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# How Postoperative Infection Affects Reoperations after Implant-based Breast Reconstruction: A National Claims Analysis of Abandonment of Reconstruction

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**Background:** Infection after implant-based breast reconstruction adversely affects surgical outcomes and increases healthcare utilization. This study aimed to quantify how postimplant breast reconstruction infections impact unplanned reoperations, hospital length of stay, and discontinuation of initially desired breast reconstruction.
**Methods:** We conducted a retrospective cohort study using Optum's de-identifed Clinformatics Data Mart Database to analyze women undergoing implant breast reconstruction from 2003 to 2019. Unplanned reoperations were identified via Current Procedural Terminology (CPT) codes. Outcomes were analyzed via multivariate linear regression with Poisson distribution to determine statistical significance at $P < 0.00625$ (Bonferroni correction).
**Results:** In our national claims-based dataset, post-IBR infection rate was 8.53%. Subsequently, 31.2% patients had an implant removed, 6.9% had an implant replaced, 3.6% underwent autologous salvage, and 20.7% discontinued further reconstruction. Patients with a postoperative infection were significantly associated with increased incidence rate of total reoperations (IRR, 3.11; 95% CI, 2.92–3.31; $P < 0.001$) and total hospital length of stay (IRR, 1.55; 95% CI, 1.48–1.63; $P < 0.001$). Postoperative infections were associated with significantly increased odds of abandoning reconstruction (OR, 2.92; 95% CI, 0.081–0.11; $P < 0.001$).
**Conclusions:** Unplanned reoperations impact patients and healthcare systems. This national, claims-level study shows that post-IBR infection was associated with a 3.11× and 1.55× increase in the incidence rate of unplanned reoperations and length of stay. Post-IBR infection was associated with 2.92× increased odds of abandoning further reconstruction after implant removal. *(Plast Reconstr Surg Glob Open 2023; 11:e5040; doi: 10.1097/GOX.0000000000005040; Published online 13 June 2023.)*

## INTRODUCTION

Postoperative infection after implant-based breast reconstruction (IBR) adversely affects surgical outcomes and significantly increases healthcare utilization. Post-IBR infection rates range from 2% to 16%, delineating risk factors such as obesity, smoking, age, and radiation therapy.[1–5] Some factors, such as the use of acellular dermal matrix (ADM), lack consensus on its impact on post-IBR infection and overall complications.[6–10] The sequelae of post-IBR infection can include explantation and subsequent implant replacement, autologous salvage, or discontinuation of further reconstruction.[11,12] Overall implant loss rates have ranged from 2.9% to 15.5%.[13–17] Single-institution or single-surgeon analyses showed that 4.9%–7.8% underwent autologous salvage and 26%–57% discontinued further reconstruction after failed IBR.[18–21] The relationship between postoperative infection and

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whether patients discontinue further has yet to be quantified on a national scale. This is a crucial metric, as abandoning reconstruction greatly impacts patients' well-being postmastectomy. Numerous studies report the psychological benefits of breast reconstruction, such as increased patient cosmesis satisfaction and lower psychosocial morbidity compared with mastectomy alone.[22–26] Al-Ghazal et al found significant benefits with respect to patient anxiety, depression, sexuality, body image, and self-esteem.[27] Identifying factors that prohibit women from continuing breast reconstruction is key to optimizing care. We hypothesize that post-IBR infection will be associated not only with more unplanned reoperations, but also with more patients abandoning reconstruction after implant loss. This study aimed to quantify how post-IBR infections impact additional reoperations nationally, adjusting for center-specific treatment practices.

### Takeaways

**Question:** Are patients who experience an infection after implant breast reconstruction more likely to abandon reconstruction after implant loss?

**Findings:** In this national, claims-based retrospective cohort analysis, patients with a postoperative infection were associated with significantly increased odds of abandoning further reconstruction (OR, 2.92; 95% CI, 0.081–0.11; $P < 0.001$). Postoperative infection was also significantly associated with increased incidence rate of total reoperations (IRR, 3.11; 95% CI, 2.92–3.31; $P < 0.001$).

**Meaning:** Patients who experience infection after implant breast reconstruction are significantly more likely to abandon reconstruction after implant loss, foregoing the psychosocial benefits of breast reconstruction.

## METHODS

#### Data Collection from Optum's De-identifed Clinformatics Data Mart Database

Within the Redivis data platform, patients in the Optum's de-identifed Clinformatics Data Mart Database who underwent all billable forms of IBR were identified via Current Procedural Terminology (CPT) codes, between 2003 and 2019.[28] Clinformatics is a de-identified database derived from a large, adjudicated claims data warehouse. The initial placement of an implant or tissue expander for breast reconstruction was our index procedure. This combines immediate and two-stage breast reconstruction together within our cohort but ensures that subsequent procedures were unplanned reoperations. Our primary outcome was the number of reoperations performed after the index procedure and abandoning further reconstruction. Reoperations of interest were implant removal, implant replacement, and autologous salvage. Capsulectomy, capsulotomy, fat grafting, scar revision, or other aesthetic/elective breast reconstruction revisions were not included. Autologous salvage was defined as patients undergoing autologous reconstruction more than 3 months after an implant removal, delineating salvage procedures and delayed-immediate reconstruction. Patients abandoning further reconstruction were defined as those whose implant was removed, and the implant was not replaced or did not undergo autologous salvage. Reoperations performed at any time interval after the index procedure were analyzed.

Our secondary outcome was length of stay (LOS), defined as the summation of total days stayed in the hospital for all unplanned reoperations associated with each patient. Data concerning these patients' demographics, comorbidities, complications, reoperations, and outcomes were collected via querying relevant reports of International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification (ICD-9-CM and ICD-10-CM) and CPT codes. **Appendix I** and **II** list all codes used to query information. Patient demographics queried were age, diabetes, obesity, hypertension, smoking status, neoadjuvant chemotherapy, radiation, and ADM use. (**See appendix, Supplemental Digital Content 1**, which shows a list of ICD-9 and ICD-10 codes. **http://links.lww.com/PRSGO/C598**.) (**See appendix, Supplemental Digital Content 2,** which shows a list of CPT Codes. **http://links.lww.com/PRSGO/C599**.) Radiation treatment was defined as receiving treatment 6 months before or after the index procedure. Neoadjuvant chemotherapy was defined as receiving treatment 1 year before the index procedure. Postoperative complications analyzed (within 90 days of the indexed procedure) were infection, seroma, hematoma, dehiscence, breast reconstruction deformity, fat necrosis, and tissue necrosis.

#### Statistical Analysis

The primary analysis and secondary analyses determined the effect of postoperative infection on the unplanned reoperations and length of stay, respectively. If a patient record did not include information for a clinical characteristic, it was assumed that the patient did not have that characteristic. No imputation was conducted throughout the investigation. Statistical analyses were conducted in the R Environment for Statistical Computing (Vienna, Austria). Summary statistics for the study cohort were computed via the TableOne package, while the variances of independent variables were assessed via the Caret package. Summary statistics included univariate analyses with simple hypothesis testing.

Multivariate regression was performed to ascertain the effects of infection, age, diabetes, hypertension, smoking status, obesity, radiation treatment, and neoadjuvant chemotherapy on the number of reoperations performed or LOS. Poisson regression, negative binomial regression, and quasi-Poisson regression were used depending on whether the variance was equal to, significantly greater than, or significantly less than the mean of the distribution analyzed, respectively. Logistic regression analyzed binary outcomes. Assumptions for the Poisson, negative binomial, and quasi-Poisson distribution were confirmed. Incidence rate ratios for effect sizes and their corresponding 95% confidence intervals (CIs) were calculated. The threshold for statistical significance in univariate analyses

**Table 1. Descriptive Patient Characteristics Stratified by Postoperative Infection**

| | Total (n = 56,327) | No Infection (n = 51,524) | Infection (n = 4803) | *P* |
|---|---|---|---|---|
| n (%) | | 51,524 (91.47) | 4803 (**8.53**) | |
| Age ($\bar{x}$ ($\sigma$)) | 52.56 (11.8) | 52.49 (11.8) | 53.34 (11.1) | <0.001 |
| Obesity (%) | 6501 (11.5) | 5639 (10.9) | 862 (18.0) | <0.001 |
| Hypertension (%) | 18,569 (33.0) | 16,578 (32.2) | 1991 (41.5) | <0.001 |
| Diabetes (%) | 6136 (10.9) | 5361 (10.4) | 775 (16.1) | <0.001 |
| Smoking status (%) | 4853 (8.6) | 4272 (8.3) | 581 (12.1) | <0.001 |
| Neoadjuvant chemotherapy (%) | 17,963 (31.9) | 16,171 (31.3) | 1792 (37.3) | <0.001 |
| Radiation (%) | 10,764 (19.1) | 9706 (18.8) | 1058 (22.0) | <0.001 |
| ADM (%) | 17,908 (31.8) | 16,061 (31.2) | 1847 (38.5) | <0.001 |

was a *P* value less than 0.005. For multivariate analyses, the threshold for statistical significance was a *P* value less than 0.00625 (Bonferroni correction applied). Interaction terms were reported when significant.

## RESULTS

Table 1 shows the descriptive patient characteristics of our cohort stratified by postoperative infection. Of our 56,327 patient cohort, 4803 (8.53%) experienced a postoperative infection. There was a significant increase in the average age and prevalence of obesity, hypertension, diabetes, and smoking status ($P < 0.001$) in patients who had a postoperative infection. There was also a significant increase in the number of patients who received radiation treatment and neoadjuvant chemotherapy in patients with post-IBR infection ($P < 0.001$). Stratified by postoperative infection, there was a significant difference in the percentage of patients who had ADM used ($P < 0.001$).

Table 2 describes the IBR postoperative complications, stratified by infection. In our total cohort, 3.7% experienced seroma; 1.8%, hematoma; 3.8%, dehiscence; 4.3%, breast reconstruction deformity; 2.3%, fat necrosis; and 1.3%, tissue necrosis. For patients who did not experience a postoperative infection, 2.5% experienced seroma; 1.6%, hematoma; 2.4%, dehiscence; 4.1%, breast reconstruction deformity; 1.5%, fat necrosis; and 0.9%, tissue necrosis. For patients who did experience a postoperative infection, 15.7% experienced seroma; 4.2%, hematoma; 19.0%, dehiscence; 6.6%, breast reconstruction deformity; 10.5%, fat necrosis; and 5.8%, tissue necrosis. There was a significant increase in the number of patients who experienced seroma, hematoma, dehiscence, breast reconstruction deformity, fat necrosis, tissue necrosis ($P < 0.001$).

**Table 2. IBR Postoperative Complications Stratified by Infection**

| | No Infection (n = 51,524) | Infection(n = 4803) | *P* |
|---|---|---|---|
| Seroma (%) | 1303 (2.5) | 756 (15.7) | <0.001 |
| Hematoma (%) | 830 (1.6) | 200 (4.2) | <0.001 |
| Dehiscence (%) | 1247 (2.4) | 910 (19.0) | <0.001 |
| Breast reconstruction deformity (%) | 2112 (4.1) | 318 (6.6) | <0.001 |
| Fat necrosis (%) | 774 (1.5) | 505 (10.5) | <0.001 |
| Tissue necrosis (%) | 481 (0.9) | 276 (5.8) | <0.001 |

Figure 1 shows the distribution of total unplanned reoperations. The overwhelming majority of women (87.4%, n = 49,233) did not have a reoperation. An estimated 9.8% of women (n = 5518) had one, 2.4% (n = 1354) had two, and 0.39% (n = 222) had three reoperations. Table 3 describes the reoperations after IBR, stratified by infection. The rate of implant removal, implant replacement, and autologous salvage in our overall cohort was 12.6%, 2.2%, and 1.0%, respectively. Nine percent (9.4%) of total patients discontinued further reconstruction. In patients without postoperative infection, 10.9% had an implant removed, 1.7% had an implant placed again, 0.8% underwent autologous salvage, and 8.4% discontinued further reconstruction. Among those with a postoperative infection, 31.2% had an implant removed, 6.9% had an implant replaced, 3.6% underwent autologous salvage, and 20.7% discontinued further reconstruction. There was a significant increase in implant removal, implant replacement, autologous salvage, and discontinuation of further reconstruction ($P < 0.001$), in patients with post-IBR infection. There was also a significant increase in the number of total reoperations ($P < 0.001$) in patients with post-IBR infection. There was a significant increase in the average LOS in patients with post-IBR infection ($P < 0.001$).

Table 4 shows a negative binomial regression analysis describing the relationships between postoperative infection, patient characteristics, comorbidities, and total reoperations. Patients who experienced a postoperative infection were associated with 3.11× greater incidence rate (IR) of unplanned reoperations than those who did not ($P < 0.001$). Patients who smoked or received radiation treatment were associated with 1.27× and 1.41× greater incidence rate of unplanned reoperations, respectively ($P < 0.001$). Age was associated with a 1% decrease in the unplanned reoperations incidence rate (IRR, 0.99; 95% CI, 0.99–1.00; $P < 0.001$). There was no significant increase in reoperations between patients who did and did not have diabetes, hypertension, obesity, or neoadjuvant chemotherapy.

Figure 2 shows the distribution of total days of hospital stay (LOS). Table 5 shows a negative binomial regression describing the relationship between postoperative infection, patient characteristics, comorbidities, and LOS. Postoperative infection, diabetes, hypertension, neoadjuvant chemotherapy, and radiation treatment were all associated with a significant increase in LOS incidence rate ($P < 0.001$, $P = 0.005$, $P = 0.002$, $P < 0.001$, $P < 0.001$, respectively). Postoperative infection was associated with 1.55× greater LOS incidence rate (in days). Diabetes was associated with 1.07×, hypertension with 1.05×, neoadjuvant chemotherapy with 1.44×, and radiation treatment with 1.11× greater LOS incidence rate ratios. Increased age was associated with decreased LOS IR, however, the confidence interval included 1.00. There was no significant increase in LOS IR among patients who were obese or smoked.

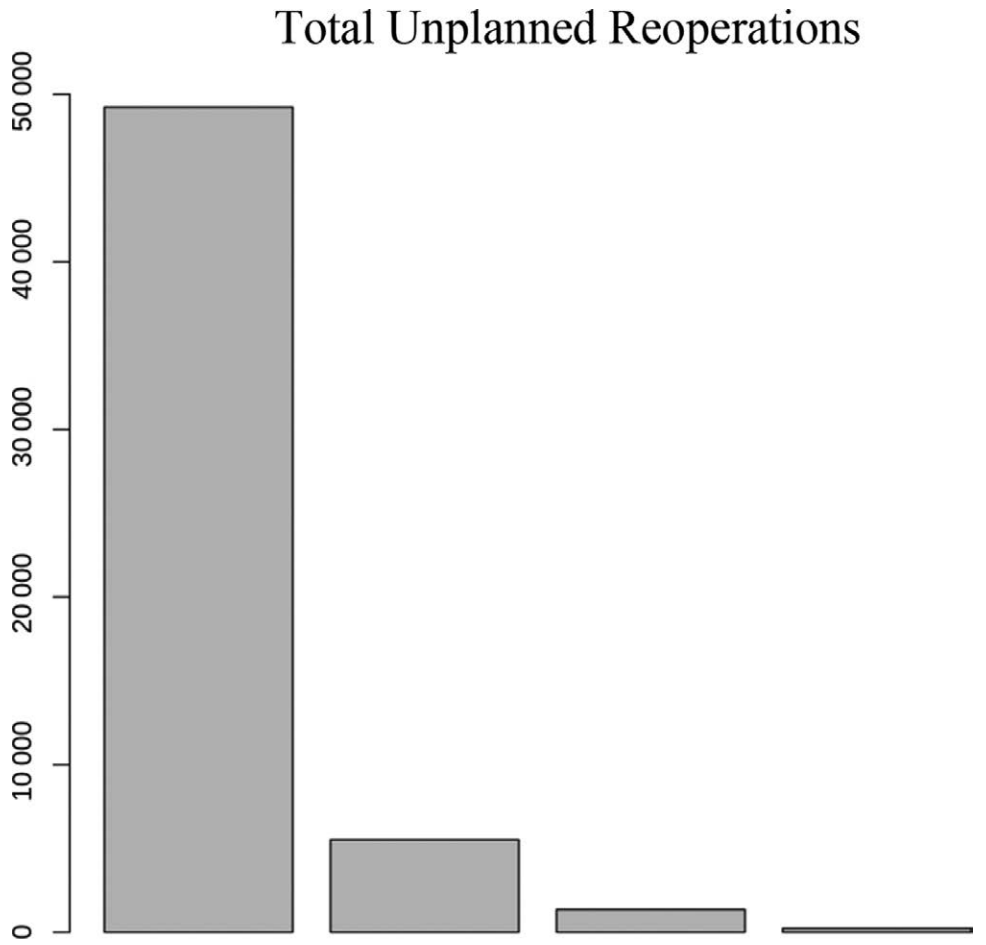


**Fig. 1.** Distribution of total reoperations.

**Table 3. Reoperations after IBR, Stratified by Infection**

| | No Infection (n = 51,524) | Infection (n = 4803) | *P* |
|---|---|---|---|
| Implant removed (%) | 5596 (10.9) | 1498 (31.2) | <0.001 |
| Implant replaced (%) | 886 (1.7) | 333 (6.9) | <0.001 |
| Autologous salvage (%) | 407 (0.8) | 172 (3.6) | <0.001 |
| Abandoned further reconstruction (%) | 4303 (8.4) | 993 (20.7) | <0.001 |
| Total unplanned reoperations (%) | | | <0.001 |
| 0 | 45,928 (89.1) | 3305 (68.8) | |
| 1 | 4466 (8.7) | 1052 (21.9) | |
| 2 | 967 (1.9) | 387 (8.1) | |
| 3 | 163 (0.3) | 59 (1.2) | |
| Total length of stay ($\bar{x}$ ($\sigma$)) | 0.678 (1.1) | 1.052 (1.4) | <0.001 |

**Table 4. Negative Binomial Regression Analysis Describing the Relationships between Postoperative Infection, Patient Characteristics, Comorbidities, and Total Reoperations**

| | IRR* | 95% CI | SE | *P*† |
|---|---|---|---|---|
| Infection | 3.11 | (2.92–3.31) | 0.032 | <0.001 |
| Diabetes | 1.04 | (0.96–1.13) | 0.042 | 0.34 |
| Age | 0.99 | (0.99–1.00) | 0.001 | <0.001 |
| Hypertension | 0.95 | (0.90–1.01) | 0.030 | 0.084 |
| Smoking status | 1.27 | (1.18–1.38) | 0.040 | <0.001 |
| Obesity | 0.93 | (0.86–1.00) | 0.040 | 0.055 |
| Neoadjuvant chemotherapy | 1.05 | (0.99–1.11) | 0.028 | 0.0709 |
| Radiation | 1.41 | (1.33–1.50) | 0.031 | <0.001 |

*IRR denotes incidence rate ratio, which compares the incidence rate of total revision procedures between patients with and without characteristics of interest.
†Significance is defined as $P < 0.00625$, adjusted per the Bonferroni correction for multivariate regression.

Table 6 shows a logistic regression describing the relationship between postoperative infection, patient characteristics, comorbidities, and abandoning further reconstruction. Patients with a postoperative infection were significantly associated with 2.92 times the increased odds of abandoning further reconstruction ($P < 0.001$). Smoking status and radiation were significantly associated with increased odds of abandoning further reconstruction ($P < 0.001$). Age, hypertension, obesity, and neoadjuvant chemotherapy were also associated with significantly different odds; however, their confidence intervals included 1.00. With the Bonferroni correction (significance defined as $P < 0.00625$), diabetes was not significant ($P = 0.015$).

Table 7 shows a logistic regression describing the relationship between postoperative infection, patient

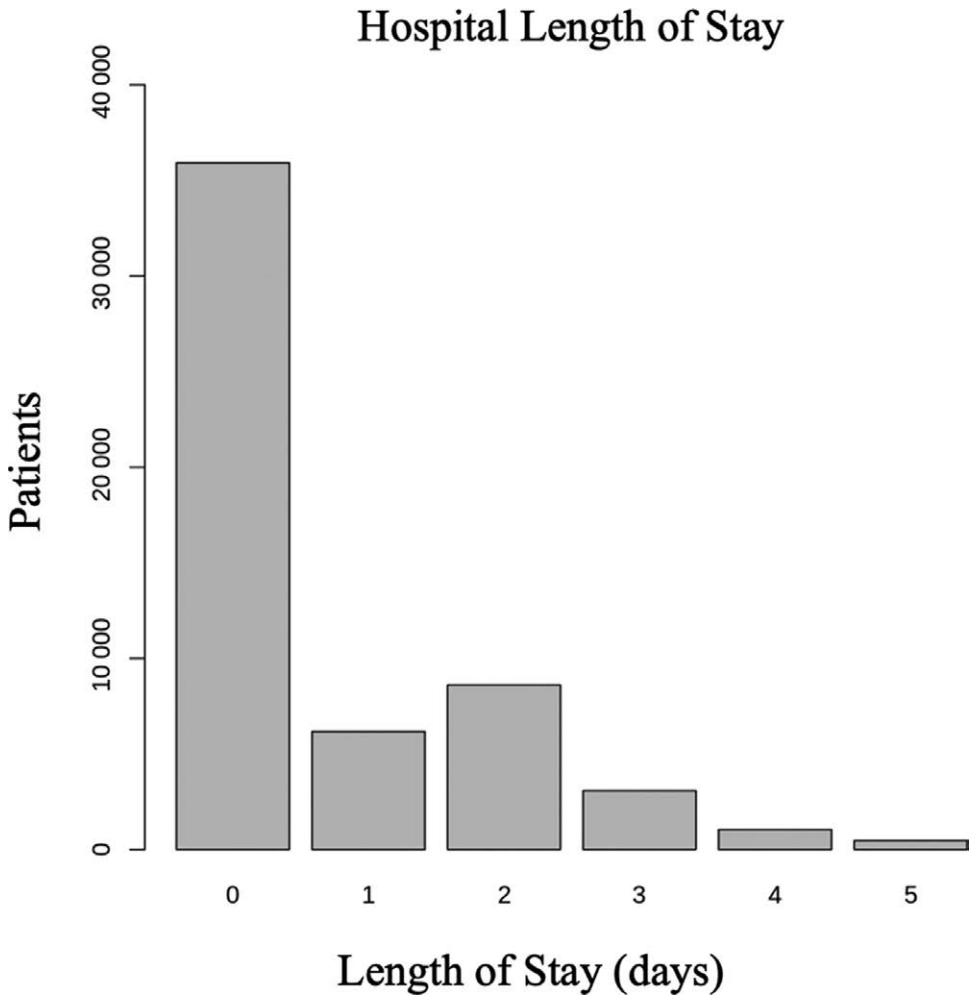


**Fig. 2.** Distribution of hospital LOS.

**Table 5. Negative Binomial Regression Describing the Relationship between Postoperative Infection, Patient Characteristics, Comorbidities, and LOS**

| | IRR* | 95% CI† | SE† | *P*‡ |
|---|---|---|---|---|
| Infection | 1.55 | (1.48–1.63) | 0.025 | <0.001 |
| Diabetes | 1.07 | (1.02–1.13) | 0.026 | 0.0054 |
| Age | 0.99 | (0.99–1.00) | 6.91e-04 | <0.001 |
| Hypertension | 1.05 | (1.02–1.10) | 0.018 | 0.0020 |
| Smoking status | 0.95 | (0.90–1.00) | 0.027 | 0.049 |
| Obesity | 0.97 | (0.93–1.02) | 0.024 | 0.25 |
| Neoadjuvant chemotherapy | 1.44 | (1.40–1.50) | 0.017 | <0.001 |
| Radiation | 1.11 | (1.06–1.15) | 0.020 | <0.001 |

*IRR denotes incidence rate ratio, which compares the incidence rate of total hospital days LOS between patients with and without characteristics of interest.
†SE, standard error.
‡Significance is defined as $P < 0.00625$, adjusted per the Bonferroni correction for multivariate regression.

**Table 6. Logistic Regression Describing the Relationship between Postoperative Infection, Patient Characteristics, Comorbidities, and Abandoning Further Reconstruction**

| | aOR* | 95% CI* | SE* | *P*† |
|---|---|---|---|---|
| Infection | 2.92 | (2.70–3.14) | 0.039 | <0.001 |
| Diabetes | 1.12 | (1.02–1.23) | 0.048 | 0.015 |
| Age | 1.00 | (0.99–1.00) | 0.001 | 0.20 |
| Hypertension | 0.97 | (0.90–1.04) | 0.035 | 0.38 |
| Smoking status | 1.18 | (1.07–1.29) | 0.048 | <0.001 |
| Obesity | 0.96 | (0.88–1.05) | 0.046 | 0.41 |
| Neoadjuvant chemotherapy | 1.05 | (0.98–1.12) | 0.033 | 0.17 |
| Radiation | 1.26 | (1.16–1.35) | 0.038 | <0.001 |

*aOR, Adjusted Odds Ratio; SE, standard error.
†Significance is defined as $P < 0.00625$, adjusted per the Bonferroni correction for multivariate regression.

characteristics, comorbidities, and autologous salvage. Patients with a postoperative infection, radiation, and smoking were associated with a 4.68×, 3.68×, and 1.57× increased odds of undergoing autologous salvage, respectively ($P < 0.001$). Age was associated with a difference in odds; however, its confidence intervals included 1.00. Diabetes, obesity, hypertension, and neoadjuvant chemotherapy were found to have no significant increase in odds of undergoing autologous salvage.

Table 8 shows a logistic regression describing the relationship between postoperative infection, patient characteristics, comorbidities, and implant loss. Patients with a

**Table 7. Logistic Regression Describing the Relationship between Postoperative Infection, Patient Characteristics, Comorbidities, and Autologous Salvage**

| | aOR* | 95% CI* | SE* | *P*† |
|---|---|---|---|---|
| Infection | 4.61 | (3.82–5.53) | 0.094 | <0.001 |
| Diabetes | 0.87 | (0.63–1.17) | 0.160 | 0.36 |
| Age | 0.98 | (0.98–1.00) | 0.004 | <0.001 |
| Hypertension | 0.81 | (0.66–1.00) | 0.110 | 0.049 |
| Smoking status | 1.57 | (1.23–1.99) | 0.120 | <0.001 |
| Obesity | 0.93 | (0.71–1.21) | 0.140 | 0.59 |
| Neoadjuvant chemotherapy | 1.02 | (0.84–1.24) | 0.099 | 0.81 |
| Radiation | 3.68 | (3.04–4.47) | 0.098 | <0.001 |

*aOR, adjusted odds ratio; SE, standard error.
†Significance is defined as $P < 0.00625$, adjusted per the Bonferroni correction for multivariate regression.

**Table 8. Logistic Regression Describing the Relationship between Postoperative Infection, Patient Characteristics, Comorbidities, and Implant Loss**

| | aOR* | 95% CI* | SE* | *P*† |
|---|---|---|---|---|
| Infection | 3.39 | (3.45–3.95) | 0.035 | <0.001 |
| Diabetes | 1.09 | (1.00–1.18) | 0.044 | 0.062 |
| Age | 1.00 | (0.99–1.00) | 0.001 | <0.001 |
| Hypertension | 0.95 | (0.89–1.01) | 0.032 | 0.11 |
| Smoking status | 1.27 | (1.16–1.38) | 0.043 | <0.001 |
| Obesity | 0.92 | (0.85–1.00) | 0.042 | 0.063 |
| Neoadjuvant chemotherapy | 1.06 | (0.99–1.12) | 0.030 | 0.0059 |
| Radiation | 1.36 | (1.27–1.45) | 0.034 | <0.001 |

*aOR, adjusted odds ratio; SE, standard error.
†Significance is defined as $P < 0.00625$, adjusted per the Bonferroni correction for multivariate regression.

postoperative infection, radiation, neoadjuvant chemotherapy, and smoking were associated with a 3.39×, 1.36×, 1.06×, and 1.27× increased odds of undergoing autologous salvage, respectively ($P < 0.001$, $P < 0.001$, $P = 0.0059$, $P < 0.001$). Age was associated with a difference in odds; however, the confidence interval included 1.00. Diabetes and obesity were found to have no significant increase in odds of undergoing autologous salvage.

## DISCUSSION

Our analysis quantifies the association between unplanned total reoperations (implant removal, implant replacement, and autologous salvage) and post-IBR infections with the largest sample size to date. A single-center study of 1028 nipple-sparing mastectomies reported an explantation rate for immediate and tissue expander IBR as 3.4% and 2.3%, respectively.[29] However, implant replacement, autologous salvage, or abandonment of reconstruction were not described. In a retrospective analysis by Qureshi et al, 33 of 382 nipple-sparing mastectomies (8.6%) with IBR resulted in explantation.[20] Twenty-three (69.8%) explantations ultimately resulted in complete reconstruction, five (15%) did not continue reconstruction, and five (15%) were lost to follow-up. Fourteen (42%) of those 33 explantations were due to infection. However, the relationship between explantations due to infections and their subsequent reoperations or discontinuations were not delineated. The same group retrospectively analyzed 413 patients who experienced IBR, with failure being defined as explantation with autologous salvage or lack of implant replacement.[30] Nineteen (4.6%) patients abandoned reconstruction due to cellulitis and 15 (3.6%) had their implant replaced. Fourteen (3.4%) underwent autologous salvage, but the indication for salvage was not specified. However, a claims-level national database has not evaluated the operative course for patients with infections in terms of autologous salvage or abandoning further reconstruction.

Our national claims-level database analysis showed that patients experiencing postoperative infections were associated with 3.11× and 1.55× increase in the incidence rate of unplanned total reoperations and LOS, respectively ($P < 0.001$). These results elucidate the burden post-IBR infection has on our healthcare system. The impact of additional operations has been analyzed by comparing the costs of direct-to-implant and two-stage IBR.[31,32] The significantly increased cost would reasonably extend to additional reoperations, as demonstrated by a database analysis by Yan et al.[33] The burden of unplanned reoperations does not solely land on the healthcare system. Our analysis also exposed the large proportion of women who abandoned reconstruction altogether, due to their implant becoming infected. Patients with a postoperative infection were significantly associated with 2.92× increased odds of abandoning further reconstruction ($P < 0.001$). Nine percent (9.4%) of all patients abandoned further reconstruction: 20.7% for patients with postoperative infection, and 8.4% for those without. This is greater than the previously reported rate of 3.5%, likely describing a national trend of patient hesitancy regarding further surgical intervention.[18] In a recent survey, 48.5% reported that they did not undergo reconstruction after mastectomy to avoid additional surgery.[34] Post-IBR infection halting the operative course reveals a population of breast cancer survivors excluded from the known psychosocial benefits of breast reconstruction.[22–27] Our analysis quantifies this national phenomenon, a crucial step to bridging this gap in care.

In our cohort, 8.53% of patients experienced a postoperative infection, consistent with previous reports ranging from 5.6% to 8.9%.[1,2,6] Stratifying our results by specific reoperations, the implant removal rate for our entire cohort was 12.6% (31.2% for patients with postoperative infection, and 10.9% for those without). This is consistent with the previously reported overall implant loss rate, ranging from 2.9% to 15.5%.[13–17] The relatively high number of patients with implant loss without an infection is likely because database analyses cannot account for patients who remove their implant due to aesthetic dissatisfaction. The implant replacement rate for our total cohort was 2.2% (6.9% for patients with postoperative infection, and 1.7% for those without). This corroborates Sue et al's single-surgeon analysis, reporting a 5.2% rate of implant replacement in their total cohort.[18] Our analysis showed that patients experiencing postoperative infections were associated with a 3.39× increase in odds of implant removal (loss). A limitation of our analysis is the lack of granularity between

direct-to-implant and two-stage IBR. Our study analyzed how postoperative infection impacts unplanned reoperations; so including the scheduled replacement of a tissue expander with a permanent prosthesis would have impacted our results. However, the literature has reported a discrepancy between postoperative outcomes between immediate and two-stage IBR. A multi-institutional study by Davila et al demonstrated that one-stage breast reconstruction had a significant increase in overall postoperative complications and prosthesis failure, without a significant difference in surgical site infections or reoperations.[35] This phenomenon could potentially confound our analysis and requires further investigation. Especially because existing literature details how patients increasingly prefer the therapeutic efficacy and aesthetic satisfaction of direct-to-implant IBR.[36–39] Our total cohort's rate of autologous salvage was 1.0%: 3.6% for patients with postoperative infection, and 0.8% for those without. This is lower than previously reported rates of 4.9%–7.8% by single-institution or single-surgeon studies.[18–20] Autologous salvage is indicated in the setting of a major complication, such as an infection. Therefore, our autologous salvage rate among post-IBR patients who experienced postoperative infection likely approximates that of smaller previous studies.

We found a significant increase in ADM use in patients who experienced a postoperative infection ($P < 0.001$). Single and multi-center studies found a significant increase in post-IBR infection rates in patients who received ADM.[8,10] The risk for major infections requiring explantation also increased when ADM was used, but it was not significant. Our positive association between ADM use and postoperative infection could be explained by implant placement location. Due to the lack of distinct ICD codes, prepectoral and subpectoral IBR were not separated. When first introduced, ADM was used primarily in subpectoral breast reconstruction.[40,41] Recently, techniques have been developed to incorporate ADM into prepectoral breast reconstruction.[42,43] Prepectoral IBR has demonstrated equal or favorable prosthetic failure or unplanned reoperation rates, compared with subpectoral IBR.[44] Our retrospective analysis between 2003 and 2019 is likely to overrepresent ADM-assisted subpectoral IBR, versus prepectoral IBR, potentially influencing our association. However, a systematic review of 58 articles from 1966 to 2019 analyzing prepectoral IBR with surgical mesh reported no significant difference in infection or explantation rates.[45] Recent single-center studies corroborated that implant loss rates between prepectoral and subpectoral IBR were not significantly different.[46,47] Although our study could reflect the overrepresentation of ADM-assisted subpectoral IBR, it is also likely that this would not affect our total reoperations. In conclusion, further investigation into the relationship between implant placement, infection, and reoperations is necessary.

### Limitations

As a national claims analysis, the limitations of this study are primarily due to variables coded. Comorbidity diagnoses that do not receive reimbursement, such as obesity, are often under-coded. This is likely why our cohort's obesity rate is much lower than the national average. Another limitation of our study is that we did not use enrollment period as inclusion criteria, as it reduced our sample size and incidence of reoperations to the point where we could not make any meaningful statistical conclusions. The lack of enrollment period as inclusion criteria also inadvertently codes patients who lost insurance or changed providers as someone who is abandoning reconstruction. This overestimates our incidence of patients who discontinues reconstruction. However, assuming patients who do and do not experience a postoperative infection are subject to the same systemic factors leading to changing providers or losing insurance, the validity of our comparative outcome measures remain. Prepectoral and subpectoral IBR are not independent CPT codes and could not be delineated.

## CONCLUSIONS

Unplanned reoperations after IBR infection significantly burden both patients and hospital systems. This national, claims-level study shows that patients with post-IBR infection were associated with 3.11× greater IR of total unplanned reoperations and a 1.55× increase in IR of total days of hospital stay, compared with those without postoperative infections. Patients with postoperative infections were also associated with 2.92× increased odds of abandoning further reconstruction, forgoing the benefits of improved body image and self-esteem postmastectomy. Further considerations should be explored to reduce strain of infectious complications on healthcare systems and patients' reconstructive course.

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## DISCLOSURE

*The authors have no financial interest to declare in relation to the content of this article.*

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