A Meta-Analysis of Bilateral Essure[®] Procedural Placement Success Rates on First Attempt

Gabriel Frietze, MA,¹ Ophra Leyser-Whalen, PhD,² Mahbubur Rahman, MD, PhD,³
Mahta Rouhani, MD,³ and Abbey B. Berenson, MD, PhD³

Abstract

Background: The Essure[®] (Bayer HealthCare Pharmaceuticals, Leverkusen, Germany) female sterilization procedure entails using a hysteroscope to guide a microinsert into the Fallopian tube openings. Failed placement can lead to patient dissatisfaction, repeat procedures, unintended or ectopic pregnancy, perforation of internal organs, or need for subsequent medical interventions. Additional interventions increase women's health risks, and costs for patients and the health care industry. Demonstrated successful placement rates are 63%–100%. To date, there have not been any systematic analyses of variables associated with placement rates. **Objectives:** The aims of this review were: (1) to estimate the average rate of successful bilateral Essure microinsert placement on first attempt; and (2) to identify variables associated with successful placement. **Materials and Methods:** A meta-analysis was conducted on 64 published studies and 19 variables. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, all published studies between November 2001 and February 2015 were reviewed. The studies were taken from PubMed and Google Scholar, and by using the “snowball” method that reported variables associated with successful bilateral Essure placement rates. **Results:** The weighted average rate of successful bilateral microinsert placement on first attempt was 92% (0.92 [95% confidence interval: 0.904–0.931]). Variables associated with successful placements were: (1) newer device models; (2) higher body mass index; and (3) a higher percent of patients who received local anesthesia. **Conclusions:** The data gathered for this review indicate that the highest bilateral success rates may be obtained by utilizing the newest Essure device model with local anesthesia in heavier patients. More standardized data reporting in published Essure studies is recommended. (J GYNECOL SURG 31:308)

Introduction

THE ESSURE[®] (Bayer HealthCare Pharmaceuticals, Leverkusen, Germany) procedure entails transcervical guidance of a hysteroscope to direct a microinsert into the opening of each Fallopian tube. The microinsert is comprised of nickel–titanium and stainless steel, which are woven into a polyethylene terephthalate fiber coil coating, and which initiate a benign fibrotic reaction that occludes the tubes for 3 or more months. This occlusion must be verified, often with a hysterosalpingogram, ultrasound, or X-ray.¹

Failed microinsert placement can lead to patient dissatisfaction; repeat procedure attempts; unintended or ectopic pregnancy; perforation of the Fallopian tube, uterus, or other internal organs; or the necessity for subsequent medical interventions, such as removal of an incorrectly placed

microinsert, laparoscopic-device removal from the peritoneal cavity, or tubal ligation.² These additional medical interventions increase health risks for women and costs for both the patients and the health care industry. Demonstrated successful placement rates are between 63% and 100%.^{2–65} Some explanations for placement success include procedure-related factors such as an in-patient setting,^{16,21} a shorter procedure time,³ greater provider experience,^{3,5} and various types of medications and medication procedures.^{3,5,7, 21,22,29,38,47} Placement success associated with patient-related factors include prior use of an intrauterine device (IUD),¹³ a history of sexually transmitted infections (STIs),³³ a lower body mass index (BMI),¹¹ and follicular phase of the menstrual cycle.^{8,11,22} To date, there are no systematic analyses of variables associated with placement rates.

Departments of ¹Psychology and ²Sociology and Anthropology, The University of Texas at El Paso, El Paso, TX.

³Center for Interdisciplinary Research in Women's Health, The University of Texas Medical Branch, Galveston, TX.

The purpose of the current study was to utilize meta-analyses to (1) identify the average rate for successful bilateral Essure microinsert placement on first attempt, and (2) identify variables associated with these successful placement rates.

Furthermore, the medical literature reveals that there disparate definitions of what constitutes, and how to calculate, a successful placement rate. Rationales vary for different calculations; for example, if the determination of a success rate is the outcome of full sterilization, multiple sterilization attempts could be included. In this article, however, an attempt is made to standardize the data from multiple studies into a consistent definition: successful bilateral microinsert placement on first procedural attempt. This is the manufacturer's definition and it is useful to patients, practitioners, and researchers.

Materials and Methods

A meta-analysis was conducted on successful bilateral Essure microinsert placement rates on first procedural attempt and potential variables associated with successful placements.* For study selection, the second and fourth authors utilized PubMed, in addition to Google Scholar, which is also a powerful search tool for identifying citation sources.⁶⁶ Snowballing (pursuing references from acquired articles' references) was also utilized; this is a particularly powerful method for finding high-quality sources in obscure locations. These multiple methods increased the likelihood of detecting relevant articles.⁶⁷

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines⁶⁸ were followed for study inclusion. All combinations of the keywords Essure, transcervical sterilization, or hysteroscopic sterilization were used both separately, and with placement rate, failure rate, and success rate. All languages were included in the search, because several authors are multilingual. Unpublished studies were not specifically sought. The earliest study found was from November 2001, and all studies until February 19, 2015 were included. The initial results included 2262 articles. Then, 306 duplicate articles were removed to yield 1956 potential articles. If an article appeared to be relevant from reading both the title and abstract, the article was reviewed. Studies of women receiving concomitant procedures were included because these women represent the general patient population.

Articles that were not original research studies on Essure ($n=1692$) were excluded. For example, the word essure yields studies on road conditions and hysteroscopic sterilization yields studies on other hysteroscopic procedures.

Other exclusions were studies on the Adiana (another hysteroscopic sterilization device used in the past) or review articles. Other exclusions included: use of Essure for other medical purposes (e.g., in-vitro fertilization; $n=39$); data only on the follow-up appointment (e.g., adherence rates, technology evaluation; $n=30$); postprocedural complica-

tions only recorded (e.g., perforations, pregnancies; $n=28$); product development ($n=6$); non-peer-review publications (e.g., conference proceedings or posters; $n=16$); fiscal cost analysis ($n=4$); procedural tips ($n=4$); language unknown to any research team members ($n=17$); nonhuman species ($n=4$); and case reports ($n=16$). This left 102 articles for full-text review. Forty-six additional studies were excluded after full-text review for the following reasons: insufficient data (no first attempt or no placement rate given; $n=28$); not an original research study on Essure ($n=9$); only provided data on the follow-up appointment ($n=4$); cost analysis with no placement rate given ($n=1$); pain assessment with no placement rate given ($n=3$); and a mixed analysis of both the Essure and Adiana ($n=1$).

Consistent with the snowball method,⁶⁷ the references of the 56 selected articles were reviewed to identify additional pertinent articles. This yielded 12 additional articles that were reviewed, with 8 that met inclusion criteria, for a total yield of 64 articles (Fig. 1). If more than one article was written by the same author(s), the current authors verified that the results were not based on identical patient populations by assessing the research year(s) and sample sizes. Several articles selected were in French^{31,32,48,64,65} and were read and translated by the second author.

Data presented in the articles were utilized and raw data were not obtained from the article authors. Some articles required converting means into percentages,^{36,42} and because use was made of a clinically significant definition of placement rate—the ability to place any number of Essure microinserts into both Fallopian tubes successfully upon first procedural attempt—several statistics were converted, which are described below.

Several studies compared two groups of women,^{48,57,59,62} whom were combined into one sample size; means for each group were calculated into raw numbers based on their individual sample sizes and then one mean for both groups was calculated with a weighted average. Four studies included separate placement rates for study group subsets but did not supply overall placement rates,^{7,17,21,29} thus, the total number of placements in both groups was divided by the total number of patients in each study. For one study⁶¹ only one group was included because the second group met the current review's exclusion criteria.

Some studies omitted failed attempts in their placement rates because of the inability to visualize the tubal ostia,^{5,15,20,32,35–37,48} yet the current authors considered these attempts as failures because the procedures were actually attempted. Thus, the total number of attempts was used as the denominator. Several studies included unilateral placement rates in women who had previous salpingectomies,^{13,22,48} so these placement rates were omitted from the total denominators and numerators as necessary. Eight articles^{9,10,17,19,25,26,30,56} only reported bilateral placement rates after more than one attempt. In these cases, the placement rate was recalculated using the data supplied in the article for the first attempt. Finally, if studies had exclusion criteria of their original cohort size,⁵ wherein women were excluded before the procedure was attempted, the original cohort size was not used as the denominator. Instead, the current authors included only those women for whom the procedure was attempted.

*This study did not have a registration number. Because there were no human participants, no informed consent was necessary, nor were institutional review board or ethics committee approvals required.

FIG. 1. Flow diagram for final sample size of Essure placement rate.

The extracted variables were entered into an Excel (Microsoft Office 2010 for Windows) spreadsheet as follows:

- (1) *Study data*—author(s); study type; months and years when, and country/ies where, the research was conducted; and author(s) funding from the Essure manufacturer
- (2) *Target population data*—number of patients; means for BMI, age, gravidity, and parity; and percent of patients in the menstrual follicular phase and contraceptive use
- (3) *Procedure data*—Essure device model(s); number of practitioners who performed the procedures; mean operating time; type of medication(s); and percent of patients medicated, prior to or during the procedure; and percent of patients with an IUD in situ, patients undergoing concomitant intrauterine procedures, in outpatient settings, and first attempt bilateral placements.

Meta-analytically combining the placement rate results from several studies into one average placement rate (i.e., effect size) surrounded by a 95% confidence interval (CI) requires a normally distributed sampling distribution; thus,

placement success rates were transformed into logits to both approximate a normal distribution and correct for overestimation of heterogeneity.⁶⁷ These logit success rates were subsequently weighted by the inverse-variance, which is standard in meta-analysis in order to account for the differences in each study's sample size. When merging the results of multiple studies into one dataset, it is inaccurate to take the average of all results, because each study has a different sample size, wherein studies with larger sample sizes will provide less variance and thus more precise estimates. In other words, if the average was taken from all the studies instead of the inverse-variance, studies that are less precise would hold as much weight as studies that are more precise. Thus, the logit transformed placement rates were multiplied by the inverse-variance to give more weight to studies with more precision. Standard errors were calculated and logit transformed placement rates were combined.

Finally, the logit placement rates were back-transformed by calculating the anti-log, in order to provide a single placement success rate of all the studies combined. Furthermore, a sensitivity analysis was run in Comprehensive

Meta-Analysis (CMA) version 2 (Biostat, Englewood New Jersey) to determine if one of the studies that contained a considerably larger sample size² than the other studies affected the results profoundly.

The trim and fill algorithm was run in CMA to assess publication bias,⁶⁹ which imputes an estimated number of missing studies that could bias placement rates. A fixed effects model (FEM) and a random effects model (REM) were also run, because each approach yields valuable information.⁷⁰ The FEM was used to test if all of the samples estimated the same underlying population and provided a placement rate unique to the samples analyzed. The REM yielded generalizable results and was used with the assumption that the samples were heterogeneous because of differences in sample characteristics. With no a-priori hypotheses in mind, exploratory meta-regressions were then run; this is a meta-analytic technique used to test the sample characteristic variables (i.e., moderator variables), with “Methods of Moments” in CMA, which enabled the examination of variable associations with variations in placement success rates.

As recommended, meta-regressions were only performed when data were available from ten or more studies for each variable.⁷¹ Therefore, variables with insufficient data, such as history of cesarean sections, ectopic pregnancies, STIs, and tobacco and drug use; epidural and regional anesthesia; type of insurance; and outpatient setting were omitted from the analysis. The country/ies where the Essure procedures were performed were also excluded from the analysis, because a method for categorization (i.e., dummy coding) was unclear because of multi-country and single-country studies.

The meta-regressions were used to assess associations with placement success rates related to 19 potential vari-

ables (i.e., moderators; Table 1). The first variable (1) was Essure device model. Based on the study months and years, the device model(s) were dummy coded as follows: 0=STOP [Selective Tubal Occlusion Procedure]; 1=1st model; 2=1st and 2nd models; 3=2nd model; 4=2nd and 3rd models; and 5=3rd model. The second variable (2) was mean BMI. If the study reported mean height and mean weight, these were converted into BMI.

Other variables included: (3) if authors received funding or reported conflicts of interest from the Essure manufacturer; (4) study type (prospective or retrospective); (5) percent of patients who underwent concomitant intrauterine procedures; (6) percent of patients who had IUDs in place during the procedure; (7) percent of use of any type of hormonal contraception; (8) percent of patients in the follicular phase of the menstrual cycle; (9) percent of use of local anesthesia; (10) percent of use of general anesthesia; (11) percent of no anesthesia used; (12) percent of use of analgesics; (13) percent of use of intravenous sedation; (14) percent of patients who were premedicated; (15) mean operating time reported in minutes; (16) number of practitioners who performed the procedures; (17) mean patient age; (18) mean patient parity; and (19) mean patient gravidity. In addition to the meta-regression analyses, a weighted average for successful bilateral microinsert placements was calculated for each of the 19 variables (Table 2).

Results

Sixty-four studies reporting Essure microinsert placement rates on data collected from 19,307 patients were included in

TABLE 1. SAMPLE CHARACTERISTICS FOR BILATERAL ESSURE® PLACEMENT RATES

<i>Variables</i>	<i>N</i>	<i>Means</i>	<i>SD</i>
Essure device model ^a	64	3.02	1.25
Patients' BMI	26	28.32	2.75
Funding from Essure ^b	64	0.42	0.50
Study type ^c	62	1.29	0.46
% of concomitant procedures	59	10.86	28.33
% of IUDs in place	55	6.06	23.21
% of patients using hormonal contraception	14	63.26	30.93
% of patients' follicular cycles	19	93.28	15.64
% of patients who received local anesthesia	42	42.93	40.72
% of patients who received general anesthesia	43	11.04	24.26
% of patients who received no anesthesia	42	18.86	33.53
% of patients who received analgesics	39	27.56	42.93
% of patients who received IV sedation	38	19.8	32.67
% of Patients who were premedicated	44	88.81	21.10
Practitioners' operating time (minutes)	38	13.57	8.11
# of practitioners performing procedure	35	10.66	23.28
Patients' ages	54	37.10	3.63
Patients' parity	43	2.40	0.39
Patients' gravidity	23	2.99	0.74

Note: Certain data were not available for all studies; thus, the number of studies varies for each variable.

^aThe Essure model was dummy coded as follows: 0=STOP [Selective Tubal Occlusion Procedure]; 1=1st model; 2=1st and 2nd models; 3=2nd model; 4=2nd and 3rd models; and 5=3rd model.

^bThe variable measuring Essure funding was dummy coded as follows: 1=authors who reported funding from Conceptus (the company that owned Essure at the time; now Essure is owned by Bayer HealthCare Pharmaceuticals, Leverkusen, Germany) or conflicts of interest from funding; and 2=authors who did not report funding from Conceptus and had no conflicts of interest.

^cStudy types were coded as: 1=prospective; and 2=retrospective.

N, number of studies; *SD*, standard deviation; *BMI*, body mass index; *IUDs*, intrauterine devices; *IV*, intravenous.

TABLE 2. META-REGRESSION RESULTS FOR ESSURE® PLACEMENT RATES

Variables	Total studies	β (95% CI)	Z-value	R2	P-value	Estimated tau-square	Pooled prevalence for subgroups (95% CI)
Essure device model ^{a,b}	64	0.179 (0.034, 0.324)	2.43	0.084	0.015	0.37	0.919 (0.904, 0.931)
Patients' BMI ^c	26	0.134 (0.056, 0.212)	3.34	0.377	>0.001	0.15	0.922 (0.901, 0.939)
Funding from Essure ^{d,e}	64	0.010 (−0.362, 0.383)	0.057	0.001	0.95	0.40	0.919 (0.904, 0.931)
Study type ^{e,f}	62	0.142 (−0.262, 0.545)	0.689	0.007	0.49	0.39	0.918 (0.903, 0.931)
% of concomitant procedures	59	−0.006 (−0.014, 0.002)	−1.50	0.033	0.133	0.38	0.919 (0.903, 0.931)
% of IUDs in place	55	−0.001 (−0.010, 0.009)	−0.09	0.001	0.92	0.37	0.920 (0.904, 0.933)
% of patients using hormonal contraception ^c	14	0.016 (−0.002, 0.035)	1.76	0.309	0.08	0.82	0.946 (0.915, 0.966)
% of patients' follicular cycles ^c	19	0.004 (−0.014, 0.024)	0.51	0.062	0.40	0.26	0.904 (0.875, 0.927)
% of patients who received local anesthesia ^c	42	0.006 (0.001, 0.011)	2.19	0.132	0.03	0.29	0.912 (0.894, 0.927)
% of patients who received general anesthesia ^c	43	0.005 (−0.007, 0.017)	0.80	0.015	0.43	0.31	0.913 (0.896, 0.928)
% of patients who received no anesthesia ^c	42	−0.004 (−0.010, 0.002)	−1.29	0.032	0.20	0.32	0.914 (0.896, 0.929)
% of patients who received analgesics ^c	39	0.004 (−0.001, 0.009)	1.47	0.212	0.14	0.32	0.913 (0.895, 0.928)
% of patients who received IV sedation ^c	38	0.004 (−0.002, 0.012)	1.24	0.039	0.22	0.31	0.913 (0.895, 0.929)
% of patients premedicated ^c	44	−0.006 (−0.019, 0.007)	−0.90	0.019	0.37	0.34	0.915 (0.898, 0.930)
Practitioners' operating times (minutes) ^c	38	−0.017 (−0.043, 0.009)	−1.27	0.051	0.21	0.29	0.912 (0.893, 0.927)
# of practitioners performing procedure ^c	35	0.007 (−0.001, 0.015)	1.622	0.069	0.10	0.29	0.919 (0.900, 0.935)
Patients' ages ^c	55	−0.039 (−0.097, 0.018)	−1.34	0.033	0.18	0.36	0.916 (0.900, 0.929)
Patients' parity ^c	43	0.141 (−0.362, 0.644)	0.55	0.006	0.58	0.22	0.912 (0.897, 0.926)
Patients' gravidity ^c	23	0.063 (−0.45, 0.59)	0.24	0.019	0.61	0.29	0.914 (0.880, 0.939)

Notes: Meta-regressions were performed using methods of moment/mixed methods regression. Random-effect models were used to provide subgroup placement success rates. β = Slope; R^2 =the coefficient of determination.

^aEssure model was dummy coded as follows: 0=STOP [Selective Tubal Occlusion Procedure]; 1=1st model; 2=1st and 2nd models; 3=2nd model; 4=2nd and 3rd models; and 5=3rd model.

^bCategorical variable.

^cContinuous variable.

^dThe variable measuring Essure funding was dummy coded as follows: 1=authors who reported funding from Conceptus (the company that owned Essure at the time; now Essure is owned by Bayer HealthCare Pharmaceuticals, Leverkusen, Germany); and 2=authors who did not report funding from Conceptus.

^eDichotomous variable.

^fStudy types were coded as: 1=prospective; and 2=retrospective.

CI, confidence interval; BMI, body mass index, IUD, intrauterine devices; IV, intravenous.

the analysis. Study sample sizes ranged from $n=8$ to $n=4306$. Successful placement rates ranged between 60% and 99% (0.6 and 0.99). The FEM produced the weighted average logit placement rate of 2.372 (95% CI: 2.136–2.427), which yielded a significant, back-transformed weighted average placement rate of 92% (0.919 [95% CI: 0.910–0.919]). Results from heterogeneity testing suggested that 1 or more of the 64 studies came from different populations ($Q=494.33$; degrees of freedom [df]=63; $p<0.001$; $I^2=87.255$). The weighted average logit placement rate yielded in the REM was 2.424 (95% CI: 2.244–2.604), with a back-transformed weighted average placement rate of 92% (0.919 [95% CI: 0.904–0.931]; Fig. 2).

The trim and fill procedure to assess publication bias was applied under the REM, and four studies were estimated to be missing; yet, this procedure produced a placement rate that was extremely close to the original REM, 91.4% (0.914

[95% CI: 0.910–0.919]), indicating that the effect of adding additional studies that may have been missed would neither reduce nor inflate the placement rate. Furthermore, the Classic Fail-Safe N was utilized as another method for assessing publication bias. The results showed that there would need to be 6332 nonsignificant findings to invalidate the placement rate that was found in this meta-analysis. Finally, the sensitivity analysis yielded an REM of 92% (0.918 [95% CI: 0.903–0.931]), suggesting that nearly no change was detected by removal of a study⁷ that contained a considerably larger sample size than the other studies in the analysis.

It was not possible to analyze covariates as a result of the combination of large p -values and small df . Subgroup analyses on each of the 19 moderator variables yielded pooled placement rates that ranged between 90% and 95% (0.904–0.946). The bivariate meta-regression results suggested that

Event rates are the Essure bilateral success rates on first attempt.

FIG. 2. Forest plot of placement success rates ($n = 64$).

each refinement of the Essure device model predicted a 0.18-unit increase in successful placement rate. The percentage of patients who received local anesthesia was also significantly associated with an ~ 0.01 unit increase in successful placement rate (Table 2).

Every unit increase in BMI was significantly associated with a 0.13-unit increase in successful placement rate. Because studies were weighted by the inverse of the variance, more weight in the initial analysis was given to a study with patients with higher BMI and a higher placement rate. Thus, this analysis was re-run with the exclusion of two studies: one with the lowest mean BMI (24.09) and a large variance (0.232) with an 86% (0.861) placement rate,³⁰ and one with the highest mean BMI (32.7) that also had one of the smallest variances (0.043) with a 92% (0.921) placement rate.³ The direction of the placement rate remained unchanged after excluding these two studies (93%, REM 0.924 [95% CI: 0.902–0.942]); higher BMI seems to be significantly associated with more successful placements.

Discussion

Currently, smaller and individual studies report on associations between provider- and patient-related variables and Essure placement rates, or systematic reviews on Essure focus on more narrow topics such as pregnancy rates.⁷² The current meta-analysis augments this literature by: (1) drawing a large amount of data on successful, first-attempt bilateral placement rates from a plethora of studies with different populations; and (2) pooling these data to identify potential moderator variables while reducing random error.

The meta-regressions in this current review yielded three significant findings. First, as Essure models were refined, successful placement rates increased (Table 2). Because the majority of the studies were conducted over a time period that utilized only one device model, some with multiple practitioners with varying levels of experience, the current authors cannot attribute these results to increasing provider experience. Similarly, provider experience was not associated with successful placement in a large, multicenter, multiphysician study.⁴⁴

Whereas the current authors estimated Essure model by the study years, it was not certain if some clinicians used older models after the newer models emerged. Furthermore, because the studies came from different countries, some with multiple countries in the same study, the estimate was not 100% precise—for instance, the first model was approved in Europe in 2001, and in the United States in 2002.⁷³ Thus, these data are estimates, yet clearly show a trend and may be important to consider as newer models are developed.⁷⁴

Second, another notable finding was the significant association between higher BMI and successful placement, which mirrors a newer study that reveals that obese women had fewer complications with the Essure procedure compared to laparoscopic tubal ligation,⁷⁵ which may suggest that women be counseled differently on sterilization options. The current authors cannot state with certainty, however, that selection bias did not confound these data. For example, physicians may choose Essure preferentially in heavier patients because these physicians view such patients as worse laparoscopic tubal candidates; or physicians may preferentially counsel multiparous women toward Essure (because

of increased ease in cervical entry) and those women often have higher BMI and are potentially less likely to have fertility-compromising uterine anomalies.

Third, several anesthetic approaches were analyzed—including no anesthesia use—yet only local anesthesia was significant. The effect, however, was not strong. Thus, the findings indicate that researchers should use more standardized and comprehensive reporting of variables in Essure studies to increase sample sizes to improve knowledge of variable associations that may moderate procedure efficacy—not only for successful bilateral microinsert placement but also with respect to other components of the hysteroscopic procedure.

Small sample sizes also restricted the ability to examine some potentially clinically useful variables. For example, clinically, the current authors know that hormonal contraception may be a significant predictor, because this kind of contraception alters the endometrial lining.⁷⁶ Even with small sample sizes for hormonal contraceptive use, (1) the confidence interval was on the cusp of including 0; (2) $p=0.08$; and (3) the df were only 13—all of which could indicate that the variable was close to significance. Thus, the current authors recommend that future studies include information on variables that were found to be close to significant (i.e., hormonal contraception). Furthermore, small sample sizes limited the current review study to bivariate analyses. Larger sample sizes would allow for covariate analyses that can show interaction effects between variables. For example, one could analyze the association between device model and practitioner experience, or between stage of the menstrual cycle and use of hormonal contraception.

The data collection process directed attention to another issue—the inconsistency in studies in what is defined and reported as a successful attempt. For example, some studies omitted failed attempts in their success rates.^{15,20,32} The current analysis included these attempts because the current authors believe that these calculations reflect a general patient population better than physicians treat on a daily basis. It is recommended that researchers be cognizant of overall patient populations when calculating placement rates, so patients can be given the most accurate information. Another consideration surrounding the issue of patient populations is that some studies in this analysis reflect general patient populations, whereas other analyses excluded patients for having certain characteristics that may influence placement rates, such as history of pelvic inflammatory disease. Thus, the current analysis cannot account for this type of selection bias in—or the overall quality of—the contributing studies.

Publication bias can be a significant problem in meta-analyses, which generally refers to a tendency to publish results that are significant, of higher quality, or from larger, well-funded studies. Thus, excluding unpublished work could have been a limitation. However, published studies have been peer-reviewed, and moreover, as shown in the Results section, several analyses were run that did not detect publication bias.

Conclusions

The current authors consider microinsert placement to be an important issue. Not only is failed Essure placement a frustrating experience for both patient and provider, it can also lead to repeat procedure attempts; unintended or

ectopic pregnancy; perforation of the Fallopian tube, uterus, or other internal organs; or the need for subsequent medical interventions,² which increase health risks for women and costs for patients and the health care industry. Expanded knowledge about variables that can predict successful Essure procedures not only has the potential to increase placement rates for future Essure procedures, but may also inform practitioners better who are counseling patients.

Acknowledgments

The authors extend thanks to Lawrence D. Cohn, PhD, in the department of psychology of The University of Texas at El Paso, for his complementary statistical advice.

Federal support for this study was provided by the Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD) as follows: Dr. Berenson, under a mid-career investigator award in patient-oriented research (K24HD043659). Dr. Leyser-Whalen, as a former NRSA postdoctoral fellow under an institutional training grant (T32HD055163; Berenson, PI). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NICHD or the National Institutes of Health.

Disclosure Statement

The authors report no conflicts of interest.

References

1. U.S. Food and Drug Administration. Medical Devices: Essure System—P020014. Online document at: www.fda.gov/medicaldevices/productsandmedicalprocedures/implantsandprosthetics/ucm371014.htm. June 29, 2009 Accessed February 5, 2015.
2. Povedano B, Arjona JE, Velasco E, Monserrat JA, Lorente J, Castelo-Branco C. Complications of hysteroscopic Essure® sterilisation: Report on 4306 procedures performed in a single centre. *BJOG* 2012;119:795.
3. Shavell VI, Abdallah ME, Shade GH, Diamond MP, Berman JM. Placement of a permanent birth control device at a university medical center. *J Reprod Med* 2009;54:218.
4. Kerin J, Cooper JM, Price T, et al. Hysteroscopic sterilisation using a micro-insert device: Results of a multicentre phase II study. *Hum Reprod* 2003;18:1223.
5. Cooper JM, Carignan CS, Cher D, Kerin JF. Microinsert nonincisional hysteroscopic sterilization. *Obstet Gynecol* 2003;102:59–67.
6. Kerin JF, Carignan CS, Cher D. The safety and effectiveness of a new hysteroscopic method for permanent birth control: Results of the first Essure pbc clinical study. *Aust N Z J Obstet Gynaecol* 2001;41:364.
7. Chern B, Siow A. Initial Asian experience in hysteroscopic sterilisation using the Essure permanent birth control device. *BJOG* 2005;112:1322.
8. Rosen DMB. Learning curve for hysteroscopic sterilisation: Lessons from the first 80 cases. *Aust N Z J Obstet Gynaecol* 2004;44:62.
9. Ubeda A, Labastida R, Dexeus S. Essure: A new device for hysteroscopic tubal sterilization in an outpatient setting. *Fertil Steril* 2004;82:196.
10. Vleugels MPH, Veersema S. Hysteroscopic sterilisation in the outpatient department without anaesthesia. *Gynecol Surg* 2005;2:155.
11. Sinha D, Kalathy V, Gupta JK, Clark TJ. The feasibility, success and patient satisfaction associated with outpatient hysteroscopic sterilisation. *BJOG* 2007;114:676.
12. Kerin JF, Munday DN, Ritossa MG, Pesce A, Rosen D. Essure hysteroscopic sterilization: Results based on utilizing a new coil catheter delivery system. *J Am Assoc Gynecol Laparosc* 2004;11:388.
13. Miño M, Arjona JE, Córdón J, et al. Success rate and patient satisfaction with the Essure sterilisation in an outpatient setting: A prospective study of 857 women. *BJOG* 2007;114:763.
14. Arjona JE, Miño M, Córdón J, Povedano B, Pelegrin B, Castelo-Branco C. Satisfaction and tolerance with office hysteroscopic tubal sterilization. *Fertil Steril* 2008;90:1182.
15. Langenveld J, Veersema S, Bongers MY, Koks CA. Tubal perforation by Essure: Three different clinical presentations. *Fertil Steril* 2008;90:e5–10.
16. Savage UK, Masters SJ, Smid MC, Hung Y, Jacobson GF. Hysteroscopic sterilization in a large group practice. *Obstet Gynecol* 2009;114:1227.
17. Panel P, Grosdemouge I, Houllier M, Renouvel F, Friederich L, Le Tohic A. Bipolar hysteroscopic procedures and placement of Essure microinserts for tubal sterilization: A case control study. *Fertil Steril* 2011;95:2422.
18. Duffy S, Marsh F, Rogerson L, et al. Female sterilization: A cohort controlled comparative study of Essure versus laparoscopic sterilisation. *BJOG* 2005;112:1522.
19. Levie MD, Chudnoff SG. Prospective analysis of office-based hysteroscopic sterilization. *J Minim Invasive Gynecol* 2006;13:98.
20. Lett C, Thiel J. The effect of menstrual phase and hormonal contraception on successful bilateral placement of the Essure micro-insert tubal coil. *Gynecol Surg* 2009;6:219.
21. Nichols M, Carter JF, Fylstra DL, Childers M. A comparative study of hysteroscopic sterilization performed in-office versus a hospital operating room. *J Minim Invasive Gynecol* 2006;13:447.
22. Panel P, Grosdemouge I. Predictive factors of Essure implant placement failure: Prospective, multicenter study of 495 patients. *Fertil Steril* 2010;93:29.
23. Thiel JA, Lukwinski A, Kamencic H, Lim H. Oral analgesia vs intravenous conscious sedation during Essure micro-insert sterilization procedure: Randomized, double-blind, controlled trial. *J Minim Invasive Gynecol* 2011;18:108.
24. McSwain H, Shaw C, Hall L. Placement of the Essure permanent birth control device with fluoroscopic guidance: A novel method for tubal sterilization. *J Vasc Interv Radiol* 2005;16:1007.
25. Vellayan M, Baxter A, Connor M, Brown V. The Essure hysteroscopic sterilization procedure: Initial experience in Sheffield, UK. *Gynecol Surg* 2006;3:303.
26. Vleugels M, Heckel S, Veersema S, et al. Hysteroscopic sterilization with Essure device in situ: A challenge? *Gynecol Surg* 2011;8:51.
27. Weston G, Bowditch J. Office ultrasound should be the first-line investigation for confirmation of correct Essure placement. *Aust N Z J Obstet Gynaecol* 2005;45:312.
28. Gerritse M, Veersema S, Timmermans A, Brölmann HAM. Incorrect position of Essure microinserts 3 months after successful bilateral placement. *Fertil Steril* 2009;91:930.e1-5.
29. Lopes P, Gibon E, Linet T, Philippe HJ. Hysteroscopic tubal sterilization with Essure intratubal devices: A case-

- control prospective with inert local anesthesia or without anesthesia. *Eur J Obstet Gynecol Reprod Biol* 2008;138:199–203.
30. Litta P, Cosmi E, Sacco G, Saccardi C, Ciavattini A, Ambrosini G. Hysteroscopic permanent tubal sterilization using a nitinol-dacron intratubal device without anaesthesia in the outpatient setting: Procedure feasibility and effectiveness. *Hum Reprod* 2005;20:3419.
 31. Gauchotte E, Masias C, Bogusz N, Koebele A. Hysteroscopic tubal sterilization with the Essure[®] system: A descriptive study and evaluation of the efficacy of hypnosis. *J Gynecol Obstet Biol Reprod* 2011;40:305.
 32. Menez C, Lopes P. A new hysteroscopic tubal sterilization technique. *J Gynecol Obstet Biol Reprod* 2004;33:221.
 33. Leyser-Whalen O, Rouhani M, Rahman M, Berenson AB. Tubal risk markers for failure to place transcervical sterilization coils. *Contraception* 2012;85:384.
 34. Veersema S, Vleugels M, Koks C, Thurkow A, van der Vaart H, Brölmann H. Confirmation of Essure placement using transvaginal ultrasound. *J Minim Invasive Gynecol* 2011;18:164.
 35. Levie M, Chudnoff SG. A comparison of novice and experienced physicians performing hysteroscopic sterilization: An analysis of an FDA-mandated trial. *Fertil Steril* 2011;96:643.e1.
 36. Chapa HO, Bakker K, Sandate J, Silver L, Antonetti AG. Essure[®] sterilization with sonographic confirmation test: Protocol description and clinical outcomes using ultrasound as an Essure confirmation test. *J Gynecol Surg* 2011;27:57.
 37. Andersson S, Eriksson S, Mints M. Hysteroscopic female sterilization with Essure[®] in an office setting. *Acta Obstet Gynecol* 2009;88:743.
 38. Ríos-Castillo JE, Velasco E, Arjona-Berral JE, Monserrat Jordán JA, Povedano-Cañizares B, Castelo-Branco C. Efficacy of Essure hysteroscopic sterilization—5 years follow up of 1200 women. *Gynecol Endocrinol* 2013;29:580.
 39. Howard DL, Wall J, Strickland JL. What are the factors predictive of hysterosalpingogram compliance after female sterilization by the Essure procedure in a publicly insured population? *Matern Child Health J* 2013;17:1760.
 40. Chapa HO, Venegas G. A novel medical protocol to treat uterotubal spasm during Essure hysteroscopic sterilization: A pilot study. *J Contraception* 2012;3:27.
 41. Chapa HO, Antonetti AG, Bakker K. Essure sterilization in patients with history of pelvic inflammatory disease and hydrosalpinges: An analysis on feasibility and clinical outcomes. *J Gynecol Surg* 2012;28:343.
 42. Shavell VI, Abdallah ME, Diamond MP, Kmak DC, Berman JM. Post-Essure hysterosalpingography compliance in a clinic population. *J Minim Invasive Gynecol* 2008;15:431.
 43. Thiel JA, Suchet IB, Lortie K. Confirmation of Essure[®] microinsert tubal coil placement with conventional and volume-contrast imaging three-dimensional ultrasound. *Fertil Steril* 2005;84:504.
 44. Janse JA, Pattij TOS, Eijkemans MJC, Broekmans FJ, Veersema S, Schreuder HWR. Learning curve of hysteroscopic placement of tubal sterilization microinserts in 15 gynecologists in the Netherlands. *Fertil Steril* 2013;100:755.
 45. Thiel J, Rattray D, Cher DJ. Pre-hysterectomy assessment of immediate tubal occlusion with the third-generation Essure insert (ESS505). *J Minim Invasive Gynecol* 2014;21:1055.
 46. Levy-Zauberman Y, Legendre G, Nazac A, Faivre E, Deffieux X, Fernandez H. Concomitant hysteroscopic endometrial ablation and Essure procedure: Feasibility, efficacy and satisfaction. *Eur J Obstet Gynecol Reprod Biol* 2014;178:51.
 47. Haimovich S, Mancebo G, Alameda F, Agramunt S, Hernández JL, Carreras R. Endometrial preparation with desogestrel before Essure hysteroscopic sterilization: Preliminary study. *J Minim Invasive Gynecol* 2013;20:591.
 48. Grosdemouge I, Engrand J-B, Dhainault C, et al. The French practice of inserting Essure[®] tubal sterilization implants. *Gynecol Obstet Fertil* 2009;37:389.
 49. Legendre G, Levailant J-M, Faivre E, Deffieux X, Gervaise A, Fernandez H. 3D ultrasound to assess the position of tubal sterilization microinserts. *Hum Reprod* 2011;26:2683.
 50. Donnadieu AC, Deffieux X, Gervaise A, Faivre E, Frydman R, Fernandez H. Essure[®] sterilization associated with endometrial ablation. *Int J Gynecol Obstet* 2007;97:139.
 51. Chapa HO, Antonetti AG, Sandate J. Office versus hospital based Essure[®] procedure: Pareto principle in action. *Gynecol Surg* 2012;28:16.
 52. Detollenaere RJ, Vleugels MPH, van Eijndhoven HWF. Combining NovaSure[®] endometrial ablation and Essure[®] hysteroscopic sterilization: A feasibility study to evaluate the confirmation tests. *Gynecol Surg* 2011;8:59.
 53. Hopkins MR, Creedon DJ, El-Nashar SA, Brown DL, Good AE, Famuyide AO. Radiofrequency global endometrial ablation followed by hysteroscopic sterilization. *J Minim Invasive Gynecol* 2007;14:494–501.
 54. Tatalovich JM, Anderson TL. Hysteroscopic sterilization in patients with a Mirena intrauterine device: Transition from extended interval to permanent contraception. *J Minim Invasive Gynecol* 2010;17:228.
 55. Agostini A, Crochet P, Petrakian M, Estrade JP, Cravello L, Gamarre M. Hysteroscopic tubal sterilization (Essure) in women with an intrauterine device. *J Minim Invasive Gynecol* 2008;15:277.
 56. Mascaro M, Mariño M, Vicens-Vidal M. Feasibility of Essure placement in intrauterine device users. *J Minim Invasive Gynecol* 2008;15:485.
 57. Chudnoff S, Einstein M, Levie M. Paracervical block efficacy in office hysteroscopic sterilization: A randomized controlled trial. *Obstet Gynecol* 2010;115:26.
 58. Levie M, Weiss G, Kaiser B, Daif J, Chudnoff SG. Analysis of pain and satisfaction with office-based hysteroscopic sterilization. *Fert Steril* 2010;94:1189.
 59. Famuyide AO, Hopkins MR, El-Nashar SA, et al. Hysteroscopic sterilization in women with severe cardiac disease: Experience at a tertiary center. *Mayo Clin Proc* 2008;83:431.
 60. Rogerson L, Hudson H, Duffy S. UK experience using the Essure[™] micro-insert for hysteroscopic sterilization. *Rev Gynaecol Pract* 2003;3:1.
 61. Valle RF, Valdez J, Wright TC, Kenney M. Sterilization with endometrial ablation. *Fertil Steril* 2006;86:152.
 62. Isley MM, Jensen JT, Nichols MD, Lehman A, Bednarek P, Edelman A. Intrauterine lidocaine infusion for pain management during outpatient transcervical tubal sterilization: A randomized controlled trial. *Contraception* 2012;85:275.
 63. Basinski CM, Price P, Burkhart J, Johnson J. Safety and effectiveness of NovaSure[®] endometrial ablation after placement of Essure[®] micro-inserts. *J Gynecol Surg* 2012;28:83.

64. Dewulf S, Decaudin B, Engrand JB, et al. Tubal Sterilization by Placement of a Medical implant Through Hysteroscopy (The Essure® System): Preliminary Feasibility Study [in French]. *Journal de Pharmacie Clinique*. 2204;23(4). Online document at: http://www.jle.com/fr/revues/jpc/e-docs/sterilisation_tubaire_par_mise_en_place_dun_dispositif_medical_implantable_par_hysteroscopie_système_essure_sup_264268/article.phtml?tab=texte Accessed February 4, 2015.
65. Gibon E, Lopès P, Linet T, Martigny H, Orioux C, Philippe H-J. Hysteroscopic Fallopian tube sterilization procedure: Feasibility and one-year follow-up. *Gynecol Obstet Fertil* 2006;34:202.
66. Pauly D, Stergiou KI. Equivalence of results from two citation analyses: Thomson ISI's Citation Index and Google's Scholar service. *Ethics Sci Environ Politics* 2005;2005:33.
67. Greenhalgh T, Peacock R. Effectiveness and efficiency of search methods in systematic reviews of complex evidence: Audit of primary sources. *BMJ* 2005;331:1064.
68. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Ann Intern Med* 2009;151:264.
69. Duval S, Tweedie R. Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics* 2000;56:455.
70. Cohn LD, Becker BJ. How meta-analysis increases statistical power. *Psychol Methods* 2003;8:243.
71. L'Abbé KA, Detsky AS, O'Rourke K. Meta-analysis in clinical research. *Ann Intern Med* 1987;107:224.
72. Cleary TP, Tepper NK, Cwiak C, et al. Pregnancies after hysteroscopic sterilization: A systematic review. *Contraception* 2013;87:539.
73. Essure.® Essure®—Permanent Birth Control. Online document at: www.essure.com/ Accessed February 5, 2015.
74. Clinical Trials.gov. Evaluation of Safety and Effectiveness of the Essure (Model ESS505) Device to Prevent Pregnancy in Women. Online document at: <https://clinicaltrials.gov/show/NCT01948882> Accessed January 17, 2005.
75. Shepherd R, Raker CA, Du NR, Savella GM, Matteson KA, Allen RH. Interval surgical sterilization and obesity. *Obstet Gynecol* 2014;123(suppl1):14S.
76. Rogers PAW, Au CL, Affandi B. Contraception: Endometrial microvascular density during the normal menstrual cycle and following exposure to long-term levonorgestrel. *Hum Reprod* 1993;8:1396.

Address correspondence to:
Ophra Leyser-Whalen, PhD
Department of Sociology and Anthropology
The University of Texas at El Paso
500 West University Avenue
El Paso, TX, 79968
E-mail: oleyserwhalen@utep.edu