

Sex Differences in the Repair of Retinal Detachments in the United States



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• **PURPOSE:** To investigate differences between women and men in the repair of rhegmatogenous retinal detachments (RRDs) in the United States.

• **DESIGN:** Retrospective cohort study.

• **METHODS:** SETTING: A large insurance claims database.

PARTICIPANTS: Subjects with an incident RRD between 2007 and 2015. Data: Demographic data, comorbid ocular conditions associated with RRD, systemic comorbidities, and surgical intervention (pneumatic retinopexy [PR], pars plana vitrectomy [PPV], laser barricade, or scleral buckle [SB]) were collected. MAIN OUTCOME MEASURES: Odds of receipt of surgical intervention for incident RRD, time to repair, type of intervention, and the rate of reoperation by sex.

• **RESULTS:** The study period included 133 million eligible records with 61,071 cases of incident RRD among which 43% ($n = 26,289$) were women. The primary outcome model had 23,933 confirmed RRD cases with a 93% retinal detachment repair rate. Women had 34% reduced odds of receipt of surgical repair of an RRD (odds ratio [OR] 0.66, 95% confidence interval [CI] 0.59, 0.73; $P < .001$) after adjusting for confounders. This effect persisted in all sensitivity models. Among patients who received repair, women were more often delayed (0.17 days, $P = .04$). Women were more likely to undergo primary laser barricade (relative risk ratio [RRR] 1.68, $P < .001$), primary SB (RRR 1.15, $P < .001$), and PR (RRR 1.07, $P < .04$) than men. The odds of reoperation were lower in women (OR 0.91, 95% CI 0.85, 0.96; $P = .002$) after adjustment.

• **CONCLUSIONS:** Insured women are less likely than insured men to receive surgical intervention for an RRD. Based on the results of this study, if the odds of repair were equal between women and men in the United States, then 781 more women would receive surgery each year, or 7,029 more during the study period. Women are more likely to have the repair performed with scleral buckle, laser barricade, and pneumatic retinopexy. The

reason for these sex differences in RRD repair remains unknown and requires further investigation. (Am J Ophthalmol 2020;219:284–294. © 2020 Elsevier Inc. All rights reserved.)

RHEGMATOGENOUS RETINAL DETACHMENT (RRD) IS a potentially blinding ophthalmic emergency requiring intervention with an incidence of more than 1 in 10,000 people.^{1–7} RRD is the most common type of retinal detachment, and it occurs in the presence of a retinal break (*rhegma* in Greek) that allows for the passage of vitreous fluid into the subretinal space. Timely repair of RRDs is critical to optimize vision outcomes and minimize long-term visual disability.^{8,9} Population-based studies have identified several risk factors for RRD development including, but not limited to, age, ethnicity, myopia, lattice degeneration, retinal breaks, trauma, pseudophakia, family history of retinal detachment, and genetic syndromes.^{3,5,6,10–12}

Research on RRD has primarily focused on the biological risk factors and surgical techniques affecting the delivery and outcomes of repair, however, relatively few studies have reported the real-world practices in the United States. Studies in other fields of medicine have found disparities between female and male patients for urgent surgical interventions that persist after controlling for confounding variables, most notably in cardiology related to repair of abdominal aortic aneurysms^{13,14} and valve surgery.^{15,16} These studies report a decreased rate of surgical intervention for women, even in the inpatient setting,^{15,16} as well as delayed diagnosis,¹⁷ increased perioperative complications,¹⁸ and increased morbidity and mortality.^{13,19,20}

In ophthalmology, studies on RRD repair have suggested in secondary analyses that there may be differences in the rates of trauma associated presentation and treatment of RRD by sex; however, no study has specifically examined the relationship of sex to RRD repair.^{21,22} The impetus for this study was to determine whether sex differences impacted the repair of RRDs in the United States. The study question was assessed using the largest outpatient insurance claims database that represents approximately one-third of commercially insured patients in the United States. We hypothesize that the rate of surgical repair of primary RRD is lower for women, that women are more often delayed, and repaired with different surgical procedures than men.

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METHODS

THE STANFORD UNIVERSITY SCHOOL OF MEDICINE INSTITUTIONAL Review Board (IRB)/Ethics Committee ruled this secondary analysis of de-identified administrative data to be exempt from IRB approval (IRB no. 53203). A waiver of informed consent for this retrospective analysis was granted. All research adhered to the tenets of the Declaration of Helsinki. This study represents a retrospective cohort study using administrative insurance claims from a large commercial administrative claims database.

• COMMERCIAL CLAIMS AND ENCOUNTERS DATABASE:

The Truven Health MarketScan Commercial Claims and Encounters database (Truven Health Analytics, San Jose, California, USA) contains administrative data from more than 150 million US beneficiaries across more than 350 insurance carriers from a wide variety of private payers including fee for service, managed care, and consumer-directed payer plans. The data set represents roughly 50% of the US population covered by employee-sponsored insurance and includes beneficiaries from all 50 states. The database contains longitudinal claims data for enrollees until the insurance is discontinued because of loss of insurance, change in insurer, or transition to Medicare. Beneficiary information includes demographic characteristics, diagnosis procedural, and billing codes. Administrative insurance claims data from the Truven Health MarketScan database from January 1, 2007, to December 31, 2015, were used for this study.

• SAMPLE SELECTION AND PREDICTOR VARIABLES:

Records from beneficiaries with an incident RRD diagnosis and at least 1 year of longitudinal data before the diagnosis and at least 30 days following the index diagnosis of RRD during the study period were included. Baseline demographic characteristics including sex, year, and comorbid ocular conditions associated with retinal detachment (myopia, pseudophakia, lattice degeneration, and vitreous hemorrhage) were collected as predictor variables. The diagnoses were identified using International Classification of Diseases 9th and 10th editions (ICD-9 and ICD-10) diagnosis codes available for each year as previously published.²² Ocular comorbidities were any diagnosis codes for the aforementioned conditions within the 1 year prior to incident RRD diagnosis or 30 days following diagnosis.

Surgical intervention was identified by current procedural terminology (CPT) codes for pneumatic retinopexy (PR), pars plana vitrectomy (PPV), laser barricade, or scleral buckle (SB).²² CPT coding does not permit the differentiation of PPV with and without a SB; thus, SB here represents the procedure alone and PPV represents vitrectomy with or without an SB. If multiple surgeries were coded on the same day, they were classified by the most invasive procedure. Laser barricade was considered the least invasive followed by PR, SB, and then PPV as most

invasive. Laterality data were also collected; however, this was only used in sensitivity analysis because laterality data were available for 12.9% ($n = 7,882$) of all records with a diagnosis of RRD and only 4.5% ($n = 2,775$) of confirmed RRD diagnosis records used for the primary outcome reporting model.

The year of diagnosis was also included as a predictor variable because prior studies have reported increasing trends in PPV utilization over time.¹ Patients with prior documented RRD during the 1-year mandatory look-back period were excluded to reduce the rate of miscoding related to a historic retinal detachment and isolate incident RRD. CPT codes for complex retinal detachments were excluded to isolate RRD. These include records with diagnoses of tractional, exudative, and serous retinal detachments, proliferative diabetic retinopathy, retinopathy of prematurity, sickle cell, retinoschisis, chorioretinitis, endophthalmitis, ruptured globe, retinal vein occlusion, and choroidal hemorrhage or rupture. Provider specialty is unavailable in the database and thus previously published methodology of presuming provider specialty using historical diagnosis and procedure code billing was applied to determine classify presumed specialty where all the required data for this analysis was available. For the majority of records there was insufficient data to presume a specialty.²²

• **PRIMARY AND SECONDARY OUTCOMES:** The primary outcome was defined as the odds of receipt of surgical intervention for women compared with men after controlling for baseline characteristics, ocular comorbidities, year of surgery, surgical procedure, and Elixhauser comorbidities. The Elixhauser comorbidity index represents a validated method for assessing systemic health originally developed for use in the inpatient setting but has since been used in ophthalmic studies as a proxy for general health.²³

Secondary outcomes for beneficiaries who received repair of incident RRD included the time to surgical repair (days) after diagnosis of RRD, the type of surgical intervention, and the rate of reoperation after controlling for the confounders described above. Reoperation was defined as a secondary RRD intervention among beneficiaries who met incident RRD criteria above and had a minimum of 30 days follow-up after the initial surgery.

• **STATISTICAL ANALYSIS:** The primary outcome was a binary variable classified as yes or no for the receipt of surgical intervention after incident RRD diagnosis. Logistic regression modeling on the full cohort to assess the receipt of surgical intervention for women and men was performed controlling for age, ocular comorbidities, total Elixhauser comorbidities index, and year of surgery. For beneficiaries who met inclusion criteria and who underwent repair of an incident RRD, the time from diagnosis of first RRD to the time of surgical intervention was collected and compared between women and men after controlling for the aforementioned potential confounders using linear regression

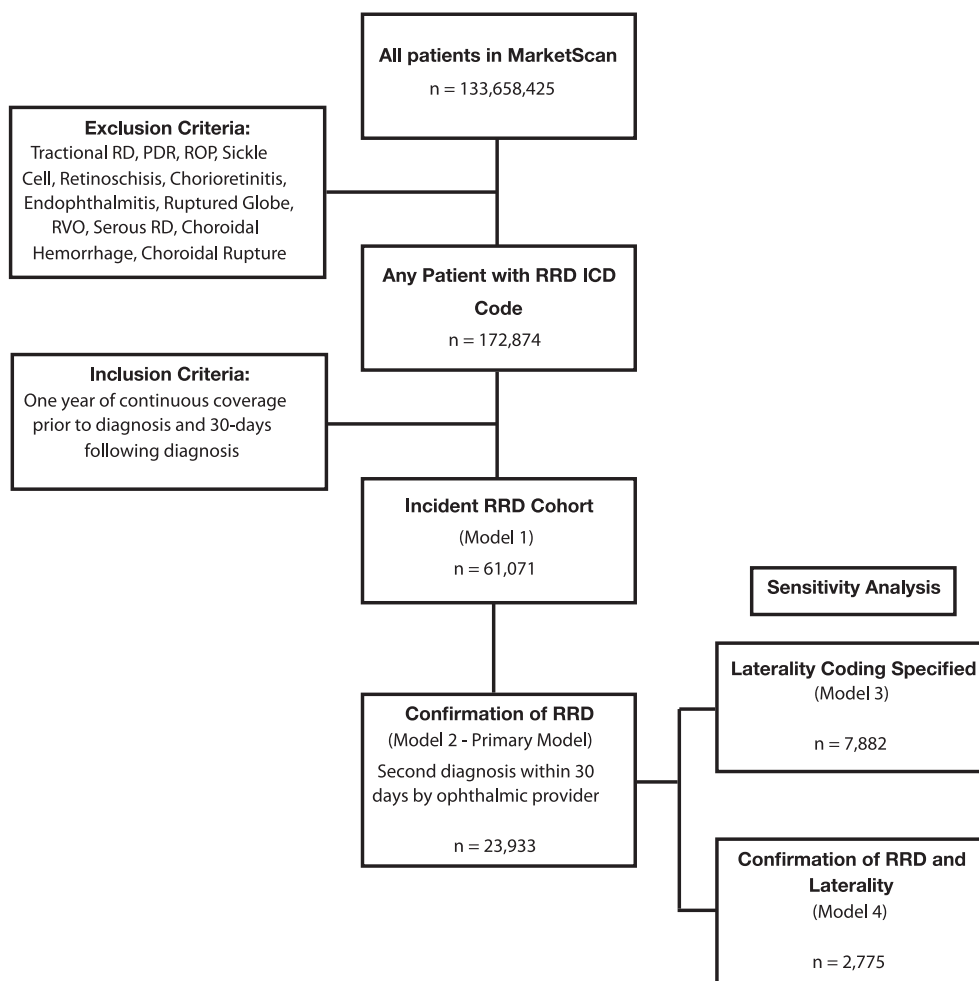


FIGURE 1. Study Inclusion Flow Diagram. ICD = International Classification of Diseases; PDR = proliferative retinal detachment; RD = retinal detachment; ROP = retinopathy of prematurity; RRD = rhegmatogenous retinal detachment; RVO = retinal vein occlusion.

modeling for this continuous outcome. Time was recorded in days as was available in the database. Time analysis was performed using all available data on beneficiaries and secondarily restricting to within 90 days of index diagnosis. The type of surgery was treated as a categorical variable modeled with multinomial logistic regression for all patients who received repair. Reoperation was a binary variable and analyzed with logistic regression modeling.

Increasingly stringent sensitivity models were then performed for all of the aforementioned outcomes. Model 1 is the full incident RRD cohort adjusted for confounders. Model 2 is the prespecified outcome-reporting model that requires a second confirmatory diagnosis of RRD by an ophthalmic provider prior to surgical intervention to reduce the chance of the miscoding of an RRD. A prior study of RRDs using this database reported significant improvement in the surgical repair rate to more than 90% with confirmatory diagnosis criteria, and thus this model was prespecified as the primary outcome reporting model.²² Model 3 is a

sensitivity analysis including only patients with laterality coding that was congruent between the diagnosis and surgical intervention side to avoid including patients who had an RRD in the other eye. Finally, model 4 required both a confirmatory RRD diagnosis and laterality. We sequentially evaluated the models as (1) the full cohort, (2) requiring confirmatory RRD diagnosis, (3) laterality, and (4) both laterality and confirmatory RRD.

Statistical analysis was performed using Stata, version 14.2 (StataCorp, College Station, Texas, USA), and a 2-tailed alpha with a $P < .05$ was considered statistically significant.

RESULTS

• **SAMPLE CHARACTERISTICS:** From a population of 133,658,425 beneficiaries, there were 61,071 retinal detachment records that met study criteria and were

TABLE 1. Baseline Demographic and Clinical Characteristics Among Patients With Primary Rhegmatogenous Retinal Detachment (RRD) by Sex in the Truven MarketScan Database, 2007-2015

Characteristic	All Patients (n = 61,071)	Female (n = 26,289; 43.0%)	Male (n = 34,782; 57.0%)	P Value
Age, y, mean (SD)	57.2 (14.5)	57.1 (15.0)	57.4 (14.1)	.02
Ocular comorbidities				
Myopia	2,419 (4.0)	1,237 (4.7)	1,182 (3.4)	<.01
Pseudophakia	1,175 (1.9)	484 (1.8)	691 (2.0)	.20
Lattice degeneration	9,916 (16.2)	4,594 (17.5)	5,322 (15.3)	<.01
Vitreous hemorrhage	7,385 (12.1)	2,958 (11.3)	4,427 (12.7)	<.01
Diagnosing provider				.03
Unknown	43,104 (70.6)	18,508 (70.4)	24,596 (70.7)	
Optometrist	2,953 (4.8)	1,349 (5.1)	1,604 (4.6)	
Ophthalmologist	2,061 (3.4)	887 (3.4)	1,174 (3.4)	
Retina specialist	12,953 (21.2)	5,545 (21.1)	7,408 (21.3)	
Type of RRD repair				<.01
None	22,534 (36.9)	10,999 (41.8)	11,535 (33.2)	
Pneumatic retinopexy	5,240 (8.6)	1,966 (7.5)	3,274 (9.4)	
Scleral buckle	3,870 (6.3)	1,590 (6.1)	2,280 (6.6)	
Laser barricade	7,044 (11.5)	3,485 (13.3)	3,559 (10.2)	
Pars plana vitrectomy	22,383 (36.7)	8,249 (31.4)	14,134 (40.6)	
Received any surgery	38,537 (63.1)	—	—	—
Second confirmatory RRD diagnosis in record	23,938 (39.2)	—	—	—
Received surgery with confirmatory RRD	22,275 (93.1)	—	—	—

RRD = rhegmatogenous retinal detachment.
Unless otherwise noted, values are n (%).

included in the full incident RRD cohort (model 1) analysis (Figure 1). Among records that met inclusion criteria for the study, 43% (n = 26,289) were women. Sixty-three percent (n = 38,537) of beneficiaries in the full incident RRD cohort received any surgery. The confirmatory model requiring a second diagnosis of RRD contained 23,938 records (62.1% of the full cohort). Among these, 93.1% (n = 22,275) received surgery. Laterality was recorded in only 7,882 (12.9% of the full cohort) of beneficiaries eligible for the study.

The baseline and clinical characteristics of the cohort are shown in Table 1. There were fewer women than men in the full cohort (43% vs 57%). The mean age at diagnosis was slightly, but significantly, younger for women by 0.3 years ($P = .02$). There was a statistically significant difference in the distribution of ocular comorbidities between women and men, with women being more likely to have a diagnosis of myopia (4.7% vs 3.4%, $P < .01$) and lattice degeneration (17.5% vs 15.3%, $P < .01$) and less likely to have vitreous hemorrhage (11.3% vs 12.7%, $P < .01$) than men. For most of the records, the diagnosing provider was unknown (70.6%), but when it was known the most common diagnosing provider was a retina specialist. In the full cohort (model 1), the percentage with surgical repair for incident RRD was 63.1%, similar to prior claims database studies on RRD repair.^{1,22} Among patients diagnosed with an RRD, women did not undergo repair as

frequently as men (41.8% vs 33.2%, $P < .01$) in the full unadjusted sample. When a second confirmatory RRD diagnosis was required (model 2), the rate of repair increased to 93.1%. In the confirmatory model, women represent 39% of RRDs (n = 9,339) and men 61% (n = 14,599), and the absolute repair rate was 91.3% for women and 94.2% for men. In the unadjusted comparison, there was a statistically significant difference in the type of surgical repair performed between women and men ($P \leq .01$).

• **WOMEN ARE LESS LIKELY TO RECEIVE SURGICAL INTERVENTION FOR A RETINAL DETACHMENT:** Adjusted regression modeling for the primary outcome of interest, odds of receipt of retinal detachment repair, in the full and sensitivity models, is shown in Table 2 and graphically represented in Figure 2. In all models, women had a statistically significant reduced odds ratio (OR) of undergoing RRD repair, with 32% reduced odds in the full cohort (model 1, OR 0.68, $P < .001$), 34% reduced odds in the confirmatory RRD model (model 2, OR 0.66, $P < .001$), 28% reduced odds in the laterality sensitivity model (model 3, OR 0.72, $P < .00001$), and 39% reduced odds in the most stringent sensitivity model requiring both confirmatory RRD and laterality coding (model 4, OR 0.61, $P < .0001$).

Other variables also demonstrated a statistically significant association with receipt of repair. Older age (OR 2.24, 95% CI 1.8, 2.79, $P < .001$, for ≥ 60 years) by decade

TABLE 2. Multinomial Logistic Regression Model for Likelihood of Receipt of Any Rhegmatogenous Retinal Detachment (RRD) Repair Within 30 Days of Diagnosis in the Truven MarketScan Database, 2007-2015

Variables	Full Incident Cohort (n = 61,071)		Cohort With Second Confirmation of Incident RRD (n = 23,933)		Cohort With RRD With Laterality (n = 7,882)		Cohort With Second Confirmation of RRD and Laterality (n = 2,775)	
	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value
Sex		<.001		<.001		<.001		<.001
Male	1.00		1.00		1.00		1.00	
Female	0.68 (0.66, 0.71)		0.66 (0.59, 0.73)		0.72 (0.66, 0.80)		0.61 (0.47, 0.79)	
Ocular comorbidities								
Myopia	0.86 (0.79, 0.94)	.001	0.87 (0.68, 1.1)	.246	0.61 (0.5, 0.76)	<.001	0.84 (0.49, 1.44)	.518
Pseudophakia	0.66 (0.58, 0.75)	<.001	0.73 (0.53, 1)	.051	1.25 (1.08, 1.44)	.002	0.95 (0.65, 1.37)	.767
Lattice Degeneration	1.79 (1.7, 1.88)	<.001	1.55 (1.35, 1.79)	<.001	1.67 (1.49, 1.87)	<.001	1.71 (1.24, 2.36)	.001
Vitreous hemorrhage	2.1 (1.98, 2.23)	<.001	1.1 (0.94, 1.28)	.258	2.02 (1.77, 2.31)	<.001	0.6 (0.44, 0.82)	.001
Age at diagnosis, y								
<30	1.00		1.00		1.00		1.00	
31-40	0.95 (0.86, 1.05)	.326	0.99 (0.76, 1.27)	.923	0.77 (0.57, 1.03)	.078	0.92 (0.47, 1.83)	.822
41-50	1.58 (1.45, 1.72)	<.001	1.64 (1.31, 2.05)	<.001	1.37 (1.08, 1.75)	.011	2.27 (1.21, 4.24)	.010
51-60	1.99 (1.84, 2.15)	<.001	2.29 (1.86, 2.81)	<.001	1.55 (1.24, 1.94)	<.001	2.01 (1.18, 3.42)	.011
>60	1.44 (1.33, 1.55)	<.001	2.24 (1.8, 2.79)	<.001	1.01 (0.81, 1.27)	.908	1.83 (1.05, 3.21)	.034
Year of diagnosis	0.92 (0.91, 0.93)	<.001	0.96 (0.94, 0.98)	.001	1.24 (1.11, 1.39)	<.001	1.3 (0.96, 1.76)	.085

CI = confidence interval; OR = odds ratio; RRD = rhegmatogenous retinal detachment.

^aAnalysis adjusted for sex, ocular comorbidities, age at diagnosis, and year of diagnosis.

was associated with higher odds of repair that persisted in most sensitivity modeling. Lattice degeneration (OR 1.55, 95% CI 1.35, 1.79, $P < .001$, in Model 2) increased the odds of receipt of repair in all models while vitreous hemorrhage (OR 2.1, 95% CI 1.98, 2.23, $P < .001$) increased the odds of receipt of repair in all but model 2 where it had no statistically significant effect. Year of diagnosis and Elixhauser comorbidity index were both statistically significant in all models ($P < .001$).

• **TIMING OF RHEGMATOGENOUS RETINAL DETACHMENT REPAIR:** When evaluating all records that met criteria, women had a 2.95-day delay in the receipt of RRD repair compared to men (95% CI for beta: 0.61, 5.29, $P = .01$) in the adjusted model (Table 3). Adjusted analysis and restricting the time to repair to within 30, 60, and 90 days after index diagnosis found a 0.06-, 0.22-, and 0.14-day delay for women, respectively, in the receipt of repair after controlling for age, year of diagnosis, ocular comorbidities, and Elixhauser comorbidities. This delay was again present in the primary outcome model requiring confirmatory RRD diagnosis. Time to repair was reduced in the 3 older decades of age across all models. Ocular comorbidities had variable effects on time to repair.

• **SEX DIFFERENCES IN THE TYPE OF SURGICAL INTERVENTION FOR RETINAL DETACHMENTS:** The selection of surgical intervention for RRD differed between women and men (Table 4). Women were more likely to undergo primary laser barricade (relative risk ratio [RRR] 1.68, $P < .001$), primary

SB (RRR 1.15, $P < .001$), and PR (RRR 1.07, $P < .04$) than men compared with PPV after controlling for age, ocular comorbidities, year of diagnosis, and Elixhauser comorbidities. Increased age by decade reduced the RRR of receiving surgical intervention with primary laser barricade or SB but had an increased RRR of receipt of PR (RRR 2.28 for those >60 years of age, $P < .001$). The ocular comorbidities that may impact surgeon decision making in regard to surgical selection were consistent with the findings in the model: the diagnosis of myopia (RRR 1.3, $P = .003$) and lattice degeneration (RRR 1.3, $P < .001$) increased the likelihood of SB whereas pseudophakia (RRR 0.15, <.001) and vitreous hemorrhage (RRR 0.33, <.001) reduced the likelihood of SB. Pseudophakia, lattice degeneration, and vitreous hemorrhage all reduced the RRR of primary repair with PR (all P values < .001). Lattice degeneration (RRR 1.25, $P < .001$) and vitreous hemorrhage (RRR 1.37, $P < .001$) increased the likelihood of repair with primary laser barricade whereas pseudophakia reduced the risk (RRR 0.42, $P < .001$).

• **REOPERATION AFTER SURGICAL INTERVENTION FOR INCIDENT RRD:** The odds of reoperation within 30 days of index surgical intervention for primary RRD is shown in Table 5. For the overall cohort, the odds of reoperation are lower in women (OR 0.91, 95% CI 0.85, 0.96, $P = .002$) after adjustment. Women were less likely than men to undergo reoperation after primary PR (OR 0.7, 95% CI 0.62, 0.79, $P < .001$). There was no statistically significant difference between women and men in regard to reoperation for beneficiaries undergoing primary SB (OR 0.97, 95% CI 0.8,

Retinal detachment is a potentially blinding emergency that can only be repaired surgically

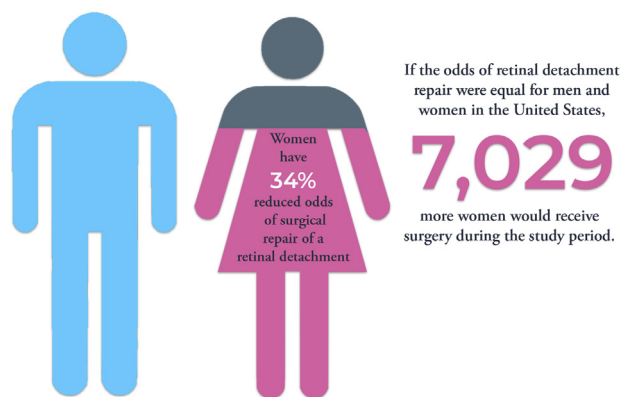


FIGURE 2. Women have reduced odds of repair of retinal detachment. In this study reviewing 133 million administrative claims records over a 9-year study period, women had 34% lower odds of receiving surgical repair for a rhegmatogenous retinal detachment compared to men after controlling for age, year of diagnosis, ocular comorbidities, and systemic comorbidities. The number of women that would be receiving surgical repair annually if the odds were equivalent was calculated using prior epidemiologic data from the United States estimating the incidence of RRD as 17.9 per 100,000 person-years and the US Census Bureau report from the last included study year (2015) estimating 350 million insured working adults in the United States where this data set would be applicable. Using these numbers, 781 more women would be receiving surgical repair annually if the odds of repair were equivalent between the sexes. Over the 9-year study period 7,029 more insured women would receive repair if the odds were equal.

1.17, $P = .74$) or PPV (OR 0.99, 95% CI 0.92, 1.08, $P = .86$).

Myopia (OR 1.57, 95% CI 1.1, 2.26, $P = .01$) and vitreous hemorrhage (OR 2.26, 95% CI 1.62, 3.16, $P < .001$) were associated with increased odds of reoperation for patients undergoing primary SB. Pseudophakia (OR 1.88, 95% CI 1.03, 3.42, $P = .04$) and vitreous hemorrhage (OR 1.81, 95% CI 1.5, 2.18, $P \leq .001$) were associated with increased odds of reoperation among patients undergoing primary PR. Vitreous hemorrhage (OR 1.27, 95% CI 1.15, 1.4, $P < .001$) increased the odds of reoperation after primary PPV. Increased age (OR 0.55, 95% CI 0.44, 0.67, $P < .001$, for 60+ years) was associated with a decreased odds of reoperation among patients who were treated with primary PPV.

DISCUSSION

WE REPORT THE RESULTS OF THE LARGEST OUTPATIENT claims database analysis representing 133 million US commercially insured patients from all 50 states and find

that women are less likely to receive surgical intervention for incident RRD. After adjusting for age, ocular comorbidities, year of diagnosis, and systemic comorbidities, women have 34% reduced odds of receipt of surgery for this vision-threatening emergent condition. The data set is a nationally representative sample containing approximately one-third of all insured adults in the United States. If the odds of repair between women and men were equal, based on our results, we estimate that 781 more women would have surgery each year, or 7,029 more during the study period (using previously reported US RRD incidence rates of 17.9 per 100,000 persons and the US Census Bureau report from 2015 estimating 350 million insured working adults in the United States where this data set would be applicable).²⁴

Secondary outcomes of this study investigate differences between women and men who do undergo surgical repair of the RRD including the time to surgical intervention, type of repair, and reoperation rate. The time from diagnosis to repair is slightly longer for women, but this effect is less than 1 day in all models. Women are more likely to undergo repair with scleral buckle, laser barricade, and pneumatic retinopexy than men and women are less likely to undergo reoperation.

Disparities in the delivery of health care and outcomes between women and men are increasingly reported and of significant concern to our profession. These include delays in the diagnosis of life-threatening conditions such as myocardial infarction,^{25,26} a reduced rate of emergent procedures,²⁶ an increased complication rate,^{15,18} and increased morbidity and mortality.^{13,15,25,27,28} Differences between women and men in the setting of life-threatening conditions is the most striking, but they also have been reported for other health care delivery and outcomes including prescription practices by physicians²⁹ and rates of elective surgical interventions.³⁰

In ophthalmology, there is limited data available on the role of sex in retinal detachment management because it is usually controlled for in regression modeling. When one controls for a variable in a model, this suggests that the variable is a confounder of the relationship between the exposure and outcome. A nationwide registry review of primary RRD in Korea reported reduced odds of surgical intervention for women after controlling for available confounders.²¹ A study on RRD repair trends over time that controlled for sex found reduced odds of repair for women in the final adjusted model.¹ Another study from the US population that also controlled for sex in their modeling focused on the relative impact of patient, physician, and geographic factors on variation in RRD management and secondarily reported a reduced odds of repair for women.²² These prior studies focused on different aspects of RRD management and secondarily identified reduced odds of repair for women. This study represents the first to focus on the difference between women and men in the treatment of an emergent potentially blinding condition. We

TABLE 3. Linear Regression Model for Time to Repair of Rhegmatogenous Retinal Detachment Among Patients Who Received Surgery in the Truven MarketScan Database, 2007-2015

Variable	Full Cohort (n = 38,537)		Patients With Repair Within 30 d of RRD Diagnosis (n = 37,111)		Patients With Repair Within 60 d of RRD Diagnosis (n = 37,535)	
	Adjusted Beta Coefficient ^a (95% CI)	P Value	Adjusted Beta Coefficient ^a (95% CI)	P Value	Adjusted Beta Coefficient ^a (95% CI)	P Value
Sex, female	2.95 (0.61, 5.29)	.014	0.06 (−0.02, 0.14)	.114	0.22 (0.10, 0.34)	<.001
Variables	Patients with Repair within 90 d of RRD Diagnosis (n = 37,963)		Patients with Repair within 90 d and with Second Confirmation RRD (n = 22,156)		Patients with Repair within 90 d and with Laterality (n = 3,372)	
	Adjusted Beta Coefficient ^a (95% CI)	P Value	Adjusted Beta Coefficient ^a (95% CI)	P Value	Adjusted Beta Coefficient ^a (95% CI)	P Value
Sex, female	0.14 (−0.01, 0.30)	.065	0.17 (0.01, 0.32)	.035	0.25 (−0.34, 0.85)	.401
Ocular comorbidities						
Myopia	0.12 (−0.28, 0.52)	.557	−0.19 (−0.59, 0.20)	.337	−0.17 (−1.54, 1.2)	.809
Pseudophakia	1.44 (0.80, 2.10)	<.001	1.20 (0.63, 1.78)	<.001	0.63 (−0.22, 1.48)	.149
Lattice Degeneration	−0.54 (−0.74, −0.35)	<.001	−0.36 (−0.55, −0.16)	<.001	−0.65 (−1.3, 0)	.050
Vitreous Hemorrhage	−0.05 (−0.26, −0.16)	.657	−0.30 (−0.52, −0.08)	.009	0.18 (−0.54, 0.9)	.625
Age at Diagnosis						
<30	1.00		1.00		1.00	
31-40	0.01 (−0.49, 0.51)	.965	−0.53 (−1.03, −0.04)	.034	0.86 (−1.05, 2.77)	.379
41-50	−1.36 (−1.76, −0.96)	<.001	−2.03 (−2.43, −1.63)	<.001	−1.19 (−2.7, 0.33)	.126
51-60	−2.32 (−2.69, −1.95)	<.001	−2.76 (−3.13, −2.39)	<.001	−2.37 (−3.76, −0.98)	.001
>60	−1.82 (−2.20, −1.44)	<.001	−2.29 (−2.67, −1.90)	<.001	−2.41 (−3.86, −0.96)	.001
Year of diagnosis	0.04 (0.00, 0.07)	.03	0.01 (−0.03, 0.04)	.755	0.74 (0.03, 1.46)	.042
Elixhauser comorbidities	0.15 (0.12, 0.19)	<.001	0.12 (0.08, 0.15)	<.001		

CI = confidence interval; OR = odds ratio; RRD = rhegmatogenous retinal detachment.
^aAnalysis adjusted for sex, ocular comorbidities, age at diagnosis, and year of diagnosis.

report a reduced rate of receipt of surgical intervention for primary RRD for women in the United States that persists in all sensitivity modeling and on review of prior published US epidemiologic RRD studies has been present all along.^{1,22}

Why is there a difference in the receipt of retinal detachment repair between women and men in the United States? Any investigation of differences in health care utilization and outcomes between women and men warrants a review of the difference between sex and gender. The World Health Organization (WHO) defines sex as the biological and physiologic characteristics of males and females driven by their chromosomal composition, whereas the term gender refers to a complex interplay of societally constructed roles and norms of men and women that affect relational, hierarchical, historical, contextual, and institutional elements of behavior.³¹ Although sex is often inextricably connected to gender, it is not defined by it and both sex and gender can impact health care outcomes. In this study, the variable available for analysis was sex as self-reported by the patient during insurance claim registration.

Men and women may present with different types of RRDs. Several epidemiologic studies report a higher incident RRD rate among men for reasons that remain poorly under-

stood.^{2-4,10,32} Proposed hypotheses for this sex difference include an increased risk of trauma, a more traumatic posterior vitreous detachment with abnormal vitreoretinal adhesions, and increased axial length among men.^{4,33} In this study, 57% of incident RRDs occurred in men. Despite these possible biological differences in the incidence of RRD, there is a scarcity of data on the difference between men and women's type of retinal detachment that may influence timing and surgical selection. One study found no significant gender difference between macula on and off detachment status between women and men, which would likely be the most crucial element in the timing of retinal detachment repair.³⁴ In the present study, there was a statistically significant difference in time of repair with a delay for women; however, the effect was less than 1 day for most models and is thus likely not clinically significant. When all the records were taken together for any available follow-up time, the delay increased to 2.95 days suggesting that women are more likely to undergo late repair of RRD or that there are other unmeasured confounders contributing to this late delay. When the time frame was restricted to the 30- or 90-day period, the time delay for surgical intervention remained statistically significant, but was much less clinically significant, representing less than a 1-day difference in repair.

TABLE 4. Multinomial Logistic Regression Model for Type of Retinal Detachment Repair Among All Patients With Repair Within 30 Days of Diagnosis in the Truven MarketScan Database, 2007-2015 (n = 38,537)

Variables	Primary Scleral Buckle (n = 3,870)		Primary Pneumatic Retinopexy (n = 5,240)		Primary Laser Barricade (n = 7,044)	
	Adjusted RRR ^a (95% CI)	P Value	Adjusted RRR ^a (95% CI)	P Value	Adjusted RRR ^a (95% CI)	P Value
Sex		<.001		.036		<.001
Male	1.00		1.00		1.00	
Female	1.15 (1.07, 1.23)		1.07 (1.00, 1.14)		1.68 (1.59, 1.77)	
Ocular comorbidities						
Myopia	1.30 (1.10, 1.53)	.003	1.10 (0.93, 1.31)	.257	1.06 (0.92, 1.23)	.398
Pseudophakia	0.15 (0.06, 0.36)	<.001	0.58 (0.42, 0.79)	.001	0.42 (0.31, 0.58)	<.001
Lattice degeneration	1.30 (1.19, 1.41)	<.001	0.75 (0.69, 0.82)	<.001	1.25 (1.16, 1.34)	<.001
Vitreous hemorrhage	0.33 (0.29, 0.39)	<.001	0.56 (0.51, 0.62)	<.001	1.37 (1.27, 1.47)	<.001
Age at diagnosis, y						
<30	1.00		1.00		1.00	
31-40	0.57 (0.48, 0.68)	<.001	1.67 (1.22, 2.30)	.002	0.78 (0.66, 0.92)	.003
41-50	0.27 (0.23, 0.31)	<.001	2.23 (1.71, 2.91)	<.001	0.39 (0.34, 0.45)	<.001
51-60	0.19 (0.16, 0.21)	<.001	2.59 (2.00, 3.35)	<.001	0.43 (0.37, 0.48)	<.001
>60	0.13 (0.11, 0.15)	<.001	2.28 (1.76, 2.96)	<.001	0.35 (0.31, 0.4)	<.001
Year of diagnosis	0.90 (0.88, 0.91)	<.001	0.96 (0.95, 0.98)	<.001	0.99 (0.97, 1.00)	.025
Elixhauser comorbidities	0.97 (0.95, 0.99)	.001	0.96 (0.94, 0.97)	<.001	0.98 (0.97, 1.00)	.015

CI = confidence interval; RRR = relative risk ratio.

^aPars plana vitrectomy (PPV) is the reference group. Analysis adjusted for sex, ocular comorbidities, age at diagnosis, year of diagnosis, and Elixhauser comorbidities.

Interestingly, in this study women were more likely to be repaired with laser barricade, scleral buckle, or pneumatic retinopexy compared with vitrectomy than men and their rate of reoperation was slightly lower. This leaves open the possibility that women and men present with different retinal detachments or ocular comorbidities that lead surgeons to choose one procedure over another, with similar and even improved success. Indeed, women in this study had higher rates of myopia and lattice degeneration, and these are both conditions that are more likely to be repaired with a scleral buckle or laser barricade for a low-lying peripheral retinal detachment as can occur with myopia. Because of the nature of claims data, we are unable to know the location or visual outcomes of RRD that may explain the difference in surgical repair selection. The lower rate of reoperation observed may be related to biological factors or it could be due to better adherence with postoperative recommendations, such as with positioning, which has been reported.³⁵ It could also be that women are not returning for or being offered secondary procedures and that there is also a reduced rate of receipt of reoperation. These potential contributing factors cannot be assessed using claims data alone and require further study.

Although there may be biological differences in incident RRDs between women and men that explain the secondary outcomes of this study, the most notable finding cannot be explained by biologic differences: women are not getting to the operating room at the same rate as men. This difference in receipt of repair is potentially related to gender. Women

are more often caregivers for children, parents, and spouses at every stage of their lives, and this informal responsibility carries with it a significant physical and emotional burden.³⁶ The stress of caregiving has been associated with an increased rate of depression, anxiety, burnout, and delays or avoidance of seeking medical care.³⁶ Surveys of female cancer caregivers report delays in seeking interventional treatment for their own medical needs because of fear of complication that would limit their ability to care for their dependent family member.³⁷ In RRD repair, where vision may be decreased for weeks due to a gas or oil tamponade, women may delay or not undergo surgery to preserve vision and fulfill their caretaker responsibilities. The caretaker role and fear of complications may also contribute to the differential surgical selection seen in this study as scleral buckle and laser barricade are less likely to have the same temporary visual reduction as a vitrectomy with tamponade.

In addition to their role as caretakers, women may be less likely to voice concerns or challenge authority—here the physician—related to the procedure or timing of surgery and this may result in “no-shows” on the date of surgery. Women also tend to outlive their husbands³⁸ and are more likely to be widowed, so they may not have the support to travel to the numerous appointments associated with surgery.³⁹ These barriers could be addressed with interventions by the physician and organization if they were better understood. Female patients may benefit from a shared decision-making model that offers flexibility of scheduling, transportation, and prescription delivery

TABLE 5. Multinomial Logistic Regression Model for Odds of Reoperation Within 30 Days Following Retinal Detachment Repair in the Truven MarketScan Database, 2007-2015

Variables	Overall Reoperation Rate for All Surgeries (n = 30,322)		Primary Scleral Buckle (n = 3,765)		Primary Pneumatic Retinopexy (n = 5,185)		Primary Pars Plana Vitrectomy (n = 21,355)	
	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value	Adjusted OR ^a (95% CI)	P Value
Sex		.002		.741		<.001		.857
Male	1.00		1.00		1.00		1.00	
Female	0.91 (0.85, 0.96)		0.97 (0.8, 1.17)		0.7 (0.62, 0.79)		0.99 (0.92, 1.08)	
Ocular comorbidities								
Myopia	1.12 (0.96, 1.31)	.159	1.57 (1.1, 2.26)	.014	1.18 (0.85, 1.62)	.321	0.98 (0.79, 1.22)	.886
Pseudophakia	1.11 (0.87, 1.43)	.401	1 (0, 0)	<.001	1.88 (1.03, 3.42)	.038	1.11 (0.83, 1.48)	.493
Lattice degeneration	0.97 (0.9, 1.05)	.495	1.03 (0.83, 1.28)	.788	1.13 (0.95, 1.34)	.153	1.01 (0.91, 1.12)	.909
Vitreous hemorrhage	1.28 (1.18, 1.4)	<.001	2.26 (1.62, 3.16)	<.001	1.81 (1.5, 2.18)	<.001	1.27 (1.15, 1.4)	<.001
Age at diagnosis, y								
<30	1.00		1.00		1.00		1.00	
31-40	1.05 (0.85, 1.28)	.664	1.06 (0.73, 1.55)	.747	1.17 (0.63, 2.17)	.618	0.82 (0.62, 1.07)	.143
41-50	0.91 (0.77, 1.07)	.265	1.02 (0.73, 1.41)	.913	1.07 (0.64, 1.81)	.793	0.55 (0.44, 0.69)	<.001
51-60	0.79 (0.68, 0.92)	.003	0.98 (0.73, 1.32)	.900	0.71 (0.43, 1.18)	.183	0.5 (0.4, 0.61)	<.001
>60	0.82 (0.7, 0.96)	.014	0.98 (0.7, 1.38)	.918	0.69 (0.41, 1.15)	.157	0.55 (0.44, 0.67)	<.001
Year of diagnosis	0.98 (0.97, 0.99)	.003	0.94 (0.9, 0.98)	.003	1 (0.97, 1.03)	.972	0.99 (0.97, 1)	.126
Elixhauser comorbidities	1.01 (1, 1.03)	.078	1.05 (1, 1.1)	.073	1.03 (1, 1.06)	.023	1.01 (0.99, 1.03)	.208

CI = confidence interval; OR = odds ratio.

^aAnalysis adjusted for sex, ocular comorbidities, age at diagnosis, year of diagnosis, and Elixhauser comorbidities.

services. Finally, provider bias cannot be excluded as a possibility for the difference in receipt of repair.

• **STRENGTHS AND LIMITATIONS:** The strengths of this study derive from the size and representative coverage area of the data set. The Truven MarketScan data represents all 50 states, all geographic regions, multiple insurance providers, and has longitudinal enrollee data that can be followed for the duration of coverage to track a beneficiary over time. A total of 133 million records were queried, and the study findings remained robust in all sensitivity models designed to reduce the contribution from miscoding. Confounding would only be expected to affect the outcomes of this study if the confounders were different between women and men and resulted in differential misclassification. Importantly, all patients in the data set were insured, reducing the concern that financial barriers limited a beneficiary's ability to receive surgical repair of an RRD promptly.

The limitations of this study are those inherent to any administrative claims study. The analysis and results rely on the accuracy of data input via ICD and CPT coding where there is a possibility of some coding and billing errors. Sensitivity models were used to address this issue by requiring confirmation of RRD diagnosis, laterality, and both of the above. In the full cohort model, RRD diagnosis underwent repair in 63.1% of subjects, which is seemingly low, but consistent with prior claims database investigations.^{1,22} When a secondary RRD diagnosis was required, this increased

to 93.1%, suggesting this was the most accurate model and was used for primary reporting in this study. Laterality was missing in the vast majority of records and was used for sensitivity analysis purposes. With claims data, we cannot determine why surgery was or was not performed nor can we identify characteristics of the detachment that may contribute to surgical selection. We cannot determine if there is a difference in visual acuity in any of the groups because this information is not available in the database. Although the claims database is one of the largest in the United States, the beneficiaries represent only insured patients and cannot be applied to Medicare beneficiaries, or children. Further, uninsured patients are not represented, and the results of this analysis may be different in this population, where the financial burden of surgical repair may play a more important role in decision making for the patient. As women are more likely to be living below the poverty line and uninsured, the odds of receipt of repair may be even lower in this population. Finally, this data set does not contain a variable for race or ethnicity, and this is likely an important confounder when evaluating health care outcomes.

CONCLUSIONS AND IMPLICATIONS

IN SUMMARY, AMONG 133 MILLION RECORDS OF INSURED adult beneficiaries from a broadly representative US

commercial claims database women were less likely to receive surgical intervention for RRD and intervention was more often delayed compared with their male counterparts. Among patients with RRD who received surgical repair, women were more likely to undergo repair with scleral buckle, laser barricade, and pneumatic retinopexy and were less likely to undergo reoperation. The reason for this difference between women and men remains poorly

understood but may be secondary to a complex and multifaceted interplay of access to care, societal gender roles, and possibly biological differences in types of RRDs. This study is the first to focus on differences in receipt of repair for a vision-threatening ophthalmic emergency. A better understanding of differences in retinal detachments between women and men and the barriers to the operating room requires further investigation.

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