

Prevalence and risk factors for postoperative incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy: a meta-analysis and systematic review

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KEY WORDS

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ABSTRACT

INTRODUCTION The prevalence and risk factors for postoperative incisional hernia (IH) following cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy (CRS-HIPEC) remain uncertain, with published studies reporting highly variable outcomes.

AIM This systematic review and meta-analysis aimed to estimate the pooled prevalence of IH after CRS-HIPEC and risk factors associated with it.

MATERIALS AND METHODS A comprehensive search of the PubMed, Embase, and Cochrane Library databases was conducted to identify relevant observational studies. A total of 12 studies reporting IH after CRS-HIPEC were included. Study quality was assessed using the Newcastle–Ottawa Scale, and random-effects models were applied to calculate pooled prevalence and risk factors for postoperative IH following CRS-HIPEC. Subgroup, sensitivity, and publication bias analyses were performed to evaluate robustness of the findings.

RESULTS A total of 12 studies comprising 2170 patients were qualified for this review. The estimated average pooled prevalence of IH after CRS-HIPEC was 13% (95% CI, 9–16), with individual study estimates ranging from 6.9% to 26.9%, and substantial heterogeneity ($I^2 = 85.2\%$). Subgroup analyses showed lower prevalence in prospective studies and larger cohorts, while multicenter studies demonstrated lower prevalence rates, as compared with single-center cohorts. Several risk factors were significantly associated with IH, including perioperative chemotherapy, bowel anastomosis or stoma formation, older age, obesity, and postoperative complications. Sensitivity analysis confirmed stability of the results, and the Egger test did not indicate significant small-study effects.

CONCLUSIONS IH is a notable and clinically relevant long-term complication following CRS-HIPEC. The risk of IH is driven primarily by patient age, obesity, perioperative chemotherapy exposure, gastrointestinal reconstruction, and postoperative complications.

INTRODUCTION Cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy (CRS-HIPEC) has become a cornerstone treatment for selected patients with peritoneal surface malignancies, including pseudomyxoma peritonei, peritoneal metastases from colorectal or

ovarian cancer, and malignant peritoneal mesothelioma.^{1–3} By integrating maximal tumor debulking with regional high-temperature chemotherapy, CRS-HIPEC can offer meaningful survival benefits and, in some cases, long-term disease control.^{4,5} However, these therapeutic gains

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come at the cost of extensive surgical trauma, prolonged operative time, substantial physiological stress, and a high overall burden of postoperative morbidity.^{6,7} As a result, the complication profile of CRS-HIPEC differs markedly from that of conventional abdominal surgery, and includes unique long-term sequelae that are often under-recognized.

Among these, postoperative incisional hernia (IH) represents one of the most consequential yet underappreciated late complications following CRS-HIPEC.^{8,9} Postoperative IH is a common long-term complication defined as a defect in the abdominal wall at the site of a previous surgical incision, with or without clinically perceivable bulging. In patients undergoing CRS-HIPEC, the management of IH is particularly challenging. IH can cause chronic pain, impaired intestinal function, poor cosmesis, and a risk of bowel obstruction or strangulation, frequently necessitating complex reoperations in patients with already significant oncologic and surgical burdens.^{10,11} Several pathophysiological mechanisms may contribute to the elevated risk of IH in this population: extensive peritonectomy and multivisceral resections degrading abdominal wall integrity, hyperthermic perfusion inducing tissue edema and protein denaturation, oncologic malnutrition impairing wound healing, and high prevalence of ostomies, bowel anastomoses, and early postoperative complications further compromising fascial recovery. Reported IH rates after CRS-HIPEC vary widely—from approximately 10% to over 40%—reflecting both genuine heterogeneity and limitations of the available evidence.^{8,10,11}

Despite increasing clinical concern, the risk factors for IH after CRS-HIPEC remain poorly defined. Existing studies are predominantly single-center cohorts with modest sample sizes, inconsistent definitions of IH, heterogeneous follow-up durations, and substantial variability in perioperative management.^{9,11} More importantly, although numerous potential predictors have been proposed—such as age, body mass index (BMI), preoperative chemotherapy exposure, extent of bowel procedures, Clavien–Dindo grade of postoperative complications, and physiological status—findings across studies are conflicting.⁹⁻¹¹ Only a subset of analyses report multivariable adjusted risk estimates, and no prior systematic review has comprehensively synthesized these adjusted data. Consequently, clinicians currently lack robust evidence to stratify IH risk, optimize perioperative decision-making, or design targeted preventive strategies in this high-risk surgical population.

Given these uncertainties, a rigorous synthesis of the adjusted evidence is urgently needed. Identifying reproducible, independent risk factors would support individualized patient counseling, inform modifiable targets for perioperative optimization, guide research into abdominal

wall closure strategies, and ultimately contribute to improving long-term survival after CRS-HIPEC.

AIM This systematic review and meta-analysis aimed to estimate the pooled prevalence of IH after CRS-HIPEC and quantitatively synthesize all available multivariable-adjusted evidence to determine the independent risk factors associated with it.

MATERIALS AND METHODS Study design This study was conducted as a systematic review and meta-analysis, designed in accordance with the 2020 PRISMA guidelines.¹²

Search strategy A comprehensive and systematic search of the literature was performed using the PubMed, Embase, and Cochrane Library databases from their inception to June 25, 2025. The search strategy incorporated MeSH and free-text terms related to CRS, HIPEC, abdominal wall complications, wound failure, and IH. Boolean operators and database-specific filters were applied to ensure maximum sensitivity while maintaining relevance. Duplicate records were removed using automated functions and manual verification. To reduce the likelihood of missing relevant studies, we also screened the reference lists of all included full-text articles and pertinent reviews. There were no restrictions in terms of publication language or geographical region, and translations were performed to ensure accurate assessment of eligibility and data extraction, where necessary.

Eligibility criteria Observational studies were eligible if they enrolled adult patients undergoing CRS-HIPEC for any peritoneal malignancy, and reported postoperative IH as a discrete outcome. To ensure reliability of the pooled risk factor analysis, multivariable-adjusted effect estimates for at least 1 candidate predictor had to be reported. Studies were excluded if they lacked extractable outcome data, failed to provide adjusted analyses, or reported composite end points in which IH could not be isolated. Case series with fewer than 10 patients, reviews, conference abstracts, letters, animal studies, and studies not involving abdominal incisions were also excluded. When overlapping datasets were suspected, the study with the largest population or longest follow-up was selected to avoid duplication.

Data extraction Two investigators (QZ and XY) independently extracted data using a structured template developed prior to the review. The extracted information included study characteristics (author, year, country, enrollment period, and cohort design), patient demographics, primary tumor origin, extent of cytoreduction, HIPEC parameters, incision type, bowel procedures, postoperative complications, and follow-up duration. Particular attention was paid to the definition and method of diagnosing IH, as this outcome may be identified clinically or radiologically. For the risk

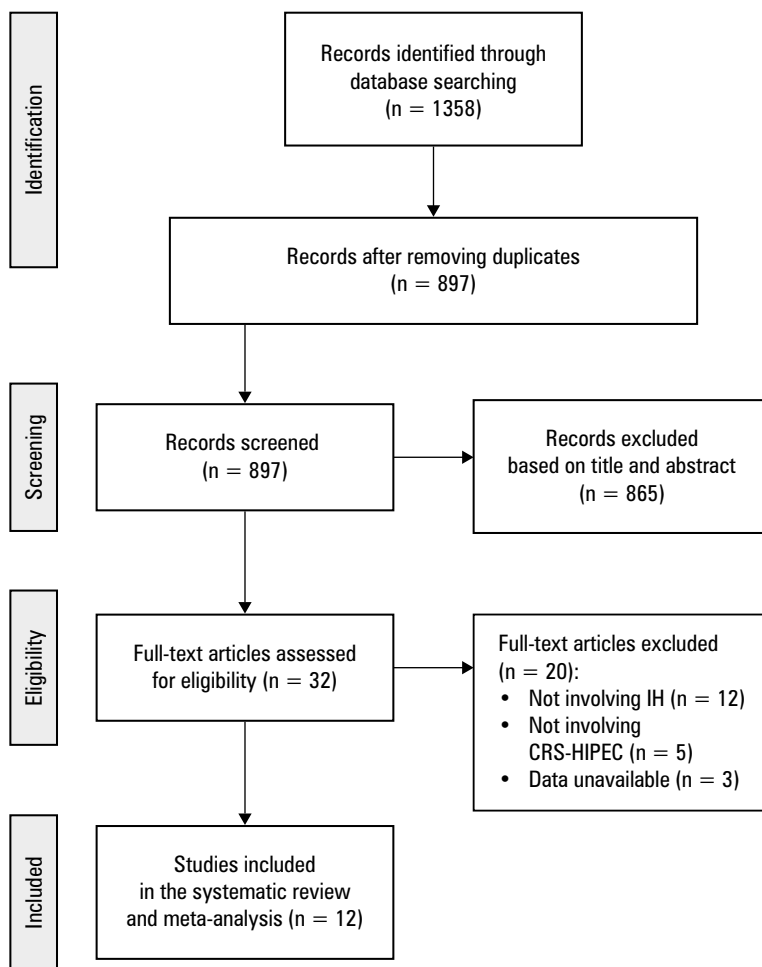


FIGURE 1 PRISMA flow diagram of the study selection process

Abbreviations: CRS-HIPEC, cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy; IH, incisional hernia

factor analysis, all multivariable-adjusted effect estimates—odds ratios (ORs), risk ratios, or hazard ratios—with corresponding 95% CIs were collected. When multiple adjusted models were presented, the most comprehensively adjusted model was selected to ensure comparability across the studies. For continuous variables, such as age and BMI, ORs were extracted based on a single-unit increase (per 1 year and per 1 kg/m², respectively), as reported in the majority of the included multivariable models. Where studies used different increments, the data were standardized to a single-unit increase, whenever possible, to ensure consistency in the pooled analysis.

Quality assessment The quality of the included studies was assessed using the Newcastle–Ottawa Scale, which evaluates selection of participants, comparability of cohorts, and adequacy of outcome ascertainment and follow-up.¹³ Because postoperative IH is a long-term complication, the completeness and duration of follow-up were considered critically important in determining study quality. We assigned scores of 0 to 3, 4 to 6, and 7 to 9 for low, moderate, and high quality of studies, respectively. The studies were independently evaluated by 2 investigators (QZ and

XY), and discrepancies were resolved through discussion.

Statistical analysis The primary outcome was the prevalence of IH after CRS-HIPEC, and the secondary outcome was its associated risk factors. For the prevalence analysis, all studies reporting the incidence of IH after CRS-HIPEC were considered. However, for the identification of risk factors, we specifically restricted our meta-analysis to studies providing multivariable-adjusted ORs or those from which adjusted data could be extracted. This criterion was applied to mitigate the risk of confounding and ensure that the identified predictors represented independent risk factors for IH development. For prevalence estimation, the number of events and total sample size were extracted from each study. Prevalence proportions were log-transformed to stabilize variance, and corresponding SEs were calculated. Pooled estimates were synthesized using the DerSimonian–Laird random-effects model. Heterogeneity was quantified using the Cochran Q statistic and the *I*² index, with thresholds of 25%, 50%, and 75% used to denote low, moderate, and high heterogeneity, respectively.¹⁴ To further investigate the sources of heterogeneity in the pooled prevalence estimates, univariable random-effects meta-regression analyses were performed. Prespecified study-level covariates included follow-up duration (continuous), HIPEC regimen (mitomycin C-based vs non-mitomycin C-based), primary tumor origin (pseudomyxoma/colorectal vs other malignancies), and the method of IH detection (imaging-based vs clinical examination only). Regression coefficients, 95% CIs, and *P* values were calculated for each variable. Given the number of eligible studies, multivariable regression was not performed. Subgroup analyses were conducted according to the study design, sample size, methodological quality, and study type (single- or multicenter) to explore potential drivers of heterogeneity. Leave-1-out sensitivity analyses were performed by sequentially removing individual studies to evaluate the robustness of the pooled prevalence estimate.

Risk factors were reported if at least 2 studies were eligible for pooling. For risk-factor analyses, adjusted ORs and their 95% CIs were extracted from multivariable models. Log-transformed ORs and SEs were calculated for each study, and random-effects models were applied to generate pooled associations due to variations in covariate adjustment and study characteristics.

Publication bias was explored using the funnel-plot inspection and the Egger regression test when sufficient studies were available.¹⁵ A *P* value below 0.05 was considered indicative of significant small-study effects. When asymmetry was suggested, the trim-and-fill procedure was planned to assess its potential impact on the pooled estimates. All statistical analyses were performed

using Stata software, version 14.0 (StataCorp., College Station, Texas, United States).

This study did not require approval of a bioethics committee.

RESULTS Study selection Study selection process is outlined in **FIGURE 1**. The initial search yielded 1358 records. After removal of duplicates and screening of titles and abstracts, 32 full-text articles were reviewed in detail. Ultimately, 12 studies fulfilled all predefined inclusion criteria and were incorporated into the quantitative synthesis.^{8-11,16-23} These studies, conducted across North America, Europe, Australia, the Middle East, and Asia, collectively represented diverse clinical settings and patient populations undergoing CRS-HIPEC for peritoneal surface malignancies. Sample sizes ranged from 26 to 360 patients, and follow-up durations extended from at least 12 months to over 7 years. According to the Newcastle–Ottawa Scale, 9 studies were classified as high quality, whereas 3 were of moderate quality. Detailed study characteristics and quality assessment are presented in **TABLES 1** and **2**.

Pooled prevalence of postoperative incisional hernia

Across the 12 studies, the incidence of postoperative IH ranged from 6.9% to 26.9%, reflecting substantial differences in patient selection, the extent of cytoreduction, HIPEC protocols, postoperative care pathways, and the modality and frequency of hernia detection. Using the DerSimonian–Laird random-effects model, the pooled prevalence of postoperative IH after CRS-HIPEC was calculated at 0.13 (95% CI, 0.09–0.16; **FIGURE 2**). Between-study heterogeneity was considerable ($I^2 = 85.2\%$; $P < 0.001$), indicating genuine variability rather than methodological inconsistency. Meta-regression analyses did not identify any study-level covariate that significantly explained the substantial heterogeneity in IH prevalence. Follow-up duration showed no association with prevalence ($P = 0.38$). HIPEC regimen was not a modifier ($P = 0.27$). Primary tumor origin demonstrated no meaningful effect ($P = 0.46$). Similarly, the method of IH detection was not associated with systematic differences across the studies ($P = 0.21$). Subgroup analyses helped clarify potential sources of heterogeneity (**TABLE 3**). Retrospective studies yielded a prevalence of 0.13 (0.09–0.17), whereas a single prospective study¹⁹ reported a lower estimate of 0.09 (0.05–0.14). Studies with fewer than 200 participants demonstrated a slightly higher prevalence (0.14 [0.09–0.2]), as compared with larger cohorts (0.11 [0.06–0.16]). High-quality studies yielded a prevalence of 0.11 (0.08–0.15), while moderate-quality studies 0.19 (0.1–0.29). Multicenter studies reported a lower pooled prevalence (0.08 [0.05–0.11]) than single-center cohorts (0.14 [0.1–0.18]), likely reflecting more standardized perioperative and follow-up protocols. Leave-1-out sensitivity analysis showed remarkable stability, with recalculated prevalence values

consistently between 0.12 and 0.14, indicating that no individual study disproportionately influenced the overall estimate.

Visual inspection of the funnel plot demonstrated mild asymmetry, suggesting a possible distortion related to publication processes (**FIGURE 3**). However, the Egger regression did not show evidence of small-study effects test ($P = 0.12$). Given the limited number of included studies and the substantial heterogeneity inherent to CRS-HIPEC cohorts, it is hard to rule out the existence of publication bias.

Risk factors for postoperative incisional hernia A total of 11 risk factors reported in 2 or more studies were eligible for a meta-analysis (**TABLE 4**). Among patient-related characteristics, advanced age was identified as a significant postoperative IH predictor (OR, 1.02; 95% CI, 1.01–1.03), indicating a 2% increase in IH risk for every additional year of age. Similarly, higher BMI (OR, 1.11; 95% CI, 1.06–1.16) was associated with an 11% increased risk per 1 kg/m² increment. Conversely, sex, diabetes, hypertension, American Society of Anesthesiologists (ASA) class, and the peritoneal cancer index (PCI) score were not significantly associated with IH development.

Treatment- and surgery-related factors demonstrated stronger and more consistent associations. Pre- or perioperative systemic chemotherapy was significantly associated with postoperative IH (OR, 2.06; 95% CI, 1.42–3.01), likely reflecting chemotherapy-mediated impairment in collagen synthesis and tissue remodeling. Gastrointestinal procedures (anastomosis/stoma) were also associated with an increased hernia risk (OR, 1.13; 95% CI, 1.04–1.23), a finding that persisted across all included cohorts, with no detectable heterogeneity ($I^2 = 0\%$).

Postoperative morbidity exerted the strongest effect. The patients who experienced postoperative complications demonstrated a markedly increased risk of subsequent IH, with a pooled OR of 4.76 (95% CI, 1.83–12.35). Although the pooled estimate for Clavien–Dindo grade did not reach significance (OR, 1.74; 95% CI, 0.64–4.71), the directionality of the association strongly favored an increased risk among the patients experiencing major postoperative events, despite considerable heterogeneity ($I^2 = 90.7\%$).

DISCUSSION In this systematic review and meta-analysis, postoperative IH was found to be a substantial and persistent morbidity cause following CRS-HIPEC. The pooled incidence of 13% highlights a considerable long-term abdominal wall burden in this population. As CRS-HIPEC becomes increasingly integrated into the management of peritoneal surface malignancies, understanding and mitigating its late structural complications, such as IH, is essential for improving long-term functional outcomes and survival.

Our findings point to several treatment- and surgery-specific factors as the primary drivers of

TABLE 1 Baseline characteristics of the studies on incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy (continued on the next page)

| Author, year | Study design | Study type | Country | Enrollment period | Age, y, mean (SD) or range | Diagnosis | HIPEC regimen | IH detection method | IH rate, % (n/N) | Follow-up duration, mean (SD) or median |
|---|----------------------|---------------|---------------|-------------------|----------------------------|---|---|---------------------------------|---|---|
| Wong et al, ¹⁶ 2014 | Retrospective cohort | Single-center | United States | 2004–2012 | 18–77 | <ul style="list-style-type: none"> • Peritoneal mesothelioma | Cisplatin (250 mg/m ²) | Clinical observation | 12 (3/26) | Median, 12.2 mo |
| Spencer et al, ¹⁷ 2015 | Retrospective cohort | Multicenter | United States | 2001–2007 | 15–85 | <ul style="list-style-type: none"> • Ovarian cancer | IV platinum + taxane | Physical examination and CT | Early, 9.8 (26/265); late, 7.9 (15/189) | Mean, 2 y |
| Struller et al, ¹⁸ 2017 | Retrospective cohort | Single-center | Germany | 2005–2014 | 17–76 | <ul style="list-style-type: none"> • Peritoneal carcinomatosis | Cisplatin or mitomycin | Physical examination and CT | 7 (19/271) | Median, 38 mo |
| Ravn et al, ¹⁹ 2018 | Prospective cohort | Single-center | Denmark | 2006–2015 | 24–75 | <ul style="list-style-type: none"> • Colorectal cancer; • Pseudomyxoma peritonei; • Malignant peritoneal mesothelioma | Mitomycin C (50 mg/m ²) for 90 min or cisplatin (50 mg/m ²) | Physical examination and CT | 9.2 (14/152) | Median, 16.6 mo |
| Pariikh et al, ²⁰ 2019 | Retrospective cohort | Multicenter | Australia | 1996–2017 | 25–83 | <ul style="list-style-type: none"> • Colorectal cancer; • Appendiceal mesothelioma; • Ovarian cancer | Cisplatin or mitomycin C | Clinical examination and CT | 8.2 (16/197) | Mean, 84.7 mo |
| Turtle et al, ⁹ 2019 | Retrospective cohort | Single-center | United States | 2001–2016 | 18–80 | <ul style="list-style-type: none"> • Peritoneal carcinomatosis | Mitomycin C (12.5–50 mg/m ²) or oxaliplatin | Physical examination and CT | 17 (26/155) | Median, 2 y |
| Lewcun et al, ²² 2020 | Retrospective cohort | Single-center | United States | 2013–2019 | 58.6 (12.4) | <ul style="list-style-type: none"> • Appendiceal cancer; • Colorectal cancer; • Ovarian cancer; • Gastric cancer | Mitomycin C, cisplatin, or doxorubicin | Physical examination | 13 (3/23) for the 4:1 SL:WL group; 34.9 (22/63) for the SFC group | Mean, 17.4 mo |
| Cascales Campos et al, ²¹ 2020 | Retrospective cohort | Single-center | Spain | 2008–2017 | 17–78 | <ul style="list-style-type: none"> • Ovarian cancer; • Colorectal cancer; • Pseudomyxoma peritonei | Paclitaxel, cisplatin, or mitomycin C | Physical examination and CT | 10 (28/282) | Median, 18 mo |
| Ben-Yaacov et al, ⁸ 2023 | Retrospective cohort | Single-center | Israel | 2015–2020 | 58 (12.6) | <ul style="list-style-type: none"> • Colorectal cancer; • Ovarian cancer; • Appendiceal mesothelioma | Cisplatin, paclitaxel, or mitomycin C | Physical examination and CT/MRI | 26.9 (54/201) | Median, 1.8 y |
| Wenzelberg et al, ²³ 2023 | Retrospective cohort | Single-center | Sweden | 2004–2019 | 17–78 | <ul style="list-style-type: none"> • Colorectal cancer; • Appendiceal cancer; • Rectal cancer; • Malignant mesothelioma | Mitomycin C or cisplatin | CT | 7.8 (10/129) | 1 (3) mo |

TABLE 1 Baseline characteristics of the studies on incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy (continued from the previous page)

| Author, year | Study design | Study type | Country | Enrollment period | Age, y, mean (SD) or range | Diagnosis | HIPEC regimen | IH detection method | IH rate, % (n/N) | Follow-up duration, mean (SD) or median |
|---|----------------------|---------------|---------|-------------------|----------------------------|---|--|-----------------------------|------------------|---|
| Ray et al, ¹¹ 2024 | Retrospective cohort | Single-center | India | 2013–2023 | 48 (11.53) | <ul style="list-style-type: none"> • Ovarian carcinoma; • Colorectal carcinoma; • Pseudomyxoma peritonei | Cisplatin, mitomycin C, or doxorubicin | Physical examination and CT | 6.9 (25/360) | Min, 2 y |
| Di Pietrantonio et al, ¹⁰ 2025 | Retrospective cohort | Single-center | Italy | 2004–2023 | 58.7 (11.3) | <ul style="list-style-type: none"> • Peritoneal surface malignancies | Mitomycin C or cisplatin | Clinical examination and CT | 23.8 (29/122) | 2 y |

Abbreviations: CT, computed tomography; IV, intravenous; MRI, magnetic resonance imaging; SFC, standard fascial closure; SL:WL, suture length to wound length ratio; others, see **FIGURE 1**

long-term IH formation. Age and obesity were significant predictors, consistent with diminished collagen quality and increased mechanical strain. The clinical magnitude of these risks becomes more apparent when considering larger increments. For example, a 10-year increase in patient age is associated with an approximately 22% increase in the odds of IH, while a 5-unit increase in BMI (eg, from 25 to 30 kg/m²) could lead to a 68% higher risk. These findings underscore the importance of vigilant postoperative monitoring and potentially reinforced closure techniques in elderly patients and individuals with obesity undergoing CRS-HIPEC. More notably, exposure to systemic chemotherapy—either pre- or perioperatively—was one of the strongest and most consistent risk factors. Chemotherapy-related impairment of fibroblast activity and extracellular matrix synthesis likely diminishes the abdominal wall's capacity to recover from extensive surgical disruption.²⁴ The need for bowel anastomosis or stoma creation further increased the risk, reflecting both the procedural complexity of CRS-HIPEC and the systemic inflammatory burden associated with gastrointestinal reconstruction.

Postoperative complications demonstrated the strongest association with IH, underscoring the central role of early physiological stress and inflammatory complications in determining long-term fascial integrity. These findings collectively suggest that IH risk in CRS-HIPEC is less a function of baseline health status and more a reflection of procedural intensity, tissue stress, and postoperative events.

Several biological and procedural mechanisms likely contribute to the elevated risk of IH observed after CRS-HIPEC. CRS involves extensive peritoneal stripping, adhesiolysis, and tissue mobilization, frequently compromising vascular supply, elevating fascial tension, and weakening the abdominal wall.¹¹ HIPEC adds a second layer of injury. Moderate hyperthermia has been shown to disrupt fibrillar collagen organization, alter extracellular matrix architecture, and induce temperature-dependent cytotoxicity in stromal tissues.²⁵ In parallel, mitomycin C—the most widely used HIPEC agent—exerts direct antifibroblast effects. Experimental studies demonstrate that myelomeningocele suppresses fibroblast proliferation, reduces collagen secretion, and induces apoptosis, thereby delaying wound maturation and weakening early fascial healing.²⁶ Chemotherapy has also been broadly implicated in impaired fibroblast function, collagen turnover, and extracellular matrix remodeling, highlighting its contribution to postoperative abdominal wall failure.²⁴

Furthermore, patients selected for CRS-HIPEC frequently present with systemic inflammation, malnutrition, a history of laparotomies, and substantial disease burden, all of which compromise the regenerative capacity of the abdominal wall and increase susceptibility to wound breakdown.¹⁰ These combined biological vulnerabilities

FIGURE 2 Forest plot of the prevalence of incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy

Abbreviations: DL, DerSimonian–Laird

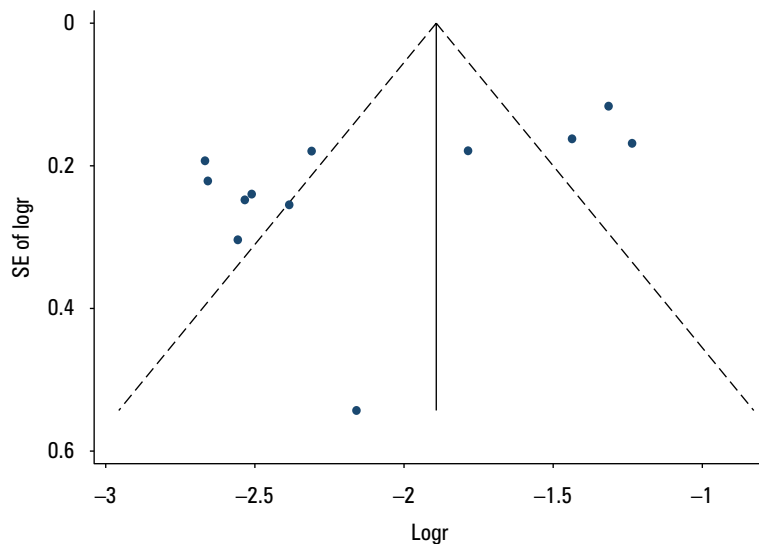
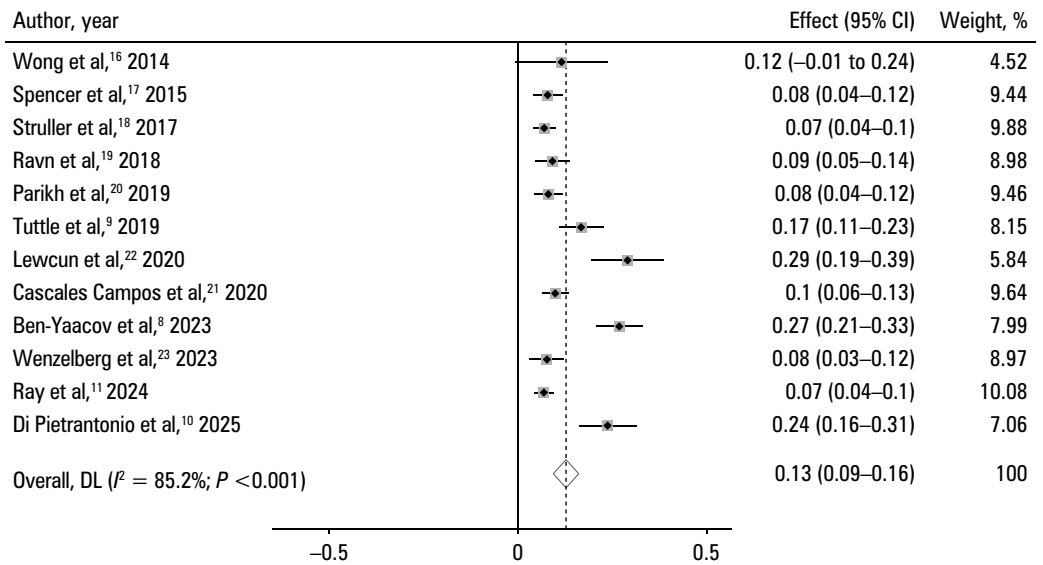


FIGURE 3 Funnel plot for the assessment of publication bias. Each dot represents an individual study. The solid vertical line indicates the pooled effect estimate, and the dashed diagonal lines represent pseudo 95% confidence limits

Abbreviations: logr, natural logarithm of the rate/prevalence estimate

may explain why traditional demographic comorbidities—such as hypertension, diabetes, and ASA class—did not demonstrate significant associations with IH formation in our pooled analyses. Taken together, these findings underscore that IH risk after CRS-HIPEC is driven primarily by treatment-related and tissue-level factors rather than baseline demographic characteristics.

Clinical implications Our observations carry important implications for clinical practice. Firstly, risk stratification should prioritize treatment-related and postoperative variables rather than rely solely on demographic comorbidity profiles. Patients who are older, individuals with obesity, heavily pretreated with chemotherapy, or undergoing complex bowel procedures may benefit from enhanced prophylactic measures, including reinforced fascial closure or early postoperative

imaging. Secondly, the strong association between postoperative complications and IH emphasizes the need for meticulous perioperative management, early recognition of infectious or wound-related events, and structured recovery protocols aimed at optimizing nutritional and immunologic status. As long-term survival after CRS-HIPEC continues to improve, preventing late structural complications will increasingly influence patient quality of life, return to function, and health care resource utilization. Additionally, the potential of minimally-invasive surgery in preventing IH deserves attention. Emerging evidence suggests that laparoscopic or robotic CRS-HIPEC may reduce IH risk by minimizing abdominal wall trauma and reducing postoperative complications. While currently limited to selected populations with lower PCI, integrating minimally-invasive surgery platforms could be a key strategy to lower the IH prevalence. Finally, beyond the patient-related risk factors identified, technical aspects of abdominal wall closure play a crucial role in preventing IH after CRS-HIPEC. Our review highlights evidence from specific cohorts^{22,23} suggesting that meticulous closure techniques are paramount. Specifically, maintaining an optimal suture length-to-wound length ratio and the potential use of prophylactic mesh or reinforced closure in high-risk patients may mitigate the mechanical stress imposed by extensive cytoreduction and heated chemotherapy. Given the high-risk nature of the CRS-HIPEC population, clinicians should consider these preventive strategies as integral components of the surgical protocol.

Limitations This study has several limitations, the most important one being the substantial heterogeneity observed. Consequently, the 13% prevalence should be interpreted as an approximate global average rather than a precise risk applicable to all surgical contexts. The observed variability likely stems from unmeasured confounding factors, such as IH detection method, follow-up

TABLE 2 Quality evaluation of the included studies (based on the Newcastle–Ottawa Scale)^a

| Author, year | a | b | c | d | e | f | g | h | i | Score | Overall quality |
|---|---|---|---|---|---|---|---|---|---|-------|-----------------|
| Wong et al, ¹⁶ 2014 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 | Moderate |
| Spencer et al, ¹⁷ 2015 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Struller et al, ¹⁸ 2017 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | High |
| Ravn et al, ¹⁹ 2018 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Parikh et al, ²⁰ 2019 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Tuttle et al, ⁹ 2019 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 | Moderate |
| Lewcun et al, ²² 2020 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 | Moderate |
| Cascales Campos et al, ²¹ 2020 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Ben-Yaacov et al, ⁸ 2023 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Wenzelberg et al, ²³ 2023 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Ray et al, ¹¹ 2024 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |
| Di Pietrantonio et al, ¹⁰ 2025 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | High |

a Letters correspond to the following domains: a – representativeness of the exposed cohort; b – selection methods for nonexposed cohorts; c – ascertainment of exposure; d – outcome of interest not present at the start of the study; e – study controlled for confounders; f – study controlled for additional factors; g – assessment of exposure; h – follow-up period long enough for outcomes to occur; i – adequacy of follow-up of cohorts.

TABLE 3 Subgroup analysis of the prevalence of incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy

| Outcomes | | Number of studies | OR (95% CI) | I ² value, % |
|--|-----------------------|-------------------|------------------|-------------------------|
| Pooled results | | 12 | 0.13 (0.09–0.16) | 85.2 |
| Subgroup analyses based on study design | Retrospective studies | 11 | 0.13 (0.09–0.17) | 86.5 |
| | Prospective studies | 1 | 0.09 (0.05–0.14) | NA |
| Subgroup analyses based on sample size | ≤200 | 7 | 0.14 (0.09–0.2) | 81.6 |
| | >200 | 5 | 0.11 (0.06–0.16) | 89.2 |
| Subgroup analyses based on study quality | Moderate | 3 | 0.19 (0.1–0.29) | 67.7 |
| | High | 9 | 0.11 (0.08–0.15) | 84.7 |
| Subgroup analyses based on study type | Single-center | 10 | 0.14 (0.1–0.18) | 87.5 |
| | Multicenter | 2 | 0.08 (0.05–0.11) | 0 |

Abbreviations: NA, not applicable; OR, odds ratio

duration, nuances in fascial closure techniques (eg, suture materials, stitch-to-wound ratios), and the rigor of postoperative surveillance, which were not consistently documented in the literature. While meta-regression was performed to explore the impact of potential factors, no significant associations were found. However, these null findings should not be overinterpreted as evidence of no effect. Given the relatively small number of included studies, our analysis may have been underpowered to detect these modifiers, and the clinical impact of these variables remains a plausible source of the observed variability. Although our findings remain robust across sensitivity analyses, the wide range of reported incidence underscores the need for standardized reporting in future CRS-HIPEC complication studies.

Secondly, the predominance of retrospective designs introduces potential misclassification bias, especially given the lack of standardized imaging protocols for diagnosing IH. Follow-up duration was inconsistently reported, raising concerns that late-presenting hernias may be underestimated in some cohorts. Furthermore, our meta-analysis

prioritized multivariable-adjusted data to identify independent risk factors, which inherently favored larger, high-volume centers with more rigorous data-reporting standards. While this may limit the generalizability of the results to smaller or older surgical series that only reported crude associations, it substantially enhances the internal validity of our findings. By excluding unadjusted data, we reduced the likelihood of identifying spurious associations, thereby providing a more reliable foundation for clinical decision-making and patient counseling in the context of CRS-HIPEC.

Thirdly, although the Egger test did not show significant small-study effects, mild funnel plot asymmetry suggests that subtle publication bias cannot be excluded.

Fourthly, it is important to distinguish between the levels of evidence for various risk factors. We found moderate-certainty evidence for age and BMI as independent IH predictors, as these were consistently reported across multiple robust cohorts. In contrast, the evidence for postoperative complications and specific gastrointestinal procedures is considered of lower certainty, given that

TABLE 4 Meta-analyses of risk factors for incisional hernia after cytoreductive surgery combined with hyperthermic intraperitoneal chemotherapy

| Risk factors | Number of trials | Pooled OR (95% CI) | <i>I</i> ² value, % |
|--|------------------|--------------------|--------------------------------|
| Age | 6 | 1.32 (1.2–1.86) | 81.5 |
| BMI/obesity | 4 | 1.22 (1.01–1.48) | 26.9 |
| Peri-/preoperative chemotherapy | 3 | 2.06 (1.42–3.01) | 36.6 |
| Hypertension | 2 | 1.6 (0.19–13.2) | 90.5 |
| Postoperative complications | 2 | 4.76 (1.83–12.35) | 50.9 |
| Clavien–Dindo grade | 2 | 1.74 (0.64–4.71) | 90.7 |
| Sex (men vs women) | 3 | 0.63 (0.29–1.37) | 47.4 |
| Diabetes | 2 | 0.48 (0.12–2) | 52.1 |
| ASA class | 2 | 2.09 (0.73–5.98) | 62.9 |
| Peritoneal cancer index | 2 | 1.12 (0.9–1.4) | 0 |
| Gastrointestinal procedures (anastomosis/stoma) ^a | 2 | 1.13 (1.04–1.23) | 0 |
| Previous surgery | 2 | 0.66 (0.3–1.43) | 0 |

a This variable includes bowel anastomosis, stoma formation, or both, as defined by the original studies included in the pooled analysis.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; others, see TABLE 3

these pooled estimates were derived from a limited number of studies and exhibited wider CIs. These findings should be interpreted as preliminary trends that require validation in larger, multicenter studies.

Finally, external generalizability may be limited, as CRS-HIPEC is performed primarily in specialized centers with varying levels of expertise and postoperative support infrastructure.

Despite these limitations, our analysis provides the clearest synthesis to date of the incidence and determinants of IH after CRS-HIPEC. The findings highlight the importance of early complication prevention, careful perioperative optimization, and the potential role of targeted prophylactic abdominal wall strategies. Future research should prioritize prospective, multicenter designs with standardized definitions, objective imaging surveillance, and comprehensive reporting of abdominal wall closure techniques. As the indications for CRS-HIPEC expand and survival rates improve, addressing long-term structural morbidity, such as IH, will be essential to advancing the overall quality of care in this complex surgical population.

CONCLUSIONS In summary, this meta-analysis estimated an approximate average IH prevalence following CRS-HIPEC at 13%, with the risk significantly influenced by advanced age, obesity, and surgical complexity. However, due to substantial heterogeneity and the limited number of studies for certain predictors, these findings should be interpreted with caution. Future research should focus on prospective registries employing standardized IH definitions and unified imaging protocols. Furthermore, detailed recording of abdominal closure techniques in future trials will be essential to establishing evidence-based guidelines for IH prevention in this complex patient population.

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AI STATEMENT Artificial intelligence was not used in the preparation of this manuscript.

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