692.

- Laine, C., Goldman, L., Soukup, J.R., & Hayes, J.G. (1993). The impact of a regulation restricting medical house staff working hours on the quality of patient care. *JAMA*, 269(3), 374-378.
- Lamont, P.M., & Scott, D.J.A. (2005). The impact of shortened training times on the discipline of vascular surgery in the United Kingdom. *American Journal of Surgery*, 190(2), 269-272.
- Landesman, L.Y., Markowitz, F., & Conde, N. (2010). Business process improvement: an electronic system to monitor compliance with medical resident work hours. *Journal of Public Health Management & Practice*, 16(2), 104-109.
- Landrigan, C.P., Barger, L.K., Cade, B.E., Ayas, N.T., & Czeisler, C.A. (2006). Interns' compliance with accreditation council for graduate medical education work-hour limits. *JAMA*, 296(9), 1063-1070.
- Landrigan, C.P., Fahrenkopf, A.M., Lewin, D., Sharek, P.J., Barger, L.K., Eisner, M., et al. (2008). Effects of the accreditation council for graduate medical education duty hour limits on sleep, work hours, and safety. *Pediatrics*, 122(2), 250-258.
- Landrigan, C.P., Rothschild, J.M., Cronin, J.W., Kaushal, R., Burdick, E., Katz, J.T., Lilly, C.M., Stone, P.H., Lockley, S.W., Bates, D.W., & Czeisler, C.A. (2004). Effects of reducing interns' work hours on serious medical errors in intensive care units. *New England Journal of Medicine*, 351, 1838-1848.
- Lehmann, K.S., Martus, P., Little-Elk, S., Maass, H., Holmer, C., Zurbuchen, U., et al. (2010). Impact of sleep deprivation on medium-term psychomotor and cognitive performance of surgeons: prospective cross-over study with a virtual surgery simulator and psychometric tests. *Surgery*, 147(2), 246-254.
- Lemoine, T., Sweney, J., Srivastava, R., Webster, H., Stout, T., & Poss, W. (2010). Impact of a change in care model on resident duty hours in a pediatric intensive care unit. *Critical Care Medicine, Conference*, 38, A30.
- Levine, A. C., Adamusilli, J., & Landrigan, C.P. (2010). Effects of reducing or eliminating resident work shifts over 16 hours: A systematic review. *Sleep*, 33(8), 1043-1053.
- Lewis, A. (2002). Safe working hours -doctors in training a best practice issue. *Australian Health Review*, 25(6), 100-108.
- Liang, J., Day, K., Orr, M., & Warren, J. (2011) Insights from an iBleep trial: Understanding the implications. *Health Care and Informatics Review Online*, 2011, 15(1), 13-22.
- Lim, E., Tsui, S., Registrars, & Consultant Cardiac Surgeons of Papworth Hospital. (2006). Impact of the European Working Time Directive on exposure to operative cardiac surgical training. *European Journal of Cardio-Thoracic Surgery*, 30(4), 574-577.
- Lim, K.G., Dunn, W.F., Klarich, K.W., & Afessa, B. (2005). Internal medicine resident education in the medical intensive care unit: The impact on education and patient care of a scheduling change for didactic sessions. *Critical Care Medicine*, 33(7), 1534-1537.
- Lin, G.A., Beck, D.C., & Garbutt, J.M. (2006). Residents' perceptions of the effects of work hour limitations at a large teaching hospital. *Academic Medicine*, 81(1), 63-67.
- Lin, G.A., Beck, D.C., Stewart, A.L., & Garbutt, J.M. (2007). Resident perceptions of the impact of work hour limitations. *Journal of General Internal Medicine*, 22(7), 969-975.
- Lindquist, L.A., Tschoe, M., Neely, D., Feinglass, J., Martin, G.J., & Baker, D.W. (2010). Medical student patient experiences before and after duty hour regulation and hospitalist support. *Journal of General Internal Medicine*, 25(3), 207-210.

- Liu, C.-C., & Wissow, L.S. (2008). Residents who stay late at hospital and how they perform the following day. *Medical Education*, 42(1), 74-81.
- Lobato, R.D., Fernandez-Alen, J., & Alday, R. (2008). [The impact of resident work hour limitations on medical student clerkships in Spain]. *Neurocirugia (Asturias, Spain)*, 19(3), 213-217.
- Lockley, S.W., Cronin, J.W., Evans, E.E., Cade, B.E., Lee, C.J., Landrigan, C.P., et al. (2004). Effect of reducing interns' weekly work hours on sleep and attentional failures. *New England Journal of Medicine*, 351(18), 1829-1837.
- Lockley, S.W., Landrigan, C.P., Barger, L.K., & Czeisler, C.A., Harvard Work Hours, Health Safety Group. (2006). When policy meets physiology: the challenge of reducing resident work hours. *Clinical Orthopaedics & Related Research*, 449, 116-127.
- Lopez, L., & Katz, J.T. (2009). Perspective: creating an ethical workplace: reverberations of resident work hours reform. *Academic Medicine*, 84(3), 315-319.
- Lowenstein, J. (2003). Where have all the giants gone? Reconciling medical education and the traditions of patient care with limitations on resident work hours. *Perspectives in Biology & Medicine*, 46(2), 273-282.
- Luks, A.M., Smith, C.S., Robins, L., & Wipf, J.E. (2010). Resident perceptions of the educational value of night float rotations. *Teaching & Learning in Medicine*, 22(3), 196-201.
- Lund, K.J., Teal, S.B., & Alvero, R. (2005). Resident job satisfaction: One year of duty hours. *American Journal of Obstetrics and Gynecology*, 193(5), 1823-1826.
- Lundberg, S., Wali, S., Thomas, P., & Cope, D. (2006). Attaining resident duty hours compliance: the acute care nurse practitioners program at Olive View-UCLA Medical Center. *Academic Medicine*, 81(12), 1021-1025.
- Mainiero, M.B., Davis, L.P., & Chertoff, J.D. (2010). Resident duty hour limits: recommendations by the IOM and the response from the radiology community. *Journal of the American College of Radiology*, 7(1), 56-60.
- Malangoni, M.A., Como, J.J., Mancuso, C., & Yowler, C.J. (2005). Life after 80 hours: the impact of resident work hours mandates on trauma and emergency experience and work effort for senior residents and faculty. *Journal of Trauma-Injury Infection & Critical Care*, 58(4), 758-761.
- Manjunath, A.M., Raja, H., & Srirangam, S.J. (2010). The impact of the European Working Time Directive (EWTd) and shift patterns on urological patient handover. *British Journal of Urology International*, 106(s1), 24.
- Mann, S. (2005). The evolution of restricted hours of duty for resident medical officers in New Zealand: a personal view. *Clinical Medicine*, 5(6), 650-652.
- Marron, C., Shah, J., Mole, D., & Slade, D. (2006). *European Working Time Directive*. London: Association of Surgeons in Training
- Martini, S., Arfken, C.L., & Balon, R. (2006). Comparison of burnout among medical residents before and after the implementation of work hours limits. *Academic Psychiatry*, 30(4), 352-355.
- Mason, J., Irani, T., Fountoulaki, G., Warwick, S., da Roza Davis, J., & Sudbury, P. (2006). Psychiatry at night: Experience of the senior house officer. *Psychiatric Bulletin*, 30(9), 329-333.

- Mather, H.M. (1998). Coping with pressures in acute medicine. The Royal College of Physicians Consultant Questionnaire Survey. *Journal of the Royal College of Physicians of London*, 32(3), 211-218.
- Mathis, B.R., Diers, T., Hornung, R., Ho, M., & Rouan, G.W. (2006). Implementing duty-hour restrictions without diminishing patient care or education: Can it be done? *Academic Medicine*, 81(1), 68-75.
- Mathur, M., Rampersad, A., Howard, K., & Goldman, G.M. (2005). Physician assistants as physician extenders in the pediatric intensive care unit setting - A 5-year experience. *Pediatric Critical Care Medicine*, 6(1), 14-19.
- Maxwell, A.J., Crocker, M., Jones, T.L., Bhagawati, D., Papadopoulos, M.C., & Bell, B.A. (2010). Implementation of the European Working Time Directive in neurosurgery reduces continuity of care and training opportunities. *Acta Neurochirurgica*, 152(7), 1207-1210.
- Mazotti, L.A., Vidyarthi, A.R., Wachter, R.M., Auerbach, A.D., & Katz, P.P. (2009). Impact of duty-hour restriction on resident inpatient teaching. *Journal of Hospital Medicine (Online)*, 4(8), 476-480.
- McBurney, P.G., Gustafson, K.K., & Darden, P.M. (2008). Effect of 80-hour workweek on continuity of care. *Clinical Pediatrics*, 47(8), 803-808.
- McCray, L.W., Cronholm, P.F., Bogner, H.R., Gallo, J.J., & Neill, R.A. (2008). Resident physician burnout: is there hope? *Family Medicine*, 40(9), 626-632.
- McElearney, S.T., Saalwachter, A.R., Hedrick, T.L., Pruett, T.L., Sanfey, H.A., & Sawyer, R.G. (2005). Effect of the 80-hour work week on cases performed by general surgery residents. *American Surgeon*, 71(7), 552-555.
- McGaghie, W.C., Issenberg, S.B., Petrusa, E.R. & Scalese, R.J. (2010), A critical review of simulation-based medical education research: 2003–2009. *Medical Education*, 44(1), 50–63.
- McIntyre, H.F., Winfield, S., Te, H.S., & Crook, D. (2010). Implementation of the European Working Time Directive in an NHS trust: impact on patient care and junior doctor welfare. *Clinical Medicine*, 10(2), 134-137.
- Mercurio, M.R., & Peterec, S.M. (2009). Attending physician work hours: ethical considerations and the last doctor standing. *Pediatrics*, 124(2), 758-762.
- Moalem, J., Salzman, P., Ruan, D.T., Cherr, G.S., Freiburg, C.B., Farkas, R.L., et al. (2009). Should all duty hours be the same? Results of a national survey of surgical trainees. *Journal of the American College of Surgeons*, 209(1), 47-54.e2.
- Mogi, K., Inoue, S., Sato, M., Taga, N., Hirabayashi, Y., & Seo, N. (2008). [Study on the working conditions of rotating residents in the department of anesthesia under the new residency programs]. *Masui - Japanese Journal of Anesthesiology*, 57(1), 92-94.
- Montgomery, F.U. (2003). [Work-time regulations - organization - liability and financing. Why young physicians run away from hospitals]. *Zeitschrift für Ärztliche Fortbildung und Qualitätssicherung*, 97(8-9), 550-552.
- Moonesinghe, S.R., Lowery, J., Shahi, N., Millen, A., & Beard, J.D. (2011). Impact of reduction in working hours for doctors in training on postgraduate medical education and patients' outcomes: systematic review. *British Medical Journal*, 342, d1580.

- Morrison, C.A., Wyatt, M.M., & Carrick, M.M. (2009). Impact of the 80-hour work week on mortality and morbidity in trauma patients: an analysis of the National Trauma Data Bank. *Journal of Surgical Research*, 154(1), 157-162.
- Moss, E.L., Bredaki, F.E., Jones, P.W., Hollingworth, J., Luesley, D.M., & Chan, K.K. (2011). Is gynaecological surgical training a cause for concern?: a questionnaire survey of trainees and trainers. *BMC Medical Education*, 11, 32.
- Moubarak, G. & Leenhard, A. (2008). [Effects of work hour regulations in France as perceived by cardiology residents]. *Revue du Praticien*, 58(9), 999-1001.
- Muraskas, J. (2007). Old school. *Journal of Perinatology*, 27(6), 385.
- Mycyk, M.B., McDaniel, M.R., Fotis, M.A., & Regalado, J. (2005). Hospitalwide adverse drug events before and after limiting weekly work hours of medical residents to 80. *American Journal of Health-System Pharmacy*, 62(15), 1592-1595.
- Myers, J.S., Bellini, L.M., Morris, J.B., Graham, D., Katz, J., Potts, J.R., et al. (2006). Internal medicine and general surgery residents' attitudes about the ACGME duty hours regulations: a multicenter study. *Academic Medicine*, 81(12), 1052-1058.
- Naik, M., Tallach, R., Visram, A., & McAteer, E. (2010). Training in paediatric anaesthesia. A 10-year review of logbooks. *Paediatric Anaesthesia*, 20, Conference(12), 1131.
- Namdari, S., Baldwin, K.D., Weinraub, B., & Mehta, S. (2010). Changes in the number of resident publications after inception of the 80-hour work week. *Clinical Orthopaedics & Related Research*, 468(8), 2278-2283.
- Naughton, P.A., Aggarwal, R., Wang, T.T., Van Herzeele, I., Keeling, A.N., Darzi, A.W., et al. (2011). Skills training after night shift work enables acquisition of endovascular technical skills on a virtual reality simulator. *Journal of Vascular Surgery*, 53(3), 858-866.
- Ngan, P., Edwards, T., & Daniels, I. (2009). Is it the BMA New Deal or the European Working Time Directive that has led to the reduction in training cases performed in colorectal surgery? *Colorectal Disease*, 11 (Conference), 34.
- Nguyen, L., Brunicardi, F.C., Dibardino, D.J., Scott, B.G., Awad, S.S., Bush, R.L., et al. (2006). Education of the modern surgical resident: novel approaches to learning in the era of the 80-hour workweek. *World Journal of Surgery*, 30(6), 1120-1127.
- NHS Management Executive. (1991) *Junior doctors – the new deal*. London: Department of Health.
- Nixon, L.J., Benson, B.J., Rogers, T.B., Sick, B.T., & Miller, W.J. (2007). Effects of Accreditation Council for Graduate Medical Education work hour restrictions on medical student experience. *Journal of General Internal Medicine*, 22(7), 937-941.
- Noroozi, A.-R., & Philbert, R.F. (2008). Residents' perception of the impact of the Bell Commission in oral surgery training: an initial study. *Journal of Oral & Maxillofacial Surgery*, 66(7), 1329-1334.
- Nuthalapaty, F.S., Carver, A.R., Nuthalapaty, E.S., & Ramsey, P.S. (2006). The perceived impact of duty hour restrictions on the residency environment: A survey of residency program directors. *American Journal of Obstetrics and Gynecology*, 194(6), 1556-1562.
- Nwomeh, B.C., Georges, A.J., Groner, J.I., Haley, K.J., Hayes, J.R., & Caniano, D.A. (2006). A leap in faith: the impact of removing the surgeon from the level II trauma response. *Journal of Pediatric Surgery*, 41(4), 693-699.

- Occhino, J.A., Hannigan, T., Baggish, M.S., & Gebhart, J.B. (2008). Duty-hour restrictions and their effect on resident operative experience in obstetrics and gynecology. *Journal of Pelvic Medicine and Surgery*, 14,Conference (4), 319.
- Ogden, P.E., Sibbitt, S., Howell, M., Rice, D., O'Brien, J., Aguirre, R., et al. (2006). Complying with ACGME resident duty hours restrictions: restructuring the 80-hour workweek to enhance education and patient safety at Texas A&M/Scott & White Memorial Hospital. *Academic Medicine*, 81(12), 1026-1031.
- O'Grady, G., Loveday, B., Harper, S., Adams, B., Civil, I.D., & Peters, M.B. (2010). Working hours and roster structures of surgical trainees in Australia and New Zealand. *ANZ Journal of Surgery*, 80(12), 890-895.
- Olson, E.J., Drage, L.A., & Auger, R.R. (2009). Sleep deprivation, physician performance, and patient safety. *Chest*, 136(5), 1389-1396.
- Ophthalmic Trainees Group (2009). *The impact of the European Working Time Directive on Ophthalmic Specialty Training – A National Trainee Survey*. London: Royal College of Ophthalmologists.
- Owens, J.A. (2001). Sleep loss and fatigue in medical training. *Current Opinion in Pulmonary Medicine*, 7(6), 411-418.
- Page, D.W. (2010). Surgical competence today: what have we gained? What have we lost? *Southern Medical Journal*, 103(12), 1232-1234.
- Pape, H.-C., & Pfeifer, R. (2009). Restricted duty hours for surgeons and impact on residents' quality of life, education, and patient care: a literature review. *Patient Safety in Surgery*, 3(1), 3.
- Papp, K.K., Miller, C.M., & Strohl, K.P. (2006). Graduate medical training, learning, relationships, and sleep loss. *Sleep Medicine Reviews*, 10(5), 339-345.
- Pappas, A., & Teague, D.C. (2006). The impact of the Accreditation Council for Graduate Medical Education work-hour regulations on the surgical experience of orthopaedic surgery residents. *Journal of Bone and Joint Surgery – American Volume*, 89, 904-909.
- Parshuram, C.S., Dhanani, S., Kirsh, J.A., & Cox, P.N. (2004). Fellowship training, workload, fatigue and physical stress: A prospective observational study. *Canadian Medical Association Journal*, 170(6), 965-970.
- Parsons, B.A., Blencowe, N.S., Hollowood, A.D., & Grant, J.R. (2011). Surgical training: the impact of changes in curriculum and experience. *Journal of Surgical Education*, 68(1), 44-51.
- Parthasarathy, S., Hettiger, K., Budhiraja, R., & Sullivan, B. (2007). Sleep and well-being of ICU housestaff. *Chest*, 131(6), 1685-1693.
- Peabody, T. (2006). The effect of work hour restrictions on the education of orthopaedic surgery residents. *Clinical Orthopaedics & Related Research*, 449, 128-133.
- Peterson, L.E., Johnson, H., Pugno, P.A., Bazemore, A., & Phillips, R.L., Jr. (2006). Training on the clock: family medicine residency directors' responses to resident duty hours reform. *Academic Medicine*, 81(12), 1032-1037.
- Pezzi, C., Leibrandt, T., Suryadevara, S., Heller, J.K., Hurley-Martoni, D., & Kukora, J.S. (2009). The present and future use of physician extenders in general surgery training programs: one response to the 80-hour work week. *Journal of the American College of Surgeons*, 208(4), 587-591.

- Philibert, I. (2005) Sleep loss and performance in residents and nonphysicians: a meta-analytic examination. *Sleep*, 28(11), 1392-402.
- Picarella, E.A., Simmons, J.D., Borman, K.R., Replogle, W.H., & Mitchell, M.E. (2011). "Do one, teach one" The new paradigm in general surgery training. *Journal of Surgical Education*, 68(2), 1126-129.
- Podnos, Y.D., Williams, R.A., Jimenez, J.C., Stemmer, E.A., Gordon, I.L., & Wilson, S.E. (2003). Reducing the noneducational and nonclinical workload of the surgical resident; defining the role of the health technician. *Current Surgery*, 60(5), 529-532.
- Poulose, B.K., Ray, W.A., Arbogast, P.G., Needleman, J., Buerhaus, P.I., Griffin, M.R., et al. (2005). Resident work hour limits and patient safety. *Annals of Surgery*, 241(6), 847-856.
- Prasad, M., Iwashyna, T.J., Christie, J.D., Kramer, A.A., Silber, J.H., Volpp, K.G., et al. (2009). Effect of work-hours regulations on intensive care unit mortality in United States teaching hospitals. *Critical Care Medicine*, 37(9), 2564-2569.
- Prince, S., Byrne, P., & Tregaskis, B. (2010). The future of (Rural) medicine in the United Kingdom. *Internal Medicine Journal, Conference*, 40, 45.
- Privette, A.R., Shackford, S.R., Osler, T., Ratcliff, J., Sartorelli, K., & Herbert, J.C. (2009). Implementation of resident work hour restrictions is associated with a reduction in mortality and provider-related complications on the surgical service: A concurrent analysis of 14,610 patients. *Annals of Surgery*, 250(2), 316-321.
- Rabjohn, P.A., & Yager, J. (2008). The effects of resident work-hour regulation on psychiatry. *American Journal of Psychiatry*, 165(3), 308-311.
- Ramsey, R.A., Anand, R., Harmer, S.G., Sharma, S., Wilbourn, M., & Brennan, P.A. (2007). Continuity of care and the European Working Time Directive: a maxillofacial perspective. *British Journal of Oral & Maxillofacial Surgery*, 45(3), 221-222.
- Rasminsky, S., Lomonaco, A., & Auchincloss, E. (2008). Work hours regulations for house staff in psychiatry: bad or good for residency training? *Academic Psychiatry*, 32(1), 54-60.
- Ratanawongsa, N., Bolen, S., Howell, E.E., Kern, D.E., Sisson, S.D., & Larriviere, D. (2006). Residents' perceptions of professionalism in training and practice: barriers, promoters, and duty hour requirements. *Journal of General Internal Medicine*, 21(7), 758-763.
- Rawnsley, A., Hurst, K., & Robinson, M. (2004). Clinical and education implications of shift work. *Medical Teacher*, 26(1), 71-73.
- Reddy, R., Guntupalli, K., Alapat, P., Surani, S., Casturi, L., & Subramanian, S. (2009). Sleepiness in medical ICU residents. *Chest*, 135(1), 81-85.
- Reddy-Kolanu, G., Anand, R., Ethunandan, M., Ramchandani, P., & Ilankovan, V. (2007). The effect of the Hospital at Night team on the maxillofacial service in a District General Hospital [conference abstract]. *British Journal of Oral and Maxillofacial Surgery*, 45, e30-e63.
- Reed, D.A., Fletcher, K. E., & Arora, V. M. (2010). Systematic review: association of shift length, protected sleep time, and night float with patient care, residents' health, and education. *Annals of Internal Medicine*, 153(12), 829-842.
- Reed, D.A., Levine, R.B., Miller, R.G., Ashar, B.H., Bass, E.B., Rice, T.N., et al. (2007). Effect of residency duty-hour limits: views of key clinical faculty. *Archives of Internal Medicine*, 167(14), 1487-1492.

- Remedy UK (2009). The First Month of the EWTD A Remedy UK Survey September 2009. Available at: http://www.remedyyuk.org/index.php/RemedyUK-News/PDFS/EWTD_Survey_August_2009.pdf/P16 [Accessed 21 July 2012].
- Ripp, J., Katz, J.T., Bazari, H., Babyatsky, M., Fallar, R., Korenstein, D., Bellini, L., Pecker, M., & Kapadia, C. (2010). Incidence and predictors of job burnout in first year internal medicine students: What's fueling the fire? *Journal of General Internal Medicine*, 25 (Conference), S311-S312.
- Roberts, C.M., Proctor, I., & Forrer, M. (2004). An evaluation by doctors in training of a pilot programme of physician assistants. *Hospital Medicine (London)*, 65(5), 298-301.
- Roey, S. (2006). Medical education and the ACGME duty hour requirements: assessing the effect of a day float system on educational activities. *Teaching & Learning in Medicine*, 18(1), 28-34.
- Romanchuk, K. (2004). The effect of limiting residents' work hours on their surgical training: a Canadian perspective. *Academic Medicine*, 79(5), 384-385.
- Rosen, A.K., Loveland, S.A., Romano, P.S., Itani, K.M.F., Silber, J.H., Even-Shoshan, O.O., et al. (2009). Effects of resident duty hour reform on surgical and procedural patient safety indicators among hospitalized veterans health administration and medicare patients. *Medical Care*, 47(7), 723-731.
- Rosenbaum, J.R. (2004). Can residents be professional in 80 or fewer hours a week? *American Journal of Medicine*, 117(11), 846-850.
- Roses, R.E., Foley, P.J., Paulson, E.C., Pray, L., Kelz, R.R., Williams, N.N., et al. (2009). Revisiting the rotating call schedule in less than 80 hours per week. *Journal of Surgical Education*, 66(6), 357-360.
- Roy, P., & Steger, A. (2011). The European Working Time Directive - Shifting the Emphasis on Training. *International Journal of Surgery*, 9, 512.
- Royal College of Anaesthetists/Royal College of Surgeons of England. (2009). WTD - Implications and Practical Suggestions to Achieve Compliance. Available at: http://www.rcoa.ac.uk/docs/RCS-RCOA_report.pdf [Accessed 21 January 2012].
- Royal College of Obstetricians and Gynaecologists/ Royal College of Paediatrics and Child Health. (2008). *Children's And Maternity Services In 2009: Working Time Solutions*.
- Royal College of Ophthalmologists. (2008). *European Working Time Directive College Suggestions*. Available at: http://www.rcophth.ac.uk/core/core_picker/download.asp?id=410 [Accessed 21 January 2012].
- Royal College of Paediatrics and Child Health (2011a). *Facing the Future: A Review of Paediatric Services*. London: Royal College of Paediatrics and Child Health.
- Royal College of Paediatrics and Child Health (2011b). *Facing the Future: Standards for Paediatric Services*. London: Royal College of Paediatrics and Child Health.
- Royal College of Psychiatrists Psychiatric Trainees Committee. (No date). *Finding the balance: The psychiatric training value of Out of Hours Working*. Available at: <http://www.rcpsych.ac.uk/pdf/PTC%20The%20training%20value%20of%20OOH.pdf> [Accessed 21 January 2012].
- Royal College of Surgeons of England (2010). *European Working Time Regulations (EWTR): Summary of responses to College Survey*. Available at: http://www.rcseng.ac.uk/news/docs/rcs_ewtd_survey_results_jul_2010.pdf [Accessed 21 January 2012].

- Royal College of Surgeons of England (2007). Rota planning: Guidance for the Working Time Directive working party. London: Royal College of Surgeons of England.
- Royal College of Surgeons of England (2007). Safe shift working for surgeons in training: Revised policy statement from the Working Time Directive working party. London: Royal College of Surgeons of England.
- Royal College of Surgeons of England (2008). Working Time Directive 2009: Meeting the challenge in surgery. London: Royal College of Surgeons of England.
- Russo, M., & Tsuda, S. (2011). Assessment of a mandatory curriculum for laparoscopic skills using a portable, self-practice box trainer outside of duty hours. *Surgical Endoscopy and Other Interventional Techniques, Conference*, 25, S285.
- Sadaba, J.R., & Urso, S. (2011). Does the introduction of duty-hour restriction in the United States negatively affect the operative volume of surgical trainees? *Interactive Cardiovascular & Thoracic Surgery*, 13(3), 316-319.
- Sakorafas, G.H., & Tsiotos, G.G. (2004). New legislative regulations, problems, and future perspectives, with a particular emphasis on surgical education. *Journal of Postgraduate Medicine*, 50(4), 274-277.
- Salim, A., Teixeira, P.G.R., Chan, L., Oncel, D., Inaba, K., Brown, C., et al. (2007). Impact of the 80-hour workweek on patient care at a level I trauma center. *Archives of Surgery*, 142(8), 708-712.
- Samuels, R.C., Chi, G.W., Rauch, D.A., Palfrey, J.S., & Shelov, S.P. (2005). Lessons from pediatrics residency program directors' experiences with work hour limitations in New York state. *Academic Medicine*, 80(5), 467-472.
- Schenarts, P., Bowen, J., Bard, M., Sagraves, S., Toschlog, E., Goettler, C., et al. (2005). The effect of a rotating night-float coverage scheme on preventable and potentially preventable morbidity at a level 1 trauma center. *American Journal of Surgery*, 190(1), 147-152.
- Schenarts, P.J., Anderson Schenarts, K.D., & Rotondo, M.F. (2006). Myths and realities of the 80-hour work week. *Current Surgery*, 63(4), 269-274.
- Schlueter, M.E., Phan, P.H., Martin, C.S. E., Breece, D., & Boysen, D.A. (2009). Understanding Accreditation Council for Graduate Medical Education (ACGME) guidelines: resident and program director interpretation of work-hour restrictions. *Journal of Surgical Education*, 66(6), 374-378.
- Schneider, J.R., Coyle, J.J., Ryan, E.R., Bell, R.H., Jr., & DaRosa, D.A. (2007). Implementation and evaluation of a new surgical residency model. *Journal of the American College of Surgeons*, 205(3), 393-404.
- Schwartz, A., Pappas, C., Bashook, P.G., Bordage, G., Edison, M., Prasad, B., et al. (2011). Conceptual frameworks in the study of duty hours changes in graduate medical education: a review. *Academic Medicine*, 86(1), 18-29.
- Searle, R.D., & Lyons, G. (2008). Vanishing experience in training for obstetric general anaesthesia: an observational study. *International Journal of Obstetric Anesthesia*, 17(3), 233-237.
- Shanafelt, T.D., Bradley, K.A., Wipf, J.E., & Back, A.L. (2002). Burnout and self-reported patient care in an internal medicine residency program. *Annals of Internal Medicine*, 136(5), 358-367.
- Shetty, K.D., & Bhattacharya, J. (2007). Changes in hospital mortality associated with residency work-hour regulations. *Annals of Internal Medicine*, 147(2), 73-80.

- Shin, S., Britt, R., & Britt, L.D. (2008). Effect of the 80-hour work week on resident case coverage: corrected article. *Journal of the American College of Surgeons*, 207(1), 148-150.
- Shin, S., Britt, R., Doviak, M., & Britt, L.D. (2010). The impact of the 80-hour work week on appropriate resident case coverage. *Journal of Surgical Research*, 162(1), 33-36.
- Shonka, D.C.Jr., Ghanem, T.A., Hubbard, M.A., Barker, D.A., & Kesser, B.W. (2009). Four years of Accreditation Council of Graduate Medical Education duty hour regulations: have they made a difference? *The Laryngoscope*, 119(4), 635-639.
- Short, A.C., Rogers, S.J., Magann, E.F., Rieg, T.S., Shapiro, A., & Morrison, J.C. (2006). The 80-hour workweek restriction: How are OB/GYN resident procedure numbers affected? *Journal of Maternal Fetal and Neonatal Medicine*, 19(12), 791-796.
- Sim, D.J., Wrigley, S.R., & Harris, S. (2004). Effects of the European Working Time Directive on anaesthetic training in the United Kingdom. *Anaesthesia*, 59(8), 781-784.
- Simien, C., Holt, K.D., & Richter, T.H. (2011). The impact of the ACGME work-hour reforms on the operative experience of fellows in surgical subspecialty programs. *Journal of Graduate Medical Education*, March, 111-117.
- Simien, C., Holt, K.D., Richter, T.H., Whalen, T.V., Coburn, M., Havlik, R.J., et al. (2010). Resident operative experience in general surgery, plastic surgery, and urology 5 years after implementation of the ACGME duty hour policy. *Annals of Surgery*, 252(2), 383-389.
- Simpson, P. (date unknown). Possible realistic and practical solutions to the problems of implementing the European Working Time Directive (EWTD) in 2004. Available at: <http://www.rcoa.ac.uk/docs/solutionsewtd.pdf> [Accessed 21 January 2012].
- Singer, M.C. (2010). The future of otolaryngology training threatened: the negative impact of residency training reforms. *Otolaryngology - Head & Neck Surgery*, 142(3), 303-305.
- Skills for Health/Workforce Projects Team (2009). Final European Working Time Directive (EWTD) Programme Report. Available at: http://www.healthcareworkforce.nhs.uk/index.php?option=com_docman&task=doc_download&gid=2237&Itemid=697 [Accessed 21 January 2012].
- Skills for Health/Workforce Projects Team. (2008). The Case for Hospital at Night - The Search for Evidence. Available at: http://www.healthcareworkforce.nhs.uk/resources/nwp_resources/case_for_hospital_at_night.html [Accessed 21 January 2012].
- Skipworth, R.J.E., Terrace, J.D., Fulton, L.A., & Anderson, D.N. (2008). Basic surgical training in the era of the European Working Time Directive: what are the problems and solutions? *Scottish Medical Journal*, 53(4), 18-21.
- Smith, A.M., Morris, P., Rowell, K.O., Clarke, S., Jones, T.H., & Channer, K.S. (2006). Junior doctors and the full shift rota - psychological and hormonal changes: a comparative cross-sectional study. *Clinical Medicine*, 6(2), 174-177.
- Smith, R.P. (2010). Resident technical experience in obstetrics and gynecology before and after implementation of work-hour rules. *Obstetrics and Gynecology*, 115(6), 1166-1171.
- Sneider, E.B., Larkin, A.C., & Shah, S.A. (2009). Has the 80-Hour Workweek Improved Surgical Resident Education in New England? *Journal of Surgical Education*, 66(3), 140-145.

- Spencer, A.U., & Teitelbaum, D.H. (2005). Impact of work-hour restrictions on residents' operative volume on a subspecialty surgical service. *Journal of the American College of Surgeons*, 200(5), 670-676.
- Spurgeon, P., Thomas, H., Bedward, J., MacNab, N., Davison, I., & Howes, J. (2008). European Working Time Directive: Lessons from the Evaluation of the Pilot Projects. Available at: http://www.healthcareworkforce.nhs.uk/index.php?option=com_docman&task=doc_details&gid=2112&Itemid=697 [Accessed 21 January 2012].
- Stamp, T., Termuhlen, P., Miller, S., Nolan, D., Hutzel, P., Gilchrist, J., et al. (2005). Before and after resident work hour limitations: an objective assessment of the well-being of surgical residents. *Current Surgery*, 62(1), 117-121.
- Swide, C.E., & Kirsch, J.R. (2007). Duty hours restriction and their effect on resident education and academic departments: the American perspective. *Current Opinion in Anaesthesiology*, 20(6), 580-584.
- Szymczak, J.E., Brooks, J.V., Volpp, K.G., & Bosk, C.L. (2010). To leave or to lie? Are concerns about a shift-work mentality and eroding professionalism as a result of duty-hour rules justified? *Milbank Quarterly*, 88(3), 350-381.
- Tabrizian, P., Rajhbeharrysingh, U., Khaitov, S., & Divino, C.M. (2011). Persistent noncompliance with the work-hour regulation. *Archives of Surgery*, 146(2), 175-178.
- Tait, M.J., Fellows, G.A., Pushpanathan, S., Sergides, Y., Papadopoulos, M.C., & Bell, B.A. (2008). Current neurosurgical trainees' perception of the European Working Time Directive and shift work. *British Journal of Neurosurgery*, 22(1), 28-31.
- Tcharmtchi, M.H., Typpo, K.V., Thomas, E.J., Castillo, L.C., Kelly, P.A., & Singh, H. (2010). Impact of duty hour limits on attending physicians; effects of Accreditation Council for Graduate Medical Education duty hour limits on intensive care unit attending physician fatigue, work hours, self-reported errors, and patient safety. *Pediatric Critical Care Medicine, Conference*, 11(5), 669.
- Temple, J. (2010). Time for Training: A review of the impact of the European Working Time Directive on the quality of training. Available at: http://www.mee.nhs.uk/pdf/JCEWTD_Final%20report.pdf [Accessed 21 January 2012].
- The Guardian (November 2011). Eurozone crisis: Cameron and Merkel agree framework for EU negotiations. Available at: <http://www.guardian.co.uk/business/2011/nov/20/cameron-merkel-working-time-directive> [Accessed 26 January 2012].
- Thomas, W.E.G. (2006). Teaching and assessing surgical competence. *Annals of the Royal College of Surgeons of England*, 88(5), 429-432.
- Thomson, G. A., Foster, M., Sheriff, R., Mendis, L., Fernando, D.J.S., Blundell, C., et al. (2005). International educational partnerships for doctors in training: A collaborative framework with the RCP. *Clinical Medicine, Journal of the Royal College of Physicians of London*, 5(2), 133-136.
- Todd, S.R., Fahy, B.N., Paukert, J.L., Mersinger, D., Johnson, M.L., & Bass, B.L. (2010). How Accurate Are Self-Reported Resident Duty Hours? *Journal of Surgical Education*, 67(2), 103-107.
- Tomasko, J.M., Pauli, E.M., Kunselman, A.R., & Haluck, R.S. (2012). Sleep deprivation increases cognitive workload during simulated surgical tasks. *The American Journal of Surgery*, 203, 37-43.

- Tompsett, L., Ahmad, Y., & Swales, H. (2010). Audit of obstetric anaesthetic response times post introduction of European Working Time Directive (EWTd) compliant rota. *International Journal of Obstetric Anaesthesia* 19 (Conference), s6.
- Tran, J., Lewis, R., & de Virgilio, C. (2006). The effect of the 80-hour work week on general surgery resident operative case volume. *American Surgeon*, 72(10), 924-928.
- Trew, A., Searles, B., Smith, T., & Darling, E. (2011). Fatigue and extended work hours among cardiovascular perfusionists: 2010 Survey. *Perfusion*, 26(5), 361-370.
- Tsouroufli, M., & Payne, H. (2008). Consultant medical trainers, modernising medical careers (MMC) and the European Time Directive (EWTd): tensions and challenges in a changing medical education context. *BMC Medical Education*, 8, 31.
- Tucker, P., Brown, M., Dahlgren, A., Davies, G., Ebden, P., Folkard, S., et al. (2010). The impact of junior doctors' worktime arrangements on their fatigue and well-being. *Scandinavian Journal of Work, Environment & Health*, 36(6), 458-465.
- Underwood, S.M., & McIndoe, A.K. (2005). Influence of changing work patterns on training in anaesthesia: an analysis of activity in a UK teaching hospital from 1996 to 2004. *British Journal of Anaesthesia*, 95(5), 616-621.
- Underwood, S.M., & McIndoe, A.K. (2009). In-theatre training of anaesthetists in a teaching hospital: has it changed over 10 years? *British Journal of Anaesthesia*, 103(4), 518-523.
- Urowitz, M., Crescenzi, A.-M., & Muharuma, L. (2003). Residents' duty hours in the province of Ontario, Canada. *Academic Medicine*, 78(1), 9-10.
- Vallier, H.A., Prokuski, L.J., Nash Jr, C.L., & Patterson, B.M. (2009). Effects of resident work-hour restrictions on orthopaedic education and patient care. *Current Orthopaedic Practice*, 20(1), 77-86.
- Van Eaton, E.G., Horvath, K.D., & Pellegrini, C.A. (2005). Professionalism and the shift mentality: how to reconcile patient ownership with limited work hours. *Archives of Surgery*, 140(3), 230-235.
- Van Eaton, E.G., McDonough, K., Lober, W.B., Johnson, E.A., Pellegrini, C.A., & Horvath, K.D. (2010). Safety of using a computerized rounding and sign-out system to reduce resident duty hours. *Academic Medicine*, 85(7), 1189-1195.
- Vanderveen, K., Chen, M., & Scherer, L. (2007). Effects of resident duty-hours restrictions on surgical and nonsurgical teaching faculty. *Archives of Surgery*, 142(8), 759-764.
- Veasey, S., Rosen, R., Barzansky, B., Rosen, I., & Owens, J. (2002). Sleep loss and fatigue in residency training. A reappraisal. *JAMA*, 288(9), 1116.
- Vidarthi, A.R., Auerbach, A.D., Wachter, R.M., & Katz, P.P. (2007). The impact of duty hours on resident self reports of errors. *Journal of General Internal Medicine*, 22(2), 205-209.
- Vidarthi, A.R., Katz, P.P., Wall, S.D., Wachter, R.M., & Auerbach, A.D. (2006). Impact of reduced duty hours on residents' educational satisfaction at the University of California, San Francisco. *Academic Medicine*, 81(1), 76-81.
- Vogel, S., Fotuhi, P., Siegrist, M., & Neises, G. (2008). Comparative survey to establish the satisfaction of junior doctors participating in medical training programmes in Germany, taking the example of the HELIOS Kliniken Group, and junior doctors participating in medical training programmes in Switzerland. *Journal of Public Health*, 16(2), 79-85.

- Volpp, K.G., Rosen, A.K., Rosenbaum, P.R., Romano, P.S., Even-Shoshan, O., Canamucio, A., et al. (2007a). Mortality among patients in VA hospitals in the first 2 years following ACGME resident duty hour reform. *JAMA*, 298(9), 984-992.
- Volpp, K.G., Rosen, A.K., Rosenbaum, P.R., Romano, P.S., Even-Shoshan, O., Wang, Y., Bellini, L., Behringer, T., & Silber, J.H. (2007b). Mortality amongst hospitalized Medicare beneficiaries in the first 2 years following ACGME resident duty hour reform. *JAMA*, 298(9), 975-983.
- Vorona, R.D., Chen, I.A. & Ware, J.C. (2009). Physicians and sleep deprivation. *Sleep Medicine Clinics*, 4(4), 527-540.
- Wagner, M.J., Wolf, S., Promes, S., McGee, D., Hobgood, C., Doty, C., et al. (2010). Duty hours in emergency medicine: balancing patient safety, resident wellness, and the resident training experience: a consensus response to the 2008 Institute of Medicine resident duty hours recommendations. *Academic Emergency Medicine*, 17(9), 1004-1011.
- Wallack, M.K., & Chao, L. (2001). Resident work hours: The evolution of a revolution. *Archives of Surgery*, 136(12), 1426-1432.
- Wasson, J., Jacobsen, N., Bowdler, D., & Hopkins, C. (2006). Optimizing training opportunities for otolaryngology senior house officers: an audit. *Journal of Laryngology & Otology*, 120(7), 583-586.
- Watson, D.R., Flesher, T.D., Ruiz, O., & Chung, J.S. (2010). Impact of the 80-hour workweek on surgical case exposure within a General Surgery residency program. *Journal of Surgical Education*, 67(5), 283-289.
- Weatherby, B.A., Rudd, J.N., Ervin, T.B., Stafford, P.R., & Norris, B.L. (2007). The effect of resident work hour regulations on orthopaedic surgical education. *Journal of Surgical Orthopaedic Advances*, 16(1), 19-22.
- West, C.P., Cook, R.J., Popkave, C., & Kolars, J.C. (2007). Perceived impact of duty hours regulations: a survey of residents and program directors. *American Journal of Medicine*, 120(7), 644-648.
- Whang, E.E., Mello, M.M., Ashley, S.W., & Zinner, M.J. (2003). Implementing resident work hour limitations: lessons from the New York State experience. *Annals of Surgery*, 237(4), 449-455.
- White, C.B., Haftel, H.M., Purkiss, J.A., Schigelone, A.S., & Hammoud, M.M. (2006). Multidimensional effects of the 80-hour work week at the University of Michigan Medical School. *Academic Medicine*, 81(1), 57-62.
- White, M.C., Walker, I.A., Jackson, E., & Thomas, M.L. (2005). Impact of the European Working Time Directive on the training of paediatric anaesthetists. *Anaesthesia*, 60(9), 870-873.
- Wiesing, U. (2007). Ethical aspects of limiting residents' work hours. *Bioethics*, 21(7), 398-405.
- Wilkinson, C. (2008). Junior doctors' working hours: perspectives on the reforms. *International Journal of Nursing Practice*, 14(3), 200-214.
- Willis, R.E., Coverdill, J.E., Mellinger, J.D., Collins, J.C., Potts, J.R., 3rd, & Dent, D.L. (2009). Views of surgery program directors on the current ACGME and proposed IOM duty-hour standards. *Journal of Surgical Education*, 66(4), 216-221.e10.
- Wilson, T., Sahu, A., Johnson, D.S., & Turner, P.G. (2010). The effect of trainee involvement on procedure and list times: A statistical analysis with discussion of current issues affecting orthopaedic training in UK. *Surgeon, Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 8(1), 15-19.

- Wilson, T.R., Wilson, J.I., & Alexander, D.J. (2005). Maximising SHO training by inclusion of research fellows into a novel hybrid rota. *Annals of the Royal College of Surgeons of England*, 87(3), 199-202.
- Winslow, E.R., Berger, L., & Klingensmith, M.E. (2004). Has the 80-hour work week increased faculty hours? *Current Surgery*, 61(6), 602-608.
- Wong, J.G., Holmboe, E.S., & Huot, S.J. (2004). Teaching and learning in an 80-hour work week: a novel day-float rotation for medical residents. *Journal of General Internal Medicine*, 19(5 Pt 2), 519-523.
- Woodrow, S.I., Segouin, C., Armbruster, J., Hamstra, S.J., & Hodges, B. (2006). Duty hours reforms in the United States, France, and Canada: is it time to refocus our attention on education? *Academic Medicine*, 81(12), 1045-1051.
- Yaghoubian, A., Saltmarsh, G., Rosing, D.K., Lewis, R.J., Stabile, B.E., & de Virgilio, C. (2008). Decreased bile duct injury rate during laparoscopic cholecystectomy in the era of the 80-hour resident workweek. *Archives of Surgery*, 143(9), 847-851.
- Zahn, C.M., Dunlow, S.G., Alvero, R., Parker, J.D., Nace, C., & Armstrong, A.Y. (2007). Too little time to teach? Medical student education and the resident work-hour restriction. *Military Medicine*, 172(10), 1053-1057.
- Zonia, S.C., LaBaere, R.J.2nd., Stommel, M., & Tomaszewski, D.D. (2005). Resident attitudes regarding the impact of the 80-duty-hours work standards. *Journal of the American Osteopathic Association*, 105(7), 307-313.
- Zuckerman, J.D., Kubiak, E.N., Immerman, I., & Dicesare, P. (2005). The early effects of code 405 work rules on attitudes of orthopaedic residents and attending surgeons. *Journal of Bone & Joint Surgery - American Volume*, 87(4), 903-908.