Adolygiad Cyflym
Canolfan Dystiolaeth COVID-19 Cymru (WCEC)

Effeithiolrwydd ymyriadau cyflenwi gwasanaeth ar gyfer cleifion orthopaedig sy'n oedolion ar restr aros llawdriniaethau
Rhif adroddiad – RR00008 (Tachwedd 2021)

Manylion yr Adolygiad Cyflym

Adolygiad wedi'i gynnal gan:
Iechyd Cyhoeddus Cymru

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- Rocio Rodriguez Lopez
- Amy Hookway
- Hannah Shaw

Adolygiad wedi'i gyflwyno i WCEC ar:
27ain Hydref 2021

Grŵp rhanddeiliaid a wnaeth y cais:
Bwrdd Iechyd Prifysgol Cwm Taf

Cyfarfod ymgynghori â rhanddeiliaid:
1af Tachwedd 2021

Adroddiad ar yr Adolygiad Cyflym wedi'i gyhoeddi gan WCEC ar:
Tachwedd 2021

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Dylid dyfynnu'r adolygiad hwn fel a ganlyn:
RR_00008. Canolfan Dystiolaeth COVID-19 Cymru. Adolygiad cyflym yn edrych ar ymyriadau i fynd i'r afael ag ôl-groniad llawdriniaethau o ganlyniad i'r pandemig COVID-19. RR_00008. Canolfan Dystiolaeth COVID-19 Cymru. Tachwedd 2021. http://www.primecentre.wales/resources/RR/RR00008-Wales_COVID19_Evidence_Centre-Rapid_Review_of_the_effectiveness_of_service_delivery_interventions_for_adult_orthopaedic_patients_on_a_surgical_waiting_list_November-2021-cy.pdf

Ymwadiad: Barn yr awduron yw'r rhai sydd wedi'u mynegi yn y cyhoeddiad hwn, yn hytrach na barn Ymchwil Iechyd a Gofal Cymru o reidrwydd. Mae WC19EC ac awduron y gwaith hwn yn datgan nad oes ganddynt unrhyw fuddiannau sy'n gwrthdaro.

Effeithiolrwydd ymyriadau cyflenwi gwasanaeth ar gyfer cleifion orthopaedig sy'n oedolion ar restr aros llawdriniaethau
Rhif adroddiad – RR00008 (Tachwedd 2021)

ADRODDIAD LLAWN

CRYNODEB O'R PRIF BWYNTIAU

Beth ydy Adolygiad Cyflym?

Mae ein hadolygiadau cyflym yn defnyddio amrywiad ar y dull adolygu systematig, gan dalfyrru neu hepgor rhai cydrannau i gynhyrchu'r dystiolaeth er mwyn hysbysu rhanddeiliaid yn brydlon ond eto bob amser rhoi sylw i duedd. Maent yn dilyn yr argymhellion methodolegol a'r safonau gofynnol ar gyfer cynnal adolygiadau cyflym ac adrodd arnynt, gan gynnwys protocol strwythuredig, chwilio systematig, sgrinio, tynnu data, arfarnu beirniadol a chyfuno tystiolaeth i ateb cwestiwn penodol a nodi bylchau allweddol mewn ymchwil. Maent yn cymryd 1-2 fis, gan ddibynnu ar ehangder a chymhlethdod y pwnc/ cwestiwn/ cwestiynau ymchwil, graddau'r sylfaen dystiolaeth a'r math o ddadansoddi sy'n ofynnol i gyfuno'r dystiolaeth.

Cefndir / Nod yr Adolygiad Cyflym

Mae'r pandemig COVID-19 wedi cael cryn effaith ar lawdriniaethau cynlluniedig ledled y byd, gan waethygu heriau amseroedd aros blaenorol. Yng Nghymru, y gred yw bod rhyw 657,539 (Awst 2021) o gleifion yn aros am driniaeth mewn ysbyty. Mae delio â'r ôl-groniad hwn mewn achosion dewisol yn bryder difrifol i'r GIG a'r cyhoedd. Ar ôl trafodaeth â rhanddeiliaid ynglŷn â'r cyd-destun yng Nghymru, gwnaethom ddewis canolbwyntio ar dystiolaeth o ymyriadau darparu gwasanaeth gan gyflenwyr **i helpu i leihau'r ôl-groniad** a fyddai'n berthnasol i **gleifion orthopaedig sy'n oedolion** ar restr aros llawdriniaethau.

Darganfyddiadau Allweddol

Graddau'r sylfaen dystiolaeth

- Nodwyd **17 o astudiaethau sylfaenol**, ond **nid oedd yr un ohonynt yn rhoi sylw i effaith y pandemig COVID-19**
- **Astudiaethau cyn-ac-ar-ôl** (n=12) oedd y mwyafrif; roedd eraill yn cynnwys dadansoddiad cyfres amser gydag ymyriad (n=2), hap-dreial wedi'i reoli (n=1), astudiaeth cohort (n=1), a dyluniadau astudiaeth led-arbrofol (n=1)
- Cynhaliwyd astudiaethau yn Awstralia (n=4), Canada (n=4), UDA (n=3), y DU (n=2), y Ffindir (n=1), Lwcsembwrg (n=1), Seland Newydd (n=1), a Norwy (n=1)
- Roedd poblogaethau astudiaethau'n cynnwys cleifion sy'n aros am **weithdrefnau llawfeddygol dewisol amrywiol**
- Roedd meintiau samplau'n amrywio o **42 i 12,030 o gyfranogion**; nid oedd un o'r astudiaethau'n nodi maint y sampl
- Roedd mesurau deilliannau'n cynnwys **amseroedd aros, amlder gweithdrefnau llawfeddygol, cyfraddau canslo, a dirprwyon ar gyfer trwygyrch**; roedd dwy astudiaeth

yn edrych ar ddeilliannau **boddhad cleifion** ac ar ba mor dderbyniol oedd yr amser aros iddynt
- Ni nodwyd unrhyw astudiaethau ynglŷn â safleoedd sy'n rhydd o COVID neu fentrau Ei Gael yn Iawn y Tro Cyntaf (GIRFT) o ran y deilliannau oedd o ddiddordeb i ni

Diweddaredd y sylfaen dystiolaeth

- Cyhoeddwyd mwyafrif yr astudiaethau rhwng **2004 a 2017** a chyhoeddwyd un ym 1991

Tystiolaeth o effeithiolrwydd

- Mae yna dystiolaeth sy'n awgrymu bod **ymyriadau gan gyflenwyr**, gan gynnwys **methodolegau Darbodus a Chwe Sigma**, **ailddylunio llwybrau llawfeddygol dewisol**, a **dyrannu adnoddau ychwanegol** yn effeithiol wrth wella amseroedd aros, trwygyrch a deilliannau perfformiad theatrau llawdriniaethau
- Gallai **methodolegau Darbodus a Chwe Sigma** leihau'r amseroedd aros, amseroedd cyflawni ac amseroedd trosiant, ac mae'n bosibl y byddent hefyd yn gwella boddhad cleifion (n=4 o astudiaethau, pob un â risg uchel iawn o duedd)
- Roedd y cynnwys mewn **ailgyfluniadau llwybrau/ gwasanaethau**'n amrywio ar draws astudiaethau ond roeddent, i bob golwg, yn gwella trwygyrch a deilliannau eraill perfformiad theatrau llawdriniaethau. Fe allent hefyd o bosibl olygu y bydd amseroedd aros yn fwy 'derbyniol' i gleifion (n=8 o astudiaethau, pob un â risg uchel iawn o duedd)
- Roedd **dyrannu adnoddau ychwanegol** yn effeithiol wrth leihau amseroedd aros a chynyddu amlder gweithdrefnau llawfeddygol, gan gynnwys cyllid ychwanegol neu staff ac offer (n=4 o astudiaethau, dwy â risg uchel iawn o duedd a dwy â risg gymedrol)
- Gallai ymyriadau llawfeddygol strwythuredig ar sail cofrestrydd i wella effeithlonrwydd ystafelloedd llawdriniaethau o bosibl leihau amseroedd cyfnewid a lleihau'r oedi (n=1, â risg gymedrol o duedd)

Goblygiadau i Bolisi

- Dylai newidiadau posibl i leihau amseroedd aros i fynd i'r afael ag ôl-groniad llawdriniaethau ystyried **dull o weithredu sy'n defnyddio nifer o gydrannau ar yr un pryd**, gan gydnabod y **cyd-destun lleol**
- Gellid ystyried **methodolegau Darbodus a Chwe Sigma**, **ailgyflunio'r llwybr llawfeddygol** a **darparu adnoddau ychwanegol** fel rhan o'r dull o weithredu sy'n defnyddio nifer o gydrannau ar yr un pryd
- Mae angen **ymchwilio ymhellach** i strategaethau a gyflwynir i fynd i'r afael â'r ôl-groniad yn sgil y pandemig COVID-19 **a'u gwerthuso** er mwyn darparu sail ar gyfer gwneud penderfyniadau parhaus ynglŷn â pholisi yn y maes hwn

Cryfder y Dystiolaeth

Roedd mwyafrif y dystiolaeth a nodwyd yn deillio o hap-astudiaethau cyn-ac-ar-ôl heb eu rheoli gyda **chyfyngiadau methodolegol difrifol a risg uchel iawn o duedd**. Mae ymyriadau cymhleth yn ei gwneud yn **anodd gwahaniaethu rhwng effeithiau cydrannau unigol**. Daw'r dystiolaeth a nodwyd yn yr adolygiad cyflym hwn o astudiaethau a gynhaliwyd **cyn y pandemig COVID-19** ac mae'n ansicr a fydd ymyriadau a oedd yn effeithiol mewn amgylchiadau cymharol 'normal' yn llwyddiannus yn ystod/ ar ôl y pandemig.

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1. BACKGROUND

This Rapid Review is being conducted as part of the Wales COVID-19 Evidence Centre Work Programme. The initial question about reducing the surgical backlog was suggested by Cwm Taf Health Board UHB and refined following Welsh Government stakeholder input to focus on evidence relevant to adult orthopaedic patients on a surgical waiting list.

1.1 Purpose of this review

The COVID-19 pandemic has had a significant impact on planned surgery in the UK and globally. At the height of the pandemic, operating theatres were closed, and surgical staff were redeployed to care for patients with COVID-19. All non-emergency surgical procedures were subsequently cancelled or postponed. It has been estimated that around 28 million operations were cancelled or postponed globally during the peak 12 weeks of the pandemic's first wave (Carr et al., 2021). This has given rise to a huge waiting list for surgical treatment, with many in the UK already waiting for more than a year. Data from August 2021 show there are 657,539 patients in Wales waiting for hospital treatment (StatsWales, 2021). Data from March 2021 show that 221,849 patients waited more than 36 weeks to start treatment in January 2021, an increase of 712% compared to 27,314 in January 2020 (Royal College of Surgeons of England in Wales, 2021). In addition, there is the possibility of additional patients yet to come forward, or who have not yet been referred, for hospital treatment (Royal College of Surgeons of England, 2021). Trauma and orthopaedic surgery have been particularly affected with millions of patients across the UK left waiting for surgical procedures. Prolonged waits for surgery can impact negatively on patients who may experience worse health outcomes, debilitating pain and psychological distress.

As elective surgeries gradually restart in the UK, dealing with the elective case backlog is a critical concern for the NHS. Some regions are increasing surgical activity by implementing 'demand-side' interventions such as prioritisation of cases and pooling of waiting lists (Carr et al., 2021). However recent UK evidence suggests that 'supply-side' strategies such as those aimed at increasing the surgical workforce and equipment, utilisation of specialist centres, and improving capacity, are crucial for a return to normal surgery (Macdonald et al., 2020).

The purpose of this rapid review is to identify and examine the evidence on the effectiveness of **supply side service delivery innovations** at addressing elective surgical backlogs, in order to inform the recovery of elective orthopaedic surgeries in Wales. Demand side innovations are also important, but supply side was felt to be the most urgent and important area to review.

2. RESULTS

2.1 Overview of the Evidence Base

A total of 17 primary studies were identified for inclusion based on our eligibility criteria. The majority of studies were before and after studies (n = 12), while the remainder were of interrupted time series (n = 2), randomised controlled trial (RCT) (n = 1), cohort study (n = 1), and quasi-experimental (n = 1) study designs. Studies were conducted in Australia (n = 4), Canada (n = 4), USA (n = 3), UK (n = 2), Finland (n = 1), Luxembourg (n = 1), New Zealand (n = 1), and Norway (n = 1). Study populations were patients awaiting various elective surgical procedures and sample sizes ranged from 42 to 12,030 participants. One study did not report sample size. Most studies

were published between 2004 and 2017, but one was published in 1991. Outcome measures identified included waiting times, frequency of surgical procedures, cancellation rates, and proxies for throughput such as turnaround time, turnover time, and changeover time. Two studies sought patient satisfaction outcomes and acceptance of wait time. Our search did not identify relevant studies with outcomes relating to wait list numbers and surgeries that can take place as day cases vs inpatient cases. Although a specific search for COVID-light sites was conducted and identified eight potential sources, none were deemed eligible as their outcome measures differed from those in our inclusion criteria. In addition, we identified no sources looking specifically at Getting It Right First Time (GIRFT) methodology in relation to our outcomes of interest. Getting It Right First Time (GIRFT) is a national programme designed to improve the treatment and care of patients through in-depth review of services (GIRFT, 2021). None of the included studies addressed the impact of the COVID-19 pandemic.

A summary of included evidence is provided in Table 1. Narrative summaries of the evidence are presented below based on types of interventions.

2.2. Lean and Six Sigma methodologies

Lean and Six Sigma methodologies are designed to increase the efficiency of a process by reducing wasteful steps. Lean methodology is a process strategy designed to continually reduce waste and improve workflow. Six Sigma is a method to reduce process variation using process metric collection and statistical analysis. Although originating in the manufacturing industry, they are an increasingly popular efficiency measures for healthcare. Four studies (three before and after studies and one quasi-experimental study) provided evidence of the effectiveness of Lean and/or Six Sigma methodologies for improving operating room (OR) efficiency and productivity (Adams et al., 2004, Cima et al., 2011, Collar et al., 2012, Schwarz et al., 2011). Three studies were conducted in USA and one from Luxembourg; sample sizes ranged from 96 to 10,927 participants. Lean and Six Sigma processes were targeted at key aspects such as reducing non operation time, standardising staff assignment or activities, automated transfer of information to eliminate redundant data entry, implementing procedure checklists, and improvements to communication lines. Relevant outcomes sought included waiting time and proxies for frequency of surgical procedures such as turnaround time (TAT) and turnover time (TOT). Generally, turnaround time and turnover time measured the interval between one surgery and another, but studies used different points to measure this. Time points included the interval between surgical dressing end and surgical incision for the subsequent patient (Adams et al., 2004), time between departure from the OR and the arrival of subsequent patient in the OR (Collar et al., 2011), and extubation of patient 1 until intubating of patient 2 (Schwarz et al., 2011). Cima et al. (2011) reported TOT as the time between subsequent cases. Schwarz et al. (2011) also measured throughput time of each patient which involved measuring the time between inward and outward transfer. **All four studies were judged to be of serious risk of bias** mostly due to confounding and bias in the measurement of outcomes. Most studies failed to control for or discuss confounding variables. Most were at risk of the 'Hawthorne effect' because it was impractical to blind surgeons to the intervention, and also at risk of or observer bias and this is likely to have influenced findings.

Adams et al. (2004), a before and after study with 96 participants from the USA, evaluated the effectiveness of Six Sigma in decreasing the length of TAT (the interval between surgical dressing end and surgical incision for the subsequent patient) between general surgery cases. **Results reported a 32% decrease in mean time from patient-out to patient-in from 22.8 minutes to 15.6 minutes, after application of Six Sigma processes**. A corresponding 32% decrease in mean time from surgeon out to surgeon in was also observed. Authors of this study noted that by sustaining the mean TAT resulting from the process changes, a potential 11 general surgical cases could be added per month. In addition, surveys conducted by independent reviewers reported an

increase in patient satisfaction with the process changes. One such survey conducted among 28 surgical patients showed that 100% felt they had been treated and released in a timely manner.

Cima et al. (2011), a before and after study conducted in the USA with 10,927 participants, assessed the effectiveness of a surgical process improvement (SPI) pathway, based on Lean and Six Sigma (LSS) approaches, in improving operating room efficiency (specifically surgery waiting times and TOTs). Results reported that **patient wait times at the surgical admissions desk of longer than 10 minutes were significantly decreased after implementation of SPI (42% versus 12%; p <0.0001). Similarly, TOTs were significantly improved across various surgical specialties after implementation of SPI (Thoracic surgery: 40 minutes versus 30 minutes; Gynaecologic surgery: 35 minutes versus 20 minutes; General/colorectal surgery: 34 minutes versus 23 minutes; p< 0.05 for all).**

Collar et al. (2012) conducted a prospective quasi-experimental study with 234 participants in the USA to assess the impact of Lean methods on efficiency and workflow in an academic otolaryngology operating room. **Results reported a significant reduction in mean TOT during the intervention compared to before the intervention (29.0 minutes vs 38.4 minutes; p< 0.001). Similarly, the TAT during the intervention period was shorter in duration than TAT during the baseline period (69.3 minutes vs 89.5 minutes; p< 0.001).**

Schwarz et al. (2011) conducted a prospective before and after study with 117 participants in Luxemburg to assess the impact of an optimised schedule using Lean management tools. The aim of the study was to improve operating room (OR) capacity utilisation by reduction of change and throughput time per patient. Value stream analysis and design (value stream mapping, VSM) were used as tools for the analysis. The VSM is a device which maps activities in a process and identifies the value-adding contribution to the final result (OR result), as well as identifying process waste. Prospective analysis of 42 patients (VSM-A2) without and 75 patients (VSM-O) with an optimised process in place were conducted. **Results reported a mean change time in seconds of (mean ± SEM) VSM-A2 1,507 s±100 versus VSM-O 933 s±66 (p< 0.001). Equally, throughput time decreased significantly by 21%.** The mean throughput time, measured in minutes, was VSM-A2 (mean ± SEM) was 151 min (±8) versus VSM-O 120 min (±10) (p< 0.05).

2.2.1. Bottom line results for lean and six sigma methodologies

This section summarised evidence from three before and after studies and one quasi-experimental study. The evidence suggests that the **application of Lean and Six Sigma could improve operating room efficiency and productivity** as demonstrated by decreased waiting times, TAT, and TOT. A survey conducted in one study reported an increase in patient satisfaction with the process changes. However, **the included studies are at serious risk of bias** particularly bias due to failure to analyse or discuss confounding and bias in the measurement of outcomes due to the potential effect of observer bias which may have influenced the findings.

2.3 Pathway/service reconfiguration to improve quality

Eight studies (six before and after studies, one RCT, and one cohort study) evaluated the effectiveness of redesigning pathways and processes for elective surgery as a strategy for improving system performance (Boisjoly et al., 2010, Cullen et al., 2012, Fletcher et al., 2017, Hovlid et al., 2012, Karvonen et al., 2004, Lowthian et al., 2011, Mizumoto et al., 2016, Singh et al., 2005). Three studies were conducted in Australia and one each from Canada, Finland, Norway, New Zealand and UK. Sample sizes ranged from 69 to 1,068 participants. Relevant outcomes sought included waiting time, cancellation rate, frequency of surgical procedures and changeover time. **All eight studies were judged to be of serious risk of bias** due to a lack of

control for confounding in the analysis and discussion and the potential for the outcome measure to have been influenced by assessors' prior knowledge of the intervention.

Boisjoly et al. (2010) conducted a before and after study in Australia with 509 participants to investigate the impact of a cataract efficiency programme on surgery wait time. The programme involved the following pathway changes: shorter time delays between cases, newest technology, trained surgical technicians, and more operating room time. The results reported a **reduction in the percentage of patients waiting more than six months for cataract surgery (39% in 1999 to 29% in 2006).** Mean wait times fell from 6 months to 4.9 months ($p< 0.001$) post intervention. In addition, there were differences in how patients rated the acceptability of their cataract surgery wait time, with a much greater percentage of patients in the earlier cohort considering their cataract surgery wait time as ''not at all acceptable,'' compared with the later cohort (16% vs 4%, $p< 0.001$). There was also a significant increase in the percentage of patients who considered their wait time to be "very acceptable" in the later cohort compared to the earlier cohort (25% vs 20%, $p< 0.001$).

Cullen et al. (2012) conducted a retrospective matched cohort study with 335 participants in New Zealand to investigate outcomes for elective hip and knee arthroplasties carried out at a pilot site. A new incentive based and clinically led model of elective surgery was piloted at the site with the aim of improving access to elective surgery for the local population by increasing throughput. Outcomes were compared between the pilot site and the main district health board hospital site. Results reported that **the pilot site averaged 4.0 procedures per full day session (all arthroplasties), while the main hospital site averaged 3.2 procedures per full day session, of which arthroplasties constituted 64%.**

Fletcher et al. (2017) conducted a before and after study in the UK with a sample of 69 procedures to evaluate the impact of a quality improvement project on elective orthopaedic theatre turnaround time. The project identified inefficiencies in the pathway from application of dressing to knife to skin on the next patient and implemented interventions in order to streamline the turnaround process. **The results reported a 45% reduction in turnaround time from 66.5 minutes at baseline to 36.8 minutes following interventions.**

Hovlid et al. (2012) conducted a before and after study in Norway to evaluate the impact of a redesigned pathway for elective surgery on cancellation rates at a general hospital. The redesigned pathway focused on earlier patient assessment, improved communication between staff, improved management, improved planning, and patient participation in the planning of their elective operations. Sample size was not reported. **The redesigned pathway facilitated the reduction of the mean cancellation rate from 8.5% to 4.9% (95% CI for mean reduction 2.6-4.5, $p <0.001$).** Additionally, the number of operations performed per month increased by 17% after the intervention, from 323 to 378 ($p =0.04$).

Karvonen et al. (2004), a before and after study with 374 participants in Finland, evaluated the effectiveness of a double-queue scheduling system, implemented alongside a wider reorganisation of a cardiothoracic department, in improving throughput in elective coronary artery bypass graft (CABG) operations. For this project, CABG patients were classified as A1 or A2 (A1 to be operated on urgently, within 30 days of diagnosis, A2 scheduled for surgery within 3 months). Results showed a **significant reduction in queuing time (time from being put on the waiting list to coming to the hospital for the CABG) from 10 days to five days in the A1 group and from 80 days to 20 days in the A2 group.**

Lowthian et al. (2011), a before and after study with 2,181 participants in Australia, evaluated the effectiveness of redesigning and streamlining clinical pathways for elective surgery. The redesign incorporated construction of a separate, dedicated elective surgery and procedural facility with 26 overnight surgical beds and 55 recovery beds, co-located on the hospital site. **The clinical process redesign resulted in a 45% reduction in the number of elective surgery patients waiting longer than national recommended maximum waiting times (<90 days).** Similarly,

there was a decrease in the hospital-initiated postponement (HIP) rates (number of patients whose elective procedure was postponed by the hospital as a percentage of the number of planned elective surgery procedures) from 28% to 6% over the study period.

Mizumoto et al. (2016) conducted a RCT with 1,068 participants in Australia, to compare a redesigned surgeon-led, team-based model of strategies versus routine patient change-over. The redesigned model was based on a set of steps applied methodically during the non-operative time between the patient change-over. The sequence of events started with anaesthetists continuously being updated about the progress of surgery, prompting and preparation of theatre staff towards the end of theatre case, dual involvement of the surgical consultant and registrar, and recovery of patient and preparation for the next case**.** The intervention consisted of a single surgeon, whilst the control included four surgeons. Results reported a **significant improvement in median changeover time using the redesigned model. The surgeon in the intervention group (Surgeon A) had a median change-over time of 12.1 ± 5.4 min (p <0.001), with a median difference of 8.5 min ± 21.4 min (p <0.0001), translating to a 58% reduction in median change-over time between the intervention and control groups.**

Singh et al. (2005) conducted a before and after study with 143 participants in Australia to evaluate the effectiveness of a pilot project aimed at increasing surgery rates and reducing elective surgical waiting lists. The project involved a restructuring of the surgical admissions process at a non-teaching hospital. This included pooling of the elective surgical referrals for admission, the use of a new booking and waiting list system administered by a dedicated nurse, restructuring of the surgical operating sessions, and planning post-discharge care at operation using model clinical pathways. **The study findings reported that more surgical operations were performed under the pilot project than for usual practice: Hernia repairs (22 vs 49), Laparoscopic cholecystectomy (24 vs 52).**

2.3.1 Bottom line results for pathway/service reconfiguration interventions

This section summarised the evidence from six before and after studies, one RCT, and one cohort study. Although the content of the pathway reconfiguration interventions varied across the studies, all of them reported an **improvement in throughput and other operating theatre performance** outcomes. One study reported an improvement in patients' acceptability of their waiting time after receiving the intervention. **All included studies were found to be at serious risk of bias, particularly bias due to a lack of control for confounding in the analysis and discussion and the potential for the outcome measure to have been influenced by assessors' prior knowledge of the intervention.**

2.4 Allocation of additional resources

Four studies (two before and after studies and two interrupted time series) investigated the impact allocation of additional resources would have on waiting times (Bellan, 2004, Levy et al., 2005, Mills and Heaton, 1991, Sobolev et al., 2012). Three studies were conducted in Canada and one in the UK. Sample sizes ranged from 445 to 12,030 participants. Additional resources included additional funding or staff and equipment. Only one study (Mills and Heaton, 1991) specified the additional funding was to employ an additional anaesthetist and extra ward nurses and the purchase of additional surgical equipment. The remaining three outlined additional funding was to increase the number the surgeries taking place, without detail of exactly how this was achieved. Outcomes measured included wait time and frequency of surgical procedures. **Two of the studies were judged to be of serious risk of bias** (Bellan, 2004; Mills and Heaton, 1991) due to a lack of consideration for confounding factors in the analysis, while the other two studies were of moderate risk of bias.

Bellan (2004) conducted a before and after study with 4,476 participants in Canada to measure the impact of additional funding on a cataract waiting list. Records from the Manitoba Cataract Waiting List Program (MCWLP) database for surgery performed between January and March 2002 inclusive and between April and June 2003 inclusive were used to determine the average waiting time for surgery. **Results reported that additional resources for cataract surgery reduced the average projected wait for surgery from 30.35 weeks to 25.40 weeks.**

Levy et al. (2005) used records from a population-based registry in an interrupted time series study with 9,321 participants from Canada to study the wait-list time for coronary artery bypass graft (CABG) operations before and after supplementary funding became available. **The results of the study found that waiting times shortened in years with more funds. There was a 13% decrease (from 54% to 41%) in the proportion of patients accessing the operation through wait lists,** indicating that supplementary funding was used to provide more operations without delay.

Mills and Heaton (1991) conducted a before and after study with 445 participants in the UK to investigate the impact of the Tayside Waiting List Initiative on an ENT surgical waiting list. In this waiting list initiative, extra resources (staff and equipment) were provided to reduce the numbers of routine cases on a department's waiting lists over a limited period of time. **The results of the study found that waiting times for minor ENT surgeries improved after application of the waiting list initiative (minor nasal operations: 28 months vs 10 months; adult tonsillectomy: 16 months vs 7 months).**

Sobolev et al. (2012) conducted an interrupted time series study with 12,030 participants in Canada to analyse the effect of increased funding on wait-list size and waiting times for CABG operations. **Study findings reported that 40% of patients in the cohorts registered in the years when supplementary funding was provided, underwent surgery within 16 to 20 weeks following the median waiting time, while it took between 27 and 37 weeks for the cohorts registered in the years when supplementary funding was not available.** The study also observed that the weekly rate of undergoing surgeries from the wait-list was 50% and 90% higher during the periods with supplementary funding compared with the period without supplementary funding.

2.4.1 Bottom line results for allocation of additional resources

This section summarised the evidence from two before and after studies and two interrupted time series. The evidence suggests that the provision of additional or supplementary resources in the form of **funding and/or staff and equipment, can significantly reduce the wait times** for elective surgery. **Half of the studies contributing to this evidence were found to be at serious risk of bias** due to confounding.

2.5 Surgical registrar-based interventions

One small before and after study; Soliman et al. (2013), conducted in Australia, evaluated the effectiveness of a structured intervention, implemented by the surgical registrar. The 9-step structured intervention involved the surgical registrar being actively involved in the patient's operative journey. This included pre theatre list briefing, assisting patient transfer on and off the bed, helping with set-up and dissembling of equipment as well as facilitating open communication between all team members. This aimed at improving operating room efficiency, reducing changeover times and minimising delays. A total of 42 patients undertaking endoscopic urological day surgery were recruited for this study. **Post-intervention results reported a 48% ($p < 0.01$) reduction in overall changeover times between cases from 27.7 minutes (95% CI 22.8–32.7) to 15.7 minutes (95% CI 13.2–18.2).** The structured intervention which focussed on the role of the

surgical registrar, also made significant improvements in all segments of changeover time in the patient's surgical journey ($p < 0.05$) except for the waiting time in the anaesthetic holding bay ($p = 0.13$). This study was judged to be of moderate risk of bias. The authors of the study expressed concern that as the surgical registrar was the intervention, their own motivation will have the most dramatic influence on the study outcome.

Table 1: Summary of included studies

Lean and Six Sigma				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Adams et al. (2004) 'Decreasing turnaround time between general surgery cases: a six sigma initiative', JONA: The Journal of Nursing Administration, 34(3), pp. 140-148. **USA**	**Study Design:** Before and after study **Type of intervention:** Six Sigma **Data collection methods:** Observation, Operating room scheduling system (ORSOS) database, survey **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 96 **Participants:** General surgery cases **Setting:** Hospital **Dates of data collection:** >January 10 2003	**Primary Findings:** The mean time from patient-out to patient-in decreased from 22.8 minutes to 15.6 minutes (32%), and the standard deviation decreased from 16.3 minutes to 13.9 minutes (15%). Cases outside specification dropped from 49% to 26%. The time from surgeon-out to surgeon-in also was positively affected. The mean time was reduced 32%, the standard deviation reduced 15%, and the percent of cases outside the 60-minute specification dropped from 47% to 34%. The authors suggest that by sustaining the mean turnaround time resulting from the process changes, there is the potential of adding 11 cases per month in general surgery. Should the improvement in general surgery turnaround time be replicated in all surgery cases, there exists the potential of adding 42 additional cases per month, or 504 cases per year. **Additional Findings:** Patient satisfaction increased. On one outpatient surgical unit, the results of surveys conducted by an independent outside source demonstrate that patients perceive improved teamwork among physicians, nurses, and staff. Another survey, conducted in March 2003, of 28 surgical patients showed that 100% felt they were treated and released in a timely manner.	This study focuses on turnaround time which can be regarded as a proxy for increase in frequency for surgical procedures. Unclear at what time points data were collected.

Lean and Six Sigma				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Cima et al. (2011) 'Use of lean and six sigma methodology to improve operating room efficiency in a high-volume tertiary-care academic medical center', J Am Coll Surg, 213(1), pp. 83-92; discussion 93-4. **USA**	**Study Design:** Before and after study **Type of intervention:** Surgical process improvement (SPI) based on the Lean and Six Sigma (LSS) approach **Data collection methods:** Not stated **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 10,927 **Participants**: General/colorectal (pre SPI n = 1,685, post SPI n= 1,907) Gynaecological (pre SPI n= 1,740, post SPI n= 2,430) Thoracic surgery (pre SPI n = 735, post SPI n = 2,430) **Setting:** Mayo Clinic, Rochester (MCR) - a tertiary-care academic medical centre located in the upper Midwest **Dates of data collection:** 2008	**Primary Findings:** Patient wait times at the surgical admissions desk of longer than 10 minutes were significantly decreased after implementation of SPI (42% versus 12%; p <0.0001). Similarly, on-time arrival (within 30 minutes of scheduled report time) to the preoperative area was significantly improved (81% versus 52%; p<0.0001). Standardisation of preoperative patient evaluation, elimination of barriers to first-case scheduling, and improved admissions processes resulted in a substantial improvement in on-time starts for each surgical specialty. Efforts to reduce non-operative time between subsequent cases for a given OR were successful across all specialties. Parallel processing significantly improved overall turnover times (TS, 40 minutes versus 30 minutes; GYN, 35 minutes versus 20 minutes; Gen/CRS, 34 minutes versus 23 minutes; p< 0.05 for all). **Additional Findings:** Although there were no specific efforts directed at reducing operative times (i.e., incision to close time), there was a trend toward decreased operative times in 2 of the 3 specialties in the absence of any noticeable change in procedure mix (TS, 133 minutes versus 115 minutes; Gen/CRS, 128 minutes versus 117 minutes; non-significant for both).	This study focuses on turnaround time which can be regarded as a proxy for increase in frequency for surgical procedures. There is a lack of information about the actual surgical patients and methods used for collecting data.

Lean and Six Sigma				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Collar et al. (2012) 'Lean management in academic surgery', J Am Coll Surg, 214(6), pp. 928-36. **USA**	**Study Design:** Prospective longitudinal quasi-experimental study **Type of intervention:** Lean methods **Data collection methods:** Observation (sham data collection), validated surveys, prospectively collected electronic database **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 234 (144 operative cases were included in the baseline period, 35 in the observer-effect period and 55 in the intervention period) **Participants:** Not specified but suggests operating room cases **Setting:** University of Michigan Hospitals **Dates of data collection:** A 9-month baseline period (October 1, 2008 through July 31, 2009) before implementation of lean changes; a 3-month observer-effect period (August 1, 2009 through October 30, 2009), during which time workers were made aware that their efficiency performance was being measured but before implementation of lean changes; and a 6-month intervention period (November 1, 2009 through April 30, 2010) after lean methods had been used	**Primary Findings:** During the intervention period of the study, the mean turnover time (TOT) was statistically shorter in duration than the TOT during the baseline period of the study (29.0 minutes vs 38.4 minutes; p< 0.001). Similarly, the turnaround time (TAT) during the intervention period was shorter in duration than TAT during the baseline period (69.3 minutes vs 89.5 minutes; P< 0.001). **Additional Findings:** Sixty-seven percent of TOT's during the intervention period were <30 minutes as compared with 18.2% during the baseline period (odds ratio=8.89). Thirty-one percent of TAT's during the intervention period were <60 minutes as compared with 13.7% during the baseline period (odds ratio= 5.49).	This study focuses on turnover time and turnaround time which can be regarded as proxies for increase in frequency for surgical procedures. Details on the surgical patients and procedures are not provided.
Schwarz et al. (2011) 'Lean processes for optimizing OR capacity utilization: prospective analysis before and after implementation of value	**Study Design:** Prospective before and after study **Type of intervention:** Optimization of OR schedule using Lean management tools (value stream analysis and optimized value stream design – value stream mapping, VSM) **Data collection methods**: It is unclear how data were collected	**Sample size:** 117 **Participants:** Surgical patients - 42 patients without an optimised process (VSM-A2) and 75 patients with an optimised process (VSM-O) **Setting:** Centre Hospitalier Emil Mayrisch Clinic for specialized care, Luxembourg **Dates of data collection:** Not explicitly stated but the study findings states that the 2 VSM processes were measured in 2009, and in 2010 prospective	**Primary Findings:** The prospective analysis resulted in a mean change time of (mean ± SEM) VSM-A2 1,507 s±100 versus VSM-O 933 s±66 (p< 0.001). The mean change time could be reduced by a highly significant 38.1% The mean throughput time VSM-A2 (mean ± SEM) was 151 min (±8) versus VSM-O 120 min (±10) (p<0.05). This was equal to a significant decrease of 21% in the throughput time. **Additional Findings:** In 2009, an average of 1107.1 surgeries per OR theatre were	This study focuses on change and throughput time which can be considered as proxies for an increase in the frequency of surgical procedures. According to the study authors, the major target criterion for optimizing VSM and avoiding waste was the reduction of waiting time for

Lean and Six Sigma				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
stream mapping (VSM)', Langenbeck 's archives of surgery, 396(7), pp. 1047-1053. **Luxembourg**	**Quality rating:** Serious ROB (ROBINS-I)	augmentation of patient flow was measured	performed. In the following year, there were 1266.9 operations per OR theatre. The difference achieved 156.6 more surgeries per OR theatre and 1256.8 surgeries/p.a. in addition (p= 0.002; according to 70% of the forecast).	patients in the OR tract. It is unclear how and when data were collected. No detail on exact surgeries performed during study period. The author's highlighted in the introduction section how a reduction in throughput time could contribute to patient satisfaction, but did not seek this as an outcome measure in the study.

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Boisjoly et al. (2010) 'Reducing wait time for cataract surgery: comparison of 2 historical cohorts of patients in	**Study Design:** Before and after study **Type of intervention:** A cataract efficiency program (shorter time delays between cases, newest technology, trained surgical technicians, and more operating room time)	**Sample size:** 509 (1999-2000) and 206 (2006-2007) **Participants:** Patients awaiting first-eye cataract surgery **Setting:** Maisonneuve-Rosemont Hospital	**Primary Findings:** There was a reduction in patients waiting more than 6 months for cataract surgery (39% in 1999 to 29% in 2006). The mean wait time in the most recent cohort was 1.1 months shorter (falling from 6 to 4.9 months (p< 0.001). The 75th percentile wait time in 1999–2000 was 8.5 months, decreasing to 6.6 months in 2006–2007 (p= 0.01).	There is a lack of information about the intervention. The study did not explain the changes implemented by the cataract efficiency program. The sample size of the second cohort is smaller, which could

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Montreal', Can J Ophthalmol, 45(2), pp. 135-9. **Canada**	**Data collection methods:** Interviews, interviewer-administered questionnaires **Quality rating:** Serious ROB (ROBINS-I)	**Dates of data collection:** first cohort 1999-2000 and second cohort 2006-2007	**Additional Findings:** There was a statistically significant increase for the percentage of patients that considered their wait time for surgery as "very acceptable" in 2006 compared with the 1999 cohort (20% vs 25%, p< 0.001) and a decrease in the percentage of patients that considered their wait time as '"not at all acceptable" (16% vs 4%, p< 0.001).	have had an effect on the results.
Cullen et al. (2012) 'Increasing productivity, reducing cost and improving quality in elective surgery in New Zealand: the Waitemata District Health Board joint arthroplasty pilot', Intern Med J, 42(6), pp. 620-6. **New Zealand**	**Study Design:** Retrospective matched cohort study **Type of intervention:** New model of elective surgery at pilot site **Data collection methods:** Routinely collected data extracted from the patient management system **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 335 patient events **Participants**: 177 patients awaiting hip replacement (77 main site, 100 pilot site) and 158 awaiting knee replacement (88 main site, 70 pilot site) **Setting:** 2 sites - Waitakere Hospital (WTH) in West Auckland (pilot site) and North Shore Hospital (NSH) (main site) **Dates of data collection:** 1 July 2010 through 31 March 2011	**Primary Findings:** The pilot site averaged 4.0 procedures per full day session (all arthroplasties), while the NSH site averaged 3.2 procedures per full day session, of which arthroplasties constituted 64%. **Additional Findings:** The median operation length was significantly shorter in the pilot groups compared with the NSH group (100 minutes pilot vs 166 minutes NSH for hips, 109 minutes pilot vs 173 minutes NSH for knees).	The paper did not explicitly state the contents of the new model of care. The discussion section states differences between the new model of care and that performed at NSH, however the contents of the new model of care is unclear.
Fletcher et al. (2017) 'Improving	**Study Design:** Before and after study	**Sample size:** 50 theatre turnaround times following observation of 69 major orthopaedic procedures	**Primary Findings:** The baseline mean theatre turnaround in July 2016 was 66.5 minutes. The overall mean turnaround time in	This study focuses on turnaround time which can be regarded as a

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
theatre turnaround time', BMJ Qual Improv Rep, 6(1), pp. u219831. w8131. **UK**	**Type of intervention:** 1. A 15 minute warning to the preoperative patient area 2. The operating department practitioner (ODP) briefly leaves theatre during surgery to check-in the next patient rather than doing this during turnaround time. 3. Dedicated cleaning team mobilized during skin closure 4. Simultaneous cleaning and sending for next patient PDSA cycle 1 (Sept 2016): interventions 1 and 2 PDSA cycle 2 (Sept 2016): assess sustainability of interventions 1 and 2 PDSA cycle 3 (Oct 2016): interventions 1, 2, 3 PDSA cycle 4 (Nov 2016): introduction of a 5 minute warning to theatre cleaners **Data collection methods:** Observation, data on turnaround time collected using proforma **Quality rating:** Serious ROB (ROBINS-I)	**Participants:** Surgical patients undergoing major orthopaedic procedures **Setting:** Elective orthopaedic theatres of Southmead Hospital North Bristol NHS Trust **Dates of data collection:** July 2016	theatre following interventions was 36.8 minutes. This equates to a 45% reduction in turnaround time. **Additional Findings:** The first cycle saw a mean turnaround time of 37 minutes, a 44% reduction in time following interventions 1 and 2. The second PDSA cycle saw a mean turnaround time of 38.5 minutes which equates to a 42% reduction. PDSA cycle 3 saw improved results with a mean turnaround time of 34.5 minutes. This is a 48% reduction in the mean turnaround time, compared with the baseline measurement. The fourth PDSA cycle also saw an improvement in the mean turnaround time compared to baseline. The mean turnaround time recorded was 40.0 minutes, a 40% reduction compared with the baseline.	proxy for increase in frequency for surgical procedures. No details on surgical patients and the exact surgical procedures conducted. Unclear what PDSA stands for from the paper, but likely to be plan-do-study-act quality improvement.
Hovlid et al. (2012) 'A new pathway for elective surgery to	**Study Design:** Before and after study **Type of intervention:** Redesigned pathway for elective	**Sample size:** Not stated **Participants:** Patients awaiting elective surgery	**Primary Findings:** The redesigned pathway facilitated the reduction of the mean cancellation rate (CR) from 8.5% to 4.9% (95% CI for mean reduction 2.6-4.5, p< 0.001). This reduction was sustained during a period of 26 months.	The authors highlighted that the observational and retrospective study design has the limitation of

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
reduce cancellation rates', BMC Health Serv Res, 12(1), pp. 154. **Norway**	surgery (implemented March 2008) The changes included earlier clinical assessment of patients, improved communication between staff, improved management, improved planning, and patient participation in the planning of their elective operations As part of the intervention: - A new day-surgery centre was designed within the existing premises. Only ambulatory surgeries were provided in this centre - A new computer system was introduced - A new position, a capacity coordinator, was created to plan and coordinate the surgery program across different departments up to 6 months ahead A program to improve logistics and coordination between facilities for preparation, surgery and recovery was also implemented **Data collection methods:** Hospital's patient administrative system and interviews **Quality rating:** Serious ROB (ROBINS-I)	**Setting:** Førde Hospital (Norwegian general hospital) **Dates of data collection:** April 2010 - February 2012	The mean number of cancellations caused by the hospital being unable to finish the scheduled surgery lists as planned was reduced from 4.2 per month (95% CI 3.1-5.4) to 3.1 (95% CI 2.1-4.1, p = 0.147) after the intervention. The mean number of cancellations caused by emergency cases overriding elective surgery was 1.46 (95% CI 0.8-2.1) per month before and 0.1 (CI −0.1-0.4, p< 0.001) after the interventions. The median number of operations performed per month increased by 17% after the intervention, from 323 to 378 (p =0.04). **Additional Findings:** Analysis of interviews found that the following factors were important for the success of the project: - Involvement of frontline professionals in redesigning processes across traditional department borders - Combining professional entrepreneurship with support from staff with knowledge about improvement techniques - Centralising patient preparation and discharge at one location - Use of computer application to improve planning and coordination of surgery programs across departments - Middle managers role in securing context-sensitive implementation of interventions	information bias and confounding, and therefore cannot prove causality between the intervention and the outcomes. This is a complex intervention and therefore we are not able to observe the effect of isolated components of this intervention.

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
			- Adaptation of interventions based on feedback from frontline clinicians	
Karvonen et al. (2004) 'Productivity improvement in heart surgery–a case study on care process development', Production Planning & Control, 15(3), pp. 238-246. **Finland**	**Study Design:** Before and after study **Type of intervention:** Double-queue scheduling system (a queue for short procedures and a separate queue for long procedures) to improve throughput. Implemented alongside a wider reorganisation of the cardiothoracic department **Data collection methods:** Not stated **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 374 **Participants:** Elective coronary artery bypass graft (CABG) patients. Patients classified as A1 or A2 (A1 to be operated on urgently, within 30 days of diagnosis, A2 scheduled for surgery within 3 months) **Setting:** Helsinki University Central Hospital (HUCH) **Dates of data collection:** Not explicitly stated but the findings for A1 group were taken from December 1999 and April 2000, while that of A2 was from January 2000 and April 2000	**Primary Findings:** The effect of the double-queue system reduced the queuing time significantly. The fluctuation of the queuing time was also reduced. Thus, the queue time of A1 group was halved from about ten days to five days between December 1999 and April 2000. After April 2000 the A1 queue time has been not more than five days. The A2 queue time was reduced from about 80 days to about 20 days between January 2000 and April 2000. Thus, the A2 queue time was reduced 75% during the study period. After April 2000 the A2 queue time has been between 20 and 30 days.	This study focuses on queuing time which the authors state starts when the patient is put on the waiting list and finishes when the patient comes to the hospital for the CABG. Data collection methods are unclear.
Lowthian et al. (2011) 'Streamlining elective surgery care in a public hospital: the Alfred experience', Med J Aust, 194(9), pp. 448-51. **Australia**	**Study Design:** Before and after study **Type of intervention:** Implementing a process redesign to streamline clinical pathways for elective surgery, with a focus on the patient journey from referral to discharge, and establishing a separate, dedicated elective surgery facility (the Alfred Centre). Implementation of all aspects completed by mid-2008.	**Sample size:** 2,181 **Participants:** Patients on a waiting list for elective surgery (n= 397 before process redesign and n=1784 post process redesign) **Setting:** The Alfred; a major tertiary hospital, Melbourne, Australia **Dates of data collection:** February 2005 – February 2010	**Primary Findings:** The study observed a 45% decrease in the number of patients waiting longer than national recommendations for semi-urgent elective surgery (<90 days) comparing data from February 2005 and February 2010. The authors reported that the downward trend was sustained after the study and there were no patients in any category waiting beyond the recommended times in February 2011. There was a 22% decrease for the HIP rate (number of patients whose elective	This is a multicomponent intervention so it is not possible to distinguish the effect of each isolated component on the outcomes. The study reported some comparisons between 2005 and 2010 but the intervention was implemented in 2007.

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
	Data collection methods: Administrative data from the hospital (Alfred Hospital) and the dedicated elective surgery facility (Alfred Centre) **Quality rating:** Serious ROB (ROBINS-I)		procedure was postponed by the hospital as a percentage of the number of planned elective surgery procedures) from February 2005 and February 2010 (28% vs 6%) The authors report that by February 2011, HIP rates at the Alfred Centre and main Alfred Hospital were less than 1% and 7% respectively.	This analysis may have introduced bias. The study used graphics to show the effect of the outcomes but tables with the original data for each outcome were not provided.
Mizumoto et al. (2016) 'A surgeon-led model to improve operating theatre change-over time and overall efficiency: A randomised controlled trial', Int J Surg, 30, pp. 83-9. **Australia**	**Study Design:** Randomised controlled trial Type of intervention: Surgeon-led, team-based model of strategies: 1. Anesthetists continuously updated about the progress of surgery 2. Prompting and preparation of theatre staff towards the end of theatre case 3. Dual involvement of the surgical consultant and registrar 4. Recovery of patient and preparation for the next case **Comparator:** routine patient change-over Participants were allocated to one of 2 arms of either the treatment group consisting of a single	**Sample size:** A target size of 1000 patients over a 12-month period was determined by analysing historical data of the surgical unit workload. Final sample of 1068 patients analysed (254 intervention group, 814 control group). **Participants:** Patients referred to the General Surgery Outpatients Department at Caboolture Hospital, Queensland. Inclusion criteria were any participants who consented for surgery, and proceeded to have a surgical procedure during the trial period **Setting:** General Surgery Outpatients Department at Caboolture Hospital, Queensland **Dates of data collection:** Not explicitly stated, however patients were recruited from 15th August 2013 to the 10th June 2015 and the 12 month trial period ran from 1st July 2014 to 29 June 2015	**Primary Findings:** For Surgeon A, 254 cases were performed over the study period with a median change-over time of 12.1 ± 5.4 min. The median change-over time was significantly less than all of the other consultant surgeons, at 8.5 min ± 21.4 min ($p < 0.0001$). **Additional Findings:** For Surgeon A, there were no operating theatre cancellations due to a lack of operating theatre time. However, there were 37 operating theatre cancellations due to lack of operating theatre time amongst the other four consultant surgeons.	This study focuses on change-over time which can be regarded as a proxy for an increase in the frequency of surgical procedures. The exact dates for data collection are unclear.

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
	surgeon, or a control group consisting of 4 surgeons **Data collection methods:** Data was collected prospectively over a 12-month period, electronically on a computer based system ORMIS (Operating Room Information Management System) **Quality rating:** High ROB (ROB2)			
Singh et al. (2005) 'The Auburn Elective Surgery Pilot Project', ANZ J Surg, 75(9), pp. 768-75. **Australia**	**Study Design:** Before and after study **Type of intervention:** The Auburn Elective Surgical Pilot Project (AESPP). The project included: - Pooling the elective surgical referrals for admission - A new booking and waiting list system administered by a dedicated nurse - New structure for the surgical operating sessions (including quarantined beds and theatre time) - Planning post-discharge care at operation and using model clinical pathways - The main principle of this project was maintaining the administration of elective surgery as a separate business unit, distinct from emergency surgery	**Sample size:** 143 **Participants:** Elective surgery patients **Setting:** Auburn Hospital; Western Sydney Health Area Service **Dates of data collection:** Not reported	**Primary Findings:** Comparison of throughput measures showed that more surgical operations were performed under the AESPP than for usual practice: Hernia repairs (22 vs 49), Laparoscopic cholecystectomy (24 vs 52). Surgeons took less time to perform procedures under the AESPP - a time saving of 35 minutes and 17 minutes for laparoscopic cholecystectomy and hernia repair, respectively. **Additional findings:** 40% of patients reported that they did not mind having a different surgeon to the one they originally consulted. 65% of patients considered “very important” knowing that their surgery would not be cancelled.	This study seems to be focused on the cost comparison and did not report much information about other outcomes.

Pathway/service reconfiguration				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
	Data collection methods: Data collected from several administrative databases and registries **Quality rating:** Serious ROB (ROBINS-I)			

Allocation of additional resources				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Bellan (2004) 'The impact of allocation of additional resources on the waiting time for cataract surgery', Healthc Q, 7(4), pp. 54-6, 4. **Canada**	**Study Design:** Before and after study **Type of intervention:** Additional resources for cataract surgery (March 2002) **Data collection methods:** Manitoba Cataract Waiting List Program database and archive **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 4,476 **Participants:** Patients waiting for cataract surgery **Setting:** Manitoba Cataract Waiting List Program (MCWLP) **Dates of data collection:** Records from February 2001 to Aug 2003 from the MCWLP active database were reviewed to determine the number of booking requests and number of patients waiting per surgeon Records from the archive for surgery performed between January and March 2002 inclusive and between April and June 2003 inclusive were used to determine the average waiting time for surgery	**Primary Findings:** The additional resources for cataract surgery reduced the average projected wait for surgery from a peak of 35.3 weeks to 24.8 weeks. The actual wait determined from the archive database for surgery performed between January and March 2002 inclusive was 30.35 weeks, while the average wait for surgery performed from April to June 2003 was 25.4 weeks.	There is a lack of information about the intervention. We do not have information about the total investment or the total number of surgeries that were increased as a result of these additional resources.

Allocation of additional resources				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Levy et al. (2005) 'Time on wait lists for coronary bypass surgery in British Columbia, Canada, 1991–2000', BMC Health Services Research, 5(1), pp. 1-10. **Canada**	**Study Design:** Interrupted time series **Type of intervention:** Extra funding for coronary artery bypass grafting (CABG) operations annually (from 1998) **Data collection methods:** Data collected from the provincial Cardiac Surgery Registry and administrative databases storing records of all hospital episodes in British Columbia **Quality rating:** Moderate ROB (ROBINS-I)	**Sample size:** 9,231 **Participants:** Patients with coronary artery disease (CAD) on waiting lists for coronary artery bypass surgery **Setting:** Hospitals in British Columbia **Dates of data collection:** 1991 – 2000	**Primary Findings:** There was a 12% increase in total number of surgeries in 1999-2000 compared to 1995-96 (from 3,696 to 4,174). An increase of the weekly number of operations per 100 patients listed was observed from 5.1 (4.8–5.3) in the 1995–96 cohort to 6.2 (5.9–6.6) in the 1999–2000 cohort. 50% of the 1995–96 cohort underwent surgery within 15 weeks following the median time, while it took 10 weeks for the 1999–2000 cohort. There was an 8% reduction of patients in 1999-2000 compared to 1995-96 that experienced an excessive wait, defined as longer than 26 weeks (22% vs 14%). **Additional Findings:** Between 1995–96 and 1999–2000, there was a 13% decrease (from 54% to 41%) in the proportion of patients accessing the operation through wait lists, indicating that supplementary funding was used to provide more operations without delay.	In-patients were not added to the waiting lists and therefore were not included in analyses of wait-list times. The study censored patients remaining on the waiting lists at 12 months. Patients removed from the list for reasons other than surgery were treated as censored observations. The authors highlighted as a limitation that this study has a short time follow up since the funding increase was started (1998-2000). The authors explained that these results may be due to the capacity of these hospitals to increase the number of operations. Therefore, for hospitals working near full capacity, additionally new health services facilities may be required to shorten waiting lists.

Allocation of additional resources				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Mills and Heaton (1991) 'Waiting list initiatives: crisis management or targeting of resources?', J R Soc Med, 84(7), pp. 405-7. **UK**	**Study Design:** Before and after study **Type of intervention:** Waiting list initiative (in which extra resources are targeted to reduce the number of routine cases on a department's waiting lists over a limited period of time). Extra resources included: - Employment of extra anesthetist and nurses - Purchase of equipment (air drills, microscope) **Data collection methods:** Not stated **Quality rating:** Serious ROB (ROBINS-I)	**Sample size:** 445 patients offered dates for surgery (280 of which subsequently underwent operations) **Participants:** ENT patients on the waiting list for surgery **Setting:** Teaching hospital providing all ENT services for the Tayside Region of Scotland **Dates of data collection:** Not stated	**Primary Findings:** Waiting times for minor ENT surgeries improved after application of the waiting list initiative - Minor nasal operations – 28 months (before initiative) vs 10 months (after initiative) - Adult tonsillectomy – 16 months vs 7 months.	It is unclear how and at what time points the data used in this study were collected. Not much detail on the surgical patients. It is unclear whether patients for some of the surgical procedures are adults or children.
Sobolev et al. (2012) 'Evaluation of supply-side initiatives to improve access to coronary bypass surgery', BMC Health Serv Res, 12(1), pp. 311. **Canada**	**Study Design:** Interrupted time series **Type of intervention:** Supplementary funding for coronary bypass surgery [funding provided for the periods 1998-1999, and 2004-2005] **Data collection methods:** Data obtained from population-based registry (British Columbia Cardiac Registries (BCCR)) **Quality rating:** Moderate ROB (ROBINS-I)	**Sample size:** 12,030 wait-listed patients. 12,818 direct admission patients **Participants:** Two groups of participants: Those registered on a wait list for first-time isolated coronary artery bypass grafting (CABG) surgery and those who underwent the procedure as a direct admission to hospital on a non-emergency basis **Setting:** Cardiac centers of British Columbia **Dates of data collection:** January 1, 1992 - December 31, 2005	**Primary Findings:** The study observed that the weekly rate of undergoing surgeries from the wait-list was 50% and 90% higher during the periods with supplementary funding (1998-1999 and 2004-2005) compared with the period 1996-1997 (the period with the longest wait times). Forty percent of patients in the 1998, 1999, 2004 and 2005 cohorts (years when supplementary funding was provided) underwent surgery within 16 to 20 weeks following the median waiting time, while it took between 27 and 37 weeks for the cohorts registered in the years when supplementary funding was not available	

Surgical registrar-based interventions				
Citation (Country)	**Study details**	**Participants & setting**	**Key findings**	**Observations/notes**
Soliman et al. (2013) 'Improving operating theatre efficiency: an intervention to significantly reduce changeover time', ANZ J Surg, 83(7-8), pp. 545-8. **Australia**	**Study Design:** Before and after study **Type of intervention:** A structured intervention implemented by a surgical registrar comprising of active involvement in patient changeover and a structured pre-theatre list briefing **Data collection methods:** Observation, data collection by a junior medical officer (unclear how data was collected) **Quality rating:** Moderate ROB (ROBINS-I)	**Sample size:** 42 (21 patients in each study arm). There were 35 men (83%) and 7 women (17%). The median age was 55 years and ages ranged from 27 to 75 **Participants:** Patients undertaking endoscopic urological day surgery requiring general anesthesia **Setting:** Wagga Wagga Base Hospital - a regional secondary referral hospital **Dates of data collection:** Not stated	**Primary Findings:** A 48% (P <0.01) reduction in overall changeover times between cases was demonstrated with the utilization of a structured intervention. The overall changeover time reduced from 27.7 min (95% CI 22.8–32.7) to 15.7 min (95% CI 13.2–18.2). **Additional Findings:** The time taken for a patient to present to the holding bay from the DSU was reduced by 40% (p <0.01) from 11 min (95% CI 7.5–14.6) to 5 min (95% CI 4.0–5.9) The time taken until onset of anesthetic assessment was reduced by 52% (P =0.13) from 17.6 min (95% CI 5.7–29.6) to 6.4 min (95% CI 4.8–8.1). Anesthetic assessment time was reduced by 50% (P <0.01) from 15.2 min (95% CI 10.7–19.8) to 9.1 min (95% CI 7.7–10.6). Induction time was reduced by 33% (P =0.02) from 7.3 min (95% CI 6.0–8.6) to 5.4 min (95% CI 4.5–6.3). The time taken from the end of the case until the patient is out of the operating theatre was reduced by 32% (P < 0.01) from 7.1 min (95% CI 5.9–8.3) to 4.1 min (95% CI 3.4–4.7).	This study focuses on changeover time which can be regarded as a proxy for an increase in the frequency of surgical procedures. It is unclear how and at what time points the data used in this study were collected. It is unclear how the pre-post assessment was done for both study arms. There are no baseline data for comparison with post-intervention data. This is a small study. The authors have expressed concern about the fact that the registrar is in fact the intervention, and their motivation will have the most dramatic influence on the study outcome.

3. DISCUSSION

3.1 Summary of the findings

There is evidence to suggest that **supply-side interventions including Lean and Six Sigma methodologies, redesigning of elective surgery pathways, and allocation of additional resources are effective at improving waiting times, throughput and other operating theatre performance outcomes.** Evidence from one small study indicates that **interventions requiring active involvement of the surgical registrar in patient changeover and a structured pre-theatre list briefing, could improve changeover times between surgical cases.** These interventions could reduce the elective surgical backlog brought about by the COVID-19 pandemic. Some studies included exclusive operating rooms for emergencies only as part of their multi-component intervention, which may have influenced the success of the interventions, particularly cancellation rates of elective surgery.

However, **most of the evidence was derived from uncontrolled before and after studies at serious risk of bias**. Biases included a lack of consideration for confounding factors in the analysis and discussion. Also, as it was impractical to blind the surgeons to the intervention, and in many cases the observers were not blinded, this may have influenced the findings.

Due to the rapid nature of this review, a formal grading of the certainty of the overall body of evidence was not conducted.

3.2 Limitations of the available evidence

Most of the evidence identified in this review was derived from non-randomised uncontrolled before and after studies with serious methodological limitations. These included no analysis of potential confounding factors, lack of transparency regarding selection of participants and the potential influence of prior knowledge of the intervention under investigation by surgeons and outcome assessors. These elements put them at serious risk of bias, particularly due to confounding. Additionally, many of the studies were retrospective in nature, therefore making them susceptible to information bias.

Some of the included interventions were complex and composed of multiple components. It was not possible to distinguish and observe the effect of each isolated component of these interventions.

The quality of reporting in studies was sometimes poor. Key details were often not adequately described in studies, such as data collection methods and time points, or the content of the interventions or programmes. Heterogeneity also existed amongst the included studies in terms of surgical procedure and study population. In some studies, it was not clear who the surgical patients were, i.e. adults or children.

Five included studies were conducted on small samples with less than 200 participants and one study did not report their sample sizes, which could limit the generalisability of findings. Only two of the 17 included studies were conducted in the UK, potentially limiting the generalisability of their findings to the Welsh context. Furthermore, all the included studies were published prior to 2018, and with the evolving COVID-19 landscape, it is uncertain if interventions that were effective at reducing waiting times for surgery prior to the pandemic,

will still be effective during and post pandemic. This is a particularly important consideration when looking at TAT and TOT as additional hygiene and infection, prevention and control measures will need to be in place to limit the spread of COVID-19 within the operating theatre environment and could delay the usual time taken to prepare between patients.

3.3 Implications for policy and practice

Evidence identified in this rapid review is from **studies conducted prior to the COVID-19 pandemic,** and it is uncertain if interventions that were effective in relatively 'normal' circumstances will be as successful during/post pandemic. **No relevant studies were identified that evaluated the use of COVID-light sites or utilised the GIRFT methodology.**

In terms of supply-side interventions, Lean and Six Sigma methodologies, reconfiguration of the surgical pathway and the provision of additional or supplementary resources in the form of funding and/or staff and equipment may reduce the wait times for elective surgery, but included studies are at high risk of bias and their generalisability to the current COVID-19 context within Wales is limited.

Many of the interventions identified were multi-component and involved changes across the surgical pathway. Therefore, potential changes aimed at reducing wait times for elective surgery should consider a multi-component approach.

Further research with robust methods is needed to inform policy decision-making around interventions to reduce elective surgical waiting lists.

Consideration needs to be given to whether individual surgical departments within hospitals have capacity before implementing interventions aimed at increasing numbers of operations. Hospitals working near full capacity may require additional resources (staff etc.) and facilities to shorten surgical waiting lists.

3.4 Strengths and limitations of this Rapid Review

In order to complete the rapid review in a timely manner, primary studies were identified by utilising the searches of existing systematic and rapid reviews. The existing reviews (Bachelet et al., 2019, Ballini et al., 2015, Damani et al., 2017, NSW COVID-19 Critical Intelligence Unit 2020, Pomey et al., 2013, Tlapa et al., 2020) were identified as part of a preliminary Rapid Evidence Summary, which included an extensive search of COVID-19 specific and general repositories of evidence reviews (please see section 5.2 for more information). Although the existing systematic reviews looked at the effectiveness of interventions to reduce waiting times of elective surgery, our review is limited by the date and comprehensiveness of their searches. The most recent reviews were published in 2021, with the searches (where reported) completed in 2020. A new comprehensive search of bibliographic databases for primary studies, may have identified other relevant studies, such as those published after these search dates. As an addition, a further search of bibliographic databases was undertaken to identify primary studies investigating the effectiveness of COVID-light sites, as studies published on this type of intervention will be more recent than those included in our identified systematic reviews.

All critical appraisal and data extraction was conducted using the full text publications of the original studies to ensure relevant data for our research question was extracted. Although publication date limits were applied during the original search for secondary sources, no date limits were placed on the eligibility of primary studies.

The risk of bias 2 (ROB2) and the Risk Of Bias In Non-randomised Studies of interventions tool (ROBINS-I) were used to critically appraise the studies included in this review. ROBINS-I is a risk of bias tool for non-randomised studies, however some of the domains assessed were not applicable to before and after study designs. Despite this limitation, we could not locate a more suitable risk of bias tool for before and after studies that did not result in similar issues.

Due to time constraints, we did not attempt to undertake any assessment of the outcomes using GRADE. Therefore, we are unable to comment on the quality of the overall body of evidence examining innovations aimed at addressing elective surgical backlogs.

Primary studies were screened independently in duplicate by two reviewers and both data extraction and critical appraisal were undertaken by one reviewer and then independently checked by another for accuracy and consistency, which can be seen as a strength of this review.

It had been our original intention to group included studies using the themes identified in a recent guideline document developed by the Royal College of Surgeons of England (Royal College of Surgeons of England, 2020). However, the interventions in the included studies could not easily be grouped into these themes. Therefore, a post-hoc decision was made to synthesise the findings according to the type of intervention being examined.

Our rapid review concentrated on supply-side interventions only, that is, interventions that increase the throughput of patients into elective surgery. We failed to identify any primary studies looking at the primary outcome of wait list numbers, and the secondary outcome of proportion of surgeries that can take place as day cases vs inpatient cases. It is likely other types of interventions are effective and should be also considered.

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5. RAPID REVIEW METHODS

5.1 Prior Rapid Evidence Summary

As an initial stage for the Rapid Review, a Rapid Evidence Summary was conducted in September 2021. The Rapid Evidence Summary represents a preliminary review of the literature that is used to clarify the decision problem and needs of the requestor, gauge the potential size of the available literature, inform the methods and design of the subsequent rapid review, and provide limited interim findings to the stakeholder. It is based on a search of key resources and the assessment of abstracts. Priority is given to studies representing robust evidence synthesis. No quality appraisal or evidence synthesis are conducted.

The Rapid Evidence Summary, addressed the slightly boarder question of “What is the effectiveness of innovations to address surgical backlogs that could be applied to adult orthopaedic patients awaiting surgery?” This included both demand-side and supply-side interventions. The findings were fed back to the stakeholders, and it was decided that the Rapid Review should focus on the evaluation of supply-side service delivery interventions, and that primary studies could be identified via exciting systematic reviews and other robust secondary resources, supplemented by more recent targeted searches of COVID-light sites.

The existing systematic reviews and other secondary sources were used to identify primary studies for inclusion in a *de Novo* Rapid Review. In other words, only the searches of existing reviews were utilised here (Robinson, 2014). The subsequent rapid review of the primary studies was based on the full text publications of relevant studies.

5.2 Eligibility criteria for the rapid review

The following eligibility criteria were used to identify studies for inclusion in the rapid review:

Review question	What is the effectiveness of **service delivery interventions** for adult orthopaedic patients on a surgical waiting list?	
	Inclusion criteria	**Exclusion criteria**
Population	Adults (≥ 18 years) on the waiting list for elective surgical operations (this includes elective orthopaedic surgery and any other specialities that may be relevant to orthopaedics)	Children and adolescents <18 years
Intervention / exposure	Service delivery interventions to reduce elective surgical waiting lists (such as interventions to expand capacity/ increase resources/ Covid green or light sites for elective surgeries)	Interventions pertaining to emergency or transplant surgery Demand side interventions such as those around prioritisation of waiting lists
Counter intervention	Usual care/no intervention	
Outcome measures	Primary outcomes: - Reduction in waiting list numbers - Reduction in waiting time - Increase in frequency of surgical procedures (number of operations, turnaround times, turnover times) Secondary outcomes: - Proportion of surgeries that can take place as day cases vs inpatient - Reduction in surgical cancellations initiated by health boards - Patient satisfaction	
Study design	Primary studies including observational and qualitative	
Countries	OECD countries (with similar healthcare structures to the NHS)	
Language of publication	English	
Publication type	Published and preprint, protocols	

5.3 Literature search

5.3.1 Methods for identifying existing reviews

As part of the initial Rapid Evidence Summary, COVID-19 specific and general repositories of evidence reviews were systematically searched between the 8th and 9th of September 2021, for relevant sources published in the English language.

A list of resources searched can be found below:

Date searched	Resource
08/09/2021	Cochrane COVID Review Bank https://covidreviews.cochrane.org/search/site
08/09/2021	VA-ESP https://www.covid19reviews.org/index.cfm
08/09/2021	L*OVE – COVID-19 https://app.iloveevidence.com/loves/5e6fdb9669c00e4ac072701d?population=5e7fce7e3d05156b5f5e032a&classification=systematic-review
08/09/2021	Collabovid https://www.collabovid.org/
08/09/2021	LitCovid https://www.ncbi.nlm.nih.gov/research/coronavirus/
08/09/2021	EPPI-Centre - Living map of the evidence of studies on COVID-19 identified in MEDLINE and EMBASE, that groups the evidence into broad themes https://eppi.ioe.ac.uk/eppi-vis/Review/Index
08/09/2021	International HTA database (ITS-HTA) https://database.inahta.org/
08/09/2021	EUnetHTA – COVID 19 response https://eunethta.eu/services/covid-19/
09/09/2021	Trip Database https://labs2020.tripdatabase.com/
09/09/2021	Cochrane Database of Systematic Reviews (CDSR) https://www.cochranelibrary.com/cdsr/reviews
09/09/2021	Campbell Collaboration https://www.campbellcollaboration.org/better-evidence.html
09/09/2021	JBI (via OVID)
09/09/2021	Epistemonikos https://www.epistemonikos.org/en/advanced_search
09/09/2021	PROSPERO https://www.crd.york.ac.uk/prospero/
09/09/2021	Pubmed Clinical Queries https://pubmed.ncbi.nlm.nih.gov/clinical/
09/09/2021	Pubmed https://pubmed.ncbi.nlm.nih.gov/
09/09/2021	Public Health England (PHE) COVID-19 Rapid Reviews https://phelibrary.koha-ptfs.co.uk/covid19rapidreviews/#Table
12/09/2021	NICE resources for COVID reviews and NICE Evidence
09/09/2021	Healthcare Improvement Scotland – COVID-19: Evidence for Scotland http://www.healthcareimprovementscotland.org/our_work/coronavirus_covid-19/evidence_for_scotland.aspx
09/09/2021	Ireland, HSE Library, Covid-19 Summaries of Evidence https://hselibrary.ie/covid19-evidence-summaries/
09/09/2021	Health Information and Quality Authority (HIQA) https://www.hiqa.ie/

09/09/2021	ECDC European Centre for Disease Prevention and Control (COVID-19 outputs)
09/09/2021	Centers for Disease Control and Prevention (CDC)https://www.cdc.gov/
09/09/2021	AHRQ Agency for Healthcare Research and Quality (US) https://www.ahrq.gov/coronavirus/health-systems-research.html
09/09/2021	NASEM The National Academy of Sciences Engineering Medicine - Coronavirus Resources Collection (US) https://www.nap.edu/collection/94/coronavirus-resources
09/09/2021	COVID-19 Evidence Alerts from McMaster PLUS | Home (Canada) https://plus.mcmaster.ca/COVID-19/
09/09/2021	NCCMT COVID-19 rapid reviews) (Canada) https://www.nccmt.ca/covid-19/covid-19-evidence-reviews (*also incorporated in VA-ESP*)
09/09/2021	WHO Global literature on coronavirus disease (COVID-19) database https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/ (*also incorporated in VA-ESP*)
09/09/2021	Google Advanced Search https://www.google.co.uk/advanced_search
08/09/2021	Medline (Dialog Proquest)

An information specialist devised and conducted the searches using the concepts: surgical procedures, backlog/waiting lists, strategies and innovations. The searches combined free text words and descriptors when available. The search strategy used for Medline is available in the Appendix. The references of the included reviews were also searched for additional sources.

The searches yielded a total of 408 records. Records were imported into an Endnote database and duplicates were removed. After deduplication, 335 records were screened at title and abstract, with twenty two subsequently being included in the Rapid Evidence Summary.

5.3.2 Methods for identifying relevant primary studies

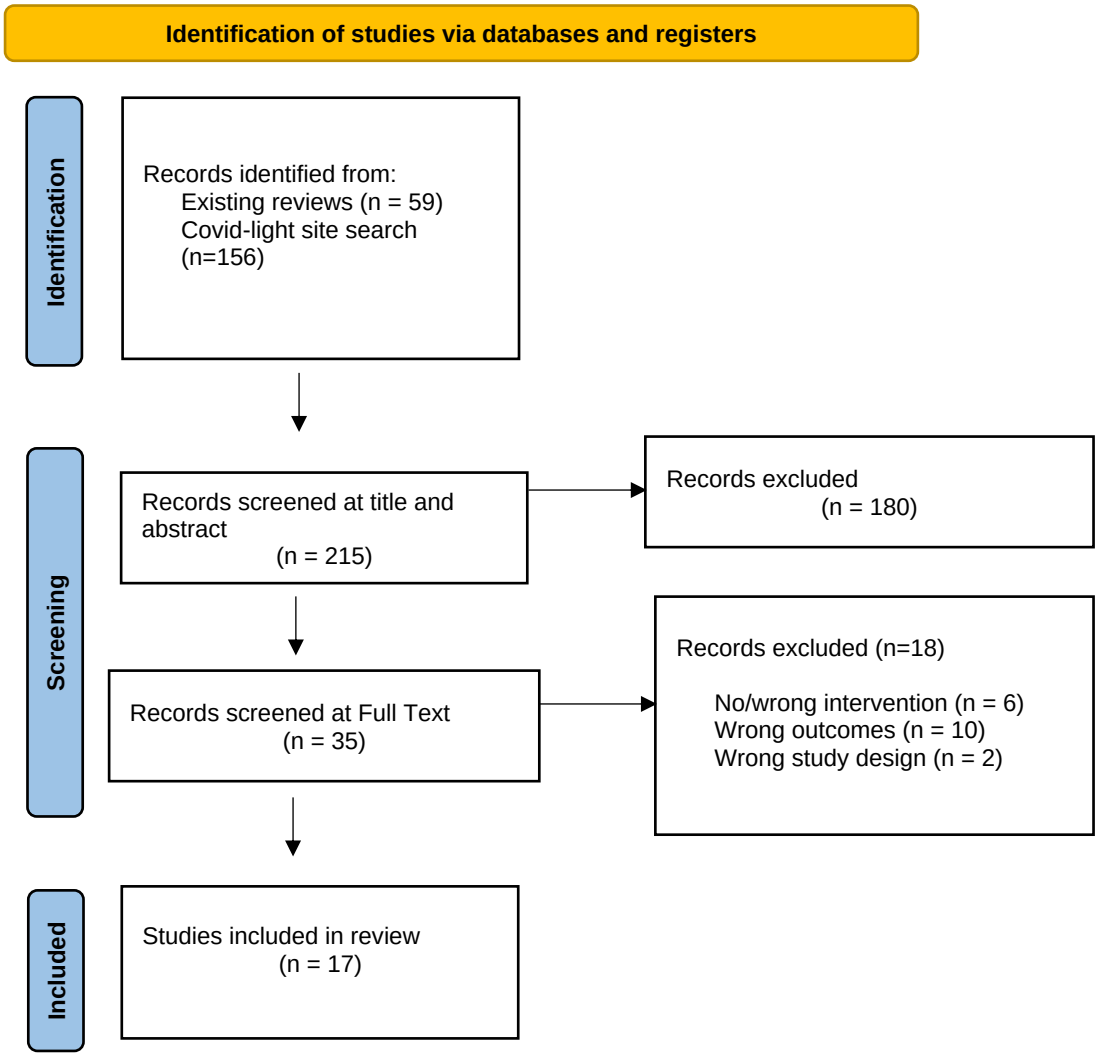
Six secondary sources included in the initial Rapid Evidence Summary were relevant to the Rapid Review question and were used to identify primary studies for inclusion in this review. The six sources included a total of 56 primary studies.

A further 156 references were identified from a specific search for COVID-light sites (See Flow chart in Section 5.4). The COVID-19 Research database (via Dialog) and Google advanced were searched on the 24September 2021 using free text terms and descriptors when available. The search for Covid-19 research database is available in the Appendix 2.

5.4 Study selection process

A total of 64 primary studies were screened for inclusion, independently in duplicate, by two reviewers using the title and abstract. Disagreements were resolved through discussion. Thirty-five primary studies included at title and abstract were then screened at full text, independently in duplicate, by two reviewers. Where there was disagreement a third reviewer was consulted to make the final inclusion decision. A total of 17 primary studies were included in the synthesis.

5.5 Study selection flow chart



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

5.6 Data extraction

Demographic and outcome data was extracted directly into tables by one reviewer and checked by a second reviewer. The following information was extracted from each primary study:

- Year
- Country
- Study design
- Type of intervention
- Data collection methods
- Sample size
- Participants
- Setting
- Dates of data collection
- Primary and additional findings

5.7 Quality appraisal

Quality assessment was undertaken by a single reviewer, with verification of all judgements by a second reviewer. Any discrepancies were discussed and resolved amongst the review team. Study specific tools were utilised for quality assessment; the revised Cochrane tool for assessing risk of bias (ROB2) (Sterne et al., 2019) was used for randomised controlled trials and the Risk Of Bias In Non-randomised Studies of interventions tool (ROBINS-I) (Sterne et al., 2016), was used for before and after, interrupted time series (ITS), quasi-experimental and cohort studies.

5.8 Synthesis

A narrative synthesis was conducted to report the results from the included studies.

6. ADDITIONAL INFORMATION

6.1 Information available on request

Reasons for exclusions at full text screening, quality appraisal of included studies and full search strategy.

6.2 Conflicts of interest

The review team declares no conflicts of interest.

6.3 Acknowledgements

The authors would like to thank Phil Coles, Olivia Shorrocks, and Caroline Mills for their contributions during stakeholder meetings in guiding the focus of the review and interpretation of findings. In addition, thanks to the WCEC core team for providing a list of useful references for the review.

6.4 Abbreviations

Acronym	Full Description
CABG	Coronary artery bypass graft
CI	Confidence interval
COVID-19	Coronavirus Disease 2019
ENT	Ear, Nose and Throat
GIRFT	Getting It Right First Time
HIP	Hospital-initiated postponement
LSS	Lean and Six Sigma
NHS	National Health Service
OECD	Organisation for Economic Co-operation and Development
OR	Operating room
RCT	Randomised controlled trial
ROB	Risk of Bias
ROBINS-I	Risk Of Bias In Non-randomized Studies - of Interventions
SEM	Standard error mean
SPI	Surgical process improvement
TAT	Turnaround time

TOT	Turnover time
UK	United Kingdom
USA	United States of America
VSM	Value stream mapping

6.5 Definition of terms

Changeover/turnover time (TOT)	The interval in minutes between patient departure from the operating room (OR), and the arrival of the subsequent patient in the OR, i.e., time during which no patient is in the OR.
COVID-light sites	Hospitals or units where only elective surgical patients who do not have COVID-19 are treated.
Getting It Right First Time (GIRFT)	A national programme designed to improve the treatment and care of patients through in-depth review of services.
Turnaround time (TAT)	The interval in minutes between surgical dressing end and surgical incision for the subsequent patient, i.e., time during which no surgery is taking place.

7. ABOUT THE WALES COVID-19 EVIDENCE CENTRE (WCEC)

The WCEC integrates with worldwide efforts to synthesise and mobilise knowledge from research.

We operate with a core team as part of Health and Care Research Wales, are hosted in the Wales Centre for Primary and Emergency Care Research (PRIME), and are led by Professor Adrian Edwards of Cardiff University.

The core team of the centre works closely with collaborating partners in Health Technology Wales, Wales Centre for Evidence-Based Care, Specialist Unit for Review Evidence centre, SAIL Databank, Bangor Institute for Health & Medical Research/ Health and Care Economics Cymru, and the Public Health Wales Observatory.

Together we aim to provide around 50 reviews per year, answering the priority questions for policy and practice in Wales as we meet the demands of the pandemic and its impacts.

Director:
Professor Adrian Edwards

Contact Email:

WC19EC@cardiff.ac.uk

Website:
https://healthandcareresearchwales.org/about-research-community/wales-covid-19-evidence-centre

8. APPENDIX

Appendix 1 Search for existing reviews - Medline search (Proquest)

Set#	Searched for	Results
S1	MJMESH.EXACT.EXPLODE("Surgical Procedures, Operative") OR MESH.EXACT("Elective Surgical Procedures") OR MESH.EXACT.EXPLODE("Orthopedic Procedures")	2220085
S2	ti((procedure* or Surger* or surgical* or surgeon* or operat* or perioperative or intraoperative or postoperative or intrapeorative or replacement* or repair* or reconstruct* or fixat* or fusion*))	1375362
S3	ti(Arthoscop* or Arthroplast* or Acetabuloplast* or Amputation or Disarticulation* or Hemipelvectom* or Arthrodes* or Cementoplast* or Vertebroplast* or Kyphoplast* or Diskectom* or Laminectom* or Meniscectom* or Osteotom* or Synovectom* or Tenodes* or Tenotom*)	91801
S4	S3 OR S2 OR S1	3049195
S5	ti(Technique* or strateg* or intervention* or Innovation* or policy or policies or system* or alternativ* or score* or criteri* or approach* or model or models or solution* or workflow* or plan? or guide? or manag*)	3126435
S6	ti(refer* or schedul* or guideline* or path* or algorithm* or ration* or prioriti* or restructur* or reform* or automat* or progress* or fund* or invest* or private or "independent sector" or telemedicine or “one stop shop” or triage* or program* or allocation or access* or booking* or pooling)	1645184
S7	ti(superclinic* or ((super or virtual) and (clinic*)) or weekend or ((covid* or coronavirus*) and free*) or ((Increas* or ris* or enhanc* or boost* or augment* or additional*) N/5 (capacit* or resoruce* or workforce* or staff* or nurse* or surgeon* or GP* or doctor* or bed* or hour*)))	12783
S8	(MESH.EXACT("Referral and Consultation"))	70448
S9	MESH.EXACT.EXPLODE("Policy")	166277
S10	MESH.EXACT("Telemedicine")	29946
S11	(MESH.EXACT("Critical Pathways"))	7239
S12	(MESH.EXACT("Private Sector"))	9561
S13	(MESH.EXACT.EXPLODE("Private Practice") OR MESH.EXACT.EXPLODE("Hospitals, Private"))	29807
S14	MESH.EXACT("Investments")	8687
S15	MESH.EXACT("Models, Organizational")	19429

S16	S15 OR S14 OR S13 OR S12 OR S11 OR S10 OR S9 OR S8 OR S7 OR S6 OR S5	4767388
S17	ti,su(backlog*) or ti((wait*) and (time* or list* or patient*))	5421
S18	(MJMESH.EXACT("Waiting Lists"))	5154
S19	S18 OR S17	8030
S20	S19 AND S16 AND S4	1173
S21	(MESH.EXACT("Systematic Reviews as Topic"))	6506
S22	DTYPE(systematic review)	167410
S23	TI,SU((Systematic or Cochrane or umbrella or scoping or rapid or integrative or collaborative or qualitative or quantitative or "mixed methods") Near/3 (overview or answer or map or review or meta*))	193274
S24	TI,SU(review Near/2 reviews)	625400
S25	MESH.EXACT.EXPLODE("Meta-Analysis as Topic")	22931
S26	DTYPE(Meta-Analysis)	141192
S27	TI,SU(meta-analys* or metaanalys* or metanaly* or met analy*)	157367
S28	TI,SU((technology near/2 (assessment* or overview*)) OR HTA[*1])	95703
S29	(MESH.EXACT("Technology Assessment, Biomedical"))	10378
S30	jn(Cochrane or "technology assessment")	20368
S31	(MESH.EXACT("Critical Pathways"))	7239
S32	(MESH.EXACT.EXPLODE("Clinical Protocols"))	177892
S33	(MESH.EXACT.EXPLODE("consensus"))	16285
S34	(MESH.EXACT.EXPLODE("Consensus Development Conferences as Topic"))	2961
S35	(MESH.EXACT.EXPLODE("Guidelines as Topic"))	171280
S36	DTYPE(Guideline)	41430
S37	(MESH.EXACT("Health Planning Guidelines"))	4140
S38	DTYPE(Consensus)	12407
S39	TI,SU(position statement* or policy statement* or practice parameter* or best practice*)	16413
S40	TI,SU(standards or guideline or guidelines or consensus*)	1026378
S41	TI,SU((critical or clinical or practice) Near/2 (path or paths or pathway or pathways or protocol*))	40581
S42	TI,SU(care Near/2 (standard or path or paths or pathway or pathways or map or maps or plan or plans))	14710

S43	TI,SU(algorithm* Near/2 (screening or examination or test or tested or testing or assessment* or diagnosis or diagnoses or diagnosed or diagnosing))	7301
S44	TI,SU(algorithm* Near/2 (pharmacotherap* or chemotherap* or chemotreatment* or therap* or treatment* or intervention*))	5464
S45	S44 OR S43 OR S42 OR S41 OR S40 OR S39 OR S38 OR S37 OR S36 OR S35 OR S34 OR S33 OR S32 OR S31 OR S30 OR S29 OR S28 OR S27 OR S26 OR S25 OR S24 OR S23 OR S22 OR S21	2028729
S46	DTYPE(Editorial OR letter OR Comment)	1991101
S47	MESH.EXACT.EXPLODE("Animals") NOT MESH.EXACT("Humans")	4882776
S48	S47 OR S46	6802568
S49	S45 NOT S48	1807434
S50	S49 AND S20	234°

Appendix 2. Search for Covid-light sites – Covid-19 Research Database (Dialog)

Set#	Searched for	Results
S1	all(surger* N/1 hub[*1])	5
S2	ti,ab(((covid* N/2 ligth) or (no[*1] P/1 covid*) or ((free or cold) N/2 covid*) or green) N/4 (site* or hospital[*1] or ward[*1] or facilit* or hub[*1] or environment[*1] or patient[*1] or pathway[*1]))	1519
S3	ti(“cold site*” and covid*)	8
S4	ti((procedure* or Surger* or surgical* or surgeon* or operat* or perioperative or intraoperative or postoperative or intrapeorative or replacement* or repair* or reconstruct* or fixat* or fusion* or theater*))	9709
S5	ti(Arthoscop* or Arthroplast* or Acetabuloplast* or Amputation or Disarticulation* or Hemipelvectom* or Arthrodes* or Cementoplast* or Vertebroplast* or Kyphoplast* or Diskectom* or Laminectom* or Meniscectom* or Osteotom* or Synovectom* or Tenodes* or Tenotom*)	142
S6	MJMESH.EXACT.EXPLODE("Surgical Procedures, Operative") OR MESH.EXACT("Elective Surgical Procedures") OR MESH.EXACT.EXPLODE("Orthopedic Procedures")	747
S7	S3 OR S2 OR S1	1525
S8	S6 OR S5 OR S4	10023
S9	S8 AND S7	151