INTRODUCTION

Reconstructive breast surgery is evolving and innovating at a rapid pace. Patients are now offered a multitude of different options in breast reconstruction, including multiple variations of autologous and alloplastic techniques.1 Certain patient-specific characteristics and preferences can suggest an optimal reconstructive option; however, absolute indications for a given technique are few in nature. This uncertainty in technique selection can be addressed by employing decision analysis.

Decision analysis is a tool that allows for the quantitative evaluation of internal algorithms developed by clinicians through experience. This is especially important for breast reconstruction surgery, as a plethora of new and improved techniques can regularly be presented to patients. Although clinical intuition often seems like a reliable way to make decisions, when looking at several surgical domains, it has been shown to be inferior to decision analysis.2,3

When no clear choice seems superior, decision analysis offers an evidence-based method of determining the most optimal strategy.4,5 This is done by combining evidence from the literature, such as complication rates and costs, with specific patient-derived data, such as quality of life metrics. In the context of probabilistic models, this combination has proven to highlight the optimal selection in a variety of situations.6–9

The clinical decision in question is usually represented by a decision tree. An example and brief explanation of such can be found in Figure 1. Once structured, the branches of the decision tree are then assigned probabilities and the outcomes are assigned utilities, allowing for the mathematical interpretation of said model. A utility is a measure of quality of life expressed as a number between 0 and 1, with 1 being complete health and 0 being death.4,9

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Fig. 1. Example of a decision tree. We read the tree from left to right, with the clinical question being the furthest left. A square represents a decision node, with the strategies being compared branching out from it. A circle represents a chance node, with possible events branching out from it. From there on, a line represents a strategy pathway, accompanied by a probability of experiencing this event. The sum of all probabilities at a chance node must equal to 1. A triangle represents an outcome node, accompanied by the cost and/or utility of that pathway. To quantitatively compare strategies, each chance node is then assigned a probability-weighted average of the outcomes stemming from it, yielding the expected value.
0 and 1, representing a scale from death to perfect health. Utilities and effectiveness measures can be generated using a variety of questionnaires, such as the BREAST-Q (a patient-reported outcome measure validated for use in cosmetic and reconstructive breast surgeries), the time-trade-off, or the visual model survey. The utility value or effectiveness measure is then multiplied by the time spent in the health state used yielding values such as quality-adjusted life years (QALYs), which are classically used in decision analyses. The more the utility is improved, the greater the benefit of the given intervention.

In addition to simple QALY analysis, decision analysis can also focus on the economic aspect of decisions, which can play a major role in private institutions and single-payer systems. In this case, either cost per utility or QALY can be calculated, yielding a cost-utility analysis. As well, the incremental cost–utility ratio or incremental cost-effectiveness ratio can be employed, which simultaneously contrast both the difference in cost and in benefit between the 2 interventions being studied. This tool is of utmost importance because it is no longer enough for clinicians to only consider efficacy of interventions in the face of growing economic constraints in the healthcare field.

There is currently limited evidence consolidating the various decision and cost analyses in breast reconstruction. Sheckter et al performed a systematic review to summarize the cost-effectiveness studies available in breast reconstruction, and Yoon et al performed a systematic review to summarize the utility scores used in breast surgery. Our review differs from these by also including studies looking at just cost, and not including those looking at solely utility measures. Otherwise, there is a paucity of articles consolidating evidence regarding decision analysis in breast reconstruction. The aim of the authors is to consolidate literature where economic evaluations and/or decision analyses have been performed to address aspects of breast reconstruction. Secondarily, methodologic quality of the articles included will be assessed.

MATERIALS AND METHODS

Data Sources and Search Strategy
The study followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Two reviewers independently conducted a search of 3 databases (Pubmed, Ovid, and Embase). The search (carried out on January 24, 2019) was performed using the keywords “Breast” or “Breast Reconstruction,” which were combined with “Decision Analysis,” “Algorithm,” “Economic Analysis.” The search was confined to the English language and included articles regardless of date of publication. It is worth to mention that although this search strategy is ideal for the goal of this article, many studies regarding solely economics that were not included in this review also exist in the literature.

Study Selection and Data Extraction
Two independent reviewers (G.B. and T.S.) performed the study selection process and then assessed the articles according to the strategy outlined in Figure 2. Duplicates were first omitted, followed by initial screening which consisted of assessing the relevance of titles and abstracts. Relevant articles were then further assessed through the full text and then appropriateness of data. The senior author (P.G.D.) was involved to settle any discrepancies between the 2 reviewers. Studies were only deemed eligible if aspects of breast reconstruction were described in the context of a decision or cost analysis. The main data endpoints included study target, decision analysis type, outcome measure, source of costing data, and sensitivity analysis characteristics.

Quality Assessment
Using the Journal of the American Medical Association (JAMA) User’s Guide to evaluating decision analysis, 2 reviewers independently assessed relevant articles by assigning a grade out of 12, based on several domains relating to risk of bias and quality of evidence. This checklist includes clarity of the clinical question, validity and credibility of the results, clarity of the final result, and clinical usability of the results. As well, the framework or the Consolidated Health Economic Evaluation Reporting Standards statement for economic evaluation publications by Mastracci et al was used to assess the reporting quality of the decision analysis evidence.

Data Synthesis
Relevant studies were first grouped within specific aspects of breast reconstruction surgery, and then further divided based on study characteristics, outcome measure, and costing data. The data were assessed from a qualitative standpoint.

RESULTS
A total of 442 abstracts were initially identified and subsequently narrowed to 27 articles that fit within the inclusion criteria, corresponding to the search strategy shown in Figure 2.

Study Characteristics
Studies that were retained (Tables 1 and 2) originated mostly from the United States (n = 17) and Canada (n = 6). Studies also trended more toward the current decade compared with the previous one: from 2000 to 2009 (n = 6) and 2010 onward (n = 21). These were also grouped according to the aspect of breast reconstruction which they discussed (Table 3).

Quality of Study
Based on the quality assessment tool of JAMA, each article was assigned a score (Tables 1 and 2). The main area where studies lost points is the lack of sensitivity analysis (n = 9). No study was removed due to poor quality based on the JAMA assessment or poor reporting of findings based on the framework or the Consolidated Health Economic Evaluation Reporting Standards statement by Mastracci et al.

Model Characteristics
The targets of the studies included were varied and most commonly included the surgeons/physician’s
perspective (n = 13) and the third-party payer’s perspective (n = 9). The time horizon of included studies was very wide as it encompassed all the way from lifetime of the patient (n = 4) to 30 days (n = 3). Results can be seen in Tables 1 and 2.

Decision Analysis

Decision Analysis versus Economic Analysis

Decision analysis includes models which evaluate an outcome based on utility measures, such as QALYs. An economic analysis, in turn, does so by assessing cost or some cost-related measure. Studies retained for review were subject of decision analysis (n = 19) (Table 1) and/or economic analyses (n = 27) (Table 2). The individual outcomes measured for each of these articles can be seen in Table 4.

Model Inputs

There are several ways to determine a utility value or effectiveness measure for specific interventions. Included studies utilized time-trade-off surveys (n = 3), visual model surveys (n = 3), BREAST-Q survey (n = 3), nonspecific questionnaires/surveys (n = 8), and literature reviewed sources (n = 3) (with some studies using >1 method). Probabilities and complications were determined through existing literature (n = 19) or retrospective review (n = 1).

For economic analyses (n = 27), data extracted also included costing sources and currency used. Most costs reported in these studies were in currencies corresponding to the same origin as the article (seen in Tables 1 and 2). Table 5 provides a visual summary of the various costing sources utilized in the studies using costing data.

Decision Analysis Models

The decision tree model was the most prevalent (n = 18). Figure 1 shows an example of a decision tree (based on the work by Chatterjee et al21). Different types of models were reported only twice in the studies retained: Hummelink et al22 utilized headroom, scenario, and threshold analyses, and Preminger et al23 created a Markov cohort model for their analysis.

Sensitivity Analysis

Most articles included in the study employed one form or another of a sensitivity analysis (n = 18), with the most common being 1-way (n = 10) (Tables 1 and 2). A sensitivity analysis is an indication of the robustness of the model utilized and is helpful in eliminating possibilities of error.
| Aspect(s)/Category | Country       | Reference              | Target          | Model                  | Time Horizon          | Outcome Measure | Strategies                                                                 | Currency       | Costing Data               | Sensitivity Analysis | Quality Score |
|-------------------|---------------|------------------------|-----------------|------------------------|-----------------------|------------------|-----------------------------------------------------------------------------|----------------|---------------------------|---------------------|---------------|
|                    |               |                        |                 |                        |                       |                  | (1) Large volume displacement oncoplastic surgery                           | USD            | - Medicare CPT codes      | 1-way and probabilistic |              |
|                    |               |                        |                 |                        |                       |                  | (2) Mastectomy with single-stage implant reconstruction                     | USD            | - DRG codes               |                      |               |
| Perioperative angiography/adjunct | United States | Chatterjee et al[11] | Third-party payer (Medicare) | Decision analysis      | /                     | Utility Cost QALY ICUR           | (1) Clinical judgment                                                   | USD            | - Medicare reimbursement CPT costs | 1-way            |              |
|                    |               |                        |                 |                        |                       |                  | (2) Lasers-assisted indocyanine green angiography                             | USD            | - LifeCell Corporation 2011 pricing catalog (laser cost)                    |                     | 12            |
|                    | United States | Grover et al[17]      | - Surgeon       | Decision analysis      | 7 y                   | Cost QALY Cost/QALY (ICER) | (1) Autologous flaps with pedicled tissue                                   | USD            | Medicare                  | Univariate and Bayesian multivariate probabilistic | 12            |
|                    |               |                        |                 |                        |                       |                  | (2) Autologous flaps with free tissue                                        |                |                          |                     |               |
|                    |               |                        |                 |                        |                       |                  | (3) Latissimus dorsi flaps with breast implants                               |                |                          |                     |               |
|                    |               |                        |                 |                        |                       |                  | (4) Expanders with implant exchange                                          |                |                          |                     |               |
|                    |               |                        |                 |                        |                       |                  | (5) Immediate implant placement                                              |                |                          |                     |               |
|                    |               |                        |                 |                        |                       |                  | (6) No reconstruction                                                         |                |                          |                     |               |
| Perioperative angiography/adjunct | The Netherlands | Hummelink et al[12] | - Surgeon       | Decision analysis      | /                     | Cost Utility QALY ICUR           | (1) DIEP flap breast reconstruction                                        | EUR            | - Radboud University Medical Center | /               | 11            |
|                    |               |                        |                 |                        |                       |                  | (2) Virtual surgical planning using CTA in DIEP flap breast reconstruction    |                | - Literature review          |                     |               |
|                    | United States | Krishnan et al[10]    | - Third-party payer (Medicare) | Decision analysis      | 30 d                  | Utility Cost QALY ICUR           | (1) Single-stage, implant-based immediate breast reconstruction using acellular dermal matrix | USD            | - Medicare reimbursement CPT costs | Multivariate      | 12            |
|                    |               |                        |                 |                        |                       |                  | (2) Single-stage, implant-based immediate breast reconstruction using an autologous dermal flap |                | - Retail costs (AlloDerm) |                     |               |
|                    | United States | Krishnan et al[18]    | - Surgeon       | Decision analysis      | 30–34 mo              | Utility Cost QALY ICUR           | (1) 2-stage, expander-implant immediate breast reconstruction with acellular dermal matrix | USD            | - Medicare reimbursement CPT costs | Univariate      | 12            |
|                    |               |                        |                 |                        |                       |                  | (2) 2-stage, expander-implant immediate breast reconstruction without acellular dermal matrix |                | - Retail costs (AlloDerm) |                     |               |
| TRAM flap and DIEP flap/autologous | United States | Krishnan et al[14]    | - Third-party payers | Decision analysis      | 30 d (mention 3 mo and 1 y) | Utility Cost QALY ICUR           | (1) DIEP flap                                                       | USD            | - Medicare reimbursement CPT codes | 2-way            |              |
|                    |               |                        | - Society       |                        |                       |                  | (2) TRAM flap                                                             | USD            | - DRG codes               |                      |               |
|                    | United States | Krishnan et al[10]    | - Third-party payer (Medicare) | Decision analysis      | 30 d                  | Utility Cost QALY ICUR           | (1) 2-stage (expander-implant) breast reconstruction                       | USD            | - Medicare reimbursement CPT costs | Multivariate      | 12            |
|                    |               |                        | - Patient       |                        |                       |                  | (2) Single-stage (direct-to-implant) breast reconstruction                  |                | - Estimated national billing charges and out-of-pocket costs for patients with and without insurance |                     |               |

(Continued)
| Aspect(s) / Category               | Country       | Reference                        | Target              | Model                      | Time Horizon | Outcome Measure                          | Strategies                                                                 | Currency                     | Costing Data                  | Sensitivity Analysis | Quality Score |
|-----------------------------------|---------------|----------------------------------|---------------------|---------------------------|--------------|-----------------------------------------|---------------------------------------------------------------------------|------------------------------|-------------------------------|----------------------|-----------------|
| Implant-based and DIEP flap / type comparison | Canada        | Matros et al43                   | Payer               | Decision analysis         | 36 y         | Cost Breast-Q QALY (breast health-related QALYs) | (1) DIEP flap reconstruction (2) Implant-based reconstruction             | /                            | - 2010 Nationwide Inpatient Sample Database | 1-way             | 12              |
| Perioperative angiography / adjunct | United States | Offodile et al25                 | Hospital / Surgeon  | Decision analysis         | /            | ICER Utility Cost QALY ICUR              | (1) CTA (2) Doppler ultrasonography                                      | USD                          | - Medicare reimbursement / CPT codes / DRG codes | 1-way             | 12              |
| BRECONDA decision aid / adjunct    | Australia     | Parkinson et al27                | Healthcare          | Decision analysis         | 6 mo         | Cost Utility QALY ICUR                  | (1) Use of BRECONDA decision aid (2) No use of BRECONDA decision aid    | AUD                          | - Australian Public Hospitals Cost Report 2013 to 2014 and the Medicare Benefits Schedule | Yes, but type not specified | 10              |
| Single / 2 - stage reconstruction / surgical technique | Colombia     | Perea and Rosselli40             | Third-party payer / Columbian health system | Decision analysis | 1 y          | Cost QALY ICUR Cost / QALY (ICER)         | (1) Immediate reconstruction (2) Delayed reconstruction                  | COP                          | - Colombian Instituto de Seguros Sociales 2001 IETS / Billing model of the Centro Javeriano de Oncología at the Hospital Universitario San Ignacio | Multivariate and probabilistic | 12              |
| Implant-based and TRAM flap / free / pedicled flap / type comparison | United States | Preminger et al20                 | Patients / Surgeons | Decision analysis         | Lifetime     | Utility Cost QALY ICUR (ICER)            | (1) Implant-based reconstruction (2) Free TRAM flap reconstruction        | USD                          | - Healthcare Cost and Utilization Project based on International Classification of Diseases | 1-way             | 12              |
| Implant-based and single / 2 - stage reconstruction / type comparison | United States | Razdan et al9                    | Payer               | Decision analysis         | 7 y          | Cost Breast-Q QALY (breast QALY) Cost / QALY (ICER) | (1) Immediate tissue expander placement followed by exchange to permanent implant with subsequent PMRT (2) Mastectomy followed by PMRT with delayed autologous reconstruction (3) Mastectomy (do-nothing option) | USD                          | - Nationwide Inpatient Sample 2010 database | 1-way             | 12              |
| Implant-based and implants | United States | Siotos et al35                   | Patients / Surgeons | Decision analysis         | 1 y          | Cost Breast-Q QALY (breast health-related QALYs) Cost / QALY (ICER) | (1) Silicone implant-based breast reconstruction (2) Saline implant-based breast reconstruction | USD                          | - Center for Medicare and Medicaid Services / Physician fee schedule / hospital costs | 1-way             | 12              |
| TRAM flap and DIEP flap / free / pedicled flap / autologous | Canada        | Tan et al26                      | /                   | Decision analysis         | 2 y          | Cost Breast-Q QALY Cost ICER              | (1) DIEP flap (2) Free MSTRAM flap                                        | CAD                          | - UHN case costing system / 9 | 1-way             | 9               |
| TRAM flap and free / pedicled flap / autologous | Canada        | Thoma et al48                    | Ministry of Health  | Decision analysis         | /            | Utility Cost QALY ICUR                    | (1) Free TRAM flap (2) Unipeded TRAM flap                                 | CAD                          | - Ontario Ministry of Health Schedule of Benefits / Budgeting Services at St. Joseph's Healthcare | 1-way             | 12              |

(Continued)
Breast Reconstruction Topics Evaluated

Adjuncts in Breast Reconstruction

Decision and economic analyses were utilized within the realm of adjuncts in breast reconstruction surgery (n = 7). Four articles studied the topic of perioperative angiography.

Chatterjee et al.\(^{21}\) conducted an economic analysis, comparing the cost, QALY, and cost per QALY gained of laser-assisted indocyanine green angiography (LACIGA) to clinical judgment.\(^{21}\) Similarly, Kanuri et al.\(^{24}\) looked at the cost-effectiveness of using LACIGA through an economic analysis, which is important considering the high cost of this technique. Offodile et al.\(^{25}\) compared computed tomographic angiography with the standard Doppler ultrasonography to assess the cost-effectiveness of this potential new technique, whereas Hummelink et al.\(^{22}\) studied the cost and QALY of Virtual Surgical Planning using computed tomographic angiography through economic and decision analyses.\(^{22}\) In terms of other adjuncts, an economic analysis was employed by Gabriel and Maxwell\(^{26}\) to determine the cost savings associated with the use of closed-incision negative pressure therapy as a potential way to address the high risk of postoperative complications in breast reconstruction. As well, the use of the Breast Reconstruction Decision Aid was evaluated through utility, cost, QALY, and cost per QALY measures by Parkinson et al.\(^{27}\) Finally, Fishman et al.\(^{28}\) discussed the utility and cost-effectiveness of histologic analysis of the mastectomy scar at the time of expander-to-implant exchange, given the possible recurrence and interference with cancer screening.

Autologous Reconstruction

Six articles compared the autologous types of breast reconstruction through decision analyses and economic evaluations. Hwang et al.\(^{29}\) conducted an economic analysis to look at the cost of a clinical pathway associated with transverse rectus abdominis myocutaneous (TRAM) reconstruction, and Thoma et al.\(^{30}\) compared the free and unipedicled variations by looking at utility, cost, QALY, and cost per QALY measures by Parkinson et al.\(^{27}\) Finally, Fishman et al.\(^{28}\) discussed the utility and cost-effectiveness of histologic analysis of the mastectomy scar at the time of expander-to-implant exchange, given the possible recurrence and interference with cancer screening.

Implant-based Reconstruction

Only Siotos et al.\(^{35}\) discussed exclusively implant-based reconstruction in the context of decision and economic analyses. Silicone and saline implant-based reconstructions were compared by looking at cost, QALY, and cost per QALY, showing that patient and surgeon preference are the most important factors, rather than cost.
Table 2. Characteristics of All Economic Evaluation Studies

| Aspect(s) / Category | Country | Reference | Target | Model | Time Horizon | Outcome Measure | Strategies | Currency | Costing Data | Sensitivity Analysis | Quality Score |
|----------------------|---------|-----------|--------|-------|--------------|----------------|------------|----------|--------------|---------------------|----------------|
| Implant-based and large volume displacement oncoplastic surgery/surgical technique | United States | Asban et al | Third-party payer - Surgeon | Decision analysis | 36 y (lifetime) | Utility QALY Cost ICUR | (1) Large volume displacement oncoplastic (2) Mastectomy with single-stage implant reconstruction | USD - Medicare CPT codes - DRG codes | 1-way and probabilistic | 11 |
| Implant-based and pre/subpectoral reconstruction/ surgical technique | Italy | Cattelan et al | Surgeon - Hospital | Economic analysis | / | Cost | (1) Prepectoral breast reconstruction (2) Subpectoral breast reconstruction | EUR - Hospital financial department (University Hospital of Parma) | / | 9* |
| Perioperative angiography/ adjunct | United States | Chatterjee et al | Third-party payer (Medicare) - Surgeon | Decision analysis | / | Utility Cost QALY ICUR | (1) Clinical judgment (2) Laser-assisted indocyanine green angiography | USD - Medicare reimbursement CPT costs - LifeCell Corporation 2011 pricing catalogue (laser cost) - Institutional charge (for scar analysis) | 1-way | 12 |
| Histologic analysis/ adjunct | United States | Fishman et al | Surgeon - Hospital | Economic analysis | / | Cost | (1) Histologic analysis of mastectomy scar at reconstruction (2) | USD - MarketScan (GOXIBM Watson Health, Somers, NY) Commercial Claims and Encounters database (complication costs) | / | 9* |
| Implant-based and single/2-stage reconstruction and free/pedicled flap and latissimus dorsi flap/type comparison | United States | Grover et al | Surgeon | Decision analysis | 7 y | Cost QALY Cost/QALY (ICER) | (1) Autologous flaps with pedicled tissue (2) Autologous flaps with free tissue (3) Latissimus dorsi flaps with breast implants (4) Expanders with implant exchange (5) Immediate implant placement (6) No reconstruction | USD - Medicare - Radboud University Medical Center - Literature review | / | 11 |
| Perioperative angiography/ adjunct | The Netherlands | Hummelink et al | Surgeon | Decision analysis | / | Cost Utility QALY | (1) DIEP flap breast reconstruction (2) Virtual surgical planning using CTA in DIEP flap breast reconstruction | EUR - Ministry of Health in British Columbia (direct medical costs), Medical Services Plan for British Columbia (surgeon fees), Institution costs (OR cost, AlloDerm, implants, etc) | / | 9* |
| TRAM flap/ autologous | United States | Hwang et al | Care providers - Surgeon | Economic analysis | / | Cost | (1) TRAM pathway (2) No TRAM pathway | USD - Medical Center Finance Department - Ministry of Health in British Columbia (direct medical costs), Medical Services Plan for British Columbia (surgeon fees), Institution costs (OR cost, AlloDerm, implants, etc) | 1-way (3 times) | 11* |
| Implant-based and single/2-stage reconstruction and acellular dermal matrix/surgical technique | Canada | Jansen and Macadam | Surgeon - Hospital | Economic analysis | 1 y | Cost | (1) Direct-to-implant with AlloDerm reconstruction (2) 2-stage non-AlloDerm reconstruction | CAD | / | 11* |
| Perioperative angiography/ adjunct | United States | Kanuri et al | Surgeon | Economic analysis | 7 y and 10 mo | Cost | (1) Use of laser-assisted indocyanine green angiography (2) No use of laser-assisted indocyanine green angiography | USD - Medicare CPT codes (complications) - Company costs (SPY Elite System [LifeCell Corp., Branchburg, N.J.]) | / | 9* | (Continued)
Table 2. (Continued)

| Aspect(s) / Category | Country | Reference | Target | Model | Time Horizon | Outcome Measure | Strategies | Currency | Costing Data | Sensitivity Analysis | Quality Score |
|----------------------|---------|-----------|--------|-------|-------------|----------------|------------|----------|--------------|---------------------|---------------|
| Implant-based and acellular dermal matrix and autologous surgical technique | United States | Krishnan et al [9] | Third-party payer (Medicare) | Decision analysis | Economic analysis | 30 d | Utility | Cost | QALY | ICUR | USD | Medicare reimbursement CPT costs - Retail costs (Alloderm) | Multivariate | 12 |
| Implant-based and acellular dermal matrix/surgical technique | United States | Krishnan et al [9] | Surgeon | Decision analysis | Economic analysis | 30–34 mo | Utility | Cost | QALY | Cost/ICUR | USD | Medicare reimbursement CPT costs - Retail costs (Alloderm) | Univariate | 12 |
| TRAM flap and DIEP flap/autologous | United States | Krishnan et al [9] | Third-party payer (Medicare) | Decision analysis | Economic analysis | 30 d (mention: 3 mo and 1 y) | Utility | Cost | QALY | ICUR | USD | Medicare reimbursement CPT codes - DRG codes - Medicare reimbursement CPT costs - Estimated national billing charges and out-of-pocket costs for patients with and without insurance | Multivariate | 12 |
| Implant-based and single/2-stage reconstruction / surgical technique | United States | Krishnan et al [9] | Third-party payer (Medicare) | Decision analysis | Economic analysis | 30 d | Utility | Cost | QALY | ICUR | USD | Medicare reimbursement CPT codes - DRG codes - Medicare reimbursement CPT costs - Estimated national billing charges and out-of-pocket costs for patients with and without insurance | Multivariate | 12 |
| Implant-based and DIEP flap/type comparison | Canada | Matros et al [9] | Payer | Decision analysis | Economic analysis | 36 y | Cost | Breast-QALY | (breast health-related QALYs) | / | USD | Medicare reimbursement CPT codes - DRG codes - Medicare reimbursement CPT costs - Estimated national billing charges and out-of-pocket costs for patients with and without insurance | 1-way | 12 |
| Perioperative Angiography/ Adjunct | United States | Offodile et al [9] | Hospital | Decision analysis | Economic analysis | / | Utility | Cost | QALY | ICUR | USD | Medicare reimbursement CPT codes - DRG codes - Australian Public Hospitals Cost Report 2013 to 2014 and the Medicare Benefits Schedule | 1-way | 12 |
| BRECONDA decision aid/ adjunct | Australia | Parkinson et al [9] | Healthcare | Decision analysis | Economic analysis | 6 mo | Utility | Cost | QALY | ICER | AUD | Medicare reimbursement CPT codes - DRG codes - Australian Public Hospitals Cost Report 2013 to 2014 and the Medicare Benefits Schedule | Yes, but type not specified | 10 |
| Aspect(s) / Category | Country         | Reference                        | Target          | Model                      | Time Horizon | Outcome Measure | Strategies                                                                                     | Currency | Costing Data          | Sensitivity Analysis | Quality Score |
|----------------------|-----------------|----------------------------------|-----------------|----------------------------|--------------|-----------------|----------------------------------------------------------------------------------------------|----------|-----------------------|----------------------|-----------------|
| Single/2-stage       | Colombia        | Perea and Rosselli[40]           | - Third-party   | Decision analysis          | 1 y          | Utility Cost    | (1) Immediate reconstruction (2) Delayed reconstruction                                         | COP      | - Colombian Instituto de Seguros Sociales 2001 IETS  |
|                      |                 |                                  | payer           | Economic analysis          |              | QALY Cost/     |                                                              |          | - Billing model of the Centro Javeriano de Oncologia at the Hospital Universitario San Ignacio |          | 1-way and probabilistic |
|                      |                 |                                  | - Columbian     |                             |              | QALY (ICER)     |                                                              |          | - Healthcare Cost and Utilization Project based on International Classification of Diseases  |
|                      |                 |                                  | health system   |                             |              |                 |                                                              |          | 1-way 12                                                          |
|                      |                 |                                  |                 |                             |              |                 |                                                              |          | 12                                                                |
|                      | United States   | Preminger et al[23]              | - Patients      | Decision analysis          | Lifetime     | Utility Cost    | (1) Implant-based reconstruction (2) Free TRAM flap reconstruction                                   | USD      | - Nationwide Inpatient Sample 2010 database                        |
|                      |                 |                                  | - Surgeons      | Economic analysis          |              | QALY Cost/     |                                                              |          | 1-way 12                                                          |
|                      |                 |                                  |                 |                             |              | QALY (ICER)     |                                                              |          | 12                                                                |
|                      | United States   | Razdan et al[45]                 | - Payer         | Decision analysis          | 7 y          | Cost Breast-Q  | (1) Immediate tissue expander placement followed by exchange to permanent implant with subsequent PMRT |
|                      |                 |                                  |                 | Economic analysis          |              | QALY Cost/     | (2) Mastectomy followed by PMRT with delayed autologous reconstruction                           | USD      | - Nationwide Inpatient Sample 2010 database                        |
|                      |                 |                                  |                 |                             |              | QALY (ICER)     | (3) Mastectomy (do-nothing option)                                                                |          | 1-way 12                                                          |
|                      |                 |                                  |                 |                             |              |                 |                                                              |          | 12                                                                |
|                      | United States   | Siotos et al[35]                 | - Patients      | Decision analysis          | 1 y          | Cost Breast-Q  | (1) Silicone implant-based breast reconstruction                                                 | USD      | - Center for Medicare and Medicaid Services                             |
|                      |                 |                                  | - Surgeons      | Economic analysis          |              | QALY Cost/     | (2) Saline implant-based breast reconstruction                                                  |          | - Physician fee schedule/hospital costs                                |
|                      |                 |                                  |                 |                             |              | QALY (ICER)     |                                                              |          | 1-way 12                                                          |
|                      | United States   | Spear et al[32]                  | - Hospital      | Economic analysis          | 7 y          | Cost           | (1) Implant-based breast reconstruction (2) TRAM flap breast reconstruction                      | USD      | - Hospital based                                                   |
|                      |                 |                                  |                 |                             |              |                 |                                                              |          | / 9                                                              |
|                      | Canada          | Tan et al[33]                    | /               | Decision analysis          | 2 y          | Breast-Q Cost  | (1) DIEP flap (2) Free MS-TRAM flap                                                               | CAD      | - UHN case costing system                                           |
|                      |                 |                                  |                 | Economic analysis          |              | ICER           |                                                              |          | / 9                                                              |
|                      | Canada          | Thoma et al[30]                  | - Ministry of    | Decision analysis          | /            | Utility Cost   | (1) Free TRAM flap (2) Unipedicled TRAM flap                                                       | CAD      | - Ontario Ministry of Health Schedule of Benefits                   |
|                      |                 |                                  | Health          | Economic analysis          |              | QALY Cost/     |                                                              |          | - Budgeting Services at St. Joseph’s Healthcare                                             |
|                      |                 |                                  |                 |                             |              | ICUR           |                                                              |          | 1-way 12                                                          |

Table 2. (Continued)
Table 2. (Continued)

| Aspect(s) / Category | Country       | Reference          | Target                  | Model                  | Time Horizon | Outcome Measure          | Strategies                                | Currency                                    | Costing Data | Sensitivity Analysis | Quality Score |
|----------------------|---------------|--------------------|-------------------------|------------------------|--------------|---------------------------|--------------------------------------------|---------------------------------------------|--------------|----------------------|----------------|
| TRAM flap and DIEP flap and free/pedicled flap/autologous | Canada        | Thoma et al [31]   | - Ministry of Health for Ontario | Decision analysis      | Lifetime     | Utility Cost QALY ICUR   | (1) DIEP flap (2) TRAM flap               | CAD - Ontario Ministry of Health Schedule of Benefits - St. Joseph’s Healthcare | Yes, but type not specified | 12          |
| DIEP flap and SIEA flap/autologous | Canada (2008) [34] | - Ontario Ministry of Health | Decision analysis | Economic analysis | /            | Utility Cost QALY ICUR   | (1) SIEA flap (2) DIEP flap               | CAD - Schedule of Benefits: Physician Services Under the Health Insurance Act (25) - Hospital (St Joseph’s Healthcare) cost (OR) - Mentor Canada (material) | 1-way | 12|
| Implant-based and DIEP flap and Single/2-stage reconstruction and acellular dermal matrix/ type comparison | United States | Tran et al [44] | / Economic analysis | / Cost       | (1) 2-staged implant reconstruction using tissue expander and acellular dermal matrix (2) DIEP flap | USD - Medicare                            | / 10* | 10* |

*Scored out of 11 as nonapplicable utility evaluation.

AUD, Australian dollar; BRECONDA, Breast Reconstruction Decision Aid; CAD, Canadian dollar; ciNPT, closed-incision negative pressure therapy; COP, Colombian Peso; OPT, Current Procedure Terminology; CTA, computed tomographic angiography; DRG, diagnosis-related group; EUR, Euro; ICER, incremental cost-effectiveness ratio; ICUR, incremental cost–utility ratio; IETS, Instituto de Evaluación Tecnológica en Salud; MS, Muscle Sparing; PMRT, Post-Mastectomy Radiation Therapy; OR, Operating Room; SIEA, superficial inferior epigastric artery; SOC, standard of care; UHN, University Health Network; USD, US dollar.

/ indicates data not available.
**Surgical Technique**

Several techniques employed in breast reconstruction have also been subject of comparison (n = 6). Considering the advent of acellular dermal matrix (ADM), now making single-stage reconstruction more feasible, single- and 2-stage reconstruction have been compared by 2 articles: first by Krishnan et al by analyzing utility, cost, QALY, and cost per QALY, and by Jansen et al by looking specifically at the cost of direct-to-implant with AlloDerm (LifeCell Corp., Branchburg, N.J.) compared with 2-stage non-AlloDerm reconstruction. Of note, Krishnan et al also specifically evaluated the cost-effectiveness of using ADM through cost per QALY gained. With the recent push for increasing prepectoral reconstructions, Cattelani et al conducted an economic analysis discussing prepectoral and subpectoral reconstructions. To address the variability of cost across the globe, Perea and Rosselli contrasted immediate and delayed reconstruction techniques, specifically in Columbia. In terms of newer surgical techniques, Asban et al compared large volume displacement oncoplastic surgery with a single-stage implant technique through decision and economic analyses, as its cost-effectiveness has yet to be affirmed.

**Type Comparison**

Determining the difference between specific types of reconstructive options was the goal of 7 articles. In terms of comparing autologous and implant-based reconstructions, a contrast with TRAM flaps was carried out by Spear et al through an economic analysis. This is useful because it has been suggested that when carried out well, implant-based reconstruction can have as good an aesthetic result as autologous tissue reconstruction, and this without the donor-site morbidity. A similar comparison was done by Preminger et al who looked at the utility, cost, QALY, and cost per QALY. Matros et al discussed the contrast between DIEP and implant-based reconstruction to determine which one would be more cost-effective, considering the premise that autologous reconstruction is suggested to be more expensive. Similarly, Tran et al compared the DIEP flap to 2-staged implant reconstruction using tissue expander and ADM through a cost analysis. Razdan et al compared autologous and implant-based reconstructive options in the light of postmastectomy radiation therapy, through cost, QALY, and cost per QALY modalities, to contribute to the debate as to which of the 2 is more advantageous. When focusing on solely implant-based type comparisons, using ADM was contrasted to using an autologous dermal flap by Krishnan et al to determine the most cost-effective of the 2, specifically taking into account the cost savings of not using an ADM. Finally, Grover et al compares 5 different types of either autologous or implant-based reconstructive options in decision and economic analyses to determine the most effective method of 5 standard procedures. To better understand the debate between autologous and implant-based reconstruction, a direct comparison of the conclusions of these studies, among other data, can be found in Table 6.

### Table 3. Aspects of Breast Reconstruction Discussed in the Decision Analysis Models

| Aspect | No. Studies |
|--------|-------------|
| Implant based | 13 |
| TRAM flap | 7 |
| DIEP flap | 6 |
| Single/2-stage reconstruction | 6 |
| Free/pediced flaps | 6 |
| Acellular dermal matrix | 5 |
| Perioperative angiography | 4 |
| BRECONDA decision aid tool | 1 |
| Histologic analysis of the mastectomy scar | 1 |
| SIEA flap | 1 |
| Pre-/subpectoral reconstruction | 1 |
| Large volume displacement oncoplastic surgery | 1 |
| Latissimus dorsi flap | 1 |
| Autologous dermal flap | 1 |

BRECONDA, Breast Reconstruction Decision Aid; SIEA, superficial inferior epigastric artery.

### Table 4. Outcome Measured in the Decision Analysis Models

| Outcome Measure | No. Studies |
|-----------------|-------------|
| Cost/QALY and breast health-related | 27 |
| QALY | 18 |
| Cost/QALY and ICUR and ICER | 18 |
| Utility | 14 |
| BRECONDA, Breast Reconstruction Decision Aid; ICUR, incremental cost–utility ratio; ICER, incremental cost-effectiveness ratio. |

### Table 5. Costing Sources Included in the Decision Analysis Models

| Costing Source | No. Studies |
|----------------|-------------|
| Individual hospital financial departments | 12 |
| Medicare | 11 |
| Company based | 5 |
| DRG codes | 3 |
| The HCUP Nationwide Inpatient Sample | 3 |
| Ontario Ministry of Health Schedule of Benefits | 3 |
| Australia Medicare Benefits Schedule and Australian Public Hospitals Cost Report | 1 |
| MarketScan Commercial Claims and Encounters database | 1 |
| Estimated national billing charges and out-of-pocket costs for patients with and without insurance | 1 |
| Ministry of Health in British Columbia and Medical Services Plan for British Columbia | 1 |
| Literature search | 1 |
| Colombian Instituto de Seguros Sociales 2001 and IETS | 1 |
| University Health Network Case Costing system (Toronto, Canada) | 1 |

DRG, diagnosis-related groups; HCUP, Healthcare Cost and Utilization Project; IETS, Instituto de Evaluación Tecnológica en Salud.
| Title                                                                 | First Author | Goal(s)                                                                 | Comparison          | Data/Analysis                                                                 | Conclusion(s)                                                                                                                                                                                                 |
|----------------------------------------------------------------------|--------------|------------------------------------------------------------------------|---------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Resource Cost Comparison of Implant-Based Breast Reconstruction versus TRAM Flap Breast Reconstruction | Spear et al | Compare the resource costs of TRAM flap and prosthetic reconstruction | TRAM flap versus implant | Cost: $USD                                                                  | The average cost of TRAM flap reconstructions was $19,607 compared with $15,497 for prosthetic reconstructions. Prosthetic breast reconstruction is significantly less expensive and uses fewer resources than the TRAM flap alternative. |
| How Should Quality-of-Life Data Be Incorporated into a Cost Analysis of Breast Reconstruction? A Consideration of Implant versus Free TRAM Flap Procedures | Preminger et al | Compare implant and free TRAM flap breast mound reconstruction in a cost-utility analysis | Free TRAM flap versus implant | Cost: $USD | Mean lifetime cost was $14,080 for a free TRAM flap and $16,940 for an implant according to the sensitivity analysis, the older the patient, the more the costs converge. Even a slight increase in utility of implants over that of free TRAM flaps makes implants a cost-effective option. The added cost of implant reconstruction decreases with age and that even a marginal increase in utility of implants over TRAM flaps makes implants a cost-effective option for reconstruction. For young patients, TRAM flaps offer a reasonable alternative to implants from a cost perspective. | Cost: $USD | Mean lifetime cost was $14,080 for a free TRAM flap and $16,940 for an implant according to the sensitivity analysis, the older the patient, the more the costs converge. Even a slight increase in utility of implants over that of free TRAM flaps makes implants a cost-effective option. The added cost of implant reconstruction decreases with age and that even a marginal increase in utility of implants over TRAM flaps makes implants a cost-effective option for reconstruction. For young patients, TRAM flaps offer a reasonable alternative to implants from a cost perspective. |
| Cost-Effectiveness Analysis of Implants versus Autologous Perforator Flaps Using the BREAST-Q | Matros et al | Determine if autologous tissue reconstructions are cost-effective compared with prosthetic techniques when health-related quality of life and patient satisfaction are considered | DIEP flap versus implant | Cost: $USD | The incremental cost of a DIEP flap compared with implants was $21,613 for unilateral reconstructions and $19,052 for bilateral procedures. For unilateral reconstructions, breast health-related quality-adjusted life years were 19.5 for DIEP flaps and 17.7 for implants, whereas for bilateral reconstructions, these were 19.7 for DIEP flaps and 19.0 for implants. The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. | Cost: $USD | The incremental cost of a DIEP flap compared with implants was $21,613 for unilateral reconstructions and $19,052 for bilateral procedures. For unilateral reconstructions, breast health-related quality-adjusted life years were 19.5 for DIEP flaps and 17.7 for implants, whereas for bilateral reconstructions, these were 19.7 for DIEP flaps and 19.0 for implants. The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. | Cost: $USD | The incremental cost of a DIEP flap compared with implants was $21,613 for unilateral reconstructions and $19,052 for bilateral procedures. For unilateral reconstructions, breast health-related quality-adjusted life years were 19.5 for DIEP flaps and 17.7 for implants, whereas for bilateral reconstructions, these were 19.7 for DIEP flaps and 19.0 for implants. The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. |
| Cost Analysis of Postmastectomy Reconstruction: A Comparison of Two Staged Implant Reconstruction Using Tissue Expander and Acellular Dermal Matrix With Abdominal-based Perforator Free Flaps | Tran et al | Perform a comprehensive cost analysis to compare TE/I + ADM and DIEP flap | DIEP flap versus 2-staged TE/I with ADM | Cost: $USD | The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. Average actual cost for successful TE/I + ADM was $13,304.55 and for DIEP flaps was $10,237.13. Incorporating complication data resulted in an increase in cost to $13,965.46 for TE/I + ADM and $12,624.29 for DIEP flap. DIEP flap breast reconstruction incurs lower costs compared with TE/I + ADM. | Cost: $USD | The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. Average actual cost for successful TE/I + ADM was $13,304.55 and for DIEP flaps was $10,237.13. Incorporating complication data resulted in an increase in cost to $13,965.46 for TE/I + ADM and $12,624.29 for DIEP flap. DIEP flap breast reconstruction incurs lower costs compared with TE/I + ADM. | Cost: $USD | The additional cost for obtaining 1 y of perfect breast-related health for a unilateral DIEP flap compared with implant reconstruction was $11,941. For bilateral DIEP flaps, the additional cost was $28,017. DIEP flaps are cost-effective compared with implants, especially for unilateral reconstructions. Average actual cost for successful TE/I + ADM was $13,304.55 and for DIEP flaps was $10,237.13. Incorporating complication data resulted in an increase in cost to $13,965.46 for TE/I + ADM and $12,624.29 for DIEP flap. DIEP flap breast reconstruction incurs lower costs compared with TE/I + ADM. |
Table 6. (Continued)

| Title                                                                 | First Author       | Goal(s)                                                                                                                                                                                                                                                                                                                                 | Comparison                                                                                               | Data/Analysis                                                                                               | Conclusion(s)                                                                                                                                                                                                                       |
|----------------------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cost-Effectiveness Analysis of Breast Reconstruction Options in the Setting of Postmastectomy Radiotherapy Using the BREAST-Q | Razdan et al.08     | Develop a cost-effectiveness model for women undergoing breast reconstruction in the setting of postmastectomy radiotherapy using BREAST-Q scores as the principal outcome measure                                                                                                                                                    | Autologous reconstruction versus implant (2-stage immediate)                                             | Cost: $USD                                                                                                     | - Compared with mastectomy alone, the incremental cost of immediate tissue expander/implant was $38,218, whereas the incremental cost for delayed autologous reconstruction was $77,907 |
| A Comparison of Acellular Dermal Matrix to Autologous Dermal Flaps in Single-Stage, Implant-based Immediate Breast Reconstruction: A Cost-Effectiveness Analysis | Krishnan et al.09   | Determine if the added procedural cost for acellular dermal matrix is cost-effective relative to using an autologous dermal flap in single-stage immediate breast reconstruction following mastectomy                                                                                                                     | Autologous dermal flap versus ADM in the context of 1-stage implant reconstruction                       | Cost: $USD                                                                                                     | - The incremental breast quality-adjusted lifeyear value of an immediate tissue expander/implant were 0.66, whereas delayed autologous was 0.76. |
| Acellular dermal matrix is not a cost-effective technology in patients who require immediate breast reconstruction. |                       |                                                                                                                                                                                                                                                                                                                                       |                                                                                                            | Probabilities: literature review Utilities: survey of experts 1-way sensitivity analysis                      | - There is a cost difference of $261,72 and a 0.001 increase in the quality-adjusted life years when using acellular dermal matrix, yielding an incremental cost–utility ratio of $261,720 per quality-adjusted life year. |
| Comparing Five Alternative Methods of Breast Reconstruction Surgery: A Cost-Effectiveness Analysis | Grover et al.10     | To assess the cost-effectiveness of 5 standardized procedures for breast reconstruction to delineate the best reconstructive approach in postmastectomy patients in the settings of nonirradiated and irradiated chest walls                                                                                   | Autologous flaps with pedicled tissue versus autologous flaps with free tissue versus latissimus dorsi flaps with breast implants versus expanders with implant exchange versus implant placement | Cost: $USD                                                                                                     | - Pedicled autologous tissue and free autologous tissue reconstruction were cost-effective compared with the do-nothing alternative, with pedicled being slightly more cost-effective. |
|                                                                     |                     |                                                                                                                                                                                                                                                                                                                                       |                                                                                                            | Probabilities: literature review Utilities: survey of experts Univariate sensitivity analyses and Bayesian multivariate probabilistic sensitivity analysis | - Autologous tissue reconstruction is the most cost-effective approach in irradiated and nonirradiated patients.                                                                                                               |

ADM, acellular dermal matrix; TE/I, tissue expander-implant; USD, US dollar.
DISCUSSION

This is the first systematic review to consolidate and appraise high-quality decision analysis models in breast reconstruction surgery. Many interesting points regarding the literature’s landscape can be highlighted.

Although patient satisfaction with their reconstruction has brought on multiple validated questionnaires, the targeted audience was rarely patients (n = 3). Considering the limit in resources available, adopting a societal perspective in economic analyses is usually the most logical approach from a public health vantage. However, in the field of breast reconstruction, patient-reported outcomes are one of the most important measures of success. The analysis of this endpoint highlights that future research in decision analysis for breast reconstruction should be geared toward more patient-specific outcomes, to optimize strategies for individuals and not just from a public health standpoint.

Decision analysis models are often based on specific situations, outcomes, and populations, and, thus, generalizing their conclusions should be done with caution. Similar models could lead to different conclusions, depending on the data that are used and in which context. For example, Chatterjee et al.11 found that LAICGA was an overall cost-effective technology, whereas Kanuri et al.12 found that it was cost-effective only for high-risk patients, such as smokers, obese patients, and patients with large breasts.21,24 This highlights the importance of being critical and meticulous when looking at a decision analysis and that certain conclusions are intrinsically dependent on the exact population studied and the data used to populate the model. Similarly, economic evaluations are highly dependent on the source of their costing data. In this review, it is noted that most of the costing data are from Medicare, which makes many of these conclusions limited to the American context. Parties should, therefore, always develop their own population and context-specific models to create relevant conclusions to their questions.

Models other than the simple decision tree were simply underutilized in the literature. Headroom, scenario, and threshold analyses and a Markov model were noted underutilized in the literature. Parties should, therefore, always develop their own population and context-specific models to create relevant conclusions to their questions.

The presence of sensitivity analyses was of importance when evaluating the quality of evidence.49 Because statistical indicators such as the P value do not apply to decision analyses, one must rely on other methods, such as sensitivity analyses, to validate the model. The majority of articles (n = 18) included sensitivity analyses, with most (n = 10) being of the 1-way type. A model often relies on many assumptions, notably the accuracy of the data used to estimate probabilities, costs, and outcomes, which can thereafter affect the overall conclusion. The best way to then assess the reliability of a model is to vary these assumptions over a reasonable range and to see if the final interpretation of the analysis then differs, which is essentially a sensitivity analysis. The Canadian Coordinating Office for Health Technology Assessment recently published guidelines demonstrating the fundamental need for even more advanced sensitivity analyses to validate a model and affirm its robustness.49 Decision analysis in breast reconstruction surgery should, in the future, conform to these guidelines to produce high-level quality evidence.

CONCLUSIONS

In conclusion, this systematic review highlights the growing literature concerning decision analyses in breast reconstruction surgery. These models allow surgeons, patients, and administrators to comparatively evaluate the quality of life and cost associated with different surgical strategies, management options, and novel adjuncts. However, this study also demonstrates several limitations uniformly present in the current evidence because more studies should focus on patient-centered perspectives and better sensitivity analysis practices. Due to their variable nature, decision analyses and economic evaluations presented cover a broad range of data for the endpoints that were studied. Nonetheless, certain features proved to be more common; the simple decision tree model was most frequently used, and implant-based reconstruction and TRAM flaps were the most commonly assessed topics.

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