OPEN

Is antibiotic prophylaxis generally safe and effective in surgical and nonsurgical scenarios? Evidence from an umbrella review of randomized controlled trials

Linhu Liu, MD^a, Zhongyu Jian, MD^{a,f}, Menghua Wang, MD^a, Chi Yuan, MD^a, Ya Li, MD^a, Yucheng Ma, MD^a, Xi Jin, MD^a, Hong Li, MD^a, Yazhou He, MD^e, Changhai Liu, MD^d, Sheyu Li, MD^{c,b,*}, Kunjie Wang, MD^{a,*}

Background: The authors aimed to comprehensively evaluate the efficacy and safety of antibiotic prophylaxis through surgical and nonsurgical scenarios and assess the strength of evidence.

Materials and methods: The authors performed an umbrella review of meta-analyses of randomized controlled trials (RCTs). An evidence map was created to summarize the absolute benefits of antibiotic prophylaxis in each scenario and certainty of evidence. **Results:** Seventy-five meta-analyses proved eligible with 725 RCTs and 78 clinical scenarios in surgical and medical prophylaxis. Of 119 health outcomes, 67 (56.3%) showed statistically significant benefits, 34 of which were supported by convincing or highly suggestive evidence from RCTs. For surgeries, antibiotic prophylaxis may minimize infection occurrences in most surgeries except Mohs surgery, simple hand surgery, herniorrhaphy surgery, hepatectomy, thyroid surgery, rhinoplasty, stented distal hypospadias repair, midurethral sling placement, endoscopic sinus surgery, and transurethral resection of bladder tumors with only low to very low certainty evidence. For nonsurgery invasive procedures, only low to very low certainty evidence showed benefits of antibiotic prophylaxis showed greater benefits in nonemergency scenarios, in which patients were mainly with weakened immune systems, or at risk of recurrent chronic infections. Antibiotics prophylaxis may increase antibiotic resistance or other adverse events in most scenarios and reached significance in cystoscopy, afebrile neutropenia following chemotherapy and hematopoietic stem cell transplantation.

Conclusions: Antibiotic prophylaxis in surgical and nonsurgical scenarios is generally effective and seems independent of surgical cleanliness and urgency of diseases. Its safety is not well determined due to lack of available data. Nevertheless, the low quality of current evidence limits the external validity of these findings, necessitating clinicians to judiciously assess indications, balancing low infection rates with antibiotic-related side effects.

Keywords: antibacterial agents, antibiotic prophylaxis, antimicrobial resistance, antimicrobial stewardship, umbrella review

Introduction

Antibiotic consumption raises from 21.1 defined daily doses (DDDs) in 2000 to 34.8 billion DDDs in 2015 and continuously

increases to now^[1]. Microbial infections are becoming the second leading cause of death globally, and unwarranted or ineffective antibiotics do not contribute to disease prognosis and may cause antibiotic resistance^[2]. Excessive use of antibiotics resulted in a

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

*Correspondings author. Address: Department of Urology, Institute of Urology (Laboratory of Reconstructive Urology), West China Hospital, Sichuan University, No. 37 Guo Xue Alley, Wuhou District, Chengdu City, Sichuan Province, People's Republic of China. Tel.: +861 898 060 1848. E-mail: wangkj@scu.edu.cn (K. Wang); Department of Endocrinology and Metabolism, Chinese Evidence-based Medicine Centre, Cochrane China Centre and MAGIC China Center, West China Hospital, Sichuan University, No. 37 Guoxue Alley, Wuhou District, Chengdu City, Sichuan Province, People's Republic of China. Tel.: +861 898 060 6701. E-mail: lisheyu@gmail.com (S. Li).

Copyright © 2023 The Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

International Journal of Surgery (2024) 110:1224-1233

Received 7 September 2023; Accepted 9 November 2023

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.lww.com/international-journal-of-surgery.

Published online 27 November 2023

http://dx.doi.org/10.1097/JS9.000000000000923

^aDepartment of Urology, Institute of Urology (Laboratory of Reconstructive Urology), and National Clinical Research Center for Geriatrics, ^bChinese Evidence-based Medicine Centre, Cochrane China Centre and MAGIC China Centre, ^cDepartment of Endocrinology and Metabolism, ^dDivision of Infectious Diseases, State Key Laboratory of Biotherapy and Centre of Infectious Disease, West China Hospital, ^eWest China School of Public Health and West China Fourth Hospital and ^fWest China Biomedical Big Data Centre, Sichuan University, Chengdu, People's Republic of China

Linhu Liu, Zhongyu Jian, Menghua Wang, and Chi Yuan contributed equally to this work.

series of healthcare crises^[3], which may lead to anticipated 10 million death globally each year by $2050^{[4]}$.

In addition to treating infection, antibiotics are for a prophylactic purpose, including the prevention of clinically relevant infection in people undergoing surgery, invasive operations, and cancer chemotherapy as well as those with other conditions that put people at high risk^[5]. Prophylactic use of antibiotics may reduce potential infections and improve disease prognosis; however, a potential link to excessive or inappropriate prescription that brings individual and population-level side effects such as hypersensitivity, secondary infection, and liver and kidney injury as well as antimicrobial resistance, extra medical cost, and longer hospital stay^[6]. Antibiotics for this purpose constitute ~25.2% of the total in-hospital antibiotic prescription and contribute to the most controversy and risk of improper use of antibiotics^[7]. Nevertheless, the rationality of such use highly relies on the specific scenario as well as the value and preference of a person and the public. The criticism regarding the prophylactic use of antibiotics never stops leaving a large gap between evidence and practice. For example, the clinical practice guideline of the European Society of Gastrointestinal Endoscopy recommended antibiotics for infection prophylaxis in people undergo endoscopic ultrasonography-guided fine needle aspiration (EUS-FNA) of pancreatic cysts^[8], despite the latest evidence synthesis demonstrating a null effect of such use^[9]. This example calls for comprehensive evidence summary for antibiotic prophylaxis for clinicians guideline developers.

To date, accumulated meta-analyses assessed the efficacy and safety of antibiotic prophylaxis, but left fragmented and controversial conclusions that confuse clinicians and public health professionals. High-quality and comprehensive evidence is urgently needed to promote the rational use of prophylactic antibiotics and improve antibiotic stewardship. In this study, we comprehensively integrated the published meta-analyses regarding the prophylactic use of antibiotics and map the evidence with an umbrella review.

Material and methods

This umbrella review followed the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020 statement) (Supplemental Digital Content 1, http://links.lww.com/JS9/B416, Supplemental Digital Content 2, http://links.lww.com/JS9/B417)^[10].

Literature search and selection criteria

We performed a systematic literature search in PubMed, EMBASE, Web of Science Core Collection, and the Cochrane Database of Systematic Reviews from inception to 30 December 2022 (latest update), for meta-analyses evaluating the efficacy and safety of antibiotic prophylaxis. We used medical subject heading (MeSH) terms and keywords in the search, including 'antibiotic prophylaxis' and 'meta-analysis' or 'systematic review' (Supplementary Table 1, Supplemental Digital Content 3, http:// links.lww.com/JS9/B418, detailed search strategies). We also manually checked the references in eligible articles. Two authors separately screened and performed full texts review for eligibility. Points of divergence were resolved by discussion among three authors of the present study.

HIGHLIGHTS

- Antibiotic prophylaxis has little or no effect in certain surgical scenarios.
- Antibiotic prophylaxis is not recommended in nonsurgery invasive procedures.
- Antibiotic resistance and other adverse events are increased in three scenarios.
- Low quality of current evidence limits the external validity of the results and necessitating clinicians to carefully balance the relative low risk of infection and antibioticrelated adverse outcomes.

Eligible pairwise meta-analyses investigated the clinical effectiveness of antibiotic prophylaxis compared to placebo or no treatment on any outcome in any clinical scenarios including randomized controlled trials (RCTs) and nonrandomized studies of intervention (NRSIs). Our study defined antibiotic prophylaxis as the prevention initial infections and subsequent complications using antibiotics when there is no clear evidence of present infection. Meta-analyses including only NRSIs or only one RCT that cannot be reanalyzed were excluded. For meta-analyses regarding the same topic, we included only the one with the largest number of included RCTs. The language was restricted to English.

Data extraction

Paired reviewers extracted the data with a common sheet and one of the two reviewers summarized and adjudicated the results. The extracted information includes first author, publication year, number of included studies, number of cases and total population, disease or condition, type of antibiotics, control, outcomes, study design, clinical scenarios, phase of prevention, follow-up duration, adverse events, control event rate (CER), effect size, and statistical profiles. For studies with more than one outcome, we only included primary outcomes to avoid multiple comparisons in a single meta-analysis.

Evidence synthesis

Stata version 14 (StataCorp) and R version 4.03 (R Foundation for Statistical Computing) facilitate the statistical analyses.

For meta-analyses included both RCTs and NRSIs, we removed the NRSIs and reanalyzed the data from RCTs using a random-effects DerSimonian-Laird (DL) estimator, assuming the existence of real differences across studies^[11]. The between-study heterogeneity was evaluated with the I^2 statistics and τ^2 statistics^[12]. For meta-analyses with statistical significance, we applied an excess significance bias test to assess whether the observed number (O) of statistically significant studies (positive studies, $P \le 0.05$) differed from the expected (E), by using a χ^2 test, and a P value ≤ 0.10 indicated the excess significance bias^[13,14]. For meta-analyses including more than three trials, the 95% prediction interval for each outcome was calculated. For outcomes with statistical significance in the reanalysis, we calculated the number need to treat (NNT) with its 95% CI^[15,16]. We assessed the small study effects and publication bias of an outcome using Begg's correlation, Egger's regression and Harbord's score if the analysis includes more than three trials^[17].

The baseline risk anticipated using the event and person-time data in the control group estimated the absolute risk difference with pooled RRs and their 95% CIs.

For meta-analyses with publication bias (Begg's correlation, Egger's regression, or Harbord's score <0.05), estimates after trim-and-fill adjustment join the presented results^[18].

Quality assessment of evidence and included meta-analyses

The quality of evidence was assessed by using GRADE (Grading of Recommendations, Assessment, Development and Evaluation) with four domains: very low, low, moderate and high. We assessed the methodological qualities of included meta-analyses using AMSTAR2 (Supplemental Digital Content 4, http://links. lww.com/JS9/B419) (A MeaSurement Tool to Assess systematic Reviews 2), an updated 16-items tool to assess systematic reviews^[19]. Based on the effect size and quality of evidence, we categorized the evidence from meta-analyses of RCTs into five grades, say convincing, highly suggestive, suggestive, weak, and nonsignificant. Supplementary Table 2 (Supplemental Digital Content 5, http://links.lww.com/JS9/B420) described the detailed criteria.

Category of outcomes and scenarios

The multidisciplinary team categorized the outcomes into six classes including 'mortality', 'overall infection', 'surgical site/wound infection', 'localized infection', 'bloodstream infection', and 'symptoms or complication'. Supplementary Table 3 (Supplemental Digital Content 6, http://links.lww.com/JS9/B421) showed the definition of each category. We divided clinical scenarios into two classes: surgical (including surgery and nonsurgery invasive procedures) and medical prophylaxis. For surgical prophylaxis with antibiotics, we followed the classification of the National Academy of Science and categorize surgical wounds into four types, say clean, clean-contaminated, contaminated and dirty or infected (Supplementary Table 3, Supplemental Digital Content 6, http://links.lww.com/JS9/B421)^[20].

Results

Characteristics of included studies

This umbrella review included 75 systematic reviews with 725 RCTs, 119 outcomes and 163 832 participants (Fig. 1). Supplementary Table 4 (Supplemental Digital Content 7, http:// links.lww.com/IS9/B422) showed the detailed results for AMSTAR2 assessment with 47 (39%) systematic reviews in high methods quality and 24 (20%) in low. Supplementary Table 5 (Supplemental Digital Content 8, http://links.lww.com/JS9/B423) summarized the GRADE findings for each outcome with 36 (30%) high to moderate certainty evidence and 83 (70%) low to very low certainty. The team reanalyzed 28 outcomes by removing the included NRSIs with two of them switching their trends, where the benefit of antibiotic prophylaxis became nonsignificant to all-cause mortality of patients with acute necrotizing pancreatitis (RR 0.75, 95% CI: 0.47-1.20) and to ventriculostomyrelated infections of patients with external ventricular drain (RR 0.43, 95% CI: 0.17–1.08) (Supplementary Table 6, Supplemental Digital Content 9, http://links.lww.com/JS9/B424, summarized estimates before and after the reanalysis). Supplementary Table 7 (Supplemental Digital Content 10, http://links.lww.com/JS9/ B425) and Supplementary Figure 1 (Supplemental Digital Content 11, http://links.lww.com/JS9/B426) summarized the full characteristics and assessments for all included systematic reviews. Supplementary Table 8 (Supplemental Digital Content 12, http:// links.lww.com/JS9/B427) listed the excluded studies as well as the rationales. Supplementary table 9 (Supplemental Digital Content 13, http://links.lww.com/JS9/B428) summarized available drugrelated adverse events which were extracted for synthesis in 21 scenarios. Supplementary Figure 2 (Supplemental Digital Content 14, http://links.lww.com/JS9/B429) illustrated statistically significant outcomes along with their number of need to treat (NNT). Shown in Supplementary Figure 3 (Supplemental Digital Content 15, http://links.lww.com/JS9/B430), Egger's regression, Begg's correlation and Harbord's score indicated potential



Figure 1. Flowchart of study selection and evaluation process.

publication bias in 21 outcomes among 18 scenarios. For afebrile neutropenia following chemotherapy^[21], urodynamic studies^[22], elective abdominal hysterectomy^[23], breast reduction surgery^[24], and history of cellulitis^[25], the effect estimates lost their robustness after applying the trim-and-fill analyses. The contourenhanced funnel plot presented the theoretical missing studies and further illustrated the publication biases.

Surgical prophylaxis

Thirty-seven types of surgeries and 11 nonsurgery invasive procedures were included. Among 55 outcomes in surgeries, 13/18 outcomes of clean, 26/33 of clean-contaminated and 3/3 of contaminated incisions showed significant benefits of antibiotic prophylaxis. 6/18 of clean, 18/33 outcomes of cleancontaminated, and 1/3 outcomes of contaminated incisions were of convincing (class I) or highly suggestive (class II) evidence (Fig. 2). Antibiotic prophylaxis had little or no effect on reducing wound infection after simple hand surgery and herniorrhaphy surgery, surgical site infections after Mohs surgery and thyroid surgery, postoperative fever and febrile urinary tract infections (UTIs) after ureteroscopic lithotripsy, UTIs after midurethral sling placement and for kidney transplant recipients with asymptomatic bacteriuria, overall infections and complications after endoscopic sinus surgery, rhinoplasty, and stented distal hypospadias repair. Convincing (Class I) evidence showed that antibiotic prophylaxis reduced surgical site infections after total joint arthroplasty (NNT = 24, moderate certainty) and breast cancer surgery (NNT=29, moderate certainty) for clean surgeries, and cesarean section (NNT = 18, moderate certainty), elective laparoscopic cholecystectomy (NNT = 62, high certainty), and abdominal hysterectomy (NNT = 31, moderate certainty) for clean-contaminated surgeries. Among 16 outcomes in nonsurgery invasive procedures, prophylactic use of antibiotics possibly reduced urinary tract infections after cystoscopy, or

Clinical scenarios	Outcomes	No. of RCTs		Random Effects (95% CI)	Baseline risk	Absolute risk difference	GRADE	AMSTAR2	Evidence Classification
Total joint arthroplasty	Surgical site infections	3	- <u> </u>	0-24 [0-16.0-37]	60 per 1000	46 fewer per 1000 (38 fewer to 50 fewer)	Moderate	Critically Low	Class I
Plastic and reconstructive surgery (Clean)	Surgical site infections	4		0.41 [0.25,0.66]	170 per 1000	100 fewer per 1000 (58 fewer to 130 fewer)	Moderate	Low	Class II
Hernioplasty surgery	Postoperative wound infection	22	_ 	0-61 [0-48,0-78]	63 per 1000	25 fewer per 1000 (14 fewer to 33 fewer)	Moderate	High	Class III
Breast cancer surgery	Surgical site infections	10		0-69 [0-54,0-88]	110 per 1000	34 fewer per 1000 (13 fewer to 51 fewer)	Moderate	High	Class I
Tube thoracostomy for traumatic chest injuries	Overall infectious complications	10		0.24 [0.12,0.49]	NA	NA	Low	Critically Low	Class III
Tube thoracostomy for traumatic chest injuries	Empvema	11		0.31 [0.17.0.59]	NA	NA	Low	Critically Low	Class I
Breast reduction surgery	Surgical site infections	5		0.50 [0.28.0.89]	210 per 1000	110 fewer per 1000 (23 fewer to 150 fewer)	Low	Critically Low	Class IV
Hepatectomy	Surgical site infections	4		1.19 [0.79.1.80]	70 per 1000	13 more per 1000 (15 fewer to 56 more)	Low	Critially Low	Class V
Simple hand surgery	Wound infection	10		0.92 [0.65.1.30]	55 per 1000	4 fewer per 1000 (19 fewer to 17 more)	Low	Critically Low	Class V
Closed fracture surgery	Deep surgical site infections (multiple dose)	10		0.39 [0.21.0.70]	50 per 1000	30 fewer per 1000 (15 fewer to 39 fewer)	Very low	High	Class I
Closed fracture surgery	Deep surgical site infections (single dose)	7		0-41(0-24.0-69)	27 per 1000	16 fewer per 1000 (8 fewer to 21 fewer)	Very low	High	Class I
Craniotomy surgery	Meningitis	7		0.42 (0.21.0.86)	26 per 1000	15 fewer per 1000 (4 fewer to 21 fewer)	Very Low	Critically Low	Class IV
Closed fracture surgery	Superficial surgical site infections (multiple dose)	7		0.43 (0.21, 0.89)	76 per 1000	43 fewer per 1000 (8 fewer to 60 fewer)	Verv low	High	Class IV
Mobs Surgery	Surgical site infections	5		0-49 (0-19 1-24)	69 per 1000	35 fewer per 1000 (56 fewer to 17 more)	Very low	Critically Low	Class V
Shunt surgery in children with hydrocenhalus	Infections	7		0-62 [0:40 0:96]	140 per 1000	53 fewer per 1000 (6 fewer to 84 fewer)	Very Low	Critically Low	Class IV
Thyroid surgery	Surgical site infections	3		0-67 [0-17 2-58]	7 per 1000	2 fewer per 1000 (6 fewer to 12 more)	Very low	Low.	Class V
Closed fracture surgery	Superficial surgical site infections (single dose)	7		0.71 [0.51 0.98]	51 per 1000	15 fewer per 1000 (1 fewer to 25 fewer)	Verview	High	Class IV
Herniorrhanby surgery	Postoperative wound infection	5		0.86 [0.56 1-33]	45 per 1000	6 fewer per 1000 (20 fewer to 15 more)	Verview	High	Class V
Clean-contaminated	i ostoperative nouna intestion		-	0 00 [0 00]1 00]	10 per 2000	e tener per zooo (zo tener to zo more)	1011	. ng. i	
Elective Janarosconic cholecystectomy	Surgical site infections	21		0.67 [0.50 0.90]	47 per 1000	16 fewer per 1000 (5 fewer to 24 fewer)	High	Critically Low	Class I
Elective vaginal hysterectomy	Polyic information	11		0.24 [0.13.0.46]	160 per 1000	120 fewer ner 1000 (90 fewer to 140 fewer)	Moderate	High	Class II
Lietave vaginai hysteretainty	Performantive bacteriuria	2		0.27 [0.11,0.62]	150 per 1000	110 fower per 1000 (50 fewer to 140 fewer)	Moderate	Critically Low	Class II
Corporation contine	Socieurs infectiours morbidity	27		0.27 [0.22 0.50]	22 per 1000	20 fourier per 1000 (12 fourier to 25 fourier)	Moderate	Wigh	Class III
Persutangeur apphreithetemu	Bestenerative sensis	4		0.30 (0.23,0.53)	32 per 1000	20 fewer per 1000 (15 fewer to 25 fewer)	Moderate	Critically Low	Class I
Corporation contine	Endometritis	4 07		0.30 (0.25,0.36)	160 per 1000	250 fewer per 1000 (100 fewer to 270 fewer)	Moderate	Winh	Class I
Cerarean section	Wound infection	87		0.41 (0.35 0.49)	95 per 1000	56 fewer per 1000 (48 fewer to 53 fewer)	Moderate	High	Class
Lesteressenie Bhetriesu	Destenerative purvie	2		0.42 (0.35,0.49)	53 per 1000	220 fewer per 1000 (48 fewer to 62 fewer)	Moderate	Critically Low	Class I
Elective varinal hysterectomy	Rostoperative pruna Rostoperative fever	<u>م</u>		0.43 (0.29 0.62)	280 per 1000	160 fewer per 1000 (110 fewer to 200 fewer)	Moderate	blinh	Class II
Elective abdominal byterectomy	UTIP	12		0.43 [0.20,0.61]	120 per 1000	70 fewer per 1000 (10 fewer to 200 fewer)	Moderate	High	Class II
Penal transplant recipients	Bacteriuria	2		0.43 [0.22 0.58]	650 per 1000	270 fewer per 1000 (370 fewer to 440 fewer)	Moderate	Critically Low	Clarr II
Percutapeour endorcopic astrostomy	Parintomal rite infaction	11		0.43 [0.22 0.58]	250 per 1000	140 fewer per 1000 (110 fewer to 170 fewer)	Moderate	Winh	Clarr
Corarean contion	Eabrila marbidity	56		0.45 [0.40.0.51]	230 per 1000	150 fewer per 1000 (120 fewer to 170 fewer)	Moderate	High	Clarr
Elective abdominal burterectomy	Abdominal wound infection	11		0.52 [0.25 0.90]	50 per 1000	20 found per 1000 (10 found to 40 found)	Moderate	High	Class II
Elective abdominal hysterectomy	Polyic inform	11		0.54 [0.26 0.81]	100 per 1000	50 fewer per 1000 (10 fewer to 30 fewer)	Moderate	High	Class I
Elective abdominal hysterectomy	Performanting four	11		0.55 [0.43 0.72]	270 per 1000	120 fower per 1000 (00 fewer to 160 fewer)	Moderate	High	Class III
Elective addominal hysteriectomy				0.55 [0.42,0.72]	270 per 1000	20 fewer per 1000 (30 fewer to 100 fewer)	Moderate	High	Class III
Plactic and reconstructive surgery (Clean contaminated)	Surgical site infections	5		0.61 (0.27,0.60)	130 per 1000	47 fourier per 1000 (20 fewer to 100 fewer)	Moderate	Low	Class IV
Surrany for incomplete abortion	Gonital tract infection	24		0.62 (0.51,0.33)	120 per 1000	NA	Moderate	High	Class III
Transurational recession of the prostate	Santicomia	24		0.32 (0.00 0.57)	12 per 1000	10 fourier par 1000 /E fourier to 12 fourier)	Low	Low	Class III
Transuretriral resection of the prostate	Septicemia	•		0-23 (0-09,0-57)	13 per 1000	To rewer per 1000 (6 rewer to 12 rewer)	LOW	LOW	Class I
Elective vaginal hysterectomy	Postoperative intections	4		0-20 (0-06,0-62)	630 per 1000	Sob rewer per 1000 (240 rewer to S90 rewer)	low	rign	Class II
Directeroscopic innorripsy	Postoperative tebrile UTIS	3		0-29 (0-07,1-23)	30 per 1000	20 fewer per 1000 (30 fewer to 7 more)	LOW	Critically Low	Class V
Dentai impiants surgery	Earry Impiant failure	a 22		0-32 [0-20,0-51]	50 per 1000	34 fewer per 1000 (29 fewer to 38 fewer)	LOW	Critically Low	Class I
Transuretnrai resection or the prostate	Postoperative bacteriuria	32		0-33 [0-25,0-43]	85 per 1000	57 fewer per 1000 (48 fewer to 64 fewer)	LOW	LOW	Class II
lootn extraction	Postsurgical infectious complications	12		0-37 [0-22,0-62]	91 per 1000	57 fewer per 1000 (35 fewer to 71 fewer)	LOW	High	Class I
Ureteroscopic iitnotripsy	Postoperative tever	2		0-82 [0-41,1-67]	90 per 1000	20 fewer per 1000 (so fewer to 60 more)	LOW	Critically Low	Class V
Kidney transplant recipients with asymptomatic bacteriuria	Symptomatic UTIs	2		0-86 [0-51,1-45]	250 per 1000	40 fewer per 1000 (120 fewer to 110 more)	Low	Low	Class V
Renal transplant recipients	Bacteremia	2		0-13 [0-02,0-70]	120 per 1000	104 fewer per 1000 (36 fewer to 120 fewer)	very low	Critically Low	Class IV
Rhinoplasty	Infectious complications	3		0.44 [0.18,1.04]	100 per 1000	60 fewer per 1000 (80 fewer to 4 more)	very low	LOW	Class V
stented distai nypospadias repair	Overall complications	3		0.50 [0.21,1-19]	80 per 1000	40 fewer per 1000 (60 fewer to 20 more)	very low	Critically Low	Class V
Post-midurethral sling placement	UTIs	3		0.72 [0.29,1.78]	NA	NA	Very low	Critically Low	Class V
Endoscopic sinus surgery	Intections	5		0.76 [0.54,1.09]	NA	NA	Very low	critically Low	ciass V
ransurethral resection of bladder tumors	Postoperative UTIs	4		1-12 [0-22,5-70]	26 per 1000	s more per 1000 (20 fewer to 120 more)	very low	High	ciass V
contaminated									
Endoscopic resection for colorectal lesions	Postoperative adverse events	5		U-16 [0-08,0-31]	180 per 1000	150 tewer per 1000 (120 fewer to 170 fewer)	Moderate	LOW	ciass II
Colorectal surgery	Surgical wound infection	30	-	0.35 [0.29,0.41]	390 per 1000	250 tewer per 1000 (230 fewer to 270 fewer)	LOW	High	Class III
I ransrectal prostate biopsy	Pooled intectious complications	12		U-58 [0-40,0-85]	150 per 1000	63 fewer per 1000 (23 fewer to 90 fewer)	LOW	High	Class III
Dirty or infected									
Incision and drainage of anorectal abscesses	Anal fistulas	2		U-89 [0-26,3-03]	270 per 1000	30 fewer per 1000 (200 fewer to 550 more)	Very low	Critically Low	Class V
Undefined									
Any surgical procedures	surgical site intections	52		0-89 [0-79,1-00]	63 per 1000	/ rewer per 1000 (0 fewer to 13 fewer)	Moderate	High	Class V

Figure 2. Summary estimates of the efficacy of antibiotic prophylaxis in surgery. Surgical procedures were categorized into clean, clean-contaminated, contaminated and dirty or infected according to their cleanliness. UTIs, urinary tract infections; NA, not applicable. Notes: baseline risk means the expected events per 1000 persons within follow-up time frame regarding each outcome. Some baseline risks and absolute effects cannot be calculated because original data are unavailable.

Clinical scenarios	Outcomes	No. of RCTs		Random Effects (95% CI)	Baseline risk	Absolute risk difference	GRADE	AMSTAR2	Evidence Classification
Adults undergoing cystoscopy	Systemic UTIs	5	→	1.09 [0.41,2.89]	30 per 1000	3 more per 1000 (20 fewer to 60 more)	Moderate	High	Class V
Adults undergoing cystoscopy	Symptomatic UTIs	11	(0.48 [0.29,0.78]	40 per 1000	20 fewer per 1000 (8 fewer to 28 fewer)	Low	High	Class III
Postoperative urinary catheterization	UTIs	8	_	0.50 [0.29,0.88]	140 per 1000	70 fewer per 1000 (17 fewer to 99 fewer)	Low	Critically Low	Class IV
Mechanical ventilation	Ventilator-associated pneumonia	5		0.61 [0.39,0.98]	380 per 1000	150 fewer per 1000 (8 fewer to 230 fewer)	Low	Critically Low	Class IV
Hematopoietic stem cell transplantation (HSCT)	All-cause mortality	6		0.95 [0.58,1.55]	60 per 1000	3 fewer per 1000 (25 fewer to 33 more)	Low	Low	Class V
Totally implantable venous access device (TIVAD) placement	Infections	2		1.17 [0.38,3.59]	23 per 1000	4 more per 1000 (14 fewer to 60 more)	Low	Critically Low	Class V
Elective endoscopic retrograde cholangiopancreatography (ERCP)	All-cause mortality	7		1-20 [0-39, 3-73]	10 per 1000	2 more per 1000 (6 fewer to 28 more)	Low	High	Class V
Shock wave lithotripsy in patients with sterile urine	Fever	4	• • •	0.39 [0.07,2.20]	140 per 1000	85 fewer per 1000 (130 fewer to 170 more)	Very low	Critically Low	Class V
External ventricular drain (EVD) placement	Ventriculostomy-related infections	3	•	0.43 [0.17,1.08]	190 per 1000	110 fewer per 1000 (160 fewer to 16 more)	Very low	Low	Class V
Elective endoscopic retrograde cholangiopancreatography (ERCP)	Septicaemia	6		0.44 [0.18,1.07]	55 per 1000	30 fewer per 1000 (45 fewer to 4 more)	Very low	High	Class V
Shock wave lithotripsy in patients with sterile urine	UTIs	8		0.67 [0.35,1.26]	52 per 1000	17 fewer per 1000 (34 fewer to 14 more)	Very low	Critically Low	Class V
Elective endoscopic retrograde cholangiopancreatography (ERCP)	Acute cholangitis	8		0.67 [0.39,1.14]	58 per 1000	19 fewer per 1000 (35 fewer to 8 more)	Very low	High	Class V
Urodynamic studies	Symptomatic UTIs	6		0.68 [0.48,0.95]	250 per 1000	80 fewer per 1000 (13 fewer to 130 fewer)	Very low	Low	Class IV
Transarterial therapy of hepatocellular carcinoma	Fever	3		0.81 [0.47,1.41]	120 per 1000	23 fewer per 1000 (64 fewer to 49 more)	Very low	Low	Class V
Shock wave lithotripsy in patients with sterile urine	Positive urine culture	10		0.96 [0.62,1.48]	99 per 1000	4 fewer per 1000 (38 fewer to 47 more)	Very low	Critically Low	Class V
Hysteroscopy	Overall infection	3		1.66 [0.43,6.50]	4 per 1000	2 more per 1000 (2 fewer to 200 more)	Very low	Low	Class V
			0.10 0.50 1.0 2.0						
Figure 3. Summary estimates of	the efficacy of ant	biotic p	rophylaxis in nonsurgery ir	vasive proced	dures. U ⁻	Fls, urinary tract infection	ons.		

postoperative urinary catheterization and urodynamic studies, but the evidence was suggestive or weak with low to very low certainty (Fig. 3).

Medical prophylaxis

Among 29 medical scenarios and 47 outcomes, 22 outcomes showed significant benefits of antibiotic prophylaxis, in which 10 outcomes were of convincing (class I) or highly suggestive (class II) evidence (Fig. 4). Convincing evidence supported antibiotic prophylaxis to reduce unfavorable events after tick bite (NNT = 69, low certainty), skin rash for cancer patients received anti-EGFR inhibitors, spontaneous bacterial peritonitis for patients with cirrhosis with ascites (NNT = 9, moderate certainty), neonatal infections for maternal Group B Streptococcal colonization (NNT = 14, moderate certainty) and to improve quality of life for patients with chronic obstructive pulmonary disease (COPD) (High certainty). Antibiotic prophylaxis reduced mortality for cirrhotic patients with gastrointestinal bleeding (moderate certainty) and cancer patients with afebrile neutropenia following chemotherapy (high certainty) but may have

Clinical scenarios	Outcomes	No. of RCTs	Random Effects (95% CI)	Baseline risk	Absolute risk difference	GRADE	AMSTAR2	Evidence Classification
Emergency								
Basilar skull fracture	Meningitis	4	0.71 [0.31,1.67]	130 per 1000	38 fewer per 1000 (90 fewer to 87 more)	Moderate	High	Class V
Gastrointestinal bleeding in cirrhotic patients	Overall mortality	12	0.79 [0.64,0.98]	220 per 1000	46 fewer per 1000 (4 fewer to 79 fewer)	Moderate	Low	Class IV
Gastrointestinal bleeding in cirrhotic patients	Bacterial infections	12	0.35 [0.26,0.47]	380 per 1000	250 fewer per 1000 (201 fewer to 280 fewer)	Low	Low	Class III
Tick bite	Unfavorable events	6	0.38 [0.22,0.66]	NA	NA	Low	Critically Low	Class I
Coma	Ventilator-associated pneumonia	2	0.41 [0.23,0.74]	440 per 1000	260 fewer per 1000 (110 fewer to 340 fewer)	Low	Critically Low	Class II
ICU stay	ICU-acquired pneumonia	5	0.46 [0.23,0.91]	290 per 1000	160 fewer per 1000 (26 fewer to 220 fewer)	Low	Low	Class IV
Acute necrotizing pancreatitis	Infected pancreatic necrosis	9	0.83 [0.62,1.12]	290 per 1000	34 fewer per 1000 (76 fewer to 24 more)	Low	Critically Low	Class V
Burn injury	Burn wound infection	7	0.84 [0.51,1.39]	220 per 1000	35 fewer per 1000 (108 fewer to 86 more)	Low	High	Class V
ICU stay	All-cause mortality	5	0.90 [0-61,1-32]	210 per 1000	21 fewer per 1000 (82 fewer to 67 more)	Low	Low	Class V
Burn injury	Sepsis	6	1.05 [0-65,1.70]	180 per 1000	9 more per 1000 (63 fewer to 130 more)	Low	High	Class V
Burn injury	Bacteremia	5	1.08 [0.67,1.72]	130 per 1000	10 more per 1000 (43 fewer to 94 more)	Low	High	Class V
Open globe injury	Visual acuity	3	1.16 [0.62,2.18]	70 per 1000	10 more per 1000 (30 fewer to 80 more)	Low	Critically Low	Class V
Open globe injury	Endophthalmitis	3	0.21 [0.07,0.64]	100 per 1000	80 fewer per 1000 (40 fewer to 90 fewer)	Very low	Critically Low	Class II
Chest Trauma	Empyema	5	0.21 [0.08,0.56]	82 per 1000	65 fewer per 1000 (36 fewer to 75 fewer)	Very low	Critically Low	Class III
Acute stroke	Poststroke infection	6	0.41 [0.20,0.87]	250 per 1000	150 fewer per 1000 (30 fewer to 200 fewer)	Very low	Low	Class IV
Chest Trauma	Pneumonia	5	0.43 [0.17,1.12]	130 per 1000	74 fewer per 1000 (108 fewer to 16 more)	Very low	Critically Low	Class V
Gastrointestinal bleeding in cirrhotic patients	Mortality due to bacterial infections	6	0.48 [0.20,1.14]	51 per 1000	27 fewer per 1000 (41 fewer to 7 more)	Very low	Low	Class V
Open distal phalanx fractures	Superficial infection	4 • • • •	0.58 [0.17,2.03]	92 per 1000	39 fewer per 1000 (76 fewer to 95 more)	Very Low	Critically Low	Class V
Cardiac arrest	Pneumonia	2	0.62 [0.31,1.24]	NA	NA	Very low	Critically Low	Class V
Premature rupture of the membranes (PROM)	Chorioamnionitis	4	0.66 [0.34,1.26]	53 per 1000	18 fewer per 1000 (35 fewer to 14 more)	Very Low	Low	Class V
Premature rupture of the membranes (PROM)	Neonatal sepsis	4	0.72 [0.30,1.75]	20 per 1000	6 fewer per 1000 (14 fewer to 15 more)	Very Low	Low	Class V
Acute necrotizing pancreatitis	All-cause mortality	9	0.75 [0.47,1.20]	160 per 1000	40 fewer per 1000 (85 fewer to 32 more)	Very Low	Critically Low	Class V
Cardiac arrest	Survival	3	0.84 [0.51,1.37]	NA	NA	Very low	Critically Low	Class V
Non-emergency								
Afebrile neutropenia following chemotherapy	All-cause mortality	46	0.71 [0.57,0.88]	110 per 1000	32 fewer per 1000 (13 fewer to 47 fewer)	High	High	Class III
Second or third trimester of pregnancy	Preterm delivery	6	0.88 [0.72,1.09]	190 per 1000	23 fewer per 1000 (53 fewer to 17 more)	High	High	Class V
Chronic obstructive pulmonary disease (COPD)	Quality of life	7	-1-94 [-3-13,-0-75]	NA	NA	High	High	Class I
Cirrhosis with ascites	Spontaneous bacterial peritonitis	6	0.23 [0.11,0.48]	160 per 1000	120 fewer per 1000 (80 fewer to 140 fewer)	Moderate	Critically Low	Class I
Maternal Group B Streptococcal Colonization	Neonatal all cause infections	11	0.30 [0.20,0.46]	120 per 1000	84 fewer per 1000 (65 fewer to 96 fewer)	Moderate	Critically Low	Class I
Cancer patients received anti-EGFR inhibitors	Grade 2–4 skin rash	9	0.40 [0.22,0.76]	NA	NA	Moderate	Critically Low	Class III
Second or third trimester of pregnancy	Puerperal sepsis/Postpartum endometritis	3	0.54 [0.35,0.83]	140 per 1000	64 fewer per 1000 (24 fewer to 91 fewer)	Moderate	High	Class II
Chronic obstructive pulmonary disease (COPD)	Exacerbation	8	0.57 [0.42,0.78]	100 per 1000	40 fewer per 1000 (20 fewer to 60 fewer)	Moderate	High	Class III
Chemotherapy for acute leukemia	Febrile neutropenia	2	0.79 [0.71,0.88]	850 per 1000	180 fewer per 1000 (100 fewer to 250 fewer)	Moderate	Critically Low	Class II
Normal vaginal birth	UTIs	2	0.25 [0.06,1.15]	40 per 1000	30 fewer per 1000 (40 fewer to 6 more)	Low	High	Class V
Peritoneal dialysis	Exit-site/Tunnel infection	3	0.45 [0.19, 1.04]	180 per 1000	99 fewer per 1000 (150 fewer to 7 more)	Low	High	Class V
History of cellulitis	Recurrence of cellulitis	5	0.45 [0.26,0.79]	370 per 1000	203 fewer per 1000 (78 fewer to 270 fewer)	Low	Low	Class II
Cancer patients received anti-EGFR inhibitors	All-grade skin rash	9	0.61 [0.44,0.85]	NA	NA	Low	Critically Low	Class I
Newly diagnosed multiple myeloma	Infections	3	0.79 [0.62,1.00]	240 per 1000	50 fewer per 1000 (0 fewer to 91 fewer)	Low	Critically Low	Class V
Peritoneal dialysis	Catheter removal or replacement	5	0.82 [0.46,1.46]	130 per 1000	23 fewer per 1000 (70 fewer to 60 more)	Low	High	Class V
Peritoneal dialysis	Peritonitis	5	0.82 [0.57,1.18]	350 per 1000	63 fewer per 1000 (150 fewer to 63 more)	Low	High	Class V
Children at risk of recurrent UTIs	Recurrent UTIs	5	0.84 [0.56,1.27]	260 per 1000	40 fewer per 1000 (110 fewer to 70 more)	Low	Low	Class V
Symptomatic or febrile UTIs in children	Infection-related renal scarring	7	0.97 [0.62,1.49]	70 per 1000	2 fewer per 1000 (30 fewer to 30 more)	Low	Critically Low	Class V
Non-HIV immunocompromise	Pneumocystis pneumonia	7	0.24 [0.06,0.93]	51 per 1000	39 fewer per 1000 (4 fewer to 48 fewer)	Very low	High	Class IV
Normal vaginal birth	Endometritis	2	0.28 [0.09,0.83]	20 per 1000	10 fewer per 1000 (3 fewer to 20 fewer)	Very low	High	Class IV
Vesicoureteral reflux	Febrile and symptomatic UTIs	8	0.63 [0.42,0.96]	220 per 1000	81 fewer per 1000 (9 fewer to 130 fewer)	Very Low	Low	Class IV
Cirrhosis with ascites	Mortality	6	0-64 [0-47,0-89]	280 per 1000	100 fewer per 1000 (30 fewer to 150 fewer)	Very low	Critically Low	Class III
Normal vaginal birth	Wound infection	2	0.78 [0-31,1.95]	50 per 1000	10 fewer per 1000 (30 fewer to 50 more)	Very low	High	Class V
Women at risk of preterm birth	Preterm birth	17	1.03 [0-86, 1-24]	140 per 1000	4 more per 1000 (20 fewer to 34 more)	Very low	Low	Class V
		0.10 0.50 1.0 2.0						

Figure 4. Summary estimates of the efficacy of antibiotic prophylaxis in medical scenarios. Medical scenarios were categorized into nonemergency and emergency scenarios. UTIs, urinary tract infections; NA, not applicable.



Figure 5. Summary estimates of adverse events of antibiotic prophylaxis. The adverse events are divided into antibiotic resistance and other drug-related adverse events. UTIs, urinary tract infections; NA, not applicable.

no benefits in mortality for patients with acute necrotizing pancreatitis (very low certainty), or after cardiac arrest (very low certainty), or during ICU stay (low certainty).

Antibiotic-related adverse events

Antibiotic resistance and other adverse events were scarcely reported, and we only extracted and pooled from 21 clinical scenarios (Fig. 5). Antibiotic resistance was reported in six scenarios^[21,26–30], and prophylactic antibiotics significantly increased the risk of developing antibiotic resistance in adults undergoing cystoscopy (two studies, RR 1.73, 95% CI: 1.04–2.87, 1 week follow-up) and afebrile neutropenia following chemotherapy (19 studies, 1.47, 1.08–2.01, 1–12 months follow-up)^[21,27]. Other adverse events were mostly skin reactions such as rash and pruritus, and gastrointestinal symptoms like nausea, vomiting, and diarrhea. Prophylactic antibiotics significantly increased the rates of adverse events in hematopoietic stem cell transplantation (eight studies, 3.32, 1.45–7.63, 5–30 days follow-up) and afebrile neutropenia following chemotherapy (37 studies, 1.58, 1.19–2.12, 1–12 months follow-up)^[21,31].

An evidence map summarizing the findings and certainty of evidence was shown in Figure 6. It displayed the effect size, number need to treat, and the grade and classification of evidence for different outcomes in surgical and medical scenarios. The color in each cell represented the classification of evidence, and the proportion of color within the cell reflects the magnitude of the NNT.

Discussion

This umbrella review involved 75 systematic reviews, including 725 RCTs and 119 outcomes and represented the most comprehensive evidence regarding the prophylactic use of antibiotics in

surgical and medical scenarios. For surgeries, antibiotic prophylaxis showed benefits in most surgeries by reducing the infection rate, while it may have little or no benefits in herniorrhaphy surgery, Mohs surgery, simple hand surgery, hepatectomy, thyroid surgery, rhinoplasty, stented distal hypospadias repair, midurethral sling placement, endoscopic sinus surgery, and transurethral resection of bladder tumors with low to very low certainty of evidence. For nonsurgery invasive procedures, although antibiotic prophylaxis showed benefits for cystoscopy, urodynamic study, and postoperative urinary catheterization, clinical guidelines discourage routine use in consideration of antibiotic resistance due to relatively high frequency of these procedures and heterogeneity between individual studies^[32,33]. For medical prophylaxis, high certainty evidence support benefits of antibiotic prophylaxis for patients with COPD or afebrile neutropenia following chemotherapy. Antibiotic resistance and other adverse events were reported in adults undergoing cystoscopy, afebrile neutropenia following chemotherapy and hematopoietic stem cell transplantation. Evidence body with low to very low certainty calls for the confirmation by well-designed randomized trials.

The US Centres for Disease Control and Prevention (CDC) recommended^[34] prophylactic antibiotics in surgery with a high risk of infection (such as cancer surgery, neurosurgery, orthopedic surgeries, and organ transplants), labor and delivery, people with immunosuppression (such as HIV, uncontrolled diabetes, and taking chemotherapy or immunosuppressive drugs), and chronic infections (such as recurrent urinary tract infections and COPD). According to a global survey, for prophylactic purposes, bone and joint infections (surgical site infection for plastic or orthopedic surgery) is the most common target accounting for 4.7% of treated patients worldwide, followed by gastrointestinal infections (4.2%), general prophylaxis (3.8%), obstetric or gynecological surgery (3.0%), and urinary tract infection after

Certainty of evidence	Necessity of artibiotic pro Necessity of artibiotic pro Necessity of artibiotic pro No necessity of artibiotic	ppykees: class II (Suggestive) aphylaxis: Class III (Suggestive) aphylaxis: Class IV (Weak) prophylaxis: Class V (Nonsignifican	a s a Modernate a s Low a Very low			
8 Scale of NNT second secon	Mot available Mortality	Overall infection	Surgical site/wound	Localized infection	Bloodstream infection	Symptom or
Surgery						
Total joint arthroplasty			24 Surgical site infections		1	
Closed fracture surgery			Deep [single] = 116 36 Deep (realized) =		-	
closed macture surgery			 66 Superficial 23 Superficial - (single) 73 Superficial - (nultiple) 			
Breast cancer surgery	L		29 Surgical site infections			
Plastic and reconstructive surgery (Clean)			Sution steinfection	22 Emplema e e		NA Overall infectiou
Craniotomy surgery				61 Meningitis o		
Breast reduction surgery			Li Sungical site infections ++++			
Hernioplasty surgery			47 votoperative wound intection			
Shunt surgery in children with hydrocephalus		20 infections e				
Herniormaphy surgery Mohs Surgery			Postoperative wound infection a Surpical site infections a			
Simple hand surgery			Wound infection			
Thyroid surgery			Surgical site infections 🔹			
Hepatectomy			Surgical site infections 0.0			
Clean-contaminated						febrie
Percutaneous nephrolithotomy			10 Wound infection	es Endometritis	Postoperative sepsis and	notidty
Percutaneous endoscopic gastrostomy	i		7 Peristomal site infection			
Elective laparoscopic cholecystectomy Dental implants surgery			62 Sugical the infections			32
Elective vaginal hysterectomy		Post operative infections +++	-	06 united to a second s		a Postope
Elective abdominal hysterectomy			31 Abdominal wound infection	Lines and 10 Paleic Infection		3 Postope
Transurethral resection of the prostate			100	6 Postoperative bacteriaria e e	30 Septicaemia +++	e
Renal transplant recipients				Bocteriuria	9 Bacteraerria +	
Tooth extraction	l		<u> </u>			18 Parturgical internet
Plastic and reconstructive surgery (Clean- contaminated)	i	l		22 Surgical site infections e.e.e		
Surgery for incomplete abortion	İ			52 Genital tract infection		
Ureteroscopic lithotripsy Rhinoplasty			-	Succentration III III III IIII IIII IIII IIIII IIIII IIII	8 Postoperative pyuria	Postoperative
Stented distal hypospadias repair						Dveral comp
Post-midurethral sling placement		lafaalaan -		Uninary tract infections @		
Kidney transplant recipients with asymptomatic		induits a		Symptomatic UTIs and		
bacteriuria Transurethral resection of bladder tumours	l			Pestopenative universities infections in		
Contaminated						
Endoscopic resection for colorectal lesions						2 Postoperative adv
Colorectal surgery			Surgical wound infection @ @			
Dirty or infected	i					TA HOUSE INSCISSI
Incision and drainage of anorectal abscesses				Anal fistulas 🌼		
Undefined						
Any surgical procedures	Ĺ		Surgical site infections			
Non-surgery invasive procedure	es					
Postoperative urinary catheterization Mechanical ventilation			-	14 Urinary tract infections 0.0 Ventilator-associated one-amonia 0.0		
Adults undergoing cystoscopy				33 Symptomatic UTIs +++	Systemic UTIs	
Urodynamic studies				12 Symptomatic UTIs a		
Shock wave lithotripsy in patients with sterile urine				culture 0 UTS 0		Pe
External ventricular drain (EVD) placement	(Ventriculostomy-related infections	5			
	L					
Elective endoscopic retrograde cholangiopancreatography (ERCP)	All-cause montality	,		Acute cholangitis =	Septicaemia o	
Elective endoscopic retrograde cholangiopancreatography (ERCP) Transarterial therapy of hepatocellular carcinoma Hematonovici, stem call transmission (MSCI)	All-cause mortality and	*		Acute cholangitis =	Septicaemia o	fe
Elective endoscopic retrograde cholangiopancreatography (ERCP) Transarterial therapy of hapatocellular corinoma Hematopoietic stem cell transplantation (HSCT) Totally implantable venous access device (TWAD)	All-cause mortality === All-cause mortality ===	e e e e e e e e e e e e e e e e e e e		Acute cholangitis =	Septicaerria +	fe
Elective endoscopic retrograde cholangiopancreatography (ERCP) Transarterial therapy of hepatecellular cardinoma Hematopoleici stem cell transplantation (HSCT) Totally implantable venous access device (TWAD) placement Hysteroscopy	All-cause mortality === All-cause mortality ===	Overallinfection o		Acute cholangitis =	Septicaentia o	fe
Elective endoscopic retrograde cholongiopancreatography (ERCP) Transtruit il threagy of hepstocollular carcinoma Hematopoletic stem cell transplantation (HSCT) Tataly implantative vonus access device (TIVAD) placement Hysteroscopy Medical scenarios	All-cause mortality === All-cause mortality ==	Trifections ++++++++++++++++++++++++++++++++++++		Acute cholangits. *	Septicaentia o	Fe
Elective endoscopic retrograde cholangiopancreatography (IRCP) Transtruit litheray of papascellular carinoma Hematopoletis stem cell transplanation (IRCT) Tatal) implantative unou access device (TIYAD) placement Hysteroscopy Medical scenarios Emergency	All-cause mortality === All-cause mortality ==	nnfections e e Overallinfection e		Acute cholangits =	Septicaerria o	fe
Elective endoacegie entregrade cholongegosternosceptier (ERCV) Transartelia Horrays of haystochular antiferiora Hornatopaleit stem cell transplantation (HSCT) tablimentation (HSCT) tablimentation (HSCT) Hysteroscopy Medical scenarios Emergency Tek hite	AF-cause mortality === AF-cause mortality ===	o Infections === Overallinfection =		Acute cholangits =	Septearria e	69
Elective endoscopie retreprete holosangesparenzerosperi (ECP) Transarterial thereay of hepatocellular cardinaes Rematopolistic startion (BTT) tasia implication (BTT) Medicical Scenarios Emergency Tak bite Open globe injury	All-case morality +++ All-case morality +++	Trifections == Overall infection =		Acute cholangitis =	Septicaenta =	69 Visual a
Eachte endersoelt entregraf Managerandersoelte entregraf Transarteri de Hange of Hagescohle entonie Handbergerandersoelte entonie Handbergerander entonie Handbergerander Handbergerander Handbergerander Entolste Entonie	All-case mortality == All-case mortality ==	Infections == Overall infections =		Acute cholangtis = 25 Endophtulnits = 3 Wortfast was charged and acute for the second	Septicarria e	69 Visual i
Eachie endercoals entregrade methodologiegonacoustices (enclosed) Transmith Unitary of Hayatochief enclosed International Unitary of Hayatochief enclosed International Unitary of Hayatochief International Unitary of H	All-case motality == All-case motality ==	Infections == Decedinencian =		Acute cholangits = 20 Endophtalmes = 8 Vertrass-succide parameters Processes = 16 Encopera c	Septicaentia e	69 Visual I
Elective endercodic entregrade metalensingeponnerosception (ECC) Transmerial theory of happeoplate anchome tenenspaciest term of transperistering (PCC) tophympicative reseau access device (PVAD) hysteroscopy Medical ascenarios Energency Tole bits Open globe injury Coma Chest Tauma Castro interfacti al bleeding in cirrhotic patients	All case monatly +++ All case monatly +++	refections		Acute cholongitis = 23 Endopticalines = 24 Wortforce acucated personals 25 November 2 12 Engineera (Segricaenta =	fa 69 Wwal
Elective endercodic entregrafie Manarati Manya of hayaceafular extinsiona Manarati Manya of hayaceafular extinsiona Manarati Manya of hayaceafular extinsiona Manarati Manya of hayaceafular extinsional Manarati Manya of hayaceafular extinsional Manarati Manya of hayaceafular Manarati Manya of hayaceafular Manya o	Al-case norship ++ Al-case norship ++ 22 Count +++ 22 Count +++ Count +++ Al-case month	Infection: ++ Consult relation: ++ Consult relation: ++ E Eacherial Infection: ++ S Paratrine Infection: ++		Acute Ordingth: * Acute Ordingth: * D D D D D D D D D D D D D	Statistics in a constraint of the second sec	fe 69 Vacal o
Eachie endersonie entregnée Michaelingenersonetware (Internet Transmith Honry of Hapatochie carolinae Internetjanie entre entre Internetjanie entre entre Internetjanie entre entre Medical scenarios Entregnery Tab bite Open globe injury Cons Cons Cons Cons Cons Cons Cons Cons Cons (Internet) Constitution (Interlet patients Andre trade Route structure Route	Al case sorably ++ Al case sorably ++ Al case sorably ++ 22 Dent +++ XL case methods ++	Ordering + c Ordering to c Ordering	bra spatislome	Acite biologity = 5 Codyptications = 8 Within an acited processing 9 Regence = 8 Kolephilanity = 8 Ko	September 1	fa 69 Waada
Elective endercodic entregrade Teamsmei Manya of Happschult exanisme Ieneraspeciet team of ImageInstein (ISCI) Teamsmei ImageInstein (ISCI) Teamsmeinisteine ensean access device (IVAU) Instervoscopy Medical ascenarios Energency Tea bite Oren globe Injury Coma Casto Teamsa Casto Teamsa Casto teatab Casto access Acute access Acute access Casto acces	Al-case monstly ++ Al-case monstly ++ 22 Owned +++ Al-case monstly ++ Al-case monstly ++	Infaction = = Infaction = = Constitution = = E Bactured Infactions == T Pactitude Infections ==	born sound Afotton ===	Aquir charages = 25 Descent and a second a s	September -	69 Viteori d
Elective entropyme Elective entropyme Transmirt Unsay of hapkochile centoms Hennassinici centom Unsupertenting (OCF) Tandari Unsupertenting (OCF) Referencesary Medical scenarios Entropyme Netroscopy Conso Conso Conso Conso Conso Castonication bloeding in circles(r particular Acida cristo Castonication bloeding in circles(r particular Acida cristo Cui dary Den faith plating fractures Baulir skall plature fractures	Al case monstly ++ Al case monstly ++ 21 Count ++= Provid ++= M case monstly ++	Medition == Medition == Medition == Exclusion infections == S Parabolic infections ==	ker stand intertion === Sperior a intertion ==	Acute Instanges = 21 22 23 24 24 25 25 26 26 26 26 27 26 27 26 27 27	Statistica e	69 Wead of
Hachine endercoale entregrade methodisate/papersone/papersy/(ECPC) Transmerial theory of hapacochiar contoma immediated in the start of hapacochiar contoma immediated in the start of the start of the menagement, and the start of the start Neutroscoale the	Al-case norship ++ Al-case norship ++ Al-case norship ++ 22 Spreat +++ Al-case monthly ++ M-case monthly ++ Soriel +	Infection: + + Orwald infection: + Parabinetic infection: + Parabinetic infection: + Parabinetic infection: +	ber sond röctor. == Samfool röctor. =	Acute instanges = 2) Endoptimisers = 20/2012 - Standard Endoptim	September	65 Wood a
Elective endercodic entregrade Teamsmer la descodie entregrade Instanzaposite stare of la translational (ISEL) Restranspareits atten of la translational (ISEL) Coma Generational Compareits attention Const Tauma Gastrationistational bledning in cirribotic pastents Acute strahe Cost data pastention Generational Instances Basilar stale fractures Basilar stale fractures Basilar stale fractures Basilar stale fractures Basilar stale fractures Costas stransl Prinstance regulares of the membranes (ISEL)	Al case months ++ Al case months ++ 22 Dents +++ Al case months ++ Dents + Dents + Microsoft +++ Al case months ++	Infaction = = Infaction = = Consolidations = Returnal infactions == Particular infections ==	Burn ward Mediton === Saperficial Mediton ==	Acute charages = Acute charages =	Septema = Interest = Interes	fe 62 Ward i
Electine entropyme Electine entropyme Transmit Untray of Haptecellur extension International Content of Unsultantian Unsultantiantiantianti Entergency Teals blar Open glebe Injury Consa Castantiantiantiantianti Castantiantiantianti Castantiantiantiantiantiantiantiantiantiant	Al cause montable ++ All cause montable ++ 28 dealer montable ++ 29 dealer 4 ++ All cause montable ++ All cause mont	Orgentations and Orgentations and Orgentations Section Information Section Information Section Information	Burn sound photon == Spenical infection ==	Acute duranges = 20 20 20 20 20 20 20 20 20 20	inpresente e intereste e intereste e Record ages e Record ages e	65 Wiscale
Elective andercode entregrade methodologic proceedings (ECC) Transmerial theory of happenolidae contomo immensioneit: entre of the immediated in ISCA Entregrency Table in Iscan and Anna and Anna and Anna and Anna Cons Con	Al-case monstly ++ Al-case monstly ++ 22 Sound +>+ Sound +>+ Sound +++ Sound +++ Sound +++ Sound +++ Sound +++ Sound ++++ Sound ++++ Sound +++++ Sound ++++++++++++++++++++++++++++++++++++	Infection: + + Orand Infection: ++ Orand Infection: ++ Description Infection: ++ Description Infection: ++ Description Infection: ++	ber stad sitetas == Sambal sitetas ==	Acute instanges = 2) Endoptimisers = 2) Writers and other provides 2) Strategies and other provides = 2) Strategies and provides = 2) Strategie	Septembra	69 Waadd
Elective andexade: entregrade metalexity of the second and an entregrade international entregrade and an entregrade international entregrade and an entregrade international entregrade and an entregrade Medical scenarios Entergrady Medical scenarios Entergrady Ander school Cont Tauma Gastrointersholl entregrad Cont and Castro and Castro and Castro and Castro and Contro and Castro and Contro an	Al case months ++ Al case months ++ 22 Dents +++ 23 Dents +++ Dents + Dents +	Infaction = = Infaction = = Consolidations = Rectared infactors == Particular infectors ==	Burn wand infection == Specifical infection ==	Acute charages = Acute charages =	Septema = Information Sector	69 View 1 View 1
Excite endercode entregrade metalectrophysics (ECP) Transmit Humay of hapacedular extension learnassipatic etter off in megaletandin (USE) Reintegrades: Metalectrophysics (EVA) Hardenscape Reintegrades: Metalectrophysics (EVA) Hardenscape Reintegrades: Metalectrophysics (EVA) Table his Open globe highry Casto atoma Casto atoma C	Al-case months += Al-case months += Al-case months += Conta +== Al-case months += Al-case months	Indectors Indectors	Bur soud Media ++	Acute changes = Acute changes = 10 10 10 10 10 10 10 10 10 10	September 2	65 Viveat
Election endercodic entregrada metabolisatipopionercology (ECC) Transmith Hony of Hapeschild excitome Immediation (Interpretention) Transmith Hony of Hapeschild excitome Immediation (Interpretention) Medical scenarios Interpretention Medical scenarios Interpretention Medical scenarios Interpretention Medical scenarios Interpretention Medical scenarios Interpretention Cons	Al-case monstly ++ Al-case monstly ++ Al-case monstly ++ Dents ++ Dents ++ Al-case monstly ++ Microse monstly ++ Microse monstly + Microse monstly +	Infection: ++ Orand Infection: ++ Orand Infection: ++ Description ++ Description: ++ Description: ++	Arr and shellon == Speedu official ==	Acute instangini - 1 23 Endophildenini - 24 Writera and action - 25 Endophildenini - 26 Writera and action - 27 Writera and action - 28 Exclamation processors + - 29 Endophildeninistics + - 20 Endophildeninistics + - 21 Endophildeninistics + - 22 Endophildeninistics + - 24 Endophildeninistics + - 24 Endophildeninistics + - 24 Endophildeninistics + - 24 Endophildeninistics + -	Septement	63 Vacad
Eachie endercapie entregrafe index and a second entregrafe international enter and a second enternation international enternation and enternation international enternation and enternation international enternation internation international enternation internation internation inter	Al case months ++ Al case months ++ 22 Dents +++ 22 Dents +++ Al case months ++ Samal + Samal	Departments Departmen	har wood abotion === Sperifical inteston ==	Acute charages	Nentral (pp. 5	69 Vecal
Excite exercised entropyme Transmit theory of haptecellar excitome termanipatic entrol of termeliatedin (USE) Entropymet theory of haptecellar Entropymet termeliatedin (USE) Entropymet termeliatedi (USE) Entropymet termeliatedin (USE) Entropymet t	Al-case monthy ++- Al-case monthy ++ 22 Count +++ Count +++ M-case monthy + Survive ++ Survive ++ Survive ++ M-case monthy + Survive ++ M-case monthy + Survive +++ M-case monthy ++ Survive +++++++++++++++++++++++++++++++++++	Infection: + + DespirationState = Second address: + + Second address: + Second address: + Second address: + Second addres	Bur soud ridetton ++	Acute charages = Acute charages = 23 Comparison = 24 Comparison = 25 Comparison = 26 Comparison = 27 Comparison = 28 Comparison = 29 Comparison = 20 C	September 2 -	69 Wood Gentles of the
Election endercodic entregrada internazione in the series of the sectorial internazione int	Al-case monstly ++ Al-case monstly ++ 22 Downt +++ Party Denty ++ Al-case manufact ++ Al-case manufa	Infection = = Oracid relation =	ker sond identitie == 1	Acute instanges = Acute instanges =	Septembra	A Destroy of Hits
Excite and exercises entropyma Transmit through of hapkeenkine exercises Hermanspiretic exercises Hermanspiretic exercises Hermanspiretic exercises Hermanspiretic exercises Hermanspiretic exercises Hermanspiretic exercises Hermanspiretic exercises Activation exercises Activat	Al case months ++ Al case months ++ 22 Dent +++ 22 Dent +++ Al case months ++ Al case months ++ Al case months ++ 34 case months +++ 34 case months ++	10 10	Burn sound arbotron == Spareficial infection ==	Acade charanges = 21 Totoportugation of a 22 Totoportugation of a 23 Totoportugation of a 24 Totoportugation of a 25 Totoportugation of a 26 Totoportugation of a 27 Totoportugation of a 28 Totoportugation of a 29 Totoportugation of a 20		A A A A A A A A A A A A A A A A A A A
lachia exercised entropyma management (Internet Internet	Al-case monstly ++ Al-case monstly ++ 22 Cerent +++ 22 Cerent +++ Al-case monstly ++ Al-case monstly ++	Infection: + + Consolination: + Consolination: + Excentral infection: ++ To Particular infection: ++ To Particular infection: + To Particular infection: ++ To Partinition: ++ To Particu	ber sond electra ==	Acute instanges = Acute instanges =	Septement = Septement = Septe	6) Weat Desiting of the Protocol of
Excite and executed entregrade international experiments (ECP) Transmerial theory of hapescellar excitemes immensationist care of transmetation (ECF) Statistical excitations and excitemes international excitemest Neutrescores Neutrescores Care and and and and and and and Care and and and and and and Care and and and and and and Care and and and and and and and And and and and and and and and And and and and and and and and Care and and and and and and and Care and and and and and and and And and and and and and and and And and and and and and and and And and and and and and and and and And and and and and and and and and and And and and and and and and and and and a	Al case monstly ++ Al case monstly ++ Al case monstly ++ 22 Ownet +++ Al case monstly ++ Al case matching ++ Social + Social +++ Social ++++ Social ++++++++++++++++++++++++++++++++++++	Infection = = Infection = = Deval infection = Deval infection == Devaluation ==	ker sond detain ==	Acute charages = = = = = = = = = = = = = = = = = = =	Septements =	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Excite advecagic entregrafts intervention of the entregrafts intervention of the entregrafts intervention of the entregrafts intervention of the entregrafts intervention intervention of the entregrafts intervention int	Al case monthy ++ Al case monthy ++ 21 Count +++ Al case monthy ++ Al case monthy ++ Al case monthy ++ Al case monthy + Al case monthy +	Projection to a Projection to a Projection to be a Projection to be a Projection to be a	Born sourd Arbotion == Saparina infection == Saparina infection == 	Acute outrangen = Acute outrangen =		Outring of Maria
Incide and according entropyma Transmith theory of hapacochia excitoma International Contention of the activity Transmith theory of hapacochia excitoma International Contention of the activity The activity of the activity of the activity International Contention of the activity Parteroscopy The activity of the activity of the activity of the activity Parteroscopy The activity of the activity of the activity of the activity Parteroscopy The activity of the activi	Al case monstly ++ Al case monstly ++ 21 Secure +== Reveal 22 Secure +== Reveal 34 case monstly += Secure +== Reveal 34 case monstly == Secure +== Reveal Secure += Reveal Secure	Infection: + + Consolination: + Bacterial infection: ++ Bacterial infection: ++ Database infectinter Database infection: ++ Database infectinter Datab	Special dictor ==	Acute instruments = 23 Conductionations = 24 Writers and and procession and any angular the 25 Conductional procession = 26 Conductional procession = 27 Conductional procession = 28 Conductional procession = 29 Conductional procession = 29 Conductional procession = 29 Conductional procession = 29 Conductional procession = 20 Conductional processio	Septement	a) a) a) a) a) a) a) a) a) a)
Section exercised entropymetal metalenergy (EEC) Transmirt Univery of Inspeccedure exercises International Content of Content Section 2000 Section 2	Al case monstly ++ Al case monstly ++ 22 Count +++ 22 Count +++ Al case monstly ++ Al case monstly ++ Al case monstly + 34 Case monstly + 35 Case monstly + 31 Monstly + 31 Monstly + 32 Case monstly + 33 Monstly + 34 Case monstly + 34 Case monstly + 35 Case monstly + 36 Case monstly + 37 Case monstly + 38 Case monstly + 39 Case monstly + 30 Case monstly + 30 Case monstly + 30 Case monstly + 31 Case monstly + 32 Case monstly + 33 Case monstly + 34 Case monstly + 34 Case monstly + 35 Case monstly + 36 Case monstly + 37 Case monstly + 38 Case	Departments Departmen	Ann anond obtion 22 September 2000 200	Acute charages = Acute charages =	Personne Remote upon Remo	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Excise advecagic entregrafts Transmit theray of hapacedular extension Hamangianitic attendit of transplantendin (USC) Reintensionitic attendit of transplantendit of transplanten Reintensionitic attendit attendit of transplantendin (USC) Reintensionitic attendit of transplantendit of transplanten Reintensionitic attendities attendities attendities Reintensionitic attendities attendities Reintensionitic attendities attendities Reintensionities attendities Reintensionities attendities Reintensionities attendities Reintensionities attendities Reintensionities attendities Reintensionities attendities Reintensionities Reintensis Reintensionities Reintensionities Reintensionit	Al case months += - Al case months += - Al case months += - 	Trebetter Trebetter	Bur sourd Metton ++	Acute charages = Acute charages =	Septement - - <	to d) Value of a value of the second second sec

Figure 6. Evidence map summarizing findings and certainty of evidence. The certainty of evidence was rated by the Grading of Recommendations Assessment, Development, and Evaluation criteria. The color of each block represents the classification of evidence and the filling fraction of color represent scale of number need to treat (range from 0 to 150 for all outcomes). *The NNT cannot be calculated because original data are unavailable.

surgery or recurrent episodes^[7]. This umbrella review suggested some evidence gaps regarding these common uses. For example, studies primarily preventing gastrointestinal infection using prophylactic antibiotics are sparse. It calls for close surveillance

for such unproved use and novel evidence with high certainty to guide the practice.

The management of perioperative antibiotics is always been the research focus, and effectiveness of appropriate prophylactic

antibiotics use to prevent surgical site infections in certain surgical procedures has been well established^[35]. American Centers for Disease Control (CDC) guidelines pointed out that a single dose of preoperative antibiotics and administered intraoperatively when indicated is effective, while prolonged postoperative prophylactic antibiotic agents should not be administered due to lack of extra benefit and higher risk of developing antimicrobial resistance^[36]. In this umbrella review, antibiotic prophylaxis might have little or no effect on reducing infections in certain surgeries such as hepatectomy and transurethral resection of bladder tumors, but the evidences were heterogeneous between individual studies and were of low to very low certainty, therefore they should be treated with caution. We considered that the cleanliness of the surgical incision is a key factor affecting the effectiveness of antibiotic prophylaxis because compared with patients who undergo clean-incision surgeries. those with contaminating surgeries are facing a two to sevenfold increased risk for overall infection^[37-40], leading to more prescriptions of antibiotics for prophylactic purposes^[41]. However, the majority of the included systematic review was regarding clean to clean-contaminated incision surgeries. Only three synthesized evidence bodies with moderate to low certainty supported such routine practice in patients meeting contaminated incisions such as endoscopic resection for colorectal lesions, colorectal surgery and transrectal prostate biopsy. This inconsistency between the evidence synthesis and real-world practice calls for the importance of the practice-guiding study design for randomized trials, observational studies, and systematic reviews.

UTI was widely studied in this umbrella review. Patients with neurogenic bladder, pregnancy, invasive urologic procedures, or urinary tract instrumentation were at risk for UTI^[42]. Our results support current guidelines, and provide new evidences for several aspects. For percutaneous nephrolithotomy, moderate quality of evidence confirmed the effectiveness of preoperative antibiotic prophylaxis to lower incidence of UTI after percutaneous nephrolithotomy^[43], especially for suspected infectious stones, while postoperative use is unnecessary, and it is consistent with the American Urological Association (AUA) Best Practice Policy Statement^[44]. As for whether to use prophylactic antibiotics to prevent genital tract infection in women receiving incomplete abortion procedures^[45], the recommendations of international guidelines vary^[46-48], and our results confirmed the effectiveness of antibiotic prophylaxis with moderate quality of evidence, especially in high-income countries. However, there are common research gaps among all the studies. UTI comprised asymptomatic UTI and symptomatic UTI, and results from urine test and urine culture in combination with clinical manifestation can distinguish between these two^[42]. In this umbrella review, they did not focus on the infection risk stratification for antibiotic strategies, and sometimes patients with positive urine culture were excluded. Further studies should focus on the benefit of antibiotic prophylaxis in different infectious risk populations to identify optimal antibiotic strategies.

We only extracted adverse events from 21 clinical scenarios. In most of the scenarios, antibiotic prophylaxis increased the risk of developing antimicrobial resistance and other drug-related adverse events in which four reached significances. Barely any serious drug-related adverse events such as severe allergic reaction, arrhythmia, or acute renal failure was reported. Due to the limited reporting or unavailability of data on antibiotic resistance and side effects associated with prophylactic antibiotic, its safety cannot be currently determined. Long-course of antibiotics may result in antimicrobial resistance or other drug-related adverse events, while too short course of therapy may lead to treatment failure. In our study, duration of prophylaxis is longer in medical scenarios than in surgical scenarios, especially for those patients at risk of chronic infection. Therefore, it is important to monitor antibiotic-related adverse effects in medical prophylaxis and improve dosing strategy. And for surgical prophylaxis, dosage, and timing of administration should be optimized.

Strengths and limitations

This umbrella review comprehensively evaluated the current evidence regarding the efficacy and safety of antibiotic prophylaxis in surgical and medical conditions after reanalyzing potentially improperly pooled evidence. The anticipated absolute effect size facilitates the decision-makers in illustrating the importance of the prophylactic use of antibiotics in different scenarios in easyto-read figures.

This review is also composed of limitations, especially the heterogeneity in quality among included systematic reviews. It represents the imbalanced development of trial design and evidence synthesis across study fields and geographic distribution. Such inequity raises the risk of publication bias when we adopted and presented the results after the trim-and-fill approach to minimize the impact. Including only the primary outcome is another limitation of this study that may miss much information reported as secondary outcomes such as the safety outcomes. Our study identified only safety issues in 21 among 78 clinical scenarios and it could be inadequate for the adverse events for antibiotics. Nevertheless, including secondary outcomes may raise the risk of multiple comparisons and even add the impact of potential publication bias. Future review focusing on safety events of antibiotic prophylaxis is thus necessary.

Conclusions

We have comprehensively synthesized and graphically represented the highest-level evidence available regarding the effectiveness and safety of antibiotic prophylaxis. Our evidence map delineates the baseline risk of outcomes for various clinical scenarios, the relative and absolute effect sizes of antibiotic prophylaxis on outcome measures, along with the quality and credibility of the evidence within each context. Our findings demonstrate that antibiotic prophylaxis generally reduces infection-related complications and enhances the prognosis of specific diseases, but with its safety warranting further investigations. Importantly, the efficacy of prophylactic antibiotics appears independent of wound cleanliness in surgical procedures and the baseline infection risk of diseases. Nevertheless, the current evidence's low quality constrains the external validity of these findings. For surgical cases, surgeons need to carefully balance the low postoperative infection rate with antibiotic-related side effects. For nonsurgical scenarios, clinicians must meticulously consider the indications for antibiotic administration.

Ethical approval

No ethical approval is needed.

Consent

Informed consent is not needed in this study.

Sources of funding

This study was supported by 1.3.5 project for disciplines of excellence, West China Hospital, Sichuan University (Grant no ZYJC18015) and National Clinical Research Center for Geriatrics, West China Hospital, Sichuan University (Y2021LC005).

Author contribution

L.L., Z.J., and M.W.: contributed equally to this paper and are joint first authors; L.L., Z.J., S.L., and K.W.: conceived and designed the study; L.L. and M.W.: performed the literature search; L.L., Z.J., M.W., C.Y., Y.L., Y.M., X.J., H.L., C.L., and Y.H.: screened studies for eligibility; L.L., Z.J., M.W., C.Y., and Y.L.: extracted the data; L.L., Z.J., and M.W.: conducted the analysis; Y.H.: examined the methods; L.L. and Z.J.: wrote the first draft of the manuscript; S.L. and K.W.: revised the draft. All authors reviewed and approved the final version of the manuscript. S.L. and K.W. are the guarantors.

Conflicts of interest disclosure

The authors declare that they have no financial conflict of interest with regard to the content of this report.

Research registration unique identifying number (UIN)

This is a systematic review, and was registered in the PROSPERO, CRD42021292543.

Guarantor

Kunjie Wang.

Data availability statement

All data are collected from published articles and data are available for researchers who request it from the authors.

Provenance and peer review

None.

References

- [1] Klein EY, Van Boeckel TP, Martinez EM, *et al.* Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. Proc Natl Acad Sci U S A 2018;115:E3463–70.
- [2] GBD 2019 Antimicrobial Resistance Collaborators. Global mortality associated with 33 bacterial pathogens in 2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2023;400:2221–48.
- [3] Hofer U. Rise in global antibiotic use. Nat Rev Microbiol 2022;20:63.
- [4] Jim O. Tackling drug-resistant infections globally: final report and recommendations: the review on antimicrobial resistance 2016. 2016. Accessed 3 March 2020. https://amr-review.org/sites/default/files/ 160518_Final%20paper_with%20cover.pdf

International Journal of Surgery

- [5] Teillant A, Gandra S, Barter D, et al. Potential burden of antibiotic resistance on surgery and cancer chemotherapy antibiotic prophylaxis in the USA: a literature review and modelling study. Lancet Infect Dis 2015; 15:1429–37.
- [6] Lm K, Ke F-D, La H. Advances in optimizing the prescription of antibiotics in outpatient settings. BMJ Clinical research ed 2018;363:k3047.
- [7] Versporten A, Zarb P, Caniaux I, et al. Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: results of an internetbased global point prevalence survey. Lancet Glob Health 2018;6:e619–29.
- [8] Polkowski M, Jenssen C, Kaye P, et al. Technical aspects of endoscopic ultrasound (EUS)-guided sampling in gastroenterology: European Society of Gastrointestinal Endoscopy (ESGE) Technical Guideline - March 2017. Endoscopy 2017;49:989–1006.
- [9] Facciorusso A, Buccino VR, Sacco R. A meta-analysis confirms that antibiotic prophylaxis is not needed for endoscopic ultrasound-guided fine needle aspiration of pancreatic cysts. Gastroenterology 2021;160:969.
- [10] Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
- [11] DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177–88.
- [12] Borenstein M. Research note: in a meta-analysis, the I2 index does not tell us how much the effect size varies across studies. J Physiother 2020;66:135–9.
- [13] Ioannidis JPA. Clarifications on the application and interpretation of the test for excess significance and its extensions. J Mathemat Psychol 2013;57:184–7.
- [14] Ioannidis JPA, Trikalinos TA. An exploratory test for an excess of significant findings. Clin Trials 2007;4:245–53.
- [15] Cochrane Handbook for Systematic Reviews of Interventions. Accessed 16 December 2021. https://training.cochrane.org/handbook/current
- [16] Vancak V, Goldberg Y, Levine SZ. Guidelines to understand and compute the number needed to treat. Evid Based Ment Health 2021;24:131–6.
- [17] Sterne JAC, Sutton AJ, Ioannidis JPA, et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ 2011;343:d4002.
- [18] Duval S, Tweedie R. Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. Biometrics 2000;56:455–63.
- [19] Bj S, Bc R, G W, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ Clinical research ed 2017;358:j4008.
- [20] Berard F, Gandon J. Postoperative wound infections: the influence of ultraviolet irradiation of the operating room and of various other factors. Ann Surg 1964;160:1–192.
- [21] Gafter-Gvili A, Fraser A, Paul M, et al. Antibiotic prophylaxis for bacterial infections in afebrile neutropenic patients following chemotherapy. *Cochrane Database of Systematic Reviews*. Published Online First: 18 January 2012. doi:10.1002/14651858.CD004386.pub3
- [22] Wu XY, Cheng Y, Xu SF, et al. Prophylactic antibiotics for urinary tract infections after urodynamic studies: a meta-analysis. Biomed Res Int 2021;2021:6661588.
- [23] Ayeleke RO, Mourad S, Marjoribanks J, et al. Antibiotic prophylaxis for elective hysterectomy. Cochrane Database Syst Rev 2017;6:CD004637.
- [24] Zapata-Copete J, Aguilera-Mosquera S, Garcia-Perdomo HA. Antibiotic prophylaxis in breast reduction surgery: A systematic review and metaanalysis. J Plast Reconstr Aesthet Surg 2017;70:1689–95.
- [25] Oh CC, Lee HY, Chlebicki MP, et al. Antibiotic prophylaxis for preventing recurrent cellulitis: a systematic review and meta-analysis. J Infect 2014;69:26–34.
- [26] Williams G, Craig JC. Long-term antibiotics for preventing recurrent urinary tract infection in children. Cochrane Database Syst Rev 2019;4:CD001534.
- [27] Zeng S, Zhang Z, Bai Y, et al. Antimicrobial agents for preventing urinary tract infections in adults undergoing cystoscopy. Cochrane Database Syst Rev 2019;2:CD012305.
- [28] Coussement J, Scemla A, Abramowicz D, et al. Antibiotics for asymptomatic bacteriuria in kidney transplant recipients. Cochrane Database Syst Rev 2018;2:CD011357.
- [29] Barajas-Nava LA, López-Alcalde J, Roqué i Figuls M, et al. Antibiotic prophylaxis for preventing burn wound infection. Cochrane Database Syst Rev 2013;6:CD008738.
- [30] Brand M, Bizos D, O'Farrell P. Antibiotic prophylaxis for patients undergoing elective endoscopic retrograde cholangiopancreatography. Cochrane Database Syst Rev 2010;10:CD007345.
- [31] Kimura S, Akahoshi Y, Nakano H, et al. Antibiotic prophylaxis in hematopoietic stem cell transplantation. A meta-analysis of randomized controlled trials. J Infect 2014;69:13–25.

- [32] Kalil AC, Metersky ML, Klompas M, et al. Executive summary: management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis 2016;63:575–82.
- [33] Bonkat G, Bartoletti R, Bruyère F, et al. Guidelines on Urological infections. ISBN 978-94-92671-16-5 presented at the EAU Annual Congress Amsterdam, the Netherlands. Published Online First: 2022.
- [34] CDC. Antibiotic Use in the United States, 2021 Update: Progress and Opportunities. US Department of Health and Human Services, CDC; 2021.
- [35] Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm 2013; 70:195–283.
- [36] Berríos-Torres SI, Umscheid CA, Bratzler DW, et al. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surg 2017;152:784–91.
- [37] Lilani SP, Jangale N, Chowdhary A, *et al.* Surgical site infection in clean and clean-contaminated cases. Indian J Med Microbiol 2005;23: 249–52.
- [38] Vazquez-Aragon P, Lizan-Garcia M, Cascales-Sanchez P, *et al.* Nosocomial infection and related risk factors in a general surgery service: a prospective study. J Infect 2003;46:17–22.
- [39] McLaws ML, Irwig LM, Mock P, et al. Predictors of surgical wound infection in Australia: a national study. Med J Aust 1988;149:591–5.

- [40] Carvalho RLR de, Campos CC, Franco LM de C, et al. Incidence and risk factors for surgical site infection in general surgeries. Rev Lat Am Enfermagem 2017;25:e2848.
- [41] Sheridan RL, Tompkins RG, Burke JF. Prophylactic antibiotics and their role in the prevention of surgical wound infection. Adv Surg 1994;27:43–65.
- [42] Gupta K, Grigoryan L, Trautner B. Urinary tract infection. Ann Intern Med 2017;167:ITC49–64.
- [43] Yu J, Xu S, Shi Q, et al. Antibiotic prophylaxis in perioperative period of percutaneous nephrolithotomy: a systematic review and meta-analysis of comparative studies. World J Urol 2020;38:1685–700.
- [44] Wolf JS, Bennett CJ, Dmochowski RR, et al. Best practice policy statement on urologic surgery antimicrobial prophylaxis. J Urol 2008;179:1379–90.
- [45] Islam N, Thalib L, Furuya-Kanamori L, et al. Prophylactic antibiotics for preventing genital tract infection in women undergoing surgical procedures for incomplete abortion: a systematic review and meta-analysis of randomised controlled trials. BJOG 2021;128:1273–81.
- [46] White KO, Jones HE, Lavelanet A, et al. First-trimester aspiration abortion practices: a survey of United States abortion providers. Contraception 2019;99:10–5.
- [47] Safe Abortion: Technical and Policy Guidance for Health Systems. 2nd ed. Geneva: World Health Organization 2012. Accessed 12 March 2022. http://www.ncbi.nlm.nih.gov/books/NBK138196/
- [48] ACOG Practice Bulletin No. 195. Prevention of infection after gynecologic procedures. Obstet Gynecol 2018;131:e172–89.