Efficient perioperative time-management methods for operating theatres: a systematic review showing how to reduce overall patient waiting times for elective surgery

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Research

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Abstract

Introduction: The effects on long waiting times for elective surgeries from lower operating theatre (OT) performance have been reported in many studies. The timeliness of perioperative processes and adherence to scheduled times is crucial for efficient performance in OT but the perioperative workflow includes multiple tasks assigned to different work teams. Each of these needs to be completed in a timely manner. This systematic review investigates the effects of efficient preoperative systems on the timeliness of upstream and downstream processes in surgical care pathways in order to reduce overall patient waiting times for elective surgery.

Methods: We searched PubMed, EMBASE, SCOPUS, Web of Science and Cochrane Library databases during December 2019 and January 2020, for articles published after 1 January 2014. All studies pertaining to perioperative time-management methods, which had an intention to reduce waiting times for elective surgery were eligible for this review. Eligibility criteria included major elective surgery lists of adult patients, excluding cancer and cancer-related surgeries. Both randomized trials and non-randomized controlled studies were considered and the quality of studies was assessed using ROBINS-I and CASP tools. The review findings are presented as a narrative synthesis due to the heterogeneity of included studies. The PROSPERO registration is CRD42019158455.

Results: The electronic search yielded 7543 records and 20 articles were eligible after deduplication and full article screening. There were two experimental studies, five quasi-experimental studies and 13 observational studies. The studies varied widely in design, scope, reported outcomes and overall quality. The first-case-start-time and patient change-over-time at OT were the main time related measures considered as affecting timeliness in many studies.

Conclusion: This review suggests that a significant amount of time could be saved with efficient scheduling and planning perioperative processes, which could reduce overall patient waiting time for elective surgeries. Managing perioperative time in isolation could be an enabling factor for an overall increase in both theatre utilisation and theatre efficiency. However, only a small number of good quality studies were available and further evaluation with higher quality study designs and rigour is recommended in order for firm conclusions to be reached.

Introduction

Demand for surgery is escalating with increased life expectancy, as multiple comorbidities and complex clinical conditions often present with advancing age. Low cost, less invasive and faster recovery options with modern surgery have also driven demand for certain surgical procedures (1–3). Long waiting lists and waiting times are therefore inevitable as excessive demand outstrips supply, especially for elective surgeries in which most of the involved activities could be pre-planned and scheduled in advance.

The perioperative processes in a surgical care pathway includes not only the patients' surgical procedures but encompasses all activities from preoperative preparation of patient, through the operation and up to the postoperative recovery. Therefore, responsibility for management of optimum perioperative processes runs across many specialties, including hospital administrators, surgeons, anaesthetists, medical officers, nurses, and, in some cases, other paramedical staff. In order to shorten waiting lists and times for elective surgeries, particular attention has been drawn in recent surgical research to non-clinical interventions to improve efficiency in perioperative practices. This includes investigation of various methods and interventions for effectively preparing patients for surgery and for moving them through the surgical phase.

Many patients who wait a long time for their surgeries are significantly more likely to report with problems associated with reduced quality of life (4). Similarly, the effects on long waiting times for elective surgeries arising from lower OT performance rates have been reported in many studies (5, 6). The impact of inconsistency in the sequencing of the elective surgery list at the OT compared to prior-schedule on patient discomfort and anxiety with prolonged fasting has also been reported (7). Frequent cancellation of scheduled elective surgical cases exerts additional burden on patients as well as on the surgical units. Consequently, patients suffer additional stress, and become frustrated and angry, due to last-minute cancellations (8). Moreover, delays in the turnaround time for patients and OT teams lead to substantial resource waste and financial loss for hospitals (9).

Researchers have identified many systems issues and organizational problems that lead to inefficient preoperative time management systems in hospitals. These include staffing shortages, transport delays, non-availability of equipment and congestion in the recovery area (10). Considerable OT time is wasted because of delays in the transfer of patients to and from the OT (11). Effective use of OT time would allow for more patients to have surgery within existing resource limits and as well as using OT utilization parameters, the numbers of people waiting for elective surgeries and the number of cancellations of scheduled surgeries are a useful managerial indicator in OT efficiency. Some researchers have investigated the amount of theatre time lost due to late-starts, early-finishes, and delays between operations, which could have been invested to carry out more operations (12).

OT processes exhibit multifunctional and multidimensional aspects and research has suggested that processes which are standardised via operations management methodologies can improve productivity of OT throughput (13). Enhancing theatre capacity by increasing the throughput of patients in OT to reduce waiting time for elective surgery is encouraged by many health system methods and interventions (14, 15).

However, despite studies noted above, there is an ongoing need for syntheses and new research to improve the balance of efficiency and responsiveness in OT (16). Methods worthy of investigation include parallel processing to reduce turnover time, redesigning perioperative processes, and ensuring that preoperative paperwork and medical examinations are completed well before the day of surgery. Many original operational and modelling studies have investigated perioperative time management methods and several reviews are available that discuss various policy strategies and interventions to reduce waiting time for elective surgeries (17, 18). However, we are not aware of any single systematic review that assesses the effects of different perioperative time-management methods to reduce waiting times for elective surgeries. This systematic review aims to fill this gap by collating the existing evidences on effective non-clinical perioperative time-management methods, particularly those that might shorten the overall waiting time of patients for elective surgery. This systematic review seeks to answer the following research problem; "What are the efficient non-clinical perioperative time management methods and systems that shorten waiting times for major elective surgeries and how consistent are the results across different health settings and health systems?"

Methods

This review assesses the effects of perioperative time-management methods on waiting times of patients for elective surgeries as one of the sub-reviews in a portfolio of systematic reviews conducted with a broader search to support a holistic approach to finding solutions for long waiting times for elective surgery (19, 20). The portfolio review was registered in PROSPERO (CRD42019158455) and the review is reported here according to the PRISMA 2009 statement and checklist (21). The broad scope of the portfolio review allowed us to include many of the existing research papers and its PRISMA flow diagram is attached as Additional file 1. At the final stage of inclusion for the review reported here, all studies of perioperative time-management methods with an intention of reducing long waiting times for elective surgery were eligible for this review.

Data sources for the portfolio review: We searched PubMed, EMBASE, SCOPUS, Web of Science, and the Cochrane Library using combinations of search terms. After pilot searches, we finalised a detailed search strategy that consisted of three sets of search terms without language restrictions. The searches were run from 14 December 2019 to 7 January 2020, for articles published between 1 January 2014 and 31 December 2019. The search strategy used for PubMed is presented in Additional file 2.

Inclusion and exclusion criteria:

We included all studies relevant to perioperative time-management interventions and strategies intended to reduce waiting time for elective surgery. All types of research studies that were published in journal papers, reports, editorials, and literature reviews from the health sector, government, and related sectors were eligible. Given that healthcare system interventions are often tested in quasi-experimental studies or observational studies, rather than experimental studies (such as randomised trials), a range of study designs were eligible for this review. We included experimental, quasi-experimental, and observational studies, as well as systematic reviews. Both qualitative and quantitative data were considered for data synthesis. Simulation and modelling studies were excluded with the assumption that they might not be a reliable guide to the effects in real-world settings.

Eligible participants were adults (≥18 years) registered for a major elective surgery. For the purposes of this review, surgeries requiring penetration of a body cavity were considered as major surgeries, including all surgeries of abdomen, chest or cranium; but we excluded studies in patients undergoing emergency surgery and cancer or cancer-related surgeries. Minor surgeries are generally superficial and do not require penetration of a body cavities (23). Although most eye surgeries are usually categorised as minor surgeries, we included studies on eye surgery lists as an exception, because these have some of the longest surgery waiting lists in many countries (24). Studies relevant to waiting times for day surgery or ambulatory surgery were considered eligible.

Article selection and data extraction:

Two reviewers (DR and VJ) selected relevant articles and checked the title and the abstracts of retrieved citations. Articles that were deemed potentially eligible based on their title or abstract were retrieved in full and assessed for eligibility and relevance (DR, VJ and VU). Each potentially eligible article was discussed with a third reviewer (MC) and agreement was reached on inclusion or exclusion. Where a study was based in a hospital ward, we assumed that the proposed intervention was targeted on perioperative time management methods and overall patient waiting time for elective surgery. As noted above, we included a wide range of study designs to make the review comprehensive and evaluated the risks of bias associated with each design (22). Our main outcome variable was waiting time, we also considered all quantitative, and qualitative reporting associated with proxy variables of change such as patient numbers, efficiency measurements (reduced surgery cancellations) and number of surgeries. We checked the reference lists of included articles for additional relevant citations (23).

Quality assessment: The validity of the results of systematic reviews of health systems interventions are based on the evidence synthesis methods used in the review rather than universal experimental criteria (24). Given the types of study that we identified, we used the ROBINS-I tool (25) for quality evaluation of all experimental studies and the CASP tool (Critical Appraisal of Skill Programme) for observational studies (26). We used common criteria to report the overall quality of evidence in observational studies with the consensus of all review authors.

Synthesis of results:

Meta-analyses were not applicable for this review because of the heterogeneity in study designs and variability of the approaches to how the outcomes were measured and reported. Instead, we planned a meta-synthesis with narrative analysis.

Our electronic search in five bibliographic databases yielded 7543 records. This fell to 5346 after electronic deduplication in EndNote citation management software. No eligible studies were identified by examining reference lists. During the title and abstract screening process, 362 citations were deemed potentially eligible. Of these, 196 were checked by full article screening for the extended scope of the portfolio review. 105 simulation and modelling studies were rejected at this stage according to our predefined exclusion criteria. After grouping the citations into different strategies for reducing waiting time for elective surgery, 20 studies were included for the final analysis of this review because their major concern was an investigation of the use of perioperative time-management methods to reduce waiting time for elective surgery. The article screening process is shown in the PRISMA flow diagram (Figure 1) and the PRISMA checklist for this article is in Additional file 3.

Among the 20 included studies, nine (45%) introduced perioperative management methods in common for all elective surgeries (27-35). There were four studies each on preoperative methods for general surgery (36-39) and for neurosurgery (40-43), two articles for eye surgery (44, 45) and one article for head and neck surgery (46).

Nineteen of the 20 studies investigated specific, institution-based interventions. In total, there were 13 observational studies, five quasi-experimental studies and two experimental studies. A summary of the characteristics of the included studies is presented in Table 1.

Table 1. Summary of included studies

Characteristics	Number (n=20)
1. Publication year	
2014	1(5%)
2015	4 (20%)
2016	6 (30%)
2017	3 (15%)
2018	3 (15%)
2019	3 (15%)
2. Country of research	
South Africa	1 (5%)
UK	2 (10%)
Japan	1 (5%)
Australia	1 (5%)
Taiwan	1 (5%)
Germany	2 (10%)
India	4 (20%)
USA	7 (35%)
New Zealand	1 (5%)
4. Study design	
Observational Studies	13 (65%)
Quasi experimental studies	5 (15%)
Experimental studies	2 (10%)
5. Study setting	
Institution	19 (95%)
Health system	1 (5%)
6. Surgery types	
Elective surgery	9 (45%)
General surgery	4 (20%)
Neurosurgery	4 (20%)

Eye surgery	2 (10%)
Otolaryngology, Head and Neck Surgery	1 (5%)

A descriptive summary of the studies is given below and fuller details are in Table 2.

Asmal (27) measured OT utilisation and the rate of day-of–surgery cancellations (DOSC) in a South African state hospital OT. This prospective study was conducted over three months in 2018, including 655 elective cases and 359 emergency cases. The DOSC rate was calculated as the number of elective cases cancelled on the day of surgery over the total number of scheduled elective cases and that was 26.2%, with 232 cases cancelled on the day of surgery. The most common reason for cancellation was lack of operative time. A significant amount of time was wasted because of delayed first-case starts, prolonged changeovers and early terminations of lists. Overall theatre utilisation was 55.2%, with actual operating time comprising only 36.9% of all available time (including both elective and emergency cases).

Hoffman (47) investigated the determinants of first case delays in start time at OT with a focus on resident training experience. This was a retrospective observational study in a tertiary care facility involving two units (2013 to 2018). The database yielded 3071 cases over a 5-year period. Days of anaesthesiology residency training had a trivial impact on operating room first-case-start-times, whereas the day of the week and attending surgeon had a significant impact on case delay.

Haldar (48) evaluated the common reasons for delay in transporting patients to a neurosurgery OT complex and its consequent effects in a tertiary care teaching hospital. They included 551 movement processes of patients and identified the common reasons for transportation delays. In the implementation phase, corrective measures were instituted for 303 cases. The incidence of delays due to porter, lifts, and the paediatric patients decreased and second-case cancellation and overrunning of OTs also reduced. As an additional finding, they observed a significant reduction in OT turnover times (16.31 ±9.29 minutes) with their interventions.

Tiwari (30) analysed 35 months of data comprising 28,882 first cases to calculate the difference between the time a patient entered the operating room (OR) and the scheduled entry time as an initiative to improve first-case-on-time-start. This was an intervention study conducted in a University Medical Centre in the USA. The reduction found demonstrates that an improvement in on-time starts resulted from the process.

Swafe (36) reported a prospective study in 2017, including data from elective theatre lists in a Department of General Surgery in the UK. They included 33 theatre lists, with 134 patients in the study and conducted a detailed time analysis. Most delays occurred pre-operatively (24%). The commonest causes were late arrival of patient (6%), delays in consenting (3%) and lack of rooms to clerk patients pre-operatively. The 18% of delays were caused intra-operatively, and mostly due to the staff issues (late arrival of surgeon, lack of theatre staff and change of staff during list). The study's results emphasised the importance of using a team-based approach to identify causes leading to theatre efficiency.

Ray (44) conducted a prospective observational study in Kolkata Medical College Hospital in India in 2015. Descriptive statistics revealed that the median waiting time of inpatients before elective surgery was 12 days (interquartile range = 11.5 days). The waiting time was influenced significantly ($P < 0.05$) by patient's age, physical status and financial status. The surgical specialty, blood product booking and procurement, cross-specialty consultation before surgery, and Intensive Care Unit (ICU) booking were identified as other important modifiable factors.

Balzer (31) reported an observational study that aimed to analyse elective surgery cases of a university hospital in Germany in a 1-year period. It included 14,014 cases scheduled on 254 regular working days and found that 36% of cases showed a change in start times, with half of these (52%) resulting in a delay of more than 15 minutes. There were wide differences across surgical specialties for planned versus actual start times. Early planning of medium-length cases resulted in the most predictive procedure in terms of start time and duration of the case.

Doll (37) reported a retrospective study to assess the inter-professional team performance that interplay OT room turnaround times, and teams that worked together over time, in Germany. They analysed 13,632 surgical cases that involved 64 surgeons and 48 anaesthesiologists during 2007 to 2013. They found significant differences in team performances among the different surgical lists. The analysis indicated that the median turnaround times would have a reduction potential of 6.8% (95% confidence interval 6.3% to 7.1%) for selected algorithms; and concluded that because the surgeon is usually predefined for scheduled surgeries, allocation of the right anaesthesiologist to a list can improve the team performance.

Nakata (49) conducted a cohort study to evaluate the impact of the revision of surgical fee schedule on surgeons' productivity in Japan. They analysed 62 surgeons who performed 7602 surgical procedures in 2015 to 2016. They found that 87% of cases started more than 10 minutes off their originally planned time and showed that revision of surgical fee schedule had various effects on the change in productivity, efficiency and technique.

Cognetti (46) reported a descriptive study of the prevalence of the practice of multiple-room surgery in the USA. 907 practitioners completed the survey, showing that multiple-room surgery was more common amongst subspecialists than general otolaryngologists. Most respondents believed that regulations disallowing multiple-room surgery would result in an increase in late starts (73.5%), an increase in the time to schedule surgery (84.5%), a detriment to residency training (63.1%), and no improvement in patient safety (60%). This survey suggests that policy makers should reconsider the use of multiple-room surgery to avoid potential unintended negative impact on patient care and access.

Mei (33) reported a before and after study from Taiwan that sought to establish an effective planning system for surgery scheduling to ensure OR efficiency and performance in a university hospital OT. Data were obtained from the medical information system before and after the intervention. The percentage of on-time start of first surgery was elevated from 95.4% to 98.1% and the cancellation rate for surgeries was lowered from 6.4% to 4.2% after the intervention.

Nagendran (45) reported three audits reflecting factors influencing theatre efficiency in a tertiary care centre in the UK. They use information from the hospital database for 2011 to 2015 and analysed the time of arrival of patient to OT, induction, first cut and the close of operation. They concluded that theatre utilisation rate was significantly higher ($p<0.01$) for whole-day lists (85%) compared to half-day lists (75%), suggesting that whole-day lists were more efficient.

Naik (5) reported a prospective 2-month observational study to achieve a high level of utilisation in OT in a 1000 bed tertiary care hospital in India. They concluded that most of the causes of delays and cancellations of surgeries were avoidable with proper preoperative planning and optimization of patients and resources and good communication between surgeons, anaesthesiologists and nursing staff.

Mizumoto (38) conducted a single-blinded, randomized controlled intervention to test a standardised surgeon-led model that would reduce patient change over time, and its impact on theatre efficiency. Data were collected from general surgery department in Australia for a one-year period and patients were randomized into one of five general surgical lists. Results demonstrate that collaboration of teamwork and using key aspects of parallel processing significantly reduced the change over time between patients.

Saikia (40) reported a prospective observational study to evaluate the OT utilisation in a neurosurgery unit of a teaching hospital in India. Data were collected over 78 days and revealed that operating and anaesthetic time for different neurosurgical operations could be used as a guide for planning operating lists.

Saw (39) reported a pre-post study to evaluate the effect of a multidisciplinary initiative to improve first patient in the room (FPIR) and first case on time start (FCOTS) metrics in a tertiary care hospital in the USA. The strategies included establishing time-specific goals and posting them visibly, empowering individuals to fulfil them, and ensuring no compromise in patient safety. The study conducted in 2007 to 2014 and revealed that there was statistically significant improvement in FPIR and FCOTS.

Mathews (41) reported a case control study to increase first case on-time start (FCOTS) in the neurosurgical OT in a tertiary care centre in the USA, which was conducted in 2009 to 2011. Factors predicting delayed start were also identified and implemented. During the study period, first cases performed outside the neurosurgical theatres were considered as a control group. The results revealed an increase of FCOTS in a rate for neurosurgical theatres from 33% to 68%.

Kamat (6) reported a retrospective observational study to explore the factors that lead to delays in the perioperative period by determining whether there has been a trend in the increasing length of case time over a 15-year period in a regional hospital in New Zealand. They concluded that although the mean anaesthetic time per operation had increased, there was no statistically significant trend in time consumed by the surgical team in the 15 years.

Han (43) reported a pre-post study to assess whether a resident-led initiative to ensure on the time in surgical site marking and documentation of surgical consent could improve first-case start time in a 600-bed academic hospital in the USA with 25 ORs, in 2009 to 2010. The resident-led quality improvement program successfully reduced delays in first case starts on the neurosurgery service.

Austin (35) conducted a retrospective cohort study to compare turnover times for a series of elective cases with same-surgeon turnover or different-surgeon turnover in a university-affiliated teaching hospital in the USA. They used 32 months of turnover data from this large academic institution from 2004 to 2007, with 52,036 elective cases in the dataset. These included 20,963 same-surgeon turnovers and 4818 different-surgeon turnovers that were planned as part of the elective schedule. The results revealed that a flexible scheduling policy allows surgeon swapping rather than requiring full blocks incurs minimal additional staffed time during the OT day while allowing the schedule to be filled with available elective cases.

Narrative synthesis

Outcomes and interventions

Measured outcome variables were heterogeneous across the included studies. Eight studies reported overall OT efficiency (6, 28, 32, 33, 36, 43, 44, 50) and eight studies reported overall OT utilisation (27, 29, 31, 39, 40, 44-46). Some studies focused on single process improvement approach in perioperative processes (29-31, 35, 41, 42, 44, 45, 50) but other studies targeted on preoperative time management with multiple approaches (27, 28, 32-34, 36, 37, 39, 40, 43, 46). Based on the pre-operative processes considered, six studies investigated management of pre-operative assessment (27, 28, 34, 36, 43, 44), seven studies discussed timely transport patients from ward to OT (28, 29, 34, 36, 40, 43, 45) and three studies evaluated timeliness of the process for obtaining consent from the patient (36, 39, 43). At the OT, planning for first case start on time was discussed in 11 studies (27, 28, 30, 31, 33, 34, 36, 39-41, 43) and eight studies focused on change over times of patients at theatre (27, 34, 36, 37, 40, 42, 50). Nine studies estimated scheduled surgery cancellation as a result of inadequate perioperative time management methods (27, 33, 34, 36, 42, 44, 50).

Risk of bias in included studies

We measured the quality of evidence in the included studies using two tools, with 7 studies assessed with the ROBINS-I Cochrane risk of bias tool and seventeen studies with the CASP tool (Table 2). The observational studies that were assessed with CASP tool, five of them showed lower risk of bias in their study methods (5, 27, 36, 44, 47). Seven of them showed high risk of bias in their methods (31, 32, 35, 40, 45, 46, 51) and one study showed moderate risk of bias in research methods according to CASP guide (37).

ROBINS-I: Of these seven studies, we assessed four to have medium to low overall risk of bias. The lowest risk of bias was for the randomized trial (38, 50, 52). The ROBINS-I evaluation for each domain for each of the seven studies is shown in Figure 2 and Figure 3 shows the overall data.

Bias due to confounding was lower in the single study that applied randomisation and blinding (52). One study demonstrated critical risk of bias, because the comparator group included different surgical specialties and different OT settings (41). One study showed critical risk of bias because the intervention did not include details in pre-post groups, with bias in relation to the multidisciplinary initiatives to improve first patient in the OT using a process improvement method (39). Bias due to deviations from intended interventions were moderate to low in all studies because the intended interventions were organisational approaches focused on OT functions (29, 33, 38, 39, 41, 43, 52). No missing data were noted for any study, because patient data were extracted from regular administrative records (29, 33, 38, 39, 41, 43, 52). The measurement of the outcome variable included in many studies that were considered in relation to perioperative times are shown in Table 3 and those time measurements associated with the waiting time was considerably unbiased (29, 30, 52).

Findings

The effectiveness of a broad range of perioperative time-management methods have been tested in OTs in various hospital settings. Although the included studies were conducted in various countries and different hospital settings, most focused on similar type of processes measuring time related outcome variables (Table 3). The perioperative workflow in OT comprises multiple tasks assigned to multidisciplinary teams which must be completed in a timely manner.

The main pre-operative processes considered as affecting timeliness in the studies in this review were pre-operative assessment of patients, patient transport from ward to OT and consent procedures performed prior to surgery. The main predisposing variables, which were affected due to delays in such processes, were the first-case-start-time and changing-over-time of patients in the OT. The number of cancelled surgeries that had been scheduled were counted in nine studies as an associated outcome variable due to the extended OT time. Incomplete pre-operative assessment and inadequate preparation of the patient before the surgery delayed surgery start time and even led to cancellation of scheduled surgery. Most patients had presented for surgery with multiple co-morbidities that required comprehensive pre-anaesthetic work-up and this was considered as one of the main reasons for delays in start time (27, 28, 36, 43, 44). Limitations in infrastructure, such as lack of room spaces to clerk the patients prior to surgery (36) and limited laboratory facilities, were reported as reasons for delaying in pre-operative investigations (28, 44).

Detailed time analysis showed that most delays occurred during pre-operative processes in the OT and the commonest cause reported is the staggered patient arrival to the OT (29, 40, 45). Prompt transportation of patients to the OT was affected by inefficiencies in nursing communications between OT and words and porters' issues (29, 34). Infrastructure related problems also caused delays with patient transport, including non-availability of wheeled trolleys and busy elevators (29). Patient-related issues that contributed to delays included poor punctuality for ward admissions (28). Timeliness to obtain the patient consent was also considered as important to avoid pre-operatively delays (36, 39).

Adherence to start-time of the first case in the OT for elective surgeries were analysed in several studies, with consideration given to the difficulties to predict the start time of cases to follow the first one. It has shown that whenever start times were substantially delayed from schedule, second cases had the largest deviations from the schedule (31). The other area focused on in many articles were strategies to reduce the turnover times between cases in OT. Due to the inherent multidisciplinary involvement in perioperative care, many factors contributed to potential delays. The most common factors discussed were delays of the surgical and anaesthetic teams attending to work (28, 30, 39), delays in instruments and material processing, delivery and setup in theatre (30) and taking resident training sessions in the OT of teaching hospitals (28) were the common factors discussed. Turnover times depend on two main factors: same-surgeon turnover (same surgeon doing the next surgery) and different-surgeon turnover (new surgeon doing the next surgery) (35). Single surgeon block booking was recommended in one study to allow planned swapping of surgeons (35). Cancellations of scheduled elective surgery cases was a consequence of inefficient perioperative time management in OT (27) and incomplete pre-anaesthetic assessment of patients or acute change in patients' medical conditions were reported as other causes for operation cancellations.

A thorough knowledge of context-specific factors and their effects for improving systems' performance are essential for moving evidence into practice. One study suggested identifying the proportion of time spent on each perioperative activity in OT as an initiative to study the processes (40). Investing such knowledge is likely to facilitate better planning of the OT schedule and result in optimal utilization. Proper preoperative planning included with good communication and coordination practices between surgeons, anaesthesiologists and the nursing staff has been used to optimised the use of currently available time (5). Scheduling whole-day lists in OT compared to half-day lists was found to be effective in this scenario (45). Multidisciplinary initiatives were recommended in many studies and these improved first case to start on time. Introducing team-based approaches to identify effective methods that suited the microenvironment were successful and could be generalised to other settings (36, 37, 41). Strategies included establishing firm, time-specific goals and posting them visibly improved outcomes with no compromise in patient safety (39). Frequent quantifying of the effect of staff shortages and assessing staff recruitment needs within institutions helped to optimise the throughput of operation theatres (27, 42). Organisation-based approaches rather than punitive or rewarding individuals were recommended to empower the OT teams but financial incentives based on constructs in the increasing performance enhanced productivity in selected hospital settings (32, 38). One study suggested having institutional policies to allow multiple-room surgery for selected sub-specialties to improve the OT time management (46).

The effectiveness of the OT performance is assessed in several ways. Most included studies used secondary data analysis for time measurements at the OT, because recording time for activities in OT is a standard protocol in theatre information systems. The operation time was recorded as anaesthetic time, surgery time and recovery time although an overall assessment was not focused to clinical procedures at OT. All these time-related variables are similarly associated in different matrices to assess the rational performance in OT (53). Theatre utilisation rate monitors the planned activities versus actual work done and represents a principal managerial measure of OT. Theatre utilisation was used as the key performance indicator of theatre performance in the National Health System (NHS) in the UK (14). Efficiency can be considered as the extent to which the same output can be produced using fewer inputs. In surgical settings, theatre efficiency focused on maximising the use of time to increase the completed number of cases or minimising the wasted time to increase the output. As shown in Table 3, managing perioperative time in isolation can be used as an enabling factor to overall increase in both theatre efficiency (28, 32, 33, 36, 42, 52) and theatre utilisation (27, 29, 31, 39, 40, 44-46).

Limitations

Only a small number of good quality studies were available for this review and further evaluations, with higher quality study designs and rigour, are recommended in order for firm conclusions to be reached. Outside of the scope of this review, there is a considerable volume of published literature on OT efficiency and effectiveness but we focused on the concept of methods, strategies and policies to reduce waiting times for elective surgery. Therefore, most of initially identified articles were not eligible because they were not focused on total amount of time that patients had to wait for surgery. Several studies were excluded because they focused on surgical methods and clinical approaches specific to a clinical condition or surgery approach, which makes drawing generalisable conclusions impossible.

Conclusions

Efficient preoperative systems improve timeliness of upstream and downstream processes in the surgical care pathway. Team-based approaches, proper communication systems, and efficient resource management methods for preoperative processes minimise delays of start time of the first case, reduce change over times of patients and cancellations of scheduled surgeries in OT lists. This review has collated the existing evidence and shows that a significant amount of time could be saved with efficient scheduling and planning perioperative processes, which reduce overall patient waiting time for elective surgeries. Managing perioperative time in isolation could be an enabling factor to increase both theatre utilisation and theatre efficiency. Our results have implications for overall performance improvement in hospitals across the world. However, more research is needed, ideally in the form of randomised trials to determine the effects of these interventions more precisely and to inform decisions around their cost-effectiveness. This may be especially important given the impact of COVID-19 on elective surgery waiting lists in many countries, and the depletion of resources for routine health care.

Declarations

- Ethics approval and consent to participate: Not applicable, given that this is a systematic review. We registered the review in PROSPERO (CRD42019158455) and reported it in accordance with the PRISMA statement.
- Availability of data and materials: Additional file 1, 2, and 3 are attached for online display.

- Competing interests: The authors declare that they have no competing interests.
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- Authors' contributions: DR and VJ designed the research concept. All three authors (DR, VJ, VU and MC contributed to finalise methods and generating results of this study. DR, EQ prepared the initial manuscript and MC revised and approved the final manuscript.
- Consent to publish: All authors consented for the publication.
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Figures

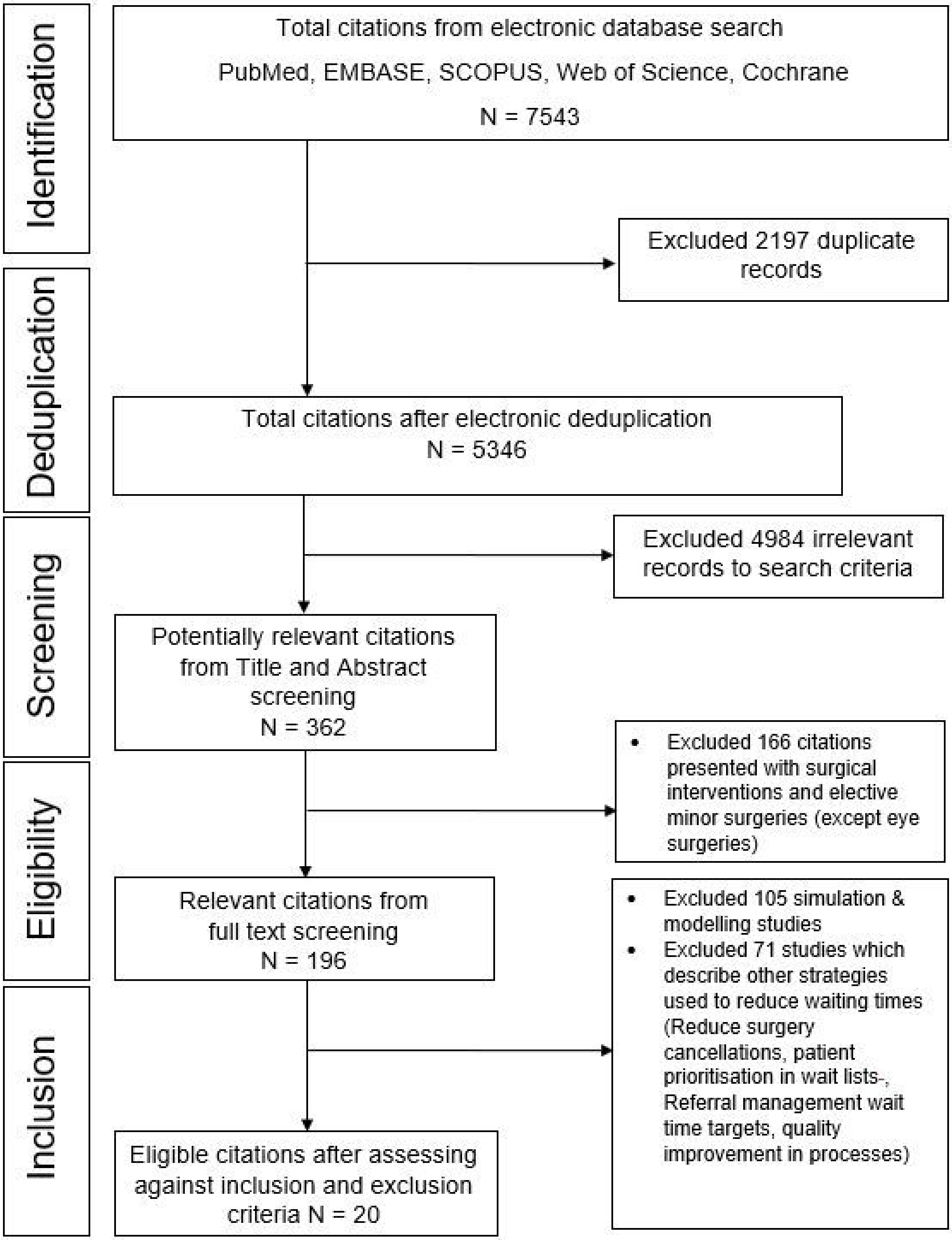

Figure 1

PRISMA flow diagram

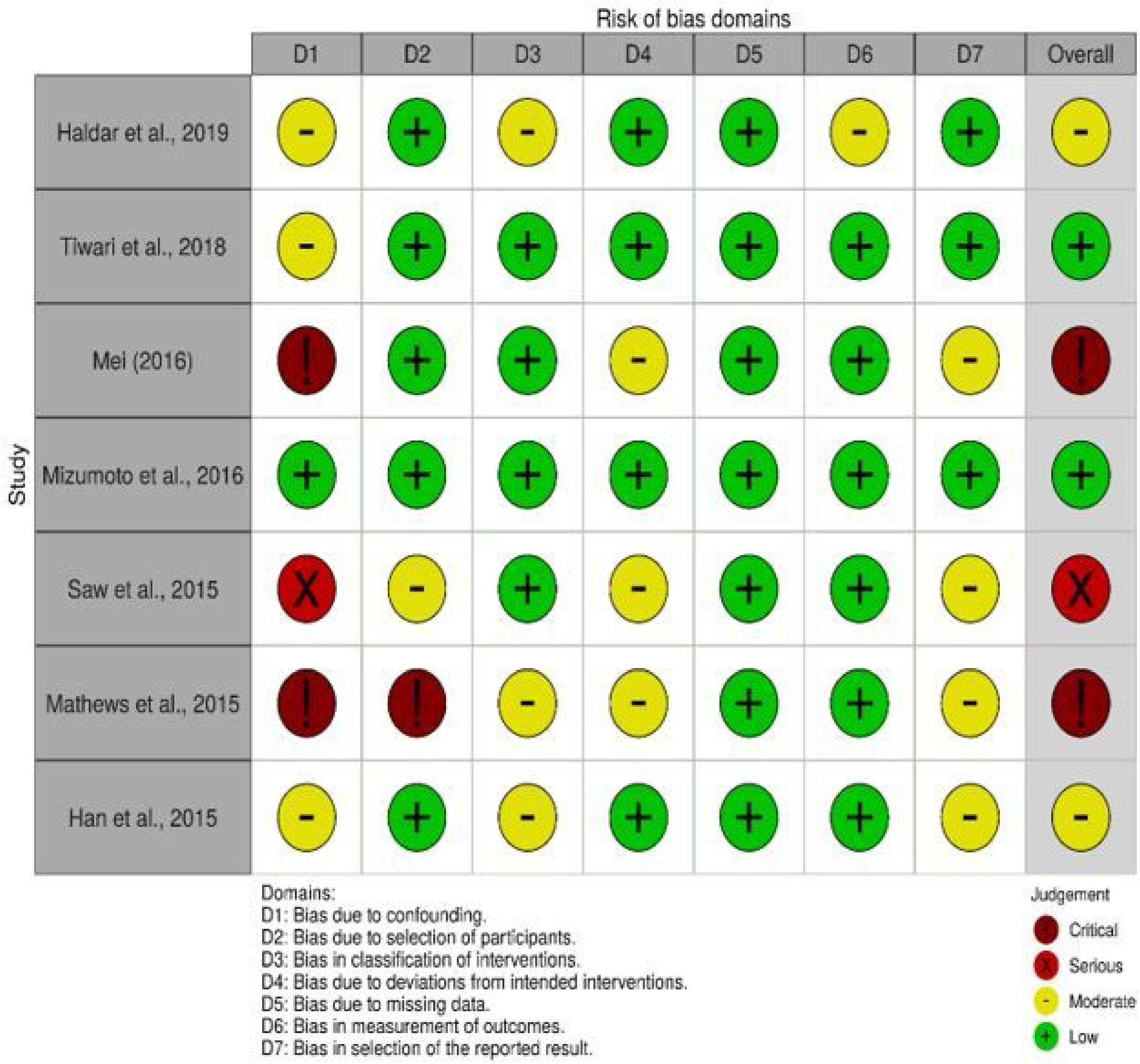

Figure 2

Risk of bias domains using ROBINS-I for the selected studies

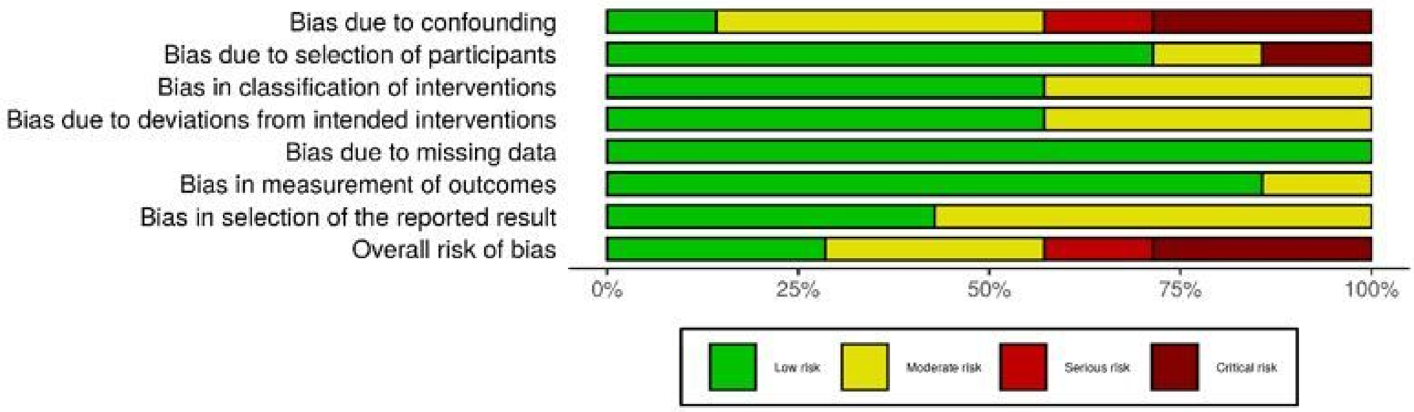

Figure 3

Bar diagram for risk of bias domains using ROBINS-I for the selected studies

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