# Descriptors of included studies

| Author, year, country | Design and sampling | Study aim | Key findings | Limitations | Implications | MMAT Score |
|---|---|---|---|---|---|---|
| Al-Hakim L et al.[20] 2016 Australia, China, Thailand | Prospective cross-sectional observational, mixed methods (qualitative analysis of interviews).<br>55 cases observed in the preoperative phase in the OR.<br>Elective, general anaesthetic, general, urological and oncological.<br>Five hospitals: two Australia (n = 33), two Thailand (n = 12), one China (n =10).<br>16 consultant anaesthetists and surgeons, 13 OR nurses interviewed, semi-structured to determine care co-ordination categories. | Evaluate the impact disruptions have on time efficiency in preoperative anaesthetic work and the correlation between them and failures in coordination of care. | Average of three disruptions/case (preoperative).<br>Four types of care coordination emerged from interviews and analysis.<br>Disruptive types measured in amount of time wasted.<br>Most timewasting caused by staff (1), patient (2) and team (3).<br>On average, disruptions caused by staff added one minute to preoperative period in OR.<br>Most frequent care coordination problems: coordination within the OR team (1), between the OR team and preop team (2). | Small number of observations and selective; however, across three countries.<br>Emergency cases not observed.<br>Human observers, potential observer bias.<br>Qualitative analysis of interview data, potential bias as subjective. | Work disruption is preventable and increases inefficiencies.<br>Better teamwork required within the OR and between OR and other departments.<br>Better planning and checking.<br>Problems upstream from OR need to be resolved. | 83% |
| Antoniadis S et al.[1] 2014, Germany | Prospective observational.<br>65 elective general, orthopaedic/ trauma and plastics procedures under four hours duration.<br>Two centres within single hospital.<br>89 hours and 57 mins total, mean length 1 hour, 57 mins. | Objectively observe interruption and distraction events in the OR and measure the surgical team's intra-operative interference from these. | High amount of distractions/interruptions in the OR, n = 803, 9.82/hour.<br>Most frequent: traffic in and out of OR (1), telephone/pager calls (2), CIC (3).<br>Highest severity: equipment failures (1), work environment-related (2), procedural issues (3).<br>Frequency and severity are not correlated.<br>Surgeons more affected by single interruptions than nurses or anaesthetists. | Observational design, limitation recognising subjective differences.<br>Unable to factor in expertise and individual's coping strategies.<br>Unable to factor in when CIC interruptions are positive or necessary/legitimate.<br>Selection bias possible, two centres within single hospital.<br>Observer fatigue and possible observer bias.<br>Limited to ortho, general, < 4 hrs duration, possible observer bias. | Team-based interventions required to reduce interruptions/ distractions.<br>Improved organisation within the OR to reduce distractions/ interruptions.<br>Future research:<br>• single and cumulative effect<br>• which distractions/interruptions are beneficial and which contribute to negative outcomes<br>• impact on stress and performance. | 60% |
| Gao J et al.[2] 2019, China | Randomised prospective experimental, simulation.<br>24 medical students, 12 males, 12 females, blinded to purpose.<br>Performed laparoscopic appendicectomies on simulator.<br>All participated in three situations:<br>1) operate with no interruption<br>2) answer cognitive arithmetic questions, no operating<br>3) dual-task, arithmetic and operating<br>Randomised block design, order permutated. | Confirm the effect of cognitive interference on surgeons' cognitive load and performance while using a simulator. | Measured pupil size and blink rate, incorrect answers, surgical metrics on simulator (objective data) and NASA task load index (NASA-TLX) (subjective data).<br>In dual-task condition, pupil and blink rate, error rate in arithmetic answers, and subjective workload all increased.<br>Operating time also increased in dual-task condition. | Arithmetic task rather than a surgical cognitive task.<br>Small sample.<br>Simulator only.<br>Medical students.<br>NASA-TLX subjective. | External cognitive distractions affect surgeons' mental workload and motor skills and need to be minimised to ensure patient safety.<br>Improve or manage cognitive distractions.<br>Future research:<br>• simulation studies to improve surgeons' experiences of surgery. | 90% |

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| Jung J et al.[13] 2019, Canada | Prospective cohort.<br>265 consecutive adult elective laparoscopic general surgical procedures.<br>Mean duration 93 mins.<br>Audio-visual data collected on 'OR black box' and then observed.<br>Single surgeon, single hospital.<br>Used a self-reported human-factors questionnaire to evaluate surgeon's perceived distraction. | Determine which intra-operative system factors are related to surgeons' perceived distraction. | Surgeon reported distraction in 45% of the surgeries.<br>High amount of distractions/interruptions in the OR.<br>Most frequent: teaching (1), equipment issues (2), CIC (3).<br>Highest numbers of cases where perceived distraction by surgeon occurred that was statistically significant: door opening (1), CIC (2).<br>Multivariable analysis revealed CIC was independently associated with an increased probability of surgeon feeling distracted. | Single surgeon, single hospital, potential selection bias.<br>Hawthorne effect, one- year pilot study to familiarise staff with the 'OR black box' recorder.<br>Questionnaire used, validity evidence is preliminary. | 'Sterile cockpit' is worthwhile intervention to minimise distraction at critical stages.<br>Future research:<br>• how surgeons interact with distraction to create system-level strategies<br>• more recording to analyse correlations between distraction and surgical performance. | 60% |
| Murji A et al.[19] 2016, Canada | Randomised cross-over, simulation.<br>30 obstetrics/gynaecology residents, powered.<br>Randomised to a quiet condition followed by distraction condition, and vice versa.<br>All performed two laparoscopic salpingectomies on simulator.<br>Pager beeped and questions asked from a handover sheet, previously viewed. | 1) Assess the safety and accuracy of surgeons' responses to clinical questions asked while using a simulator.<br>2) Determine if pager distractions influence surgical performance (simulated). | Correct answers in distraction phase was 80% mean.<br>63% made minimum one unsafe clinical decision when distracted.<br>Higher number completed task in set time in the quiet, compared to distraction.<br>No difference between the two conditions for task completion and blood loss.<br>Six months later, in quiet, no surgical tasks, correct response to questions was 93% and only 20% made an unsafe decision. | Lack of blinding of residents.<br>Laboratory conditions, not real-life, therefore limited generalisability; ethics eliminates experimental design in OR.<br>Unable to determine if responses due to baseline knowledge or multi-tasking, although six months later response rate was high when no multi-tasking.<br>Trainees, hence no generalisability for experienced surgeons. | Simulators are validated for assessing surgical performance.<br>Care of patients on wards is diminished when surgeons distracted.<br>Future research:<br>• effect of distractions on experienced surgeons.<br>• effects of distractions on clinical decisions. | 80% |
| Sevdalis, N et al.[5] 2014 UK | Prospective descriptive observational.<br>19 elective urological procedures.<br>Single hospital.<br>Mean length 70 mins. | Determine if intra-operative distractions are associated with a decline in patient safety checks being performed. | High level distractions n = 136, 6/hour.<br>Most frequent: CIC and equipment issues.<br>Highest severity: coordination issues with other departments or teaching.<br>The highest severity within CIC came from external visitors and surgeons.<br>Safety checks completed most frequently: patient tasks (1), equipment tasks (2), communication tasks (3).<br>The higher frequent and severe communication distractions were associated with lower rates of completion of intra-operative patient checks (statistically significant).<br>Distractions did lead to a decline in intra-operative patient checks performed. | Small sample size.<br>Single hospital.<br>Single specialty.<br>Single surgeon.<br>No data on direct patient outcomes.<br>Hawthorne effect: potential observation bias, controlled for by familiarisation period.<br>Difficult for an observer to assess true impact as some distractions are necessary.<br>Tool not validated.<br>Potential selection bias. | Improving coordination between departments.<br>Implement 'sterile OR/cockpit'.<br>Future research:<br>• direct patient outcomes<br>• how impacts workload and teamwork<br>• optimal work process design. | 60% |

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| Sirihorachai R et al.[6] 2018, USA | Mixed-methods, (observational, experimental and qualitative)<br>Observations of 15 general surgeries, total 40 hours.<br>Five most frequent interruptions and two most affected tasks incorporated into simulation scenarios.<br>30 OR nurses participated in scenario and then participated in debrief interviews to explore cognitive processes used. | Identify most frequent interruptions in OR.<br>Develop and test simulation scenarios to assess decision-making when responding to interruptions. Explore circulating nurses' cognitive process when responding to interruptions. | Most frequent: traffic (1), phone/pager/music (2), CIC (3).<br>Highest severity: CIC (1), equipment issues (2), phone/music/pager (3).<br>Distractions occur frequently during critical tasks in OR: induction (1), first count (2), specimen handling (3).<br>Frequent distractions do not always involve circulating nurses.<br>Experienced nurses breached policy more frequently than inexperienced nurses.<br>Nurses used two cognitive processes when distracted, prioritisation and remaining focused on the primary task. | Observation phase: Hawthorne effect.<br>Only one observer, no inter-rater reliability.<br>Single centre, possible selection bias.<br>Only general surgery, not complex cases. | Knowledge can reduce interruptions during critical events/times for nurses.<br>Teach prioritisation and remaining focused on primary task.<br>Influence policy and professional guidelines to suggest unnecessary interruptions are minimised during critical phases.<br>Ongoing safety and quality. | 83% |
| Sujka J et al.[22] 2018, USA | Randomised prospective experimental, simulation.<br>12 general surgical residents, first to fifth year, from a level 1 trauma centre.<br>Four females, eight males.<br>Each performed six simulated laparoscopic cholecystectomies, three with interruptions (two clinical questions/vignettes from pager for each one, the first question easier than the second, asked at critical stage) and three without interruption. Random number generator determined order the six were performed in. | Determine if pager interruptions affect safety, operative time or patient complications and management of them during a simulated laparoscopic cholecystectomy. | Simulator measured operative endpoints, (including operative time, safety and complications), no significant difference when interrupted or not.<br>Correct management of the pager issues, pass or fail; when interrupted the residents only passed 25% of the time.<br>No difference between the correct management of the first question (easier) and second question (harder). | Small sample size, powered would require 100.<br>Subjective nature of distraction.<br>Vignettes, high failure rate for answers, was validated with surgical director.<br>Only trainees, not experienced staff. | Care of patients on ward, affected from intra-operative distractions.<br>Inability of trainees to multi-task.<br>Future research:<br>• different vignettes and more robust grading system. | 80% |
| Weber J et al.[9] 2018, Germany | Prospective observational.<br>40 robotic-assisted radical prostatectomies.<br>Total observational time 146 hours, 55 mins.<br>216 post-operative reports (nurses n = 93, surgeons n = 81, anaesthetists n = 42), using validated survey tool SURG-TLX to assess mental demands, distractions and situational stress.<br>Single hospital. | Identify the frequency and severity of flow disruptions during robotic-assisted surgery and evaluate the association between them and the performance and mental workload of all OR professionals. | High amount of disruptions in the OR n = 2285, mean 15.8/hour.<br>Highest rate of disruptions occurred after insufflation of the abdomen and before console time.<br>Most frequent: traffic in and out of OR (1), CIC (2), procedural (3).<br>Highest severity: equipment (1), instrument changes (2), co-ordination (3).<br>Perceived distractions increased with disruption frequency.<br>Severity of distractions due to communication and coordination correlated with workload (statistically significantly). | Observational, therefore possible observer bias.<br>Single hospital.<br>Only robotic surgery.<br>Could not factor in individual's outcomes from disruptions.<br>Unable to factor in when CIC interruptions are positive or necessary/legitimate.<br>Recall bias in self-report.<br>Could not assess workload ratings throughout case, only at end.<br>SURG-TLX is subjective, but validated.<br>Hawthorne effect. | System-based analyses and solutions required.<br>Further understanding of deep systems problems to enhance patient safety.<br>Multidisciplinary training.<br>Future research:<br>• OR team familiarity, OR team roles, individual's stress management strategies<br>• how high severity disruptions impact surgical outcomes<br>• impact of accumulation of minor disruptions. | 60% |

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| Weigl M et al.[8] 2015, Germany | Observational, cross study.<br>56 elective general and orthopaedic cases, under general anaesthetic with less than four hours duration.<br>Total observation time 77.1 hours, mean 1 hour, 37 mins.<br>Two departments, single hospital.<br>229 post-operative reports (surgeons n = 94, nurses n = 81, anaesthetists n = 54), using validated survey tool SURG-TLX to assess mental demands, situational stress and distractions. | Evaluate the impact different intra-operative workflow interruptions have on the ability of surgeons to manage their workload efficiently and safely. | High amount of disruptions in the OR n = 725, mean 9.78/hour.<br>Most frequent: traffic in and out of OR (1), telephone/pager (2), CIC (3).<br>Highest severity: equipment / OR environment (1), procedural (2), CIC (3).<br>CIC associated with less situational stress and mental fatigue of surgeons.<br>Surgeons reported CIC and procedural disruptions increased their distraction.<br>Nurses and anaesthetists perceive their workload as being affected by intra-operative interruptions. | Observational studies limited, cannot infer causality, only controlled study can.<br>Selection bias possible, two specialities, single hospital.<br>Hawthorne effect.<br>Observer fatigue possibility (did try to control, < four hour duration).<br>Electives, in-hours.<br>Confounding factors unable to control:<br>• complexity of procedure<br>• possibility of subjective bias with SURG-TLX tool<br>• expertise and familiarity of OR team.<br>• Could not assess workload ratings throughout case, only at end. | Reduction in interruptions.<br>Enhanced communication, surgical flow and organisation are required.<br>'Sterile cockpit'.<br>Future research:<br>• emergency procedures<br>• physiological monitoring during case to assess stress-related variables<br>• appropriate/necessary interruptions<br>• how different interruptions affect increased workload. | 60% |
| Weigl M et al.[4] 2016, Germany | Randomised prospective experimental, simulation.<br>19 junior surgeons (first and second year), 63.2% male.<br>Randomly allocated to one of two groups:<br>1) phone call disruption re external case<br>2) patient discomfort related to case.<br>Performed one step of a vertebroplasty on simulator.<br>Disruptions occurred once needle at a certain depth. | Investigate the effect of surgical flow disruptions on the intra-operative workload and technical performance of surgeons. | Mental workload through the SURG-TLX measured through training and simulation, significantly higher through simulation.<br>Phone calls were more distracting than patient discomfort.<br>Disruptions caused more physical demands and situational stress.<br>In simulation, significant correlation between mental workload and technical inaccuracy.<br>No technical significant difference between groups. | SURG-TLX is subjective, therefore potential bias.<br>Can only measure workload at end of case, not throughout the case.<br>Junior surgeons, not experienced.<br>Only a single step in a single procedure. | Actively manage distractions.<br>Different distractions impact differently on surgeons' mental workload.<br>Future research:<br>• distinguish between appropriate/necessary distractions from unnecessary<br>• effect of different distractions<br>• cumulative effects of distractions. | 70% |

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| Willett et al.[7] 2019, UK | Prospective observational.<br>Fifty-six caesarean sections, 33 elective and 23 emergency.<br>Total observational time, 38 hours, 29 minutes; mean duration 41.23 mins.<br>Performed by consultants or trainees. | Investigate the frequency and type of distractions during caesarean sections and their impact on patient safety and OR efficiency. | High amount of distractions in the OR n =1396, mean 25.05/patient.<br>Mean number higher during elective cases than emergency.<br>Most frequent: CIC (1), traffic (2) and baby crying (3).<br>Mean level II or III distraction i.e. severity (greater than 1 member or whole team distracted) 13.2/patient.<br>Highest severity: CIC (1), others (2) and equipment (3).<br>17.89% distractions occurred during critical stage, prior to delivery of baby.<br>11.25% of operating time involved Level II or III distractions<br>Surgeons' task activity affected, procedure prolonged by 26.8% mean, 11.05 mins/case mean.<br>No intra-operative or post-operative complications. | Small sample.<br>Single procedure.<br>Too small a sample to establish correlation between distracting events and patient complications.<br>Potential selection bias.<br>Single procedure controlled against confounding factor of teaching.<br>Hawthorne effect. | 'Sterile cockpit'.<br>Reducing unnecessary prolongation of operating time saves money.<br>Reducing distractions improves efficiency and can lead to improved patient safety.<br>Teamwork, staff training, preoperative briefings to recognise distractions and their impact. | 60% |
| Yang C et al.[10] 2017, UK | Single-centre prospective experimental, simulation.<br>Thirty medical students: 22 females, 8 males.<br>No previous laparoscopic surgery experience.<br>Two tasks, peg transfer (easy) and precision cutting (difficult), performed by each under no distraction, mild distraction (one call and answer question) and strong distraction (two calls and questions). | Assess whether laparoscopic performance in novice surgeons is compromised by intra-operative phone calls. | Easy task (peg transfer): strong distraction was significantly correlated with error, inefficiency and deteriorated performance in addition to an increase in subjective stress levels.<br>Hard task (precision-cutting): task accuracy and quality of answers to clinical questions from phone calls was significantly less in addition to a more subjective disturbance when strongly distracted. | Small sample, unpowered.<br>Applied tasks shorter than real-life surgery.<br>Novice surgeons, not experienced.<br>Subjective perceived disturbance. | Phone calls should be minimised to ensure patient safety.<br>Future research:<br>• influence of phone calls on experienced surgeons. | 60% |
| Yoong, W et al.[11] 2015, UK | Prospective observational.<br>Thirty-five elective gynaecological procedures from 10 consecutive sessions.<br>Single consultant and senior trainees.<br>Total 29.95 hours observed. | Observe and determine the frequency and impact of distractions and interruptions on elective gynaecological surgeries. | High level distractions n = 650, 26/patient.<br>Mean level II or III distraction i.e. severity (greater than one member or whole team distracted) 17/patient, 80.9%.<br>90% occur in first 30 mins.<br>Surgeries prolonged for mean of 18.46 minutes/case due to distractions.<br>No complications or adverse events were attributable to distractions.<br>Most frequent: equipment issues (1), CIC (2), and) others (3).<br>Highest severity: equipment issues (1), others (2) and CIC (3). | Small sample.<br>Single specialty, single hospital.<br>Hawthorne effect.<br>Potential selection bias. | Implement 'sterile cockpit'.<br>Implement preoperative briefings to enhance planning.<br>Education on how to minimise distractions. | 60% |

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