Effect of the surgical safety checklist on provider and patient outcomes: a systematic review

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Supplementary Material

Search strategy

Medline (OVID)

1 surgical checklist*.af. (198)
2 exp Surgical Procedures, Operative/ (3064537)
3 surger*.ti,ab,kf. (1206480)
4 surgical.ti,ab,kf. (941134)
5 Operating theat:.ti,ab,kf. (4939)
6 Operating Rooms/ (13446)
7 operating room*.ti,ab,kf. (27127)
8 operating theater.ti,ab,kf. (954)
9 operating theatr*.ti,ab,kf. (3842)
10 or/2-9 (3940858)
11 checklist/ (6007)
12 checklist*.ti,ab,kf. (36856)
13 check list*.ti,ab,kf. (3040)
14 or/11-13 (41310)
15 10 and 14 (5103)
16 1 or 15 (5103)
17 surgeons/ (6374)
18 surgeon*.ti,ab,kf. (193717)
19 surgical.ti,ab,kf. (941134)
20 surger*.ti,ab,kf. (1206480)
21 or/17-19 (1059947)
22 briefing.ti,ab,kf. (1212)
23 debreif*.ti,ab,kf. (0)
24 sign-in.ti,ab,kf. (5844)
25 pause.ti,ab,kf. (6023)
26 sign-out.ti,ab,kf. (394)
27 Time out.ti,ab,kf. (1515)
28 22 or 23 or 24 or 26 or 27 (8872)
29 21 and 28 (845)
30 17 or 29 (5763)
31 Comment/ (822610)
32 Letter/ (1057769)
33 Editorial/ (513974)
34 exp Case Reports/ (2068196)
35 31 or 32 or 33 or 34 (3655388)
36 30 not 35 (5305)
37 remove duplicates from 36 (5283)

CINAHL

S1	"surgical checklist" (70)
S2	(MH "Surgery, Operative+"; 589,405)
S3	(MM "Operating Rooms") OR (MH "Operating Room Personnel+") OR (MM "Perioperative Nursing"; 32,194)
S4	TI operative or operating or surgical or surgery (134,913)
S5	S2 OR S3 OR S4 (658,337)
S6	(MM "Checklists"; 1,943)
S7	SU (operative or perioperative or surgical) AND SU (checklist or check list or brief* or debreif* or sign-in or sign out or pause or timeout or time out; 60)
S8	S6 OR S7 (2,001)
S9	S5 AND S8 (589)
S10	S1 OR S9 (613)
S11	S1 OR S9

Embase

1	surgical checklist.af. (246)
2	exp operating room/ (37886)
3	(operating adj2 (room* or theater or theatre)).ti,ab. (44114)
4	operative period.ti,ab. (10181)
5	exp surgery/ (5118877)
6	exp surgeons/ (155804)
7	surger*.ti,kw. (582597)
8	surgical.ti,kw. (348618)
9	surgeon*.ti,kw. (35318)
10	or/2-9 (5306586)
11	exp checklist/ (23200)
12	(Checklist or check list).ti,kw. (7736)
13	exp operating room/ (37886)
14	surgical team.ti,kw. (389)
15	exp surgical nursing/ (208)
16	(surgeon or surger* or surgical or operating).ti,kw. (917898)
17	13 or 14 or 15 or 16 (941172)
18	(brief* or briefing).ti,kw. (37420)

19 (debrief* or debriefing).ti,kw. (1117)
20 pause.ti,ab,kw. (8511)
21 (sign in or sign out).ti,kw. (3132)
22 (timeout or time out).ti,kw. (594)
23 18 or 19 or 20 or 21 or 22 (50693)
24 17 and 23 (1068)
25 11 or 12 or 24 (28238)
26 10 and 25 (5680)
27 limit 26 to (books or chapter or conference abstract or conference paper or "conference review" or editorial or letter or note or short survey or tombstone) (2845)
28 26 not 27 (2835)

PsycINFO

1 surgical checklist*.af. (35)
2 surger*.ti,ab. (24985)
3 surgical*.ti,ab. (17424)
4 Operating theat:.ti,ab. (182)
5 operating room*.ti,ab. (466)
6 2 or 3 or 4 or 5 (36722)
7 exp "Checklist (Testing)"/ (3105)
8 checklist*.ti,ab. (25069)
9 check list*.ti,ab. (1990)
10 surgical team*.ti,ab. (126)
11 surgical nursing.ti,ab. (71)
12 10 or 11 (196)
13 briefing.ti,ab. (337)
14 debriefing.ti,ab. (2277)
15 pause.ti,ab. (1723)
16 sign-in.ti,ab. (487)
17 sign-out.ti,ab. (35)
18 Time out.ti,ab. (1000)
19 13 or 14 or 15 or 16 or 17 or 18 (5794)
20 12 and 19 (10)
21 7 or 8 or 9 or 20 (27081)
22 6 and 21 (306)
23 1 or 22 (328)
24 limit 23 to (bibliography or chapter or clarification or "column/opinion" or "comment/reply" or editorial or encyclopedia entry or interview or letter or obituary or review-book or review-media or review-software & other) (15)
25 23 not 24 (313)

PubMed

Results: 865

(((checklists[MeSH Terms]) AND (surgical or surgery or operating room))) AND (perioperative care OR surgical nursing or patient safety)

Scopus

Results 3997

(TITLE-ABS-KEY (surgical AND checklist*) OR TITLE-ABS-KEY ((surgery OR surgeries OR surgical OR surgeon* OR operation OR operating)) AND TITLE-ABS-KEY (checklist)) AND (LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "NURS"))

Web of Science

Results: 1,393

Refined by: Web of Science categories: (SURGERY OR ANESTHESIOLOGY OR MEDICINE

GENERAL INTERNAL OR HEALTH CARE SCIENCES SERVICES)

Timespan: All years. Indexes: SCI-EXPANDED, SSCI.

Supplementary Methods

Study selection

Inter-rater reliability (IRR), that is the average agreement and a kappa coefficient representing both the accuracy and reliability of choice between two raters (0 = no agreeance or reliability; 1 = perfect agreeance and reliability), was calculated for each review stage (title/abstract: 93% IRR, .73 kappa; full text: 80% IRR, .61 kappa; data extraction: 94% IRR, .86 kappa), with substantial agreement achieved at each stage. All discrepancies were resolved through discussion with the final selection of studies representing 100% agreement amongst reviewers.

Data extraction and coding

For all studies, descriptive study information and outcome variable results were extracted. Key potential moderating factors extracted included the following: **sample size** was categorized as low (0-1000), medium (1,001-10,000) and high (10,001+) for objective studies, and low (0-100), medium (101-1,000), and high (1,001+) for subjective studies; **checklist component** represented the pause points of the checklist that were reported on and were categorized as follows: all = all three components, sign-in, time-out, sign-out or a combination of two components such as sign-in and time-out or time-out and sign-out; **compliance** rates were categorized as low (0-50% compliance), medium (51-75% compliance) and high (76-100% compliance); **checklist type** was categorized as yes (original WHO SSC was used), modified WHO (original WHO SSC was modified), or no (a checklist other than the WHO was used); **surgical risk** was categorized as low risk (superficial procedures, breast surgery, cataract surgery, endoscopic procedures, most ambulatory surgeries or oral surgery), intermediate risk (carotid endarterectomy, head and neck surgery, intraperitoneal or intrathoracic surgery,

orthopedic surgery, prostate surgery, neurosurgery, interventional radiology or cardiology) and high risk (aortic or other major vascular surgery, peripheral vascular surgery, trauma, hepatobiliary, and cardiac surgery; 1); **observer present** was categorized as a third-party researcher being either present in the OR (yes) or absent (no); **attention** was categorized as yes (team paid attention as the SSC was being conducted), no (team did not pay attention as the SSC was conducted), or mixed (some team members paid attention, while others did not while the SSC was conducted); **attitudes** were categorized as positive (positive attitudes towards SSC), negative (negative attitudes towards SSC), or mixed (positive and negative attitudes towards SSC); **location income level** categorized into low, lower middle, upper middle, high and mixed income economies based on the World Bank Atlas method (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).

Studies that reported on complications and mortality commonly measured those variables as primary outcomes. Studies that reported on CUSC did not measure CUSC as primary outcomes but rather briefly mentioned them in addition to their primary interests. Therefore, studies that reported any impact the SSC had on CUSC were extracted and the results were categorized as follows: decreased, increased, no change or mixed results. Studies that implemented the SSC and reported on complications and mortality rate were also extracted, with the direction of statistically significant results categorized as follows: increased, decreased, no change or mixed results.

That is, the population, exposure, comparison, and outcome (PECO) that structured this systematic review was as follows:

- Population: staff that represented a surgical team

- Exposure: surgical safety checklist
- Comparisons: sample size, checklist component, compliance rates, checklist type, surgical risk, observer present, attention, attitudes, economic income-level
- Outcome: communication, shared understanding of the case, safety culture, patient complications, and mortality rate

Analytic plan

The systematic review included all 300 studies in the analysis. Reports of the SSCs' effect on the surgical teams' CUSC and statistical directional findings (e.g., a significant decrease in patient complications after SSC implementation) of complications and mortality were extracted and used as primary and secondary outcomes, respectively. Variables that potentially moderate the effect of the SSC on CUSC, complications and mortality were also extracted and analyzed.

Quality assessment

The NIH scale consisted of 12 questions in which reviewers had to answer yes or no for each question. Based on their ratings, reviewers had to assign the article an overall score of either poor, fair, or good, which were then categorized to low, medium, and high, respectively, to synchronize overall ratings with the other tools. The NOS consisted of 8 questions for both case-control and cohort studies with 10 representing the highest score. Overall quality scores were categorized as follows: 0-6 = low; 7-8 = medium; 9-10 = high. The Nagpal tool was used for studies reporting subjective data such as surveys or questionnaires. It consisted of 12 questions in which reviewers had to assign a 0, 1, or 2 to each, and with 24 representing the highest possible score. Overall quality scores were categorized as follows: 0-7 = low; 8-15 medium; 16-24 = high.

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Table S1. Data extracted from each study included in the systematic review

Author	Study Type	Surgery Type	Sample Size	Component, Type, Who	Extraction Method	Everyone who was present	Observer in Room	% Compliance	Attention, Attitude	Location, Income	Communication, Understanding, Culture	Complications, Mortality	Risk of Bias

Abdel-Rehim et al. (2011)[1]	Direct	Plastic surgery	90 participants	All, modified, n/a	Audit	--	--	O: 82% SI: 100% TO: 80% SO: 96%	--	UK, high	--	N/a, improved	L
Alidina et al. (2017)[2]	Indirect	Mixed	1909 participants	--	Survey	Surg, anes, certified registered nurse anes, nurses, technicians	--	--	N/a, positive	--	Worsened, n/a, worsened	--	M
Allard et al. (2007)[3]	Direct	Mixed	118 participants	Briefing, no, n/a	Survey, observation, interviews	Surg, anes, theatre practitioners (scrub & anes)	Yes	O: n/a SI: n/a TO: 18% SO: n/a	N/a, mixed	UK, high	Improved, n/a, improved	--	M
Allard et al. (2011)[4]	Indirect	Mixed	597 participants	Briefing, no, n/a	Questionnaire	OT practitioners	No	--	--	UK, high	N/a, n/a, no change	--	M
Alloni et al. (2016)[5]	Indirect	Mixed	100 records 34 participants, 44 respondents	All, n/a, n/a	Records, survey	Surg, nurse	--	--	Yes, mixed	Italy, high	N/a, n/a, improved	--	L
Almeida et al. (2019)[6]	Direct	Pediatric	431 surgeries	All, yes, nurse	Observation	Surg, nurses, nursing assistants, anes, residents	Yes	O: 19l.9% SI: 85.5% TO: 0% SO: 32.0%	--	Brazil, upper-middle	--	--	L
Al-Qahtani (2017)[7]	Direct	Ear, nose, throat	5144 procedures	All, modified, n/a	Chart review, audit	Surg, anes, nurse	No	O: 98.4% SI: n/a TO: n/a SO: n/a	--	Saudi Arabia, high	--	--	L
Ambulkar et al. (2018)[8]	Direct	Oncology	352 patients 600 procedures	All, modified, surg, nurse and/or anes	Observation	Surg, anes, nurse	Yes	O: n/a SI: 100% TO: 78% SO: 76.5%	--	India, lower-middle	--	--	L
Anderson et al. (2018)[9]	Direct	Pediatric	591 procedures	TO, no, n/a	Observation, audits	--	Yes	O: n/a SI: n/a TO: 96.3% SO: n/a	--	USA, high	--	--	L

Anwer et al. (2016)[10]	Indirect	General	3638 patients	All, yes, n/a	chart review	--	No	O: 56.6% SI: n/a TO: n/a SO: n/a	--	Pakistan, lower-middle	--	Improved, no change	L
Askarian et al. (2011)[11]	Indirect	--	150 patients	All, modified, n/a	Chart review	Surg, anes, nurses	--	--	--	Iran, upper-middle	--	Improved, n/a	H
Aveling et al. (2013)[12]	Direct	Mixed	39 participants	All, modified, n/a	Interviews (semi-structured), observation, informal discussions, review of documentation	Surg, anes, managers/administrator, nurses, theatre practitioners	Yes	--	Yes, mixed	UK and Indirect Saharan African country (anonymized for confidentiality), mixed	--	--	M
Barbanti-Brodano (2019)[13]	Indirect	Spine	632 procedures	All, yes, n/a	Chart review	--	No	--	--	Italy, high	--	Improved, n/a	H
Bartz-Kurycki et al. (2017)[14]	Direct	Mixed (pediatric)	603 procedures	TO, modified, nurse, surg, anes	Observation	Surg, anes scrub technologist	Yes	O: n/a SI: n/a TO: n/a SO: 91.9%	--	USA, high	--	--	L
Bartz-Kurycki et al. (2018)[15]	Direct	Pediatric (non-emergent)	484 procedures	SI, modified, nurse and/or anes	Observation/audits	Nurse, anes	Yes	O: n/a SI: 41% TO: n/a SO: n/a	--	USA, high	--	--	L
Bashford et al. (2014)[16]	Direct	Plastic	289 procedures 19 questionnaires	All, modified, n/a	Observation, questionnaire	Surg, anes, nurse	Yes	O: 65% SI: 20% TO: 46% SO: 34%	N/a, positive	Ethiopia, low	--	--	M
Bergs et al. (2015)[17]	Indirect	--	36 hospitals	All, modified, n/a	Questionnaire	--	No	O: 69.4% SI: 48.6% TO: 25.7% SO: 37.1%	Improved, n/a	Belgium, high	--	--	M
Berrisford et al. (2012)[18]	Indirect	Thoracic	990 patients	TO, n/a, n/a	Hospital database	Surg, anes, nurse, operating department assistant	--	O: n/a SI: n/a TO: 96.8% SO: n/a	Yes (increased), n/a	UK, high	--	--	L
Biffl et al.	Direct	Mixed	854	N/a,	Observatio	Surg, anes,	Yes	--	No,	USA,	--	--	L

(2015)[19]			procedures	modified, n/a	n	nurse			n/a	high			
Birnbach et al. (2017)[20]	Indirect	Mixed	150 participants	TO, n/a, n/a	Interview	Surg, anes, resident, nurse	No	--	--	USA, high	Worsened, n/a, n/a	--	M
Biskup et al. (2016)[21]	Indirect	Plastic	Before: 2166 procedures; after: 2310 procedures	All, modified, n/a	Hospital records	--	--	--	--	USA, high	N/a, n/a, Improved	No change, n/a	M
Bliss et al. (2012)[22]	Direct	General	73 procedures	All, modified, n/a	Observation, hospital records (ACS NSQIP)	Nurse	Yes	O: 97.3% SI: n/a TO: n/a SO: n/a	--	USA, high	--	--	L
Boaz et al. (2014)[23]	Indirect	Orthopedic	380 procedures	TO, modified, n/a	Chart review	Surg, anes, nurse	No	--	--	Israel, high	--	Worsened, improved	M
Bock et al. (2016)[24]	Indirect	Mixed	5297 patients	All, modified, nurses and/or surg	Admin record	Physicians, nurses	No	O: 89.4% SI: n/a TO: n/a SO: n/a	--	Italy, high	--	No change, n/a	H
Bohmer et al. (2012)[25]	Indirect	Orthopedic	71 participants	All, modified, n/a	Questionnaire	Medical staff and other personnel involved in surgery/in the OR	No	--	N/a, positive	Germany, high	Improved, improved, n/a	--	L
Bohmer et al. (2013)[26]	Indirect	Orthopedic	99 participants	All, modified, n/a	Questionnaire	Physician, anes	No	--	--	Germany, high	Improved, improved, n/a	--	M
Borgmann et al. (2015)[27]	Indirect	Urology	--	All, yes, surg, nurse, anes	Survey	--	--	O: 91% SI: n/a TO: n/a SO: n/a	N/a, positive	Germany, high	--	--	M
Braaf et al. (2013)[28]	Indirect	--	125 participants	TO, n/a, n/a	Focus group, interview	Healthcare professionals	Yes	O: n/a SI: n/a TO: 10% SO: n/a	--	--	Worsened, n/a, no change	--	H
Cabral et al. (2016)[29]	Indirect	--	93 participants	N/a, modified,	Questionnaire (safety	Surgical team	--	--	--	USA, high	Improved, n/a,	--	M

				n/a	attitudes questionnaire)	members					no change		
Carpenter et al. (2017)[30]	Direct	--	--	All, modified, surg	Observation	Surg, anes, nurse	Yes	O: improved substantially SI: n/a TO: n/a SO: n/a	Yes, positive	USA, high	Improved, improved, improved	--	L
Catchpole et al. (2010)[31]	Direct	Maxillofacial, vascular, pediatric	61 procedures	All, no, n/a	Questionnaires, observation	--	Yes	O: n/a SI: 58% TO: 66% SO: 32%	N/a, positive	UK, high	No change, n/a, n/a	--	M
Cavallini et al. (2013)[32]	Indirect	Ophthalmology	849 procedures	All, modified, n/a	Documentation system	Surg, anes, nurse	No	--	--	Italy, high	--	Improved, n/a	L
Chaudhary et al. (2015)[33]	Indirect	Gastro-intestinal	350 participants (control) 350 participants (SSC)	All, modified, n/a	Electronic database	Surg, anes, nurse	No	Braaf	--	India, lower-middle	Improved, n/a, n/a	Improved, improved	M
Chhabra et al. (2019)[34]	Indirect	--	Before: 250 patients; after: 250 patients	All, yes, n/a	Chart review	Surg, anes, nurse	No	--	--	India, lower-middle	--	Improved, n/a	L
Close et al. (2017)[35]	Indirect	Mixed	21 hospitals	All, yes, n/a	Survey, focus group	--	No	--	--	Madagascar, low	Improved, n/a, n/a	--	H
Conley et al. (2011)[36]	Indirect	--	10 participants	N/a, yes, n/a	Interviews (semi-structured)	Surg, anes, nurse	No	--	--	USA, high	--	--	L
Correia et al. (2019)[37]	Indirect	Mixed (mostly general)	171 participants (surgeons)	All, yes, n/a	Questionnaire	Active and non-active Brazilian College of Surgeons members	No	O: 78.4% SI: n/a TO: n/a SO: n/a	N/a, positive	Brazil, upper-middle	--	--	M
Corso et al. (2014)[38]	Indirect	Interventional radiology	112 procedures	TO, modified, n/a	Questionnaire (attitudes) questionnaire, compilation rate	Interventional radiologists, nurses, radiographer, neuro-radiologist	--	--	N/a, mixed	--	--	--	L

					evaluation								
Cullati et al. (2013)[39]	Direct	Mixed	TO: 80 periods; SO: 81 periods	TO, yes, surg operator, scrub nurse, anes nurse	Observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 84% SO: 58%	--	Switzerland, high	Worsened, n/a, n/a	--	L
Cullati et al. (2014)[40]	Indirect	Mixed	152 participants	All, yes, n/a	Questionnaire	Surg, anes	--	--	N/a, positive	Switzerland, high	Improved, n/a, improved	--	M
Cunat et al. (2011)[41]	Direct	Mixed	934 procedures	All, no, n/a	Chart review, observation, interview	--	Yes	O: 86% SI: n/a TO: n/a SO: n/a	--	France, high	--	--	L
Dabholkar et al. (2018)[42]	Indirect	Otolaryngology	37 participants; 126 procedures	All, modified, n/a	Survey	Surg, anes, nurse	Yes	--	Improved, n/a	India, lower-middle	Improved, n/a, n/a	--	M
Dackiewicz et al. (2012)[43]	Direct	Mixed	387 procedures	All, yes, n/a	Observation	--	Yes	--	--	Argentina, upper-middle	--	--	L
Dayuta et al. (2013)[44]	Direct	Mixed	14,000 procedures	SI and TO, no, surg (SI) and anes (TO)	Observation, nursing care record review	Surg, anes, nurse	Yes	O: n/a SI: 98% TO: 98% SO: n/a	--	Singapore, high	Improved, n/a, n/a	--	M
De Freitas et al. (2014)[45]	Indirect	Gynecology, urology	375 procedures	All, modified, nurse and/or surg	Chart review, checklist review	Surg, nurse, resident	No	O: 61% SI: 3% TO: 13% SO: 28%	--	Brazil, upper-middle	--	--	L
De Oliveira Junior et al. (2017)[46]	Direct	Mixed	--	All, yes, n/a	Focus groups, observation	Nursing technicians	--	--	N/a, mixed	Brazil, upper-middle	--	--	M
De Vries et al. (2010)[47]	Indirect	General	Before: 4364; after: 4387	N/a, no, n/a	Chart review	Ward doctor, nurse, surg, anes, operating assistant	No	O: 80% SI: n/a TO: n/a SO: n/a	--	Netherlands, high	--	Mixed, improved	H
De Vries et al. (2010)[48]	Indirect	General, vascular	Before: 369 procedures; after: 403	N/a, no, n/a	Chart review	Surg, anes, operating assistant	Yes	--	--	Netherlands, high	--	--	M

			procedures										
De Vries et al. (2012)[49]	Indirect	Mixed (mostly general)	6313 procedures	N/a, no, n/a	Checklist review	Surg, anes, operating assistant, ward doctor, ward nurse	No	O: 72.2% SI: n/a TO:82.9% SO: n/a	--	Netherlands, high	--	--	M
Defontes et al. (2004)[50]	Direct	--	--	TO, no, surg, nurse, anes	Questionnaire (safety attitudes questionnaire), risk data reports	Surg, anes, nurse (surg & anes)	No	--	N/a, positive	USA, high	Improved, improved, improved	Improved, n/a	M
Delisle et al. (2020)[51]	Direct	Mixed	85,957 patients	All, modified, n/a	Multiple previous GlobalSurg and Surgical Outcomes studies	--	No	O: 79.1% SI: n/a TO: n/a SO: n/a	--	Multi-Country (Europe, Africa, etc.), mixed	--	--	M
Dell'Atti (2013)[52]	Direct	Urology	324 patients	All, modified, n/a	--	Surg, anes, nurse	No	--	--	Italy, high	--	Improved, improved	L
Dharampal et al. (2016)[53]	Indirect	Mixed	--	All, modified, n/a	Interview (transcribed)	Surg, anes, nurse	--	--	N/a, mixed	Canada, high	Improved, n/a, improved	N/a, worsened	H
Diedhiou et al. (2017)[54]	Direct	--	474 procedures	All, no, n/a	--	Surg, anes, nurse	No	O: 60% SI: n/a TO: n/a SO: n/a	--	Senegal, lower-middle	--	--	L
Dixon et al. (2013)[55]	Direct	Mixed	40 procedures	TO, yes, circulating nurse	Survey, observation	Surg, anes, nurse	Yes	--	N/a, positive	USA, high	--	--	M
Dixon et al. (2016)[56]	Direct	Mixed	80 procedures	TO, modified, n/a	Observation, questionnaire	Surg, anes, nurse, scrub technician	Yes	--	Yes, positive	USA, high	N/a, n/a, no change	--	M
Dobbie et al. (2019)[57]	Direct	--	--	TO, modified, nurse	Observation, records	Surg, anes, nurse	No	O: n/a SI: n/a TO: 95% SO: n/a	--	USA, high	--	--	L
Dommaraju	Direct	--	100	TO,	Observatio	--	Yes	O: n/a	--	USA,	Improved,	--	M

et al. (2019)[58]			procedures; 137 participants	no, n/a	n, survey			SI: n/a TO: 100% SO: n/a		high	improved, n/a		
Duclos et al. (2016)[59]	Indirect	Mixed	8623 patients	All, n/a, n/a	Computerized case report forms	Surg, anes, nurse, quality manager	No	O: 83.2% SI: n/a TO: n/a SO: n/a	--	France, high	--	Improved, no change	H
Einav et al. (2010)[60]	Direct	Mixed (gynecology, orthopedic)	Before: 130 procedures; after:102 procedures	TO, n/a, n/a	Observation	Surg, anes, nurse	--	--	--	Israel, high	--	Improved, n/a	H
Ellis et al. (2017)[61]	Direct	General, gynecology	Phase I: 30 patients	All, modified, n/a	Observation, checklist completion	Surg, nurse	Yes	O: 50% (phase I), 98.5% (phase II) SI: 47% TO: 87% SO: 73%	N/a, positive	Ethiopia, low	Worsened, n/a, n/a	--	L
Epiu et al. (2016)[62]	Indirect	Obstetrics	85 participants (anes)	All, yes, n/a	Survey, interviews	--	No	--	--	East Africa (Uganda, Kenya, Tanzania, Rwanda, Burundi), mixed	--	--	M
Epiu et al. (2018)[63]	Indirect	--	64 hospitals	N/a, yes, n/a	Survey, interviews	--	No	O: 34.4% SI: n/a TO: n/a SO: n/a		Uganda, low	--		M
Erestam et al. (2017)[64]	Indirect	--	Before:150; after:143	All, modified, n/a	Questionnaire	Surg, anes, nurse (scrub, anes, assistants)	No	--	--	--	No change, n/a, no change	--	M
Fatima et al. (2018)[65]	Direct	Mixed	55 procedures	All, yes, n/a	Observation, interviews	Surg, anes, nurse, operation theatre assistant	Yes	--	--	Pakistan, lower-middle	--	--	L
Finch et al. (2019)[66]	Direct	--	506 forms	Debriefing, modified, n/a	Audit	Surg, resident, anes, surg technologis	No	O: n/a SI: n/a TO: n/a SO: 95%	--	USA, high	--	--	M

						t, nurse							
Forrester et al. (2018)[67]	Direct	Mixed	302 procedures	All, modified, n/a	Observation, staff interviews	Surg, anes, nurse, administration	Yes	O: 79% SI: n/a TO: n/a SO: n/a	--	Ethiopia, low	--	--	H
Forsyth et al. (2019)[68]	Direct	Gynecology	45 procedures	Briefing, no, surg	Video recording, survey	Surg, resident, anes, certified registered nurse anes, circulating nurse, certified surgical assistant, certified surgical technologist	Yes	--	--	USA, high	--	--	L
Fourcade et al. (2012)[69]	Direct	Mixed	1440 procedures	All, modified, n/a	Interviews, questionnaire, observation	Surg, anes, nurse, quality manager	Yes	O: 90.2% SI: 77.4% TO: 77.4% SO: 52.6%	Yes, n/a	France, high	--	--	L
Freedman et al. (2017)[70]	Direct	--	1116 procedures	All, yes, n/a	Observation, checklist completion	--	Yes	O: 52% SI: 63% TO: n/a SO: n/a	--	Uganda, low	--	--	L
Freundlich et al. (2020)[71]	Direct	--	166 procedures	TO, modified, nurse	Observation	Surg, anes, nurses, scrub technicians	Yes	O: n/a SI: n/a TO: 98.2% SO: n/a	--	USA, high	--	--	L
Fyfe et al. (2013)[72]	Direct	Oral	--	N/a, modified, nurses	Audit	Surg, nurse	No	O: 100% SI: n/a TO: n/a SO: n/a	N/a, positive	UK, high	--	--	L
Gagliardi et al. (2014)[73]	Indirect	--	51 participants	--	Interviews (qualitative)	Surg, anes, nurse	--	--	Improved, mixed	Canada, high	Improved, n/a, n/a	--	M
Gagne et al. (2015)[74]	Direct	Neurosurgery	171 procedures	All, modified, nurse or anes (SI), surg, nurse,	Observation	Surg, anes, resident, nurse	Yes	O: n/a SI: 82% TO: 99% SO: 93%	--	Canada, high	--	--	L

				anesthesia (TO, SO)									
Gama et al. (2019)[75]	Indirect	Colorectal	Before: 348 procedures; after:1012 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	No	O: 98.8% (Canada) and 64% (Brazil) SI: n/a TO: n/a SO: n/a	--	Canada and Brazil, mixed	--	No change, n/a	H
Garland et al. (2017)[76]	Direct	Orthopedic	--	All, modified, surg, nurses, anes	Observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: >99% SO: n/a	N/a, mixed	Cambodia, lower-middle	--	--	L
Georgiou et al. (2018)[77]	Indirect	--	23 participants (nurses)	N/a, yes, circulating nurse	Focus groups (qualitative)	Surg, anes, nurse	No	--	N/a, mixed	Cyprus, high	Worsened, n/a, n/a	--	M
Geraghty et al. (2014)[78]	Indirect	Urology	28 participants	--	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	UK, high	--	--	M
Giles et al. (2017)[79]	Direct	Mixed	103 procedures (11 hospitals)	All, mixed, n/a	Observation, audit medical records	--	Yes	O: 27% (observed), 86% (medical record audit) SI: 16.6% TO: 36.7% SO: 21.3%	--	Australia, high	--	--	L
Gillespie et al. (2010)[80]	Indirect	Mixed	16 participants	TO, no, n/a	Individual and group interviews	Surg, anes, nurse, nurse manager	No	--	N/a, negative	Australia, high	Worsened, n/a, n/a	--	M
Gillespie et al. (2016)[81]	Direct	Mixed; except transplant	70 participants	All, yes, n/a	Observation, field notes, individual and group interviews	Surg, anes, nurse	Yes	--	Yes, n/a	Australia, high	--	--	M
Gillespie et al. (2016)[82]	Direct	Mixed	80 participants observed; 70	All, modified, n/a	Observation, field notes, individual	Surg, anes, nurse (anes, scrub, scout,	Yes	--	--	Australia, high	--	--	M

			participants interviewed		and group interviews	PACU, management/education), patients							
Gillespie et al. (2017)[83]	Direct	Mixed (cardiac, hepatobiliary, upper gastrointestinal, vascular)	179 participants (before: 99 procedures; after: 80 procedures)	All, yes, n/a	Observation, field notes	surg, anes, nurse	Yes	O: n/a SI: 100% TO: 85% SO: 33.8%	--	Australia, high	--	--	M
Gillespie et al. (2017)[84]	Direct	Mixed (cardiac, hepatobiliary, upper gastrointestinal, vascular)	179 participants (before: 99 procedures; after: 80 procedures)	N/a, yes, n/a	Observation, survey, interview (semi-structured)	Surg, anes, nurses (scrub, circulating, anes)	Yes	O: n/a SI: 100% TO: 85% SO: 33.8%	--	Australia, high	No change, n/a, no change	--	H
Gillespie et al. (2018)[85]	Direct	Mixed	77 surgical teams	All, modified, anesthetic nurse (SI), surg (TO), circulating nurse (SO)	Electronic database audit, observation	Surg (consultant, registrar, resident medical officer), anes (consultant, registrar, resident medical officer), nurse (anes, scrub, scout), theatre assistant	Yes	O: 75.9-82.8% SI: 74.7% TO: 200% SO: 94.5%	--	Australia, high	--	--	M
Gillespie et al. (2018)[86]	Indirect	--	59 participants surveyed; 26 participants interviewed	All, modified, circulating or anes nurse (SI), circulating nurse or surg (TO), circulating	Individual and focus group interviews, survey	Medical, nursing and operational (i.e., porters and administration officers) staff	No	--	Improved, n/a	Australia, high	--	--	M

				nurse (SO)									
Gillespie et al. (2019)[87]	Indirect	Mixed	Before: 16262 procedures; after: 16755 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	No	--	--	Australia, high	--	--	M
Gitelis et al. (2017)[88]	Direct	Mixed	1204 patients	All, modified, surg, nurse and/or anes	Observation, survey, electronic records	Surg, anes, nurse	Yes	O: 48% (paper checklist), 92% (electronic checklist) SI: n/a TO: n/a SO: n/a	--	USA, high	--	--	M
Globalsurg Collaborative (2016)[89]	Indirect	Intra-peritoneal	10,745 procedures	N/a, yes, n/a	Chart review	Surg, anes	No	--	--	--	--	N/a, improved	M
Globalsurg Collaborative (2019)[90]	Indirect	Intra-peritoneal and gastrointestinal, excluding laparoscopy	12,296 patients	N/a, yes, n/a	Chart review	--	No	--	--	--	--	N/a, improved	M
Goransson et al. (2016)[91]	Indirect	General (abdominal)	17 participants	All, yes, n/a	Survey, interview	--	--	--	--	Sweden, high	--	--	M
Govindappagari et al. (2016)[92]	Indirect	Obstetric	600 procedures	All, modified, n/a	Data form	Surg, anes, nurse, pediatrician	--	--	--	--	--	--	M
Gueguen et al. (2011)[93]	Indirect	Pediatric, ophthalmic, neurosurgery	28 medical files; 80 participants	N/a, no, n/a	Medical file analysis, survey	OR personnel	--	O: 70% (hospital 1), 20% (hospital 2) SI: n/a TO: n/a SO: n/a	--	--	Improved, n/a, n/a	--	M
Hacquard et al. (2013)[94]	Indirect	Mixed	170 participants	All, yes, surg, nurses,	Questionnaire, observation	OR personnel	No	--	--	France, high	Worsened, n/a, n/a	--	L

				anes	, audit								
Hafeez et al. (2016)[95]	Indirect	--	--	All, n/a, n/a	Questionnaire	Surg, anes, nurses, support staff	--	--	--	--	--	--	L
Hang et al. (2018)[96]	Direct	Obstetric, gynecology	--	All, n/a, n/a	--	--	--	--	--	--	--	--	L
Hanna et al. (2014)[97]	Direct	--	--	All, yes, n/a	--	Surg, anes, theatre staff	--	O: n/a SI: n/a TO: n/a SO: 10%	--	--	--	--	L
Hannam et al. (2013)[98]	Direct	Mixed (general, orthopaedic, plastic, urology, vascular, neurosurgery, gynecology)	200 procedures (100 per hospital)	All, modified, surg, nurses, anes	Observation	Surg, anes, nurse	Yes	O: n/a SI: 96% (hospital 1), 31% (hospital 2) TO: 99% (hospital 1), 48% (hospital 2) SO: 22% (hospital 1), 9% (hospital 2)	Yes, n/a	New Zealand, high	--	--	L
Haridarshan et al. (2018)[99]	Indirect	General	464 patients (before: 216; after: 248)	All, yes, n/a	Data forms, chart review	Surg, anes, theatre staff	--	--	Yes, n/a	India, lower-middle	Improved, n/a, n/a	Improved, improved	M
Haugen et al. (2013)[100]	Indirect	Mixed	641 participants	All, modified, anes (SI), nurse (TO, SO)	Chart review, survey	Surg, anes, nurse, ancillary personnel	No	O: 75% SI: 85% TO: 84% SO: 77%	--	Norway, high	No change, n/a, no change	--	M
Haugen et al. (2013)[101]	Indirect	Mixed	427 participants	TO, no, n/a	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	Norway, high	N/a, n/a, no change	--	M
Haugen et al. (2015)[102]	Indirect	Mixed (cardiothoracic, neurosurgery, orthopedic, general,	Before: 2212 procedures; after: 3083 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	No	--	--	Norway, high	--	Improved, no change	H

		urology)											
Haugen et al. (2015)[103]	Indirect	Mixed	--	All, yes, n/a	Qualitative, focus group interviews	Surg, anes, nurse	No	--	Improved, mixed	Norway, high	Improved, improved, improved	--	M
Haugen et al. (2019)[104]	Indirect	Mixed (cardiothoracic, neurosurgery, orthopedic, general, urology)	2304 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	Yes (to provide feedback only, not to record data points)	O: 75.7% SI: n/a TO: n/a SO: n/a	--	Norway, high	--	Improved, n/a	H
Hawranek et al. (2015)[105]	Indirect	Cardiac	1053 patients	All, no, surg and nurses	Chart review	Doctor, nurse, medical technician	No	--	--	Poland, high	--	Improved, n/a	L
Haynes et al. (2009)[106]	Direct	Mixed (non-cardiac)	7688 procedures	All, yes, n/a	Chart review, observation	Surg, anes, nurse	Yes	--	--	Canada, India, Jordan, New Zealand, Philippines, Tanzania, England, USA, mixed	--	Improved, improved	H
Haynes et al. (2011)[107]	Indirect	--	538 participants	N/a, yes, n/a	Chart review, questionnaire	Surg, anes, nurse, surg technologist, trainee	No	--	N/a, positive	USA, high	Improved, n/a, improved	Improved, n/a	H
Haynes et al. (2017)[108]	Indirect	Mixed, excluding obstetric	109,720 patients	All, yes, n/a	Chart review	--	No	--	--	USA, high	--	N/a, improved	M
Hellar et al. (2020)[109]	Direct	--	14,580 procedures	N/a, yes, n/a	Self-reported data, observation, audits	Surg, anes, nurse	Yes	O: 89% SI: n/a TO: n/a SO: n/a	--	Tanzania, high	--	--	L
Helmiö et al. (2011)[110]	Indirect	Otolaryngology	--	All, modified, nurse	Questionnaire	Surg, anes, nurse	No	--	Improved, n/a	Finland, high	Improved, n/a, improved	--	H
Helmiö et	Indirect	Otolaryngol	100	All,	Questionna	Surg, anes,	No	--	N/a,	Finland,	Improved,	--	M

al. (2012)[111]		ogy	participants	yes, nurse	ire	nurse			positive	high	n/a, improved		
Helmiö et al. (2012)[112]	Indirect	--	--	--	--	--	--	--	--	--	--	--	M
Henderson et al. (2012)[113]	Direct	Urology	100 procedures (50 original; 50 simplified)	All, modified, n/a	Observation	Surg, anes, nurse	Yes	O: 53% (original), 92% (simplified) SI: n/a TO: n/a SO: n/a	--	UK, high	--	Improved, n/a	H
Hill et al. (2015)[114]	Indirect	Orthopaedic	52 participants	All, modified, n/a	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	UK, high	Improved, n/a, improved		M
Hovaguimian et al. (2011)[115]	Indirect	"High risk", gynecology excluded	Before: 609 patients; after: 1110 patients	--	Chart review	--	No	O: 63.5% SI: n/a TO: n/a SO: n/a	--	Switzerland, high	--	No change, no change	M
Høyland et al. (2014)[116]	Indirect	--	14 participants	All, yes, n/a	Focus group interviews	Surg, anes, nurse	--	--	--	Norway, high	--	--	H
Hurtado et al. (2012)[117]	Indirect	--	147 participants (3 hospitals: 2 public, 1 private)	All, yes, circulating nurse	Questionnaire	Nurse, anes, residents	No	--	N/a, positive	Guatemala, Upper-middle	Improved, n/a, improved	--	M
Igaga et al. (2018)[118]	Direct	Mixed (58% gynecology)	859 patients	All, yes, n/a	Observation, chart review	Surg, anes, anes officer, medical officer, intern doctor, nurse, midwife, medical student	Yes	O: 41.7% SI: 44% TO: 42% SO: 33.3%	--	Uganda, low	--	No change, no change	M
Jager et al. (2019)[119]	Indirect	Mixed	21306 procedures	All, modified, n/a	Chart review	--	No	--	--	Australia, high	--	No change, worsened	H

Jammer et al. (2015)[120]	Indirect	Non-cardiac (planned day-case surgery, cardiac, neurosurgery, radiological or obstetric procedures were excluded)	45591 procedures	All, yes, n/a	Secondary analysis of the European Surgical Outcome Study data set	--	No	O: 67.5% SI: n/a TO: n/a SO: n/a	--	European countries, mixed	--	N/a, improved	L
Johnston et al. (2009)[121]	Direct	Orthopedic	231 procedures (SI and TO); 48 procedures (SI)	TO, no, n/a	Observation	--	Yes	O: n/a SI: n/a TO: 76 % (emergency cases) and 68% (elective cases) SO: n/a	--	Canada, high	--	--	M
Johnston et al. (2014)[122]	Direct	Mixed	63 procedures	Briefing and debriefing, no, surg or circulating nurse	Audit tool	Surg, anes, nurse, technologist	Yes	O: 26% SI: n/a TO: n/a SO: n/a	Yes, n/a	USA, high	--	--	L
Jones (2019)[123]	Indirect	--	--	TO, yes, n/a	Medical records , survey (nursing staff)	Surg, nurse	No	O: 79% SI: n/a TO: n/a SO: n/a	N/a, mixed	Australia, high	N/a, n/a, Improved	N/a, improved	M
Kaderli et al. (2013)[124]	Indirect	--	799 participants	All, yes, n/a	Questionnaire	--	--	--	N/a, positive	Switzerland, high	Worsened, n/a, worsened	--	H
Kasatpibal et al. (2012)[125]	Direct	Mixed	4,340 procedures	All, modified, n/a	Observation (by nurse)	Surg, anes, nurse	No	--	N/a, mixed	Thailand, upper-middle	--	--	L
Kasatpibal, et al. (2018)[126]	Indirect	--	89 participants (39 nurses in focus groups, 50 surgical	All, yes, n/a	Focus group, interview	OR nurses	--	--	--	Thailand, upper-middle	--	--	H

			personnel interviewed)										
Kawano et al. (2014)[127]	Indirect	--	Before: 177 participants; after: 162 participants	All, yes, n/a	Questionnaire	Surg, anes, nurse	--	--	--	Japan, high	Improved, n/a, improved	--	M
Keijzer et al. (2017)[128]	Indirect	Plastic	80 participants	All, yes, n/a	Chart review	--	No	O: 91% SI: 85.5% TO: 95% SO: 87.5%	--	UK, high	N/a, n/a, improved	--	L
Khoshbin et al. (2009)[129]	Direct	Mixed	391 procedures	N/a, no, n/a	Observation, questionnaires, interviews	Surg (staff, fellows, residents), anes (staff, fellows, residents), nurses (scrub circulating, cardiovascular perfusionists)	Yes	O: n/a SI: 64.1% TO: 99.1% SO: n/a	N/a, mixed	Canada, high	N/a, n/a, improved	--	M
Kiefel et al. (2018)[130]	Indirect	Mixed	12 participants	All, modified, n/a	Literature review, interviews, questionnaire	Surg, anes, nurse, surgery manager	No	--	N/a, positive	Austria, high	--	--	M
Kieffer et al. (2013)[131]	Direct	Orthopedic	147 procedures	All, n/a, n/a	Audit	--	--	O: 95% SI: n/a TO: n/a SO: n/a	--	--	--	--	M
Kim et al. (2015)[132]	Indirect	Mixed	637 participants	N/a, yes, n/a	Medical records	--	Yes	O: 90% SI: n/a TO: n/a SO: n/a	--	Moldova, lower-middle	N/a, n/a, improved	Worsened, improved	M
Kisacik et al. (2019)[133]	Indirect	--	--	N/a, yes, scrub nurse	Questionnaire	Nurses	--	--	--	Turkey, upper-middle	--	--	M
Korkiakangas	Direct	Mixed	--	--	Video recordings	Surg, anes, nurse,	No	--	--	UK, high	--	--	M

(2017)[134]						residents, operating department practitioners							
Kilduff et al. (2018)[135]	Indirect	--	3338 participants	N/a, yes, n/a	Electronic Survey	--	--	--	--	UK, high	--	--	M
Kwok et al. (2013)[136]	Direct	Mixed	Before: 2145 procedures; after: 2212 procedures	All, yes, n/a	Intraoperative data form, chart review, observation	Surg, anes, nurse	Yes	O: 38.5% SI: n/a TO: n/a SO: n/a		Moldova, lower-middle		Improved, no change	H
Lacassie et al. (2016)[137]	Indirect	Cardiothoracic	29858 procedures	All, yes, n/a	Admin database	--	No	O: 42.3% SI: n/a TO: n/a SO: n/a	--	Chile, high	--	No change, improved	H
Lagoo et al. (2019)[138]	Indirect	Mixed	55 participants	All, modified, n/a	Survey	Representatives and clinicians participating in the device briefing tool training	No	--	--	Thailand, upper-middle	--	--	M
Lee (2010)[139]	Indirect	--	583 procedures	TO, no, n/a	Survey	Surg, anes, nurse	--	--	--	USA, high	Improved, n/a, n/a	--	L
Lee et al. (2012)[140]	Indirect	Mixed	35,416 procedures	TO, no, n/a	Form collection, questionnaire	Surg, anes, nurse, assistants, technicians	No	--	N/a, mixed	New Zealand, high	--	--	L
Lennon et al. (2020)[141]	Direct	Obstetric	--	All, modified, n/a	--	--	--	O: n/a SI: 94% TO: 83% SO: 69%	--	Ireland, high	--	--	L
Lepanluoma et al. (2014)[142]	Indirect	Neurosurgery	67 procedures	All, yes, n/a	Chart review , questionnaire	Surg, anes, nurse	No	--	--	Finland, high	Improved, n/a, improved	Improved, n/a	M
Lepanluoma et al. (2015)[143]	Indirect	Neurosurgery reoperations	72 procedures	All, yes, n/a	Hospital/patient charts	--	No	O: n/a SI: n/a TO: 74%	--	Finland, high	--	Improved, n/a	M

								SO: n/a					
Levy et al. (2012)[144]	Direct	Mixed	140 procedures; 29 participants	All, modified, n/a	Observation, survey	Surg, anes, nurse	--	O: 21% SI: n/a TO: 97% SO: n/a	--	USA, high	N/a, n/a, worsened	--	L
Lilaonitkul et al. (2015)[145]	Indirect	Mixed	2,645 procedures	All, modified, nurse, anes officers, anes, medical students and/or surg	Operative information from operating theatre logbook, patient medical records	--	No	O: 69% SI: 91.2% TO: 89.9% SO: 87.5%	--	Uganda, low	--	--	L
Lindsay et al. (2018)[146]	Indirect	Cardiac catheterization	8991 procedures	All, modified, n/a	Chart review, patient questionnaire, staff survey	Surg, anes, nurse, technicians, cardiologists, paediatricians	No	O: 70.9% SI: n/a TO: n/a SO: n/a	N/a, mixed	UK, high	--	Improved, no change	M
Lingard et al. (2005)[147]	Direct	Vascular	18 procedures	N/a, no, surg	Observation, interviews	Surg, anes, residents	Yes	--	--	Canada, high	--	--	M
Lingard et al. (2006)[148]	Direct	General	302 procedures	TO, no, surg	Field notes	Surg, anes, nurse	Yes	--	N/a, mixed	Canada, high	--	--	M
Lingard et al. (2008)[149]	Direct	General	86 procedures	SI, no, surg	Observation, survey	Surg, anes, nurse	Yes	--	N/a, positive	Canada, high	Improved, improved, n/a	--	H
Lingard et al. (2011)[150]	Direct	General (mostly colon)	340 procedures	TO, no, surg	Chart review, observation	Surg, anes, nurse, resident, trainee, respiratory therapist, technical assistant	Yes	--	--	Canada, high	--	--	H
Logan et al. (2012)[151]	Direct	Mixed	98 procedures	TO, no, n/a	Observation (form)	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 98% SO: n/a	Yes, n/a	USA, high	--	--	M
Lübbeke et al.	Indirect	Mixed	2427 procedures	All, yes, n/a	Chart review	Surg, anes, nurse,	No	O: 63.4% SI: n/a	--	Switzerlan	--	Improved, no change	H

(2013)[152]						quality officer		TO: n/a SO: n/a		d, high			
Lyons et al. (2017)[153]	Indirect	-- --	134 participants	TO, mixed, n/a	Survey	Perioperative staff members	--	O: 83.5% SI: n/a TO: 99.4% SO: n/a	--	--	--	--	M
Magill et al. (2017)[154]	Indirect	Neurosurgery	112 participants	TO, n/a, n/a	Survey (safety attitudes questionnaire)	Surg, anes, nurse	--	--	N/a, positive	USA, high	--	--	M
Mahmood et al. (2019)[155]	Direct	Mixed	51 surgeries; 18 participants	TO, modified, nurse (SI), surg (TO), anes (SO)	Observation, interview	Surg, anes, nurse	Yes	O: 94% SI: 94% TO: 100% SO: 100%	--	Canada, high	--	--	L
Mainthia et al. (2012)[156]	Direct	Otolaryngology	240 procedures (before: 80; after: 160)	TO, no, surg, nurse	Observation	Surg, nurse, resident, certified registered nurse anes, technician	Yes	O: n/a SI: n/a TO: 100% SO: n/a	--	USA, high	Improved, n/a, n/a	--	H
Makary et al. (2007)[157]	Direct	Mixed	116 participants	TO, no, surg	Questionnaire (safety attitudes questionnaire), observation	Surg, anes, nurse	No	--	N/a, positive	USA, high	Improved, improved, n/a	--	M
Marquet et al. (2013)[158]	Direct	Otolaryngology	2 hospitals	All, modified, surg, nurse and/or anes	Observation	--	Yes	O: 42% (hospital A), 16.9% (hospital B) SI: n/a TO: n/a SO: n/a	--	Belgium, high	--	--	L
Martis et al. (2016)[159]	Direct	Mixed	9825 specimens (before: 4760; after: 5065)	TO, yes, n/a	Specimen labelling assessment	--	No	--	--	New Zealand, high	--	--	M
Mascherek et al. (2013)[160]	Indirect	--	1378 participants	N/a, mixed, n/a	Survey	Doctors, anes, nurse, surgical	No	--	N/a, mixed	Switzerland,	--	--	M

						technicians				high			
Mascherek et al. (2015)[161]	Indirect	--	1139 participants	--	Survey	Doctors, nurse, surgical technicians, attendants for surgical positioning	No	--	--	Switzerland, high	--	--	M
Mascherek et al. (2016)[162]	Indirect	--	Before: 2708 participants; after: 2264 participants	N/a, yes, n/a	Surveys (attitudes, knowledge, safety climate)	Doctors, nurse, surgical technicians, attendants for surgical positioning	No	--	N/a, no change	Switzerland, high	N/a, n/a, improved	--	M
Mata et al. (2010)[163]	Indirect	--	184 patients	All, modified, n/a	Chart review (form)	Surg, anes, nurse	No	O: 58.2% SI: n/a TO: n/a SO: n/a	--	Spain, high	--	--	L
Mattingly et al. (2019)[164]	Indirect	--	20 participants	--	Group interviews (semi-structured)	Surg, anes, nurse, OR managers, quality personnel, hospital administrator	No	--	--	Ethiopia, low	--	--	H
Mayer et al. (2016)[165]	Direct	General, urology, orthopedic	6714 patients	All, yes, n/a	Form completed by anesthesia	Surg, anes, nurse	No	O: 62.1% SI: n/a TO: n/a SO: n/a	--	UK, high	--	Improved, no change	M
Maziero et al. (2015)[166]	Direct	Orthopedics	20 procedures	All, modified, n/a	Observation	Surg, anes, nurse, resident, technician	Yes	--	--	Brazil, upper-middle	--	--	L
McCarroll et al. (2015)[167]	Indirect	Gynecology	121 patients	N/a, modified, nurses	Chart review	Surg, nurse	No	--	--	USA, high	--	--	M
McDowell et al. (2016)[168]	Indirect	--	346 surveys	--	Questionnaire	Surg, anes, nurse (perioperative registered nurses,	No	--	--	USA, high	--	--	M

						certified surgical technologist)							
McGinlay et al. (2015)[169]	Direct	Mixed	40 procedures; 15 participants	All, yes, n/a	Observation , questionnaire	Surg, anes, nurse	Yes	--	--	Romania, high	--	--	L
McLaughlin et al. (2012)[170]	Direct	Neurosurgery	--	TO, modified, surg	--	Surg, anes, nurses	Yes	O: 77-100% SI: n/a TO: n/a SO: n/a	N/a, positive	USA, high	Improved, n/a, improved	No change, n/a	M
McLaughlin et al. (2014)[171]	Indirect	Neurosurgery	--	TO, yes, n/a	Questionnaire (safety attitudes questionnaire)	Surg, anes, nurse, resident, technician	--	--	N/a, positive	USA, high	Improved, n/a, improved	--	M
Medvedev et al. (2019)[172]	Direct	--	--	All, n/a, n/a	WHOBAR	--	Yes	--	--	--	--	--	L
Mehta et al. (2018)[173]	Indirect	--	Before: 200 procedures; after: 172 procedures	All, no, n/a	Chart review	--	--	--	--	India, lower-middle	--	Improved, n/a	M
Melekie et al. (2015)[174]	Direct	Mixed	282 participants	All, modified, circulating nurses	Observation	Surg, anes, nurse resident	Yes	O: 39.7% SI: n/a TO: n/a SO: n/a	--	Ethiopia, low	--	--	L
Mhamdi et al. (2014)[175]	Direct	General	508 patients (before: 185; after: 323)	TO, yes, n/a	--	--	Yes	--	--	Tunisia, lower-middle	--	Mixed, no change	M
Michel et al. (2015)[176]	Indirect	Mixed	81 participants	All, modified, surg, nurses, anes	Survey	--	No	O: 87.5% SI: n/a TO: n/a SO: n/a	N/a, mixed	Belgium, high	--	--	M
Minhas et al. (2017)[177]	Indirect	General, orthopaedic, neurosurgery	--	All, yes, n/a	Questionnaire (safety attitude questionnaire)	Surg, anes, nurse, trainee technician	--	--	--	Pakistan, lower-middle	--	--	L
Moccia et	Direct	Mixed	177	All,	Observatio	Surg, anes,	Yes	O: 97%	N/a,	Italy,	--	No change,	M

al. (2017)[178]			procedures	modified, n/a	n, review of incident reporting system, chart review	nurse		SI: n/a TO: 89% SO: n/a	mixed	high		no change	
Mody et al. (2014)[179]	Indirect	Obstetrics (C-sections)	Before: 63 procedures; after: 90 procedures	N/a, modified, n/a	Chart review	Surg, anes, nurse	No	--	--	Rwanda, low	--	--	M
Mohammed et al. (2013)[180]	Indirect	Obstetrics	389 procedures	All, yes, n/a	Chart review	--	No	--	--	UK, high	Improved, improved, n/a	--	M
Molina et al. (2016)[181]	Indirect	--	Before: 929 participants ; after: 815 participants	All, yes, n/a	Survey	Surg, anes, nurse, certified registered nurse anes, technicians	No	--	N/a, mixed	USA, high	Improved, n/a, n/a	--	M
Montgomery et al. (2016)[182]	Direct	Mixed (pediatric)	39 procedures	TO, modified, nurse	Observation (nurses as data collectors, other staff unaware of study)	Surg, anes, nurse	Yes (scrub nurse)	O: n/a SI: n/a TO: 77% SO: n/a	Yes, n/a	Scotland, high	--	--	H
Morgan et al. (2013)[183]	Direct	--	Before: 180 procedures; after: 195 procedures	All, modified, n/a	--	Surg, anes, nurse	Yes	O: n/a SI: 99.5% TO: 98.0% SO: 96.9%	--	Canada, high	--	--	M
Morgan et al. (2015)[184]	Direct	Orthopaedic (lower limb)	101 procedures	TO, modified, n/a	Observation	--	Yes	O: n/a SI: n/a TO: 47% SO: 19%	Yes, n/a	UK, high	Improved, n/a, n/a	No change, n/a	M
Morgan et al. (2015)[185]	Direct	Orthopaedic	105 procedures	TO, yes, n/a	Observation, hospital records	Surg, anes, nurse	Yes	O: SI: TO: 89.5% SO: .28%	--	UK, high	No change, n/a, n/a	No change, n/a	L
Motta Filho et al. (2013)[186]	Indirect	Orthopaedic	502 participants	All, yes, n/a	Survey	--	No	--	--	Brazil, upper-middle	--	--	M
Munn et al. (2018)[187]	Direct	Interventional radiology	39 procedures	All, no, n/a	Observation, record	--	Yes	O: 38% (observed),	--	--	Worsened, n/a,	--	M

					audit , focus group			64% (record audit) SI: n/a TO: n/a SO: n/a			n/a		
Myers et al. (2016)[188]	Indirect	Wound patients (soft tissue reconstruction of chronic wounds)	233 patients	TO, modified, surg	Chart review	Surg, anes, nurse	No	--	--	USA, high	--	--	L
Naidoo et al. (2017)[189]	Direct	Obstetrics	10,479 procedures	All, modified, anes (SI, TO), surg (TO), nurse (SO)	Observation (theatre staff)/charting, focus groups	Surg, anes nurse	Yes	--	--	South Africa, upper-middle	--	Improved, no change	M
Neuhaus et al. (2017)[190]	Indirect	--	316 participants (anesthetists)	N/a, yes, n/a	Survey	Anes, nurses	No	--	Improved, mixed	Germany, high	--	--	M
Nilsson et al. (2010)[191]	Indirect	Mixed	331 participants	TO, yes, OR team	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	Sweden, high	Mixed, n/a, n/a	--	M
Nissan et al. (2014)[192]	Indirect	--	46 participants	All, yes, n/a	Survey, report	Physician, nurse, certified registered nurse anes, resident, technician	No	O: n/a SI: 89% TO: 99% SO: 82%	N/a, positive	USA, high	Improved, n/a, improved	--	M
Nørgaard et al. (2016)[193]	Indirect	Mixed	2,487 procedures	All, modified, n/a	Chart review	--	No	O: 47% SI: n/a TO: n/a SO: n/a	--	Norway, high	--	--	M
Norton et al. (2016)[194]	Indirect	--	196 participants	N/a, modified, n/a	Staff survey	Anes, nurse, certified nurse anes, technologists	No	--	N/a, positive	USA, high	--	--	M

Nugent et al. (2013)[195]	Indirect	--	41 hospitals	N/a, modified, n/a	Survey	--	No	--	Improved, n/a	Ireland, high	Worsened, n/a, n/a	--	M
O'Brien et al. (2017)[196]	Indirect	--	58 participants	All, yes, nurse	Interviews (semi-structured)	Nurses	No	--	N/a, positive	Ireland, high	--	--	H H
O'Connor et al. (2013)[197]	Indirect	--	107 participants	All, modified, nurse	Questionnaire, interviews	Surg, anes, nurse	No	--	Improved, mixed	Ireland, high	--	--	M
Ogunlusi et al. (2017)[198]	Indirect	Mixed	66 participants	All, yes, n/a	Survey	Surg, anes, nurse	No	--	--	Nigeria, lower-middle	--	--	M
Olatosi et al. (2018)[199]	Indirect	Mixed	102 participants	All, yes, nurse, anes	Survey	--	No	--	--	Nigeria, lower-middle	Improved, n/a, n/a	--	M
O'Leary et al. (2016)[200]	Indirect	Mixed (pediatric)	14,314 procedures	All, yes, n/a	Chart review)	--	No	O: >98% SI: n/a TO: n/a SO: n/a	--	Canada, high	--	No change, no change	H
Ong et al. (2016)[201]	Direct	Mixed	111 procedures	All, yes, anes (SI), surg (TO), nurse (SO)	Observation	Surg, anes, nurse	Yes	O: n/a SI: 98% TO: 99% SO: 84%	Yes, n/a	New Zealand, high	--	--	H
Overdyk et al. (2016)[202]	Direct	Mixed	2693 procedures	All, modified, n/a	Video recording, live audit	Surg, anes, nurse, support staff	Yes (via video)	O: n/a SI: 64.1% TO: 84.4% SO: 65.8%	Yes, n/a	USA, high	--	--	M
Owers et al. (2010)[203]	Direct	Mixed	First audit: 95 records; second audit: 96 records	N/a, modified, n/a	Chart audit of "correct side surgery" documentation	Surg, anes, nurse	No	--	--	UK, high	--	--	L
Paige et al. (2008)[204]	Indirect	General	16 procedures	TO, no, n/a	Self-assessment questionnaire	Surg, anes, nurse, technologist	No	--	--	Alaska, high	Improved, n/a, n/a	--	M
Paige et al. (2009)[205]	Indirect	General	16 participants	TO, no, n/a	Survey	Surgeon, nurse,	No	--	--	Alaska, high	Improved, improved,	--	M

						certified registered nurse anes, technician					n/a		
Papaconstantinou et al. (2013)[206]	Indirect	Mixed	35570 procedures (before: 17,204; after: 18,366)	All, modified, n/a	Hospital charts	Surg, anes, nurse,	--	O: 85% SI: n/a TO: n/a SO: n/a	--	USA, high	--	--	H
Papaconstantinou et al. (2013)[207]	Indirect	Mixed	355 participants	All, modified, surg, nurses, anes	Survey	Surg, anes, nurse,	No	--	N/a, positive	USA, high	Improved, n/a, n/a	--	M
Paull et al. (2010)[208]	Indirect	Mixed	74 hospitals	Briefing and debriefing, no, n/a	Interviews, chart review	OR staff, post-anes care unit, surgical intensive care unit providers	--	O: n/a SI: 98% (briefing) TO: n/a SO: n/a	--	USA, high	--	--	L
Pavlová et al. (2019)[209]	Indirect	--	--	All, yes, n/a	Questionnaire	Operating theatre supervisors of perioperative nurses	--	--		Czech, high	--	--	M
Phadnis et al. (2018)[210]	Direct	Orthopedic	47 procedures	TO, yes, n/a	Audits, questionnaire	Surg, anes, nurse	No	O: 81% SI: n/a TO: n/a SO: n/a	--	UK, high	N/a, n/a, improved	Improved, n/a	H
Pickering et al. (2013)[211]	Direct	Mixed	294 procedures	TO, yes, surg, nurses, anes	Observation	--	Yes	O: 38.5% SI n/a: TO: 33.7% SO: 19.0%	Somewhat, n/a	UK, high	Improved, n/a, n/a	--	L
Prates et al. (2018)[212]	Direct	Mixed	Before: 5481 records; after: 9838 records	All, yes, circulating nurse	Chart review, daily follow up with patients, post discharge	Surg, anes, nurse	No	--	--	Brazil, upper-middle	--	Improved, n/a	H

					surveillance (phone or email)								
Putnam et al. (2014)[213]	Direct	Mixed (pediatric)	873 procedures	TO, modified, nurse	Observation, questionnaire	Surg, anes, nurse, technician	Yes	O: 30% (baseline), 76% (intervention 1), 96% (intervention 2) SI: n/a TO: 30% (baseline), 76% (intervention 1), 96% (intervention 2) SO: n/a	--	USA, high	N/a, n/a, improved	--	M
Putnam et al. (2016)[214]	Direct	Mixed (pediatric)	1346 procedures	All, no, anes, nurse, surg	Observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 56% SO: 95%	N/a, positive	USA, high	--	--	L
Rakoff et al. (2018)[215]	Direct	Cardiothoracic, vascular	--	All, modified, n/a	Chart review, observation, multiple choice exam	Surg, anes, nurse, perfusionist	Yes	O: 87% (customized training group) and 49% (standard training group) SI: n/a TO: n/a SO: n/a	--	India, lower-middle	--	--	M
Raman et al. (2016)[216]	Direct	Complex cardiac	380 procedures	TO, modified, nurse	Database (Society of Thoracic Surgeons database), observation	Surg, anes, nurse	Yes	O: 100% SI: n/a TO: n/a SO: n/a	--	USA, high	Worsened, n/a, n/a	--	L
Ramsay et al. (2019)[217]	Indirect	--	6,839,736 procedures	All, yes, n/a	Chart review	--	No	--	--	Scotland, high	--	N/a, improved	H
Raphael et	Direct	Gastroentero	12,008	TO,	Observatio	Surg, anes,	Yes	O: 95.3%	--	USA,	--	--	H

al. (2019)[218]		logy	procedures	modified, anes	n, video analysis	nurse, technician		SI: n/a TO: 95.3% SO: n/a		high			
Reames et al. (2015)[219]	Indirect	General, vascular	1,002,241 patients	Briefing and debriefing, no, n/a	Chart review	--	No	--	--	USA, high	--	No change, no change	H
Reames et al. (2015)[220]	Indirect	General	Before: 14005 participants ; after: 14801 participants ; control hospital: 36085 participants	Briefing and debriefing, no, n/a	Chart review	Surg, anes, nurse	No	--	--	USA, high	--	No change, no change	M
Reed et al. (2016)[221]	Direct	Mixed	92 procedures	TO, modified, n/a	Observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 99.1% SO: 94.3%	--	--	--	--	L
Rhee et al. (2017)[222]	Direct	--	--	--	Observation/audit	Surg, anes, nurse, technician	Yes	--	--	USA, high	--	Improved, n/a	L
Ribeiro et al. (2017)[223]	Indirect	Mixed	24421 procedures	All, modified, nurse	Chart review	--	No	O: 58.5% SI: 70.0% TO: 93.5% SO: 59.4%	--	Brazil, upper-middle	--	--	L
Ribeiro et al. (2019)[224]	Indirect	Mixed	423 patients	All, modified, nurse	Chart review	Surg, anes, nurse	No	O: 67.4% SI: 84.2% TO: 84.2% SO: n/a	--	Brazil, upper-middle	--	--	L
Ricci et al. (2012)[225]	Direct	--	70 procedures	Briefing and debriefing, no, surg, nurses	--	Surg, anes, nurse, technician, OR assistant	--	--	--	USA, high	--	Improved, n/a	M
Rodella et al. (2018)[226]	Indirect	Mixed	1,166,424 patients	All, yes, n/a	Regional database	--	No	O: 47.3% SI: n/a TO: n/a SO: n/a	--	Italy, high	--	No change, n/a	L
Rodrigo-Rincon et al. (2015)[227]	Indirect	Mixed	801 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	No	O: 88% SI: n/a TO: n/a SO: n/a	--	Spain, high	--	Mixed, no change	H

Ronnberg et al. (2015)[228]	Indirect	Mixed	47 participants	All, modified, nurse anes (SI)	Questionnaire	Certified registered nurse anes	--	O: 60% SI: 30% TO: 70% SO: 70%	N/a, mixed	Sweden, high	--	--	M
Rose et al. (2018)[229]	Indirect	--	54,003 procedures	TO, no, n/a	Questionnaire	Surg	No	--	--	USA, high	Improved, n/a, improved	N/a, improved	H
Rosenberg et al. (2008)[230]	Indirect	Orthopedic (spine, hip and knee replacement)	319 patients	TO, no, n/a	Chart review	Surg, anes, nurse	No	--	--	USA, high	--	--	M
Rothmund et al. (2015)[231]	Indirect	Mixed	3,328 participants	All, modified, n/a	Survey	--	No	O: 60% SI: n/a TO: n/a SO: n/a	N/a, positive	Germany, high	--	--	M
Roybal et al. (2018)[232]	Indirect	Mixed	353 participants	All, yes, n/a	Survey	--	No	O: 93.6% SI: 79% TO: 83.8% SO: 29%	N/a, mixed	USA, high	--		M
Russ et al. (2015)[233]	Direct	Mixed	TO: 565 procedures SO: 309 procedures	TO, yes, surg, nurses, anes	Observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 97.5% SO: 60.8%	No, n/a	UK, high	--	--	L
Rydenfalt et al. (2013)[234]	Direct	Mixed	24 procedures	TO, modified, surg and anes	Observation, video recordings	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 96% SO: n/a	Yes, n/a	Sweden, high	--	--	L
Salgado et al. (2019)[235]	Direct	Mixed	100 procedures	All, modified, n/a	Audio recordings	Nurse, physician, resident/student, technician	No	O: 74% (recording) and 96.8% (self-reported) SI: 15.6% TO: n/a SO: n/a	Yes, n/a	USA, high	--	--	L
Santana et al. (2016)[236]	Direct	Mixed	1052 procedures	All, yes, n/a	Observation, chart review, survey	Surg, anes, nurse, hospital infection control committee, quality risk manageme	Yes	--	--	Brazil, upper-middle	--	No change, no change	H

						nt							
Santana et al. (2016)[237]	Indirect	Mixed	215 participants	All, yes, n/a	Survey	Surg, anes, nurse, technician, assistant, resident physician, student, department heads	No	--	N/a, positive	Brazil, upper-middle	Improved, n/a, improved	--	H
Saturno et al. (2014)[238]	Direct	General, gynecology, ophthalmology	280 procedures	TO, yes, n/a	Observation, interview, survey	Surg, anes, nurse	Yes	O: 83.1% SI: 49.3% TO: 51.8% SO: 43.1%	N/a, mixed	Spain, high	N/a, n/a, improved	--	M
Sayed et al. (2013)[239]	Indirect	General, urology	100 procedures	All, yes, nurse and surg	Interviews, chart review	Surg, anes, nurse	No	--	--	Egypt, lower-middle	No change. No change, n/a	--	L
Schwendimann et al. (2019)[240]	Direct	Mixed	11 participants; 104 procedures	TO, yes, surg and nurse	Interviews, observation	Surg, anes, nurse	Yes	O: n/a SI: n/a TO: 99.0% SO: n/a	N/a, negative	Switzerland, high	Worsened, n/a, n/a	--	M
Secanell et al. (2014)[241]	Indirect	--	2891 procedures	All, modified, n/a	Checklist review, survey	Surg, anes, nurse	No	O: n/a SI: 75.1% TO: 77.1% SO: 88.3%	--	Spain, high	--	--	H
Semachew et al. (2018)[242]	Direct	--	313 procedures	All, modified, n/a	Structured checklist	Surg, anes, nurse	--	O: 32.6% SI: n/a TO: n/a SO: n/a	--	Ethiopia, low	--	--	L
Sendlhofer et al. (2015)[243]	Direct	Mixed	305 procedures	All, modified, nurse or anes (SI), surg (TO, SO)	Survey, electronic system, audit	Surg, anes, nurse	Yes	O: 65.1% SI: n/a TO: n/a SO: n/a	N/a, mixed	Austria, high	--	--	M
Sendlhofer et al. (2016)[244]	Direct	--	291 procedures	All, modified, n/a	Survey, audits, electronic documentation system	Surg, anes, nurse	No	O: 59.3% SI: n/a TO: n/a SO: n/a	N/a, mixed	Austria, high	--	--	M
Sendhofer et al.	Direct	--	136 procedures	All, yes,	Audit	Surg, anes, nurse	Yes	O: n/a SI: 52.9%	--	Norway, high	--	--	L

(2018)[245]				scrub nurse, anes nurse and anes (SI), surg (TO, SO)				TO: 33.3% SO: 21.4%					
Seppey et al. (2019)[246]	Direct	Mixed	824 operations	All, modified, surg	Observation	Surg, anes, nurse	Yes	O: 95.3% SI:100% TO: 94.3-96.3% SO: n/a	--	Switzerland, high	--	--	L
Sewell et al. (2011)[247]	Direct	Orthopaedic	485 participants	All, yes, n/a	Audits, questionnaire	Surg, anes, nurse, allied health care professional	--	O: 96.9% SI: n/a TO: n/a SO: n/a	N/a, positive	--	--	Mixed, no change	M
Shankar (2018)[248]	Indirect	Mixed	1778 procedures	All, modified, nurse	Chart review, questionnaire	--	No	--	--	India, lower-middle	--	Improved, improved	L
Shear et al. (2018)[249]	Direct	Mixed	300 procedures	TO, modified, surg	Observation	Surg, anes, nurse	Yes	O: poor SI: n/a TO: n/a SO: n/a	--	--	--	--	L
Sheena et al. (2012)[250]	Direct	Otolaryngology	72 procedures	All, n/a, n/a	Observation	Surg, anes, nurse	--	O: 90.4% SI: improved TO: n/a improved SO: 94%	--	UK, high	--	--	L
Singer et al. (2016)[251]	Direct	Mixed	207 procedures	All, modified, n/a	Observation using two tools: The Surgical Teamwork Coaching Tool and SSC Coaching Tool	Surg, nurse	Yes	--	N/a, positive	USA, high	Improved, n/a, n/a	--	L
Siu et al. (2016)[252]	Direct	Mixed	51 procedures	TO, yes, n/a	Observation, interviews	Surg, anes, nurse, student	Yes	O: 66.7% SI: n/a TO: 67% SO: n/a	--	Scotland, high	--	--	L

Skarsgard (2016)[253]	Indirect	Pediatric	15 hospitals	All, modified, n/a	Questionnaire	--	No	--	--	Canada, high	--	--	M
Smiley et al. (2019)[254]	Direct	General, gynecology	10 procedures	All, yes, n/a	Observation, survey	Surg, anes, nurse	Yes	O: 100% SI: n/a TO: n/a SO: n/a	N/a, positive	Ghana, lower-middle	--	--	M
Sokhanvar et al. (2018)[255]	Indirect	Mixed	145 participants	All, modified, n/a	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	Iran, upper-middle	Improved, n/a, improved	--	M
Sparks et al. (2013)[256]	Indirect	Mixed	265 procedures	All, modified, n/a	Chart review	--	No	--	--	USA, high	--	--	L
Spence et al. (2011)[257]	Direct	Mixed	65 procedures	All, no, nurse and anes (SI), surg, anes, nurse (TO), nurse (SO)	Observation, focus groups	Surg, anes, nurse	Yes	--	N/a, positive	Canada, high	--	--	L
Starr et al. (2019)[258]	Direct	--	--	All, yes, n/a	Observation	--	Yes	O: n/a SI: 82.2% (emergency cases), 96.6% (elective cases) TO: 82.0% (emergency cases), 96.4% (elective cases) SO: 74.9% (emergency cases), 90.8% (elective cases)	--	--	--	--	L
Styer et al. (2011)[259]	Direct	Mixed	--	N/a, modified, anes (SI),	Observation, checklist review	Surg, anes, nurse	Yes	O: 100% SI: n/a TO: n/a	--	USA, high	--	--	L

				surg (TO), nurse (SO)				SO: n/a					
Taicher et al. (2018)[260]	Indirect	Pediatric, general, urology	--	N/a, no, circulating nurse	Chart review, focus groups	Surg, anes, nurse	No	--	--	Guatemala, upper-middle	--	--	L
Takala et al. (2011)[261]	Indirect	Mixed	1748 procedures/ questionnaires (847 after implementation)	N/a, yes, n/a	Questionnaire	Surg, anes, nurse	--	--	--	Finland, high	No change, improved, n/a	--	M
Thomasson et al. (2016)[262]	Indirect	Orthopedic	Before: 457 procedures; after: 518 procedures	N/a, modified, n/a	Chart review, questionnaire	Surg, anes, nurse, technician	No	O: 100% SI: n/a TO: n/a SO: n/a	--	USA, high	--	--	L
Tian et al. (2019)[263]	Indirect	Dermatology	454 participants; 25 questionnaires	All, modified, n/a	Survey	Dermatology doctor, nurse	--	O: 48.7% SI: n/a TO: n/a SO: n/a	--	UK, high	--	--	M
Tillman et al. (2013)[264]	Indirect	Mixed	277 participants	SI and TO, yes, n/a	Survey, NSQIP report	Surg, anes, nurse	No	--	--	USA, high	--	Improved, n/a	H
Todd et al. (2018)[265]	Direct	Mixed	34 procedures	All, yes, n/a	Audit	Surg, anes, nurse	Yes	O: n/a SI: 94% TO: 88% SO: 53%	Yes, n/a	UK, high	--	--	L
Toor et al. (2013)[266]	Direct	Mixed	103 procedures	N/a, yes, n/a	Observation, questionnaire	Surg, anes, nurse	Yes	--	--	--	--	--	M
Toor et al. (2015)[267]	Indirect	Mixed (non-cardiac, non-obstetric)	Before: 303 patients; after: 310 patients	N/a, yes, n/a	Chart review	Surg, anes, nurse, assistant	No	--	--	--	--	Improved, n/a	M
Tostes et al. (2019)[268]	Indirect	--	91 participants (nurses)	All, yes, n/a	Survey	Nurse	No	--	--	Brazil, upper-middle	Improved, n/a, improved	--	M
Truran et al. (2011)[269]	Direct	--	--	--	--	--	--	--	--	--	--	--	H

Uppot et al. (2017)[270]	Direct	Interventional radiology	201 procedures	All, yes, n/a	Observation, survey	--	--	--	--	--	--	--	L
Urbach et al. (2014)[271]	Indirect	Mixed	130 hospitals	N/a, mixed, n/a	Chart review	--	No	O: 91.6-100% SI: n/a TO: n/a SO: n/a	--	Canada, high	-- ----	No change, no change	H
Vachhani et al. (2013)[272]	Indirect	Neurosurgery	15,457 procedures	SI, no, n/a	Morbidity and Mortality Conference database	--	No	--	--	USA, high	--	--	H
Van Klei et al. (2012)[273]	Indirect	Mixed	11,151 participants	All, yes, n/a	Hospital records, patient records	Surg, anes, nurse	No	O: 39% SI: 58.6% TO: 59.2% SO: 44.6%	--	--	--	N/a, improved	L
Van Schoten et al. (2014)[274]	Direct	Mixed	1281 procedures	TO, no, n/a	Observation	Surg	Yes	O: n/a SI: n/a TO: 71.3% SO: n/a	--	Netherlands, high	--	--	M
Vatter et al. (2012)[275]	Indirect	Neurosurgery	12,390 procedures	All, modified, n/a	Chart review	Surg, anes, nurse	No	O: 97% SI: n/a TO: n/a SO: n/a	--	Germany, high	--	--	H
Verwey et al. (2018)[276]	Indirect	Mixed	225 participants	N/a, yes, n/a	Questionnaire	Surg, anes, nurse	No	--	N/a, positive	South Africa, upper middle	Improved, n/a, improved	Improved, improved	M
Vilz et al. (2016)[277]	Direct	--	358 procedures	All, modified, n/a	--	Surg, anes, nurse	--	O: n/a SI: 48% TO: 64% SO: 41%	--	--	--	--	L
Vogts et al. (2011)[278]	Direct	Mixed	--	All, yes, n/a	Observation, compliance assessment tool	Surg, anes, nurse	Yes	O: n/a SI: 56% TO: 69% SO: 40%	No, n/a	New Zealand, high	No change, n/a, n/a	--	L
Waehle et al. (2012)[279]	Direct	--	--	All, modified, nurse	Observer recorded, interviews	Surg, anes, nurse	Yes	--	Mixed, mixed	Norway, high	Mixed, mixed, mixed	--	M
Waehle et al. (2019)[280]	Direct	Mixed	--	TO, yes, anes or nurse	Observation, interviews	Surg, anes, nurse	Yes	--	--	Norway, high	Improved, n/a, n/a	Improved, n/a	M

Wang et al. (2019)[281]	Indirect	Gastrointestinal tumors (elective)	3971 procedures	All, yes, surg (SI), circulating nurse (TO, SO)	Patient follow up, chart review, electronic database	Surg, anes, nurse	No	--	Yes, n/a	China, upper-middle	Improved, n/a, n/a	Improved, improved	H
Wangoo et al. (2018)[282]	Direct	Mixed	205 participants; 165 procedures	All, yes, n/a	Questionnaire, observation	Surg, anes, nurse	Yes	O: n/a SI: <70% TO: <70% SO: 18%	N/a, mixed	Australia, high	Improved, n/a, improved	--	M
Watkins et al. (2010)[283]	Direct	Mixed	2,383 procedures	TO, no, n/a	Data collection form	--	No	O: n/a SI: n/a TO: 98% SO: n/a	--	USA, high	--	--	L
Weingessel et al. (2017)[284]	Direct	Ophthalmology	18081 procedures	TO, no, circulating nurse	Form	Surg, anes, nurse, patient	No	--	--	Austria, high	--	--	L
Weiser et al. (2010)[285]	Direct	Mixed	1750 patients	All, yes, n/a	Observation	--	Yes	O: 11.7% SI: n/a TO: n/a SO: n/a	--	USA, high	--	Mixed, improved	M
Weller et al. (2018)[286]	Direct	Mixed	59 procedures	All, modified, anes (SI), surg (TO), nurse (SO)	Observation, interviews	Surg, anes, nurse, assistant	Yes	--	N/a, positive	New Zealand, high	Improved, n/a, improved	--	M
Westman et al. (2018)[287]	Indirect	Neurosurgery	104 participants	TO, yes, n/a	Electronic OR record checklist	--	No	O: 68% SI: n/a TO: 82% SO: n/a	--	Finland, high	--	No change, n/a	L
White et al. (2017)[288]	Indirect	--	--	All, yes, n/a	Questionnaire, interview	Surg, certified registered nurse, anes	No	--	--	Republic of Congo, low	Improved, n/a, n/a	--	M
White et al. (2018)[289]	Direct	--	149 participants	All, yes, n/a	Questionnaire, focus groups, observation	Surg, anes, nurse	Yes	O: 49% SI: n/a TO: n/a SO: n/a	N/a, positive	Madagascar, low	Improved, improved, improved	--	H
White et al. (2018)[290]	Direct	--	427 participants	All, yes, n/a	Questionnaire, observation, focus	Surg, anes, nurse, assistant	Yes	O: 65% SI: n/a TO: n/a SO: n/a	--	Madagascar, low	--	--	M

					groups								
White et al. (2019)[291]	Direct	--	17 hospitals; 110 participants	All, yes, n/a	Questionnaire, focus group, observation	Surg, anes, nurse, assistant	Yes	O: 55% SI: n/a TO: n/a SO: n/a	N/a, mixed	Benin, lower-middle	No change, n/a, worsened	--	H
White et al. (2020)[292]	Direct	--	425 participants	All, yes, n/a	Questionnaire, observation	Surg, anes, nurse, technician, student	Yes	O: 56% SI: n/a TO: n/a SO: n/a	N/a, positive	Cameroon, lower-middle	--	--	M
Willassen et al. (2018)[293]	Indirect	--	20 participants	N/a, yes, anes (SI), surg (TO, SO)	Focus groups	Nurse, student	No	--	Improved, mixed	Norway, high	Mixed, n/a, n/a	--	H
Wong et al. (2016)[294]	Direct	Neurosurgery	16 procedures	All, modified, nurse or surg	Observation, questionnaire	Surg, resident, anes, nurse, technician	Yes	O: 56% SI: n/a TO: n/a SO: n/a	N/a, positive	USA, high	--	--	M
Wright (2005)[295]	Direct	--	--	TO, no, n/a	Audit, questionnaire	Surg, anes, nurse, assistant	No	O: 80% SI: n/a TO: n/a SO: n/a	--	USA, high	N/a, n/a, improved	--	L
Wu et al. (2019)[296]	Indirect	Mixed	1558 participants	All, yes, n/a	Survey	--	No	O: 78.4% SI: n/a TO: n/a SO: n/a	--	Europe, mixed	--	--	M
Yu et al. (2017)[297]	Direct	--	30 654 procedures (before: 1852; after: 1822) 2211	All, no, n/a	Observation, survey	Surg, anes, nurse	Yes	O: n/a SI: 94% TO: 97% SO: 95%	Improved, negative	China, upper-middle	Improved, n/a, n/a	--	M
[illegible] (2017)[300]	[illegible]	[illegible]	(OR team members)	[illegible] modified, n/a	[illegible] chart review	resident, technician	[illegible]	[illegible]	[illegible]	high	[illegible] improved	no change	[illegible]

Notes. Created by the authors. Direct = direct data collection method. Indirect = indirect data collection method. Surg = surgeon. Anes = anesthesiologist. O = overall. SI = sign-in. TO = time-out. SO = sign-out. H = high. M = medium. L = low. SSC = surgical safety checklist. UK = United Kingdom. USA = United State of America. OR = operating room. ICU = intensive care unit. PACU = post anesthesia care unit. OT = occupational therapist. WHO = World Health Organization. WHOBARS = World Health Organization Behaviourally Anchored Rating Scale. ACS = American College of Surgeons. NSQIP = National Surgical Quality Improvement Program. N/a = not applicable

Table S2. Quality assessment: Newcastle-Ottawa Scale for case and cohort, non-randomized studies

Article	Study Design	Selection	Comparability	Exposure/Outcome	Quality Score	Overall Rating
Al-Qahtani (2017)	Cohort	3	0	2	Low	Low
Ambulkar et al. (2018)	Cohort	3	0	1	Low	Low
Anderson et al. (2018)	Cohort	1	2	3	Low	Low
Anwer et al. (2016)	Cohort	2	0	3	Low	Low
Bartz-Kurycki et al. (2017)	Cohort	2	0	3	Low	Low
Bartz-Kurycki et al. (2018)	Cohort	2	0	3	Low	Low
Berrisford et al. (2012)	Cohort	3	0	1	Low	Low
Biffl et al. (2015)	Cohort	2	0	0	Low	Low
Bliss et al. (2012)	Case-control	4	0	2	Low	Low
Boaz et al. (2014)	Case control	4	2	2	Medium	Medium
Cavallini et al. (2013)	Cohort	3	0	2	Low	Low
Corso et al. (2014)	Cohort	3	0	1	Low	Low
Cullati et al. (2013)	Cohort	2	2	1	Low	Low
Cunat et al. (2011)	Cohort	2	0	2	Low	Low
Dackiweicz et al. (2012)	Cohort	4	0	1	Low	Low
de Almeida et al. (2019)	Cohort	3	0	1	Low	Low
de Vries et al (2012)	Cohort	4	1	3	Medium	Medium
Delisle et al. (2020)	Cohort	2	2	3	Medium	Medium
Diedhiou et al. (2017)	Cohort	2	0	2	Low	Low

Dobbie et al. (2019)	Cohort	1	0	3	Low	Low
Ellis et al. (2017)	Cohort	3	0	2	Low	Low
Fatima et al. (2018)	Cohort	2	0	2	Low	Low
Forsyth et al. (2019)	Cohort	1	0	3	Low	Low
Fourcade et al. (2011)	Cohort	2	1	2	Low	Low
Freedman et al. (2017)	Cohort	3	0	0	Low	Low
Freundlich et al. (2019)	Cohort	3	0	1	Low	Low
Fyfe et al. (2013)	Cohort	2	0	3	Low	Low
Gagne et al. (2015)	Cohort	1	1	2	Low	Low
Garland et al. (2017)	Cohort	2	0	2	Low	Low
Giles et al. (2017)	Cohort	2	0	3	Low	Low
Gitelis et al. (2017)	Cohort	4	0	3	Medium	Medium
GlobalSurg Collaborative (2016)	Cohort	4	1	2	Medium	Medium
GlobalSurg Collaborative (2019)	Cohort	4	1	2	Medium	Medium
Hang et al. (2018)	Cohort	2	0	1	Low	Low
Hanna et al. (2015)	Cohort	1	0	0	Low	Low
Hannam et al. (2013)	Cohort	1	2	2	Low	Low
Hawranek et al. (2015)	Case control	3	1	2	Low	Low
Haynes et al (2017)	Cohort	4	1	2	Medium	Medium
Hellar et al (2019)	Cohort	3	0	1	Low	Low
Igaga et al (2018)	Cohort	3	1	3	Medium	Medium
Jammer et al. (2015)	Cohort	3	0	2	Low	Low

Johnston et al (2014)	Cohort	2	0	3	Low	Low
Kasatpibal et al. (2012)	Cohort	3	0	1	Low	Low
Khoshbin et al (2009)	Cohort	3	1	3	Medium	Medium
Kieffer et al. (2013)	Cohort	2	2	1	Medium	Medium
Kim et al. (2015)	Cohort	4	1	2	Medium	Medium
Lee et al (2009)	Cohort	4	0	1	Low	Low
Lee et al. (2010)	Cohort	2	0	0	Low	Low
Lennon et al. (2020)	Cohort	3	0	1	Low	Low
Levy et al. (2012)	Cohort	3	2	1	Low	Low
Lilaonitkul et al. (2015)	Cohort	3	0	3	Low	Low
Logan et al (2012)	Cohort	3	1	3	Medium	Medium
Mahmood et al. (2019)	Cohort	3	0	2	Low	Low
Marquet et al. (2013)	Cohort	3	0	2	Low	Low
Mata et al (2010)	Cohort	3	0	2	Low	Low
Mayer et al (2016)	Cohort	4	0	3	Medium	Medium
Maziero et al (2015)	Cohort	2	1	2	Low	Low
McGinlay et al (2015)	Cohort	2	0	2	Low	Low
Medvedev et al. (2019)	Cohort	2	0	1	Low	Low
Melekie et al. (2015)	Cohort	3	0	2	Low	Low
Mehta et al. (2018)	Case control	3	2	2	Medium	Medium
Myers et al. (2016)	Cohort	3	0	3	Low	Low
Naidoo et al. (2017)	Case-control	4	2	2	Medium	Medium

Norgaard et al (2016)	Cohort	4	1	2	Medium	Medium
Owers et al (2010)	Cohort	3	0	2	Low	Low
Pickering et al. (2013)	Cohort	1	0	1	Low	Low
Putnam et al. (2016)	Cohort	1	0	3	Low	Low
Raman et al. (2016)	Cohort	2	0	2	Low	Low
Reed et al. (2012)	Cohort	3	0	0	Low	Low
Reis de Freitas et al. (2014)	Cohort	3	0	1	Low	Low
Rhee et al (2017)	Cohort	3	0	1	Low	Low
Ribeiro et al. (2017)	Cohort	2	0	3	Low	Low
Ribeiro et al. (2019)	Cohort	2	1	3	Low	Low
Rodella et al. (2018)	Cohort	4	0	2	Low	Low
Russ et al. (2015)	Cohort	2	2	1	Low	Low
Rydenfalt et al (2103)	Cohort	4	0	2	Low	Low
Salgado et al (2019)	Cohort	3	0	2	Low	Low
Sayed et al. (2013)	Cohort	2	0	3	Low	Low
Semachew et al (2018)	Cohort	3	0	1	Low	Low
Seppey et al. (2020)	Cohort	3	0	1	Low	Low
Shankar (2018)	Cohort	4	0	1	Low	Low
Shear et al. (2018)	Cohort	4	0	2	Low	Low
Sheena et al. (2012)	Cohort	4	1	0	Low	Low
Sendhofer et al (2016)	Cohort	3	1	2	Low	Low
Singer et al. (2016)	Cohort	3	0	1	Low	Low

Siu et al. (2016)	Cohort	1	0	3	Low	Low
Sparks et al (2012)	Cohort	2	1	1	Low	Low
Starr et al. (2019)	Cohort	3	0	1	Low	Low
Styer et al. (2011)	Cohort	1	0	1	Low	Low
Taicher et al (2018)	Cohort	4	0	2	Low	Low
Thomasson et al (2016)	Cohort	3	0	3	Low	Low
Todd et al. (2018)	Cohort	1	0	2	Low	Low
van Klei et al. (2012)	Cohort	4	0	2	Low	Low
van Schoten et al (2014)	Cohort	3	2	1	Medium	Medium
Vilz et al. (2016)	Cohort	3	2	1	Low	Low
Vogts et al. (2011)	Cohort	2	0	1	Low	Low
Watkins et al. (2010)	Cohort	1	0	2	Low	Low
Weingessel et al (2017)	Cohort	3	0	2	Low	Low

Notes. Created by the authors.

Table S3. Quality assessment: National Institute of Health for before and after studies

Article	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Total	Overall Rating
Abdel-Rehim et al. (2011)	Y	Y	Y	C/D	N	Y	N	C/D	N/A	N	Y	N/A	P	Low
Ali Toor et al (2015)	Y	Y	Y	Y	N	Y	Y	N	N	Y	N	N	F	Medium
Alidina et al. (2017)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	N	N/A	F	Medium
Askarian et al. (2011)	Y	Y	Y	N/R	N	Y	Y	N/A	N/R	Y	N/A	Y	G	High
Barbanti-Brodano et al. (2019)	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	N/A	N/A	G	High
Biskup et al. (2016)	Y	Y	Y	C/D	Y	Y	Y	C/D	N/A	Y	N	N/A	F	Medium
Bock et al. (2016)	Y	Y	Y	N/R	Y	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Cabralet al. (2016)	Y	Y	Y	C/D	N	Y	Y	C/D	N/A	Y	N	N/A	F	Medium
Carpenter et al. (2017)	N	N	Y	N/R	N/R	Y	Y	N/A	N/R	N	N/A	N/A	P	Low
Chhabra et al. (2019)	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	P	Low
Dabholkar et al. (2018)	Y	Y	Y	Y	N	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
Dayuta et al. (2013)	Y	N	Y	Y	Y	Y	Y	N/A	Y	N	N/A	Y	F	Medium
de Vries et al (2010)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	G	High
de Vries et al (2010)	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	N	F	Medium
Dell'Atti (2013)	Y	Y	Y	N/R	Y	Y	Y	N/A	N/R	N	N/A	N/A	P	Low
Eerestam et al. (2017)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	Y	N	F	Medium
Einav et al. (2010)	Y	Y	Y	C/D	Y	Y	Y	Y	N/A	Y	Y	N/A	G	High
Finch et al (2019)	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	N	F	Medium
Forrester et al. (2018)	Y	N	Y	N/R	Y	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Gillespie et al	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	F	Medium

(2017)														
Gillespie et al. (2018)	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	F	Medium
Gillespie et al (2019)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	F	Medium
Govindappagaro et al. (2016)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	N	N/A	F	Medium
Haugen et al (2015)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Haugen et al (2019)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Haridarshan et al. (2018)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	N	N	N/A	F	Medium
Haynes et al (2009)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Helmio et al. (2011)	Y	Y	Y	Y	Y	Y	Y	C/D	Y	Y	N	N/A	G	High
Henderson et al. (2012)	Y	Y	Y	N/R	Y	Y	Y	N	N	Y	N/A	Y	G	High
Hovaguimian et al (2011)	Y	Y	C/D	C/D	C/D	Y	Y	C/D	Y	Y	Y	C/D	F	Medium
Jager et al. (2019)	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	G	High
Johnston et al. (2009)	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	F	Medium
Kawano et al. (2014)	Y	Y	Y	Y	Y	Y	Y	C/D	N	Y	Y	N/A	F	Medium
Keijzer et al. (2017)	Y	Y	Y	N	N	Y	Y	C/D	C/D	N	N	N/A	P	Low
Kwok et al (2013)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Lacassie et al. (2016)	Y	Y	Y	Y	Y	N/R	Y	N/A	N/A	Y	N/A	Y	G	High
Lagoo et al. (2019)	Y	N	Y	N/R	N	Y	Y	N/A	N/R	N	N/A	Y	F	Medium
Lepanluoma et al. (2014)	Y	Y	Y	N/R	N	N	Y	N/A	N/R	Y	N/A	Y	F	Medium
Lepanluoma et al. (2015)	Y	Y	N	Y	N	Y	Y	N/A	N/R	Y	N/A	Y	F	Medium
Lindsay et al. (2018)	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	F	Medium
Lingard et al. (2008)	Y	Y	Y	Y	Y	Y	Y	N/A	N/R	Y	N/A	Y	G	High
Lingard et al.	Y	Y	Y	Y	Y	Y	Y	N/A	N/R	Y	N/A	Y	G	High

(2011)														
Lubbeke et al. (2013)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Magill et al. (2017)	Y	Y	Y	Y	Y	Y	Y	C/D	C/D	Y	Y	N/A	F	Medium
Mainthia et al. (2012)	Y	Y	Y	Y	Y	Y	Y	Y	C/D	Y	Y	N/A	G	High
Mamdi et al. (2014)	Y	N	C/D	C/D	Y	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
Martis et al. (2016)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
McCarroll et al. (2015)	Y	Y	Y	Y	N	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
Moccia et al. (2017)	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	F	Medium
Mody et al (2014)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	F	Medium
Mohammed et al. (2013)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	F	Medium
Montgomery et al. (2016)	Y	N	Y	N/R	N	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Morgan et al. (2013)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
Morgan et al. (2015)	Y	N	Y	N/R	Y	Y	Y	N/A	N/R	Y	Y	N/A	F	Medium
Morgan et al. (2015)	Y	N	Y	N	N	Y	Y	N/A	N/R	Y	Y	N/A	P	Low
O'Leary et al. (2016)	Y	Y	Y	Y	Y	N	Y	N/A	N/R	Y	N/A	Y	G	High
Ong et al. (2016)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Overdyk et al. (2016)	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	F	Medium
Paige et al. (2008)	Y	N	Y	N/R	N	Y	Y	N/A	N/A	Y	N/A	Y	F	Medium
Paige et al. (2009)	Y	N	Y	N/R	N	Y	Y	N/A	N/A	Y	N/A	Y	F	Medium
Papaconstantinou et al. (2013)	Y	Y	Y	Y	Y	Y	Y	C/D	C/D	Y	Y	N/A	G	High
Papaconstantinou et al. (2013)	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Phadnis et al. (2018)	Y	N	Y	Y	N	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Prates et al	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High

(2018)														
Putnam et al. (2014)	Y	N	Y	N	Y	Y	Y	N/A	N/R	Y	N/A	Y	F	Medium
Ramsay et al. (2019)	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	G	High
Raphael et al. (2019)	Y	Y	Y	N/R	Y	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Reames et al (2015)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Reames et al (2015)	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	N	F	Medium
Ricci et al. (2012)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	N	Y	N/A	F	Medium
Rodrigo-Rincon et al. (2016)	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	N/A	Y	G	High
Rose et al. (2018)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	Y	Y	G	High
Rosenberg et al (2008)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	F	Medium
Santana et al. (2016)	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	N/A	Y	G	High
Sarmento Gama et al (2019)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Sewell et al. (2011)	Y	Y	Y	N/R	Y	Y	Y	N/A	N/R	N	N/A	Y	F	Medium
Sheena et al. (2012)	Y	Y	Y	C/D	N	Y	Y	C/D	N/A	Y	Y	N/A	F	Medium
Takala et al. (2011)	Y	Y	Y	Y	Y	Y	Y	N	C/D	Y	N	N/A	F	Medium
Tillman et al. (2013)	Y	N	Y	N/R	Y	Y	Y	N/A	Y	Y	N/A	Y	G	High
Truran et al. (2011)	Y	Y	Y	Y	Y	Y	Y	C/D	C/D	Y	Y	N/A	G	High
Urbach et al (2014)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Vachhani et al. (2013)	Y	Y	Y	Y	Y	N	Y	N	N/A	Y	N/A	N/A	G	High
Vatter et al (2012)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High
Wang et al. (2019)	Y	Y	Y	Y	Y	Y	Y	N/A	N	Y	N/A	N/A	G	High
Weiser et al. (2010)	Y	Y	Y	Y	Y	Y	Y	C/D	N/A	Y	N	N/A	F	Medium
Westman et al.	Y	Y	N	N	N	N	Y	N/A	N/A	Y	N/A	Y	P	Low

(2018)														
White et al. (2018)	Y	N	Y	N/R	Y	Y	Y	N/A	N	Y	N/A	Y	G	High
White et al. (2019)	Y	N	Y	C/D	Y	Y	Y	C/D	N/A	Y	N	Y	F	Medium
Wong et al. (2016)	Y	N	Y	N/R	N	Y	Y	N/A	N/A	Y	N/A	Y	F	Medium
Yu and Zhao (2019)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	G	High

Notes. Created by the authors. C/D = Cannot Determine. F = Fair. G = Good. N = No. N/A = Not Applicable. N/R = Not Reported. P = Poor. Y = Yes.

Table S4. Quality assessment: National Institute of Health for controlled intervention studies

Article	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Total	Overall Rating
Chaudhary et al. (2015)	Y	Y	Y	Y	Y	Y	CD	CD	Y	CD	Y	N	Y	Y	G	High
Duclos et al. (2016)	Y	CD	Y	CD	CD	Y	CD	CD	CD	CD	Y	Y	Y	Y	F	Medium
Rakoff et al. (2015)	Y	Y	CD	CD	Y	CD	CD	CD	Y	CD	Y	CD	Y	Y	F	Medium

Notes. Created by the authors. C/D = Cannot Determine; F = Fair; G = Good; N = No; P = Poor; Y = Yes.

Table S5. Quality Assessment: Nagpal scale for qualitative studies

Article	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Total	Overall Rating
Ali Toor et al. (2013)	2	1	1	0	1	1	0	0	0	1	0	1	8	Medium
Aveling et al (2013)	2	2	1	1	2	0	0	0	2	2	0	2	14	Medium
Allard et al. (2007)	2	2	1	2	1	0	0	0	0	1	0	2	9	Medium
Allard et al. (2011)	2	2	1	0	1	0	0	0	0	0	0	2	8	Medium
Alloni et al. (2016)	2	1	2	1	0	0	N/A	N/A	N/A	1	0	0	7	Low
Bashford et al. (2014)	2	1	2	1	2	0	N/A	N/A	N/A	2	0	2	12	Medium
Bergs et al. (2015)	2	0	1	2	2	0	1	0	1	1	0	2	12	Medium
Bohmer et al. (2012)	2	0	1	0	2	0	1	0	0	1	0	0	7	Low
Bohmer et al. (2013)	2	0	1	1	2	0	1	0	0	1	0	2	10	Medium
Borgmann et al. (2015)	2	2	1	1	0	0	1	0	1	1	0	2	11	Medium
Birnbach et al. (2017)	2	0	2	1	2	2	1	0	0	1	0	2	13	Medium
Braaf et al. (2013)	2	0	1	2	2	1	2	2	2	2	0	2	18	High
Catchpole et al. (2010)	2	0	2	1	0	1	1	0	0	1	0	2	10	Medium
Close et al. (2017)	2	1	2	2	2	0	2	0	2	2	0	2	17	High
Conley et al. (2011)	1	0	1	1	0	0	1	0	0	2	0	1	7	Low
Correia et al. (2019)	2	2	1	1	0	0	1	0	0	1	0	1	9	Medium
Cullat et al. (2014)	2	2	2	2	2	0	N/A	N/A	N/A	2	0	2	14	Medium
da Rocha Motta Filho et al. (2013)	2	2	2	2	0	0	1	0	0	1	0	1	11	Medium
de Oliveira Junior et al. (2017)	2	1	2	1	2	0	2	N/A	N/A	2	0	1	13	Medium
Defonte et al. (2004)	2	1	2	1	0	0	1	0	2	1	0	2	12	Medium

Delgado-Hurtado et al. (2012)	1	2	2	2	2	0	1	0	0	1	0	2	13	Medium
Dharampal et al. (2016)	2	0	2	1	2	0	2	1	2	2	2	2	18	High
Dixon et al. (2013)	2	0	1	1	2	0	1	0	0	1	0	2	9	Medium
Dixon et al. (2016)	2	0	1	1	1	0	1	0	0	1	0	2	9	Medium
Dommaraju et al. (2019)	2	1	2	2	1	0	N/A	N/A	N/A	1	0	2	11	Medium
Epiu et al. (2016)	2	1	2	2	2	0	1	0	0	1	0	2	13	Medium
Epiu et al. (2018)	2	0	1	1	2	0	1	0	0	1	0	1	9	Medium
Gagliardi et al. (2014)	2	2	2	1	2	1	0	0	2	0	0	2	12	Medium
Georgiou et al. (2018)	2	2	1	1	2	0	1	0	0	2	0	1	12	Medium
Geraghty et al. (2013)	2	2	2	1	0	0	1	0	0	1	0	1	10	Medium
Gillespie et al. (2010)	2	0	1	1	2	0	1	0	0	2	1	2	12	Medium
Gillespie et al. (2016)	2	0	0	1	2	0	2	1	0	2	1	1	12	Medium
Gillespie et al. (2016)	2	0	1	1	2	2	0	0	0	2	0	2	12	Medium
Gillespie et al. (2017)	2	0	1	2	2	0	2	1	1	2	1	2	16	High
Gillespie et al. (2018)	2	0	2	0	2	0	0	0	2	2	0	2	12	Medium
Goransson et al. (2016)	2	0	1	1	N/A	1	0	0	2	1	0	1	9	Medium
Gueguen et al. (2011)	2	1	1	2	0	0	0	N/A	N/A	1	0	1	8	Medium
Hacquard et al. (2013)	2	1	2	1	0	0	N/A	N/A	N/A	1	0	0	7	Low
Hafeez et al. (2016)	2	0	1	0	0	0	N/A	N/A	N/A	1	0	0	4	Low
Haugen et al. (2013)	2	2	2	1	2	0	1	0	0	2	0	2	14	Medium
Haugen et al. (2015)	2	0	1	1	2	0	0	0	2	0	0	2	10	Medium
Haynes et al. (2011)	2	1	2	2	2	0	2	0	0	1	0	2	14	High

Helmio et al. (2012)	2	1	2	1	0	0	N/A	N/A	N/A	2	0	1	9	Medium
Helmio et al. (2012)	2	1	2	2	2	0	N/A	N/A	N/A	2	0	0	11	Medium
Hill et al. (2015)	2	2	2	1	N/A	0	2	0	1	1	0	2	13	Medium
Hoyland et al. (2014)	2	0	2	2	2	1	2	1	2	2	1	2	19	High
Jones (2019)	2	1	2	0	1	0	0	N/A	0	2	0	0	8	Medium
Kaderli et al. (2013)	2	1	2	1	2	2	2	N/A	2	2	0	2	18	High
Kasatpibal et al. (2018)	2	0	2	2	2	2	2	1	2	2	1	2	20	High
Kiefel et al. (2018)	2	0	1	2	0	0	1	0	1	1	0	0	8	Medium
Kilduff et al. (2018)	2	2	2	2	2	0	1	0	1	1	0	2	15	Medium
Kisacik et al. (2019)	2	2	2	2	2	0	N/A	N/A	N/A	1	0	0	11	Medium
Korkiakangas (2016)	2	0	2	1	2	0	2	N/A	N/A	2	0	2	13	Medium
Lingard et al. (2005)	2	0	2	1	1	1	2	0	1	2	0	1	13	Medium
Lingard et al. (2006)	2	1	1	1	1	1	1	0	1	2	0	0	11	Medium
Lyons et al. (2017)	2	0	2	2	2	0	2	N/A	N/A	2	0	2	14	Medium
Makary et al. (2007)	2	2	1	1	0	0	1	0	1	1	0	2	11	Medium
Mascherek et al. (2013)	2	2	2	2	2	0	1	0	0	1	0	2	14	Medium
Mascherek et al. (2015)	2	2	2	2	2	0	2	0	0	1	0	2	15	Medium
Mascherek et al. (2016)	2	2	2	2	2	0	1	0	0	1	0	2	14	Medium
Mattingly et al. (2019)	2	0	2	1	2	0	1	0	2	2	2	2	16	High
MC/Dowell et al. (2016)	2	2	2	1	2	0	1	0	0	1	0	1	12	Medium
McLaughlin et al. (2012)	2	1	2	1	0	0	0	N/A	2	1	0	0	9	Medium
McLaughlin et al. (2014)	2	2	2	1	2	0	N/A	N/A	N/A	2	0	2	13	Medium

Michel et al. (2016)	2	2	2	2	0	0	1	0	0	2	0	0	11	Medium
Minhas et al. (2017)	2	0	1	2	0	0	0	N/A	N/A	1	0	0	6	Low
Molina et al. (2016)	2	2	2	2	2	0	1	0	0	2	0	2	15	Medium
Munn et al. (2018)	2	0	1	1	1	0	1	0	0	2	0	2	10	Medium
Neuhaus et al. (2017)	2	2	2	2	2	0	0	0	0	1	0	2	13	Medium
Nilsson et al. (2010)	2	2	1	1	0	0	1	0	0	1	0	2	10	Medium
Nissan et al. (2014)	2	0	2	1	0	1	0	1	1	1	0	0	9	Medium
Norton et al. (2016)	2	2	1	2	2	0	1	0	0	1	0	2	13	Medium
Nugent et al. (2013)	2	2	2	1	0	0	0	0	0	1	0	1	9	Medium
O'Brien et al. (2016)	2	1	1	1	2	0	2	2	1	2	1	1	16	High
O'Connor et al. (2013)	2	2	1	1	2	0	2	0	1	1	0	2	14	Medium
Ogunlusi et al. (2017)	2	2	1	2	0	0	0	0	0	1	0	1	9	Medium
Olatosi et al. (2018)	2	2	2	2	0	0	1	0	0	1	0	0	10	Medium
Papaconstantinou et al. (2013)	2	2	2	1	1	0	1	0	0	1	0	2	12	Medium
Paull et al (2010)	2	0	1	0	0	N/A	N/A	N/A	0	0	0	2	5	Low
Pavlová et al. (2019)	2	1	2	1	0	0	0	N/A	N/A	1	0	2	9	Medium
Ronnberg et al. (2015)	2	2	2	2	2	0	1	0	0	2	0	2	15	Medium
Rothmund et al. (2015)	2	2	2	2	0	0	1	0	0	1	N/A	2	12	Medium
Roybal et al. (2018)	2	2	1	0	0	0	2	0	2	2	0	2	13	Medium
Santana et al. (2016)	2	1	2	2	2	1	1	1	1	1	0	2	16	High
Saturno et al. (2014)	2	0	1	1	0	0	N/A	N/A	2	0	0	2	8	Medium
Schwendimann et al. (2019)	2	0	1	2	2	0	1	1	1	2	0	1	13	Medium

Secanell et al. (2014)	2	2	2	2	2	2	0	0	2	2	0	2	18	High
Sendlhofer et al. (2015)	2	2	2	2	1	2	0	0	2	0	0	2	15	Medium
Sendlhofer et al. (2016)	2	2	2	2	2	0	1	0	0	1	0	2	14	Medium
Skarsgard (2016)	2	2	2	1	0	0	1	0	0	1	0	0	9	Medium
Smiley et al. (2019)	2	0	2	2	2	0	2	0	0	1	0	2	13	Medium
Sokhanvar et al. (2018)	2	1	2	2	2	0	N/A	N/A	N/A	1	0	2	12	Medium
Spence et al. (2011)	2	0	0	1	2	0	1	0	0	2	0	0	7	Low
Tian et al. (2019)	2	1	2	2	0	0	1	N/A	N/A	2	0	2	12	Medium
Tostes et al. (2019)	2	2	2	1	2	0	1	0	0	1	0	2	13	Medium
Uppot et al. (2017)	2	1	0	0	0	0	N/A	N/A	N/A	1	0	2	6	Low
Verwey et al. (2018)	2	1	2	2	2	0	0	0	1	1	0	2	13	Medium
Waehle et al. (2012)	2	0	2	1	0	1	2	0	2	2	2	1	15	Medium
Waehle et al. (2019)	1	0	1	1	N/A	2	1	0	2	2	1	1	13	Medium
Wangoo et al. (2018)	2	1	1	2	2	0	1	0	0	1	0	2	12	Medium
Weller et al. (2018)	2	0	2	1	2	0	2	0	1	1	0	2	13	Medium
White et al. (2017)	2	1	2	1	2	1	1	N/A	1	2	0	2	15	Medium
White et al. (2018)	2	1	2	2	2	2	2	N/A	2	2	0	2	19	High
White et al. (2018)	2	0	1	2	2	0	1	N/A	2	1	0	2	13	Medium
Willassen et al. (2018)	2	0	2	1	2	1	2	1	1	2	0	2	16	High
Wright (2005)	2	0	2	0	0	0	2	0	0	1	0	0	7	Low
Wu et al. (2019)	2	2	2	2	2	1	1	0	0	1	0	2	15	Medium
Yu et al. (2017)	2	0	2	2	2	0	1	N/A	N/A	1	0	2	12	Medium

Ziman et al. (2018)	2	0	2	2	2	0	2	1	2	2	0	1	16	High
Zingiryan et al. (2017)	2	2	2	2	2	0	1	0	0	1	0	1	13	Medium

Notes. Created by the authors. N/A = Not Applicable.