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Review Article

Risk factors for surgical site infections following hepatobiliary surgery: An umbrella review and meta-analyses

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ABSTRACT

Background: In the hepatobiliary (HPB) surgical cohort, surgical site infections (SSI) can extend hospital stays, result in higher morbidity, and poor patient outcomes. This umbrella review and meta-analysis aimed to synthesise the evidence for the association between clinical and patient risk factors and SSI in patients following HPB surgery.

Methods: We searched MEDLINE, CINAHL, EMBASE and Scopus from January 2000 to April 2023 to identify systematic reviews and meta-analyses where patient and/or clinical factors of SSIs following HPB surgery were reported. The summary effect size, its 95 % CI and the 95 % PI were calculated for each meta-analysis using random-effects models. 30-day cumulative SSI incidence was presented as the pooled estimate with 95 % CIs. Between-study heterogeneity was explored using the I^2 statistic.

Results: Nine systematic reviews and meta-analyses were included. Our findings suggest open surgical approach, type of pancreas procedure, preoperative biliary drainage, older age, male sex and high BMI ($>25mg/k^2$) as statistically significant factors for increasing a patient's risk of SSI following HPB surgery. The cumulative incidence of SSI in the HPB cohort of 43,296 was 11 % (95 % CI 6%–20 %), with substantial variation between the reviews.

Conclusion: We identified several patient and clinical factors, however only one was graded as a high level of evidence.

1. Introduction

Surgical site infection (SSI) [1] is the most common postoperative complication [2] and associated with increased mortality rates, prolonged hospital stays and higher treatment costs [3]. SSIs impose a significant burden on patients' physical and psychological well-being, with research suggesting patients who develop an SSI are 60 % more likely to require a critical care admission [4]. Further, SSIs impose significant financial costs on the healthcare system due to direct treatment costs, increased hospital length of stay, and unplanned readmissions [4]. Patient (e.g. age) and clinical factors (e.g. surgical approach) may increase the risk of developing an SSI [5]. For example, surgical types such as hepatobiliary (HPB) surgery carry a higher risk for SSIs [6]. HPB surgery is an umbrella term for surgical procedures involving the biliary systems, including the liver, pancreas, gallbladder, and bile ducts [7]. HPB operative approaches include laparoscopic, robotic-assisted, endoscopic, and open surgery, with liver resections, pancreatic resections, and cholecystectomies more commonly performed [7]. Higher SSI incidence rates in the HPB surgical cohort may be attributed to the factors related to the intricate nature of the procedures and increased risk of exposure to contaminants [3].

Since 2018, there has been a substantial body of primary research,

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including systematic reviews and meta-analyses investigating patient and clinical risk factors for SSIs following HPB surgery [8–11]. However, there is a lack of consolidated, high-level synthesis of best evidence based on existing systematic reviews in this area. This umbrella review aims to synthesise the evidence of patient and clinical risk factors for SSIs following HPB surgery. This will deepen our understanding of the topic, identify any inconsistencies in the literature and potentially advance clinical insights and practices, to improve patient care and surgical outcomes. Establishing the key risk factors that contribute to SSIs in this cohort may inform the implementation of preventative measures before, during, and after surgery that can reduce the risk of SSI.

The umbrella review questions were.

1. What is the cumulative incidence of SSIs up to 30-days postoperative in adult patients undergoing HBP surgeries?
2. What are the most accurate predictive risk factors associated with SSIs in adult HBP surgery patients up to 30-days postoperative?

2. Methods

We conducted an umbrella review to consolidate the strength and quality of evidence from existing systematic reviews and meta-analyses, providing a holistic understanding of the current state of knowledge. The methodology followed the Joanna Briggs Institute (JBI) umbrella review guidelines [12]. The reporting of this review was guided by the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [13]. An a priori protocol was registered with the PROSPERO International Prospective Register of Systematic Reviews (CRD42023438061).

3. Literature search

With the assistance of a specialist health librarian, the primary investigator (MB) developed a search strategy (Supplementary File 1) using the PEO acronym (Population, Exposure, Outcome) [14]. MB searched for relevant literature published from January 2000 to April 2023 using database-specific subject headings and search operators in the following electronic databases: MEDLINE (Ovid), Cumulative Index of Nursing and Allied Health Literature (CINAHL) (EBSCO), EMBASE (Elsevier) and Scopus. Searches were supplemented with forward and backward citation searching of the reference lists of relevant papers.

4. Study selection and screening

We included systematic reviews and meta-analyses of observational, cohort and case control studies where the patient and/or clinical factors of SSIs following open, robotic-assisted and/or laparoscopic HBP surgeries were reported. Randomised controlled trials assessing the effect of interventions were excluded. Endoscopic surgeries were also excluded. Published reviews in peer-reviewed journals from 2000 onwards were included. The justification of the date range was informed by the Centers for Disease Control and Prevention's *(CDC)* pivotal work, "The Guideline for Prevention of Surgical Site Infection, 1999" [15]. No restrictions were placed on publication language. Reviews were excluded if they were conducted in palliative care and outpatient settings, paediatrics (<16 years), obstetrics, non-HPB and transplant cohorts [5]. Search results were exported to Covidence software and duplicates removed. Title/abstract screening followed by the full text, were conducted independently by two reviewers (MB, SL) and conflicts were adjudicated by a third reviewer (BG).

5. Data extraction and quality appraisal

The lead reviewer (MB) extracted the data, and a second reviewer (SL) independently verified the data for completeness. A standardised data extraction form that was specifically developed for this study included data related to authors, year of review, aims, number of studies, definition of SSI used, SSI incidence (superficial, deep, organ) up to 30-days postoperation, patient and clinical SSI risk factor(s) assessed, summary effect estimates, 95 % confidence intervals, p-value for the summary effect estimates, descriptive results of risk factor(s), heterogeneity, risk of bias assessment and limitations were extracted.

The methodological quality of the reviews were independently assessed by two reviewers (MB, BG) using the Risk of Bias in Systematic Reviews (ROBIS) tool. We used the ROBIS tool, as our umbrella review included reviews of observational studies, which the ROBIS tool was specifically designed [17]. Disagreements were resolved through researcher discussions, and involvement of a third researcher (SL).

6. Data synthesis

Under the guidance of a biostatistician (LT), statistical analysis was performed using *RStudio version 2023.12.0 and the* metaumbrella *and* meta *statistical packages*. The summary effect size and its 95 % confidence interval (CI) were calculated for each meta-analysis using random-effects models. Between-study heterogeneity was assessed using Higgins I^2 statistics with values of less than 25 %, 25–75 % or greater than 75 % indicating low, moderate, or high heterogeneity, respectively [18]. For each meta-analysis, we estimated the 95 % prediction interval (PI) for the effect measures related to each risk factor. The PI interval provides a range where the true effect size is expected to fall in 95 % of similar future studies, accounting for the observed between-study heterogeneity [38]. All effect size measures for continuous data were converted to estimated Odds Ratios (eORs), providing a consistent scale for interpretation across different studies. The 30-day cumulative HPB SSI incidence was calculated using a random-effects model and presented as the pooled estimate with 95 % CIs. We did not need to calculate the corrected cover area (CCA) because we manually cross-checked the primary studies included in each review, ensuring that there were no overlaps in our pooling statistics. The presence of small-study effects and publication bias was assessed using the Egger's regression test, with a p-value <0·10 indicative of possible publication bias.

7. Level of evidence classification

Levels of evidence were classified using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria. The GRADE rating system in the *metaumbrella* package categorises evidence into four levels: high, moderate, low, and very low. All factors are initially rated as 'high' and downgraded according to predetermined criterion. Similar to the traditional GRADE criterion, the *metaumbrella* criterion considers limitations, imprecision, inconsistency, and publication bias [26].

8. Results

8.1. Eligible studies

Our search yielded 949 records from the four electronic databases and citation reference searching of relevant studies (Fig. 1). A list of reviews that were assessed in full text, as well as the reasons for exclusion is provided in Supplementary File 2. Nine systematic reviews and meta-analyses met the inclusion criteria [10,11,19–25]. However, one review was excluded from quantitative analyses as it contained repeated primary studies [21]. Characteristics of the included reviews are summarised in Supplementary File 3.

8.2. Risk of bias assessment results

Following assessing the relevance of the reviews (Phase 1), the results of 'Phase 2' and 'Phase 3' of the ROBIS tool are presented in

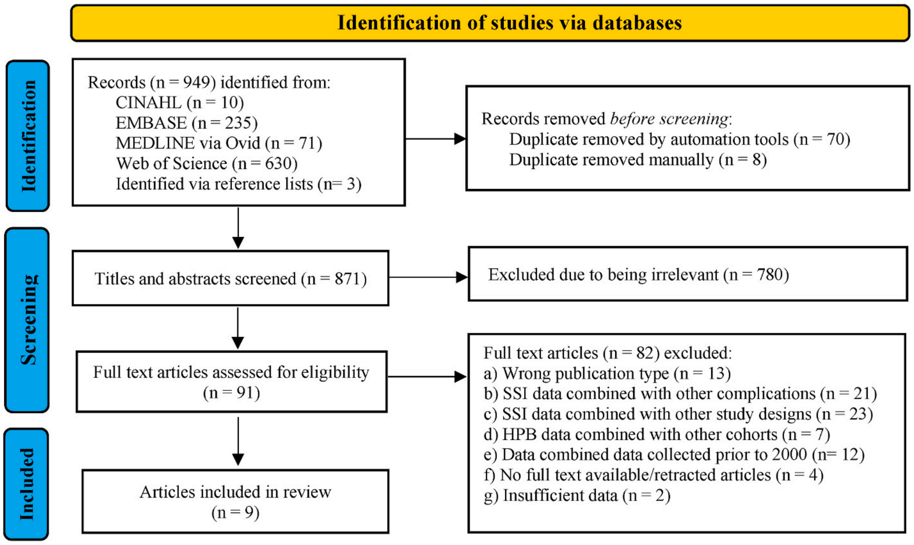

Fig. 1. Prisma Flow Diagram of Search (Page et al., 2020).

Supplementary File 4. Overall, three of the included reviews were judged as low risk [11,21–25], three were deemed to have an unclear risk of bias [20], and three were judged to have high risk of bias [10].

8.3. *Meta-analysis of surgical site infection*

The overall SSI cumulative incidence in 43,296 HPB surgeries, across the eight included systematic reviews reviews using a random effects model was 11 % (95 % CI 6%–20 %, I^2 = 100 %) (Fig. 2). Across the included reviews, SSI rates varied from 2 % to 29 %.

8.4. *Statistical analysis of predictive risk factors*

The association between SSIs and risk factor results are presented Table 1. There was no association (eOR 0·93, p = 0·77**)** between patient age >75 years versus <75 years and SSIs. However, when >65 years were compared to <65 years, risk of SSI was almost double in the older age group (eOR 1·95). The 95 % CI of 0·99-3·82 suggested borderline significance (p = 0·05). Male sex was associated with almost 50 % increase in SSIs compared to females (eOR 1·51, p = 0.02), however, the 95 % PI interval was wide (0·03–83·65) indicating significant uncertainty. For individuals with BMI of >25 kg/m^2, the eOR was 1·76 (95 % CI 1·54-2·02), suggesting a 76 % increase in SSIs in overweight or obese patients compared to individuals with a BMI of <25 kg/m^2 (p = 0.00).

Regarding clinical risk factors, the risk of SSIs in patients undergoing OPD doubled compared to those undergoing MIPD (eOR 2·01, 95 % CI 1·33-3·03, p < 0·001). Similarly, patients who had ODP procedures were at higher risk of developing SSI compared to those who had LDP (eOR 2·15, p < 0·001). Likewise, those having PD had higher risk of SSIs compared to those who had DP (eOR 1·44, 95 % CI 1·07-1·96, p < 0·01), however, the wide 95 % PI interval (95 % PI 0·04–47·93) suggests greater uncertainty. Lastly, PBD was associated with a statistically significant 14 % increase in the risk of SSIs compared to those who did not have PBD (eOR 1·14, 95 % CI 1·01-1·29, p = 0·03).

8.5. *GRADE level of evidence of associations*

Predictive risk factors were graded into level/class of evidence using the *metaumbrella* package GRADE criteria (Fig. 3). Only one patient risk factor (‘SARC vs Non-SARC’) was graded as ‘high’. The ‘>75 vs < 75yrs’ factor was graded as ‘moderate’ most likely due to smaller sample size (n = 533). The remaining patient risk factors (‘>65 vs < 65yrs’, ‘BMI >25/<25 kg/m^2’, ‘BR vs NBR’, ‘Male vs Female’) were graded as ‘weak’ or ‘very weak’ due to substantial heterogeneity, high risk of bias, and study bias in the reviews. The only clinical factor that was graded to a ‘high’ level of evidence was the ‘OPD vs MIPD’ surgical approach. Although, the ‘PD vs DP’ had ‘moderate’ level of evidence, GRADE classification downgraded the class of evidence, due to high heterogeneity (I^2>50 %). Likewise, ‘PDB vs NPDB’, was downgraded due to small sample sizes (n = 436).

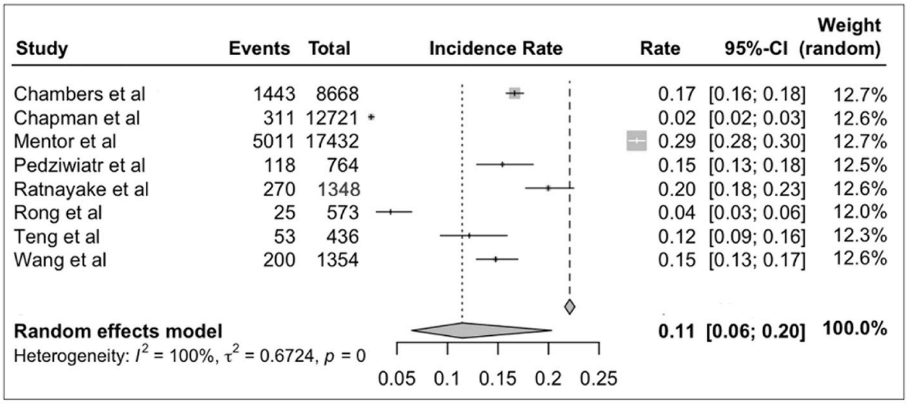

Fig. 2. Forest plot results using random effects model for 30-day cumulative incidence of SSI following HPB surgery.

Table 1
Level of evidence for the association of patient and clinical risk factors and SSI following HPB surgery.

Risk factors	k	Random-effects ES (95 % CI)	p-value	eOR ES	eOR 95 % PI	Features used for level of evidence					Largest study		GRADE
						Cases/total	vv	test p	Low RoB	ESB p	Effect size (95 % CI)	SE	
Patient risk factors													
SARC vs Non-SARC	6	RR 1·04 (0·95-1·14)	**0·36**	1·04	0·92-1·19	851/1348	0 %	0·45	100 %	0·72	1·09 (0·96-1·24)	0·06	High
>75yrs vs < 75yrs	5	RR 0·93 (0·57-1·52)	0·77	0·93	0·36-2·43	145/533	0 %	0·26	100 %	0·67	1·14 (0·68-1·91)	0·26	Moderate
>65yrs vs < 65yrs	3	OR 1·95 (0·99-3·82)	0·05	1·95	0·01–1324·3	960/2313	28 %	0·55	4·9 %	0·64	2·50 (1·69-3·70)	0·20	Weak
BMI >25 vs < 25kg/m2	4	OR 1·76 (1·54-2·02)	0·00	1·76	1·32-2·37	3858/6720	0 %	0·67	8·5 %	0·31	1·75 (1·52-2·00)	0.07	Weak
Male vs Female	3	OR 1·51 (1·07-2·12)	0·02	1·51	0·03–83·65	4247/8490	83 %	0·35	0 %	0·00	1·17 (1·03-1·33)	0·07	Very Weak
Clinical risk factors													
OPD vs MIPD	13	OR 2·01 (1·33-3·03)	0·00	**2·01**	1·27-3·19	432/1354	0 %	**0·26**	100 %	0·47	1·22 (0·50-3·01)	0·46	High
PD vs DP	3	OR 1·44 (1·07-1·96)	0·01	1·44	0·04–47·93	11,151/16,417	89 %	0·78	100 %	0·54	1·81 (1·62-2·02)	0·06	Moderate
PBD vs NPBD	4	RR 1·14 (1·01-1·29)	0·03	1·14	0·88-1·48	289/436	0 %	0·42	100 %	0·82	1·13 (0·99-1·27)	0·06	Moderate
BR vs NBR	3	OR 1·58 (0·37-6·75)	0·54	1·58	0·01–100834428	180/1087	93 %	0·74	100 %	0·67	0·51 (0·25-1·03)	0·36	Weak
ODP vs LDP	16	OR 2·15 (1·34-3·47)	0·00	2·15	0·5–9·29	2407/15,242	63 %	0·03	0 %	0·97	2·09 (0·83-5·22)	0·47	Very Weak

BMI - Body Mass Index, BR – Biliary Resection, CI - Confidence Interval, DP - Distal Pancreatectomy, eOR - Equivalent Odds Ratio, ES - Effect Size, ESB - Excess Significance Bias, NBR - No Biliary Resection, k - Number of primary studies, LDP - Laparoscopic Distal Pancreatectomy, MIPD - Minimally Invasive Pancreaticoduodenectomy, NPBD - No Preoperative Biliary Drainage, ODP - Open Distal Pancreatectomy, OPD - Open Pancreaticoduodenectomy, OR - Odds Ratio, PBD - Preoperative Biliary Draining, PD - Pancreaticoduodenectomy, PI - Prediction Interval, RoB - Risk of Bias, RR - Relative Risk, SARC - Sarcopenia.

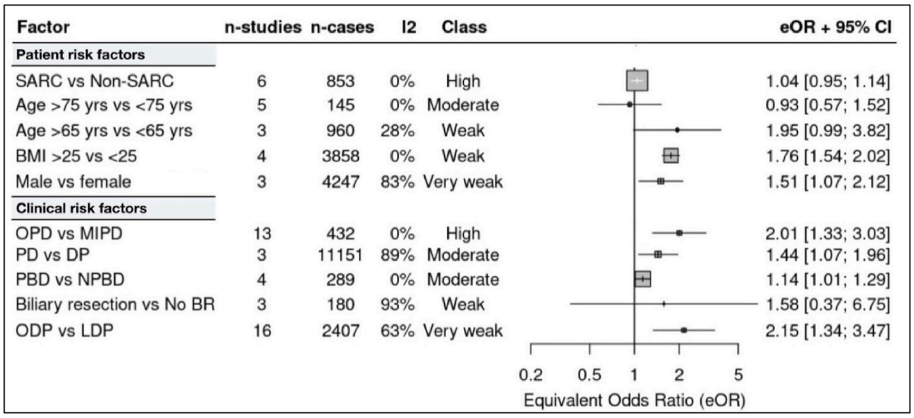

Fig. 3. Forest plot results of random effects model for the associations between risk factors and SSI following HPB surgery.

9. Heterogeneity and publication bias

No heterogeneity was observed with the following risk factors: sarcopenia, >75 vs < 75 years, BMI group, OPD vs MIPD and preoperative biliary drainage. Moderate heterogeneity was found in >65 vs < 65 years (I^2=28 %) and ODP vs LDP (I^2 = 63 %). High heterogeneity was seen in biological sex (I^2 = 83 %), PD vs DP (I^2 = 89 %), and biliary resection (I^2 = 93 %). Egger's test for ODP vs LDP was statistically significant (p=<0.10).

10. Discussion

The results of this umbrella review suggest that the overall cumulative incidence of SSI in the HPB cohort of 43,296 is 11 % (95 % CI 6%–20 %), with substantial variation in the incidence rates between the reviews. Two of the reviews [19,23] reported SSI rates as low as 2 % [19] and 4 % [23] while other studies found the rates to be between 12 % and 29 % [10,11,20–22,24,25]. Notably, our estimates are lower compared to findings from a recent systematic review and meta-analysis, which reported a SSI incidence rate of 19 % (95 % CI 15.0–23.0 %, I^2 = 98.8)[6] in a cohort of 46,203 HPB surgeries. This difference in SSI incidence may be explained by differences in primary study methodologies, primary study surveillance methods and classification of SSIs. We found SSI definitions, SSI diagnosis, measurement and/or follow-up periods were not always defined sufficiently in the reviews included in our analysis. Consequently, our reported SSI rates may be under-estimated due to incorrect coding, inadequate surveillance programs, use of different criteria, and/or biased data interpretation [31].

Our analysis suggests a statistically significant association between higher BMI and SSI risk, however, the evidence supporting this finding is weak. The availability of empirical literature with consistent cut-offs for each BMI category is lacking making it difficult to compare findings, therefore we can only assess a BMI grouping of <25 kg/m^2 versus >25 kg/m^2. Higher BMI has been associated with an increased risk of SSIs in the broader literature [11,22]. Ramsey et al. suggest that higher BMI in patients undergoing pancreatic surgery complicates open surgical procedures, potentially affecting postoperative outcomes, rather than obesity alone predicting SSI [29]. The results of our meta-analysis and the broader literature suggest the link between higher BMI and SSI risk may be explained by the complex interplay of several mechanisms [5, 34]. These mechanisms include increased adipose tissue that is avascular (impairing healing potential), immune dysfunction, altered anatomy due to increased visceral abdominal tissue, and the presence of comorbid conditions commonly observed in obese individuals [34].

We also found an association between male sex and higher risk of SSI [10]. Despite the level of evidence for sex being classified as very weak, our finding is similar to that of Mentor et al. whose review suggests that male sex is associated with an increased risk of SSIs in both pancreatic and liver resections [11]. Similarly, Mazmudar et al. report male sex as a significant risk factor for all types of SSIs in patients undergoing elective pancreatectomy [27]. A recent 10-year surveillance study of 1,266,782 surgical procedures report that for many of the surgical procedures analysed, including abdominal surgery, males had higher SSI rates. However, the study also highlighted SSI rates differed by sex for certain procedures, offering differences in bacterial skin colonisation as a possible explanation [28]. While males may be more susceptible to SSIs in HPB surgery compared to females, the relationship between sex and SSI risk is complex and multifactorial. Further research is needed to better understand the underlying mechanisms and to develop an appropriate targeted interventions to reduce SSI risk in patients undergoing HPB surgery.

Our results revealed no significant link between age (>75 vs < 75) and SSI risk, but a borderline association was found for age (>65 vs < 65) in 2846 pancreatic and liver surgeries [10,20]. Our findings largely support Mentor et al.'s systematic review of 14 studies, finding that advanced patient age does not increase the risk of SSI [11]. Notably, Mentor et al.'s review encountered similar challenges to our study where included studies used varying cut-off points for advanced age. However, this result is inconsistent with other reviews in this field that report advanced age as a risk factor for SSIs [20]. Regardless, it is accepted that patients of advanced age are more likely to have comorbidities, such as diabetes, that may negatively impact their pre-operative, intra-operative, and postoperative outcomes [20].

In reviews comparing open and minimally invasive pancreatic surgeries, our meta-analysis indicates a strong positive link between open PD and SSIs, supported by high-grade evidence and wider literature [25]. Further, our results suggest significantly higher odds of SSI in the open DP surgical approach compared with the laparoscopic DP surgical approach, however, the level of evidence for this risk factor was weak. The association between open surgical approaches and higher risk of SSI has been well documented in the literature [11,21,25]. Wang et al. reported SSI rates at 17 % for open PD compared to 8 % for the minimally invasive approach, which combines laparoscopic and robotic assisted PD [25]. While a smaller study by Peng et al. comparing only the robotic approach with open PD surgery reported SSI rates of 11 % for open PD and 1.7 % for robotic PD [21]. There may be a myriad of explanations for higher SSI rates among open surgical approaches. Open incisions have a larger surface area, inherently posing a greater risk of contamination from the environment intraoperatively and during the postoperative wound healing phases [31]. Additionally, open surgery is associated with increased manipulation of tissues which can disrupt normal protective barriers and decrease blood supply, which is associated with poor wound perfusion [36]. While our data, corroborated by the broader literature [11,21,25], indicates a significantly lower rate of infections associated with minimally invasive surgery approaches, it is important to weigh these findings against the clinical implications of this approach. Minimally invasive pancreatic surgery demands highly skilled surgeons due to the technical challenges of navigating the deep, soft pancreas and potential anatomical variations [30,32]. Although minimally invasive techniques are gaining popularity in resource rich countries, the open surgical approach largely remains the standard of care for PD surgery [32].

Our analyses suggest PD surgery carries higher SSI risk compared to the DP surgical procedure. Similarly, Mentor et al. reports SSI rates in PD surgery at 32.4 % compared to 23.1 % following DP surgery (OR 1.59, 95 % CI 1.48–1.72, $p = 0.001$) [11]. PD surgery is notoriously complex and requires gastrointestinal tract and biliary system reconstruction, increasing the risk of biliary contamination and higher conversion rates [16]. While bile contamination remains a potential contributor to infection risk, postoperative pancreatic fistula and other procedure-related factors play a substantial role in influencing morbidity following PD [39]. Our analyses found preoperative biliary drainage marginally increased the risk of SSI in hepatectomies, although the level of evidence was moderate. Yet, previous literature has demonstrated higher rates of postoperative wound infections associated with preoperative biliary drainage [11,24,35]. The benefits and drawbacks of preoperative biliary drainage are mostly speculative, with limited empirical evidence showing whether its clinical advantages outweigh procedure-related risks [33].

10.1. Statistical heterogeneity between studies

As expected in a meta-analysis assessing incidence rates from multiple retrospective and prospective studies in diverse environments, our review has substantial between-study heterogeneity [38]. *Clinical heterogeneity is one possible explanation for the high heterogeneity in our review. The target populations, outcome measures, follow-up times and/or the* analytical methods *of the included reviews varied greatly. In this context, we used a random-effects model* [37]. *The* metaumbrella *package employs the Restricted Maximum Likelihood (REML) estimator, which is ideal for our review as it performs effectively in high heterogeneity situations with varying study sample sizes.* Further, *in* the presence of significant heterogeneity, we used prediction intervals, which are valuable as they explicitly account for the variability among studies [38]. *Unfortunately, performing subgroup analyses was not possible due to the lack of demographic characteristics reported in the reviews.*

10.2. Limitations of this study

The findings of our review have some limitations. Firstly, the primary studies may have had their own biases which can impact the results of this umbrella review. However, unlike primary meta-analyses, the grading of epidemiological evidence in umbrella reviews attempts to account for issues related to heterogeneity, *publication bias*, and small study effects [23]. Although publication bias might be underestimated, especially in risk factors with high heterogeneity, we mitigated this by using systematic methods, i.e., a comprehensive search across four databases and not limiting reviews to English-language. Inconsistencies in both risk factor definitions and SSI definitions were present, and many of the included reviews did not report the criterion used to diagnose an SSI.

11. Conclusion

The findings of this umbrella review synthesised the current best evidence available for the association between clinical and patient risk factors and SSI in patients undergoing HPB surgery. Open PD procedure was found to significantly increase the risk of SSI compared to minimally invasive surgeries. We have reported several key risk factors related to patient and clinical characteristics that may be used to develop predictive risk stratification models. Further high-quality studies are warranted to accurately determine the extent of associations between patient and clinical risk factors and SSIs.

Reporting method

The Preferred Reporting Items for Systematic Reviews and Meta-analysis checklists were used to report the screening process.

CRediT authorship contribution statement

Madeline Bone: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft. **Sharon Latimer:** Conceptualization, Investigation, Writing – review & editing. **Rachel M. Walker:** Conceptualization, Writing – review & editing. **Lukman Thalib:** Formal analysis, Validation, Writing – review & editing. **Brigid M. Gillespie:** Conceptualization, Investigation, Writing – review & editing.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

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List of abbreviations:

CCA – corrected cover area
CDC – Centers for Disease Control and Prevention
CI – Confidence interval
CINAHL – Cumulative Index of Nursing and Allied Health Literature
eOR – estimated Odds Ratios
GRADE – Grading of Recommendations Assessment, Development, and Evaluation
HPB – Hepatobiliary
JBI – Joanna Briggs Institute
LDP – Laparoscopic distal pancreatectomy
MIPD – Minimally invasive pancreaticoduodenectomy
NBR – No biliary resection
NPBD – No preoperative biliary draining
ODP – Open distal pancreatectomy
OPD – Open pancreaticoduodenectomy
PBD – Preoperative biliary draining
PD – Pancreaticoduodenectomy
PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-analyses
ROB – Risk of bias
ROBIS – Risk of Bias in Systematic Reviews
SARC – Sarcopenia
SSI – Surgical Site Infection

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2024.109468.

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