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Use of Guideline-Based Antibiotic Prophylaxis in Women Undergoing Gynecologic Surgery

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Abstract

Objective—To examine guideline-based use of prophylactic antibiotics in patients who underwent gynecologic surgery.

Methods—We identified women who underwent gynecologic surgery between 2003–2010. Procedures were stratified as antibiotic-appropriate (abdominal, vaginal, or laparoscopically assisted vaginal hysterectomy) or antibiotic-inappropriate (oophorectomy, cystectomy, tubal ligation, dilation and curettage, myomectomy, and tubal ligation). Antibiotic use was examined using hierarchical regression models.

Results—Among 545,332 women who underwent procedures for which antibiotics were recommended, 87.1% received appropriate antibiotic prophylaxis, 2.3% received non-guideline recommended antibiotics, and 10.6% received no prophylaxis. Use of antibiotics increased from 88.0% in 2003 to 90.7% in 2010 ($P<0.001$). After excluding patients with infectious complications, 26.7% of women received antibiotics more than 24 hours after surgery. Among 491,071, who had operations in which antibiotics were not recommended, antibiotics were administered to 197,226 (40.2%) women. Use of nonguideline based antibiotics also increased over time from 33.4% in 2003 to 43.7% in 2010 ($P<0.001$). Year of diagnosis, surgeon and hospital procedural volume, and area of residence were the strongest predictors of guideline-based and non-guideline-based antibiotic use.

Conclusion—Although use of antibiotics is high for women who should receive antibiotics, antibiotics are increasingly being administered to women for whom the drugs are of unproven benefit.

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Introduction

Surgical site infections (SSI) are a major cause of morbidity in patients undergoing operative procedures.^{1–4} Surgical site infections not only result in substantial pain and suffering, but are also costly to treat; one study estimated that the development of an SSI resulted, on average, in over \$10,000 of excess hospital costs and prolonged the length of stay by over 4 days.¹ For women undergoing hysterectomy, wound complications have been reported to occur in over 20% of patients in some reports.⁵

Over the past four decades numerous studies have suggested that the administration of perioperative antibiotics reduces infectious morbidity for high-risk surgical procedures.^{6–10} For hysterectomy, a clean contaminated procedure in which the vagina is entered, one meta-analysis of 17 studies that included 2752 subjects noted that antibiotic prophylaxis reduced the infection rate by 65%.⁸ Based on these data, the American College of Obstetricians and Gynecologists recommends antibiotic prophylaxis for hysterectomy, urogynecologic procedures, hysterosalpingogram, and induced abortion.⁹ For procedures with a low risk of infection, these guidelines do not recommend antibiotic prophylaxis for lower risk, clean procedures including operative and diagnostic laparoscopy, tubal sterilization, hysteroscopy, and laparotomy.⁹ Numerous other professional societies have developed similar guidelines for prophylaxis for high-risk surgeries.^{10–13}

In addition to published guidelines, national efforts have been developed to promote proper antibiotic use.⁴ Despite these efforts, little is known about the actual adherence to recommendations for the allocation of perioperative antibiotics in women undergoing gynecologic surgery. We performed a population-based analysis to determine the patterns and predictors of guideline-based use and prolonged use of antibiotics in women who underwent gynecologic surgery.

Methods

Data Source

The Perspective database (Premier Inc, Charlotte, NC), a voluntary database that captures data from more than 500 acute-care hospitals from throughout the United States was used.¹⁴ Participating hospitals submit electronic updates on a quarterly basis. The data is audited regularly to ensure quality and integrity. The database captures clinical and demographic data, diagnoses, procedures, and all billed services rendered during a hospital stay,¹⁵ and therefore contains information on all drugs, devices, radiologic tests, laboratory tests and therapeutic services rendered during a patient's hospitalization. In 2006, nearly 5.5 million hospital discharges that represent approximately 15% of all hospitalizations were captured in the database.¹⁶ The database has been validated and utilized in a large number of outcomes studies. The Columbia University Institutional Review Board deemed this study exempt.

Patient Selection

We analyzed women aged 18 years or older who underwent inpatient or outpatient gynecologic surgery between 2003 and the first quarter of 2010. Surgical procedures were identified through ICD-9 coding. Based on published practice guidelines by the American

College of Obstetricians and Gynecologists, procedures were classified as either antibiotic-appropriate procedures, those operations in which antibiotics were recommended, or antibiotic-inappropriate procedures, surgeries in which antibiotics were not routinely recommended.⁹ Antibiotic appropriate procedures included: abdominal hysterectomy (ICD-9 68.3, 68.39, 68.4, 68.49, 68.90), vaginal hysterectomy (ICD-9 68.5, 68.59), and laparoscopically assisted vaginal hysterectomy (ICD-9 68.31, 68.41, 68.51). Antibiotic-inappropriate procedures included: myomectomy (ICD-9 68.29), open and laparoscopic oophorectomy with or with salpingectomy (ICD-9 65.3x, 65.4x, 65.6x, 65.6x), open and laparoscopic ovarian cystectomy ICD-9 65.2x), dilation and curettage with or without hysteroscopy (ICD-9 69.0, 69.09, 68.12), and laparoscopic tubal ligation (ICD-9 66.2, 66.21, 66.22, 66.29).⁹

Patients were classified through a hierarchy, based on the order of procedures listed above, so that they were only included once even if they underwent multiple procedures. For example, if a patient underwent hysteroscopy along with a tubal ligation they were classified in the hysteroscopy group. Pregnant patients, including those with ectopic gestations and patients who underwent abortion, were excluded from the analysis (ICD-9 codes 630.x–679.x). To capture elective or planned surgery, we only included women who underwent surgery on the first day of hospitalization.¹⁷

Clinical and Demographic Characteristics

Demographic data analyzed included age (<40, 40–49, 50–59, 60–69, and >70 years of age), year of surgery, race (white, black, Hispanic, and other), marital status, and insurance status (Medicare, Medicaid, commercial, self-pay, and unknown). Hospitals in which patients were treated were characterized based on location (metropolitan, non-metropolitan), region of the country (northeast, midwest, west, south), size (<400 beds, 400–600 beds, and >600 beds) and teaching status (teaching, non-teaching). Risk adjustment for medical comorbidities was performed using the Elixhauser comorbidity index. Patients were categorized based on the number of medical comorbidities as 0, 1, 2, and 3 as previously reported.¹⁸

A composite surgical volume for all procedures was determined for hospitals and surgeons. Annualized procedural volume was estimated for each surgeon or hospital by dividing the total number of procedures performed by the number of years in which the individual hospital or surgeon contributed at least one operation.^{19,20} The volume distributions were examined visually and volume classified into approximately equal patient-based quartiles for surgeons (lowest 18.5 cases per year, second 18.51–33.99 cases per year, third 34.00–56.60 cases per year, and highest 56.6 cases per year) and hospitals (lowest <320.15 cases per year, second 320.15–524.15 cases per year, third 524.16–888.25 cases per year, and highest >888.25 cases per year).

Antibiotic Utilization

The database captures all drugs administered to patients and records the hospital day on which the drug is administered. To capture perioperative antibiotic use, we classified antibiotics administered on hospital day 1 as perioperative antibiotics. Antibiotics were categorized based on whether the antibiotic has been recommended in published guidelines

for gynecologic surgery.⁹ For this classification schema, we used a permissive definition of guideline-adherent antibiotics and included any drug or class of drugs previously described in the ACOG guidelines, including: cefazolin, cefotetan, ceftiofur, cefuroxime, ampicillin-sulbactam, clindamycin, gentamicin, aztreonam, metronidazole, ciprofloxacin, enoxacin, gatifloxacin, levofloxacin, lomefloxacin, moxifloxacin, nalidixic acid, norfloxacin, ofloxacin, trovafloxacin, grepafloxacin, sparfloxacin, temafloxacin. Other antibiotics were categorized as non-guideline based antibiotics.⁹

Statistical Analysis

Frequency distributions between categorical variables were compared using χ^2 tests. Separate analyses were performed for antibiotic-appropriate and antibiotic-inappropriate procedures. Hierarchical logistic regression analysis was used to determine factors associated with use of perioperative antibiotics. These models included all patient, physician, and hospital characteristics as well as physician-specific and hospital-specific random effects to account for clustering. For antibiotic-appropriate procedures, we modeled failure to utilize antibiotics, while for antibiotic-inappropriate procedures we modeled use of perioperative antibiotics. All outcomes are reported as risk ratios with 95% confidence intervals. All analyses were performed with SAS version 9.3 (SAS Institute Inc, Cary, North Carolina).

Results

A total of 1,036,403 women, including 545,332 (52.6%) who underwent procedures in which antibiotics were recommended and 491,071 (47.4%) who had operations in which antibiotics were not recommended, were identified. Within the cohort of women who had procedures in which antibiotics were recommended, 475,180 (87.1%) received appropriate antibiotic prophylaxis, while 12,451 (2.3%) received non-guideline recommended antibiotics and 57,901 (10.6%) received no prophylaxis. Within this cohort, use of antibiotics increased from 88.0% in 2003 to 90.7% in 2010 ($P<0.001$). Likewise, for each procedure antibiotic use increased over time: abdominal hysterectomy (87.4% in 2003 to 89.0% in 2010) laparoscopically assisted vaginal hysterectomy (89.2% to 91.5%) and vaginal hysterectomy (88.9% to 92.4%) ($P<0.001$ for all) (Figure 1A).

Table 1 displays the characteristics of the patients in which antibiotics were recommended. In an adjusted, multivariable model, patients who underwent surgery more recently, those residing in non-metropolitan areas, those with 3 or more medical comorbidities, women living in areas other than the eastern U.S., and patients treated by higher volume surgeons were more likely to receive antibiotics. High-volume surgeons were 41% less likely to omit antibiotics (RR=0.59; 95% CI, 0.52–0.66) than low-volume surgeons, while non-teaching hospitals were 25% less likely than teaching hospitals to omit antibiotics (RR=0.75; 95% CI, 0.70–0.81).

Among women who underwent a procedure in which antibiotics were not recommended, antibiotics were administered to 197,226 (40.2%) women. Use of antibiotics increased over time from 33.4% in 2003 to 43.7% in 2010 ($P<0.001$). Increased antibiotic use over time from 2003 to 2010 was noted for all of the individual procedures: myomectomy (63.1% to

66.5%), oophorectomy (79.0% to 82.6%), laparoscopic oophorectomy (47.2% to 63.3%), cystectomy (69.1% to 77.1%), laparoscopic cystectomy (37.2% to 50.9%), dilation and curettage with or without hysteroscopy (23.1% to 33.2%) and laparoscopic tubal ligation (14.9% to 29.6%) ($P<0.001$ for all) (Figure 1B).

Use of antibiotics in patients who underwent procedures in which antibiotics were not required is shown in Table 2. In a multivariable model, patients treated more recently were more likely to receive antibiotics (RR=1.32; 95% CI, 1.29–1.36 for 2010 compared to 2003). Medicaid (RR=0.93; 95% CI, 0.92–0.95) and uninsured (RR=0.97; 95% CI, 0.94–0.99) women as well as those treated at non-metropolitan centers (RR=0.94; 95% CI, 0.90–0.98) were less likely to receive antibiotics, while patients in areas other than the eastern U.S. were more likely to receive antibiotics. High-volume hospitals and high-volume surgeons were less likely to administer perioperative antibiotics in these women; compared to low-volume surgeons, high-volume surgeons were 13% less likely to prescribe antibiotics (RR=0.87; 95% CI, 0.83–0.92). Women who underwent laparotomy were more likely to receive antibiotics than those who had laparoscopic surgery.

Discussion

Our findings suggest that the use of perioperative antibiotics in women undergoing gynecologic surgery is poorly aligned with published guidelines. Although use of antibiotics is high (87%) for women who should receive antibiotics, antibiotics are being increasingly administered to women for whom the drugs are likely of little benefit.

To promote the utilization of appropriate antibiotic prophylaxis, a national collaborative developed the Surgical Care Improvement Project (SCIP) in 2003.^{4,21,23–26} The SCIP initiatives include perioperative quality measures including several focused on the proper allocation of antibiotics. Importantly, hysterectomy is one of the procedures targeted in the SCIP collaborative. While hospital participation in SCIP is voluntary, reimbursement by the Centers for Medicare and Medicaid Services is reduced by 2% if hospitals do not report their outcomes.²⁶ Our data suggest that use of antibiotic prophylaxis for hysterectomy is high.

While use of antibiotics for appropriate procedures was relatively high, we also noted that antibiotics were frequently (40%) administered for procedures where the drugs are of little benefit. Other studies have also noted that the introduction of quality measures often leads to unintended overuse of medications.^{27–29} After CMS adopted a quality measure that required antibiotic administration within 4 hours of hospital arrival for patients with community acquired pneumonia, there was a dramatic increase in the use of antibiotics for patients who did not have pneumonia.^{28,29} Similarly, guidelines for venous thromboembolism prophylaxis for non-surgical patients may promote pharmacologic prophylaxis in very low-risk patients and in those with contraindications to anticoagulation.²⁷ Inappropriate use of antibiotics in low-risk patients not only exposes patients to toxicity with little potential benefit, but also leads to substantial resource utilization and may alter patterns of antimicrobial resistance. Concern about non-compliance with a quality metric may in part explain the overuse of perioperative antibiotics for gynecologic procedures that we noted.

We found that surgical volume was an important predictor of guideline adherence. Compared to low-volume surgeons, high-volume physicians were 41% less likely to omit antibiotics in patients for whom the drugs were indicated, and 13% less likely to give antibiotics when they were not indicated. While the relationship between surgical volume and morbidity and mortality for gynecologic procedures is modest, there is a more robust association between higher surgical volume and decreased resource utilization for pelvic surgery.^{30–33} These data suggest that adherence to best practice perioperative guidelines may, at least in part, explain the lower costs incurred by higher volume gynecologic surgeons. Our group has previously demonstrated that higher volume surgeons are also more likely to employ appropriate perioperative prophylaxis against venous thromboembolism.^{34,35}

Non-clinical factors appeared to play an important role in the allocation of perioperative antibiotics. Patients treated in the eastern U.S. were more likely to receive antibiotics regardless of procedure type. Prior studies have shown substantial regional variation in surgical practice patterns.^{17,31} Patients with a greater number of comorbid medical conditions more frequently received unindicated and prolonged antibiotics while older patients were less likely to receive antibiotics for antibiotic-inappropriate procedures, older women more frequently received prolonged antibiotics. Finally, hospital characteristics were associated with antibiotic use; patients treated at non-teaching hospitals were 25% less likely to receive antibiotics when indicated.

Although our analysis benefits from the inclusion of a large number of women, we acknowledge a number of important limitations. We cannot exclude the possibility that prophylaxis was misclassified in a small number of women. However, the database has been validated and utilized in a number of studies including analyses examining antibiotic utilization.^{26,36} A priori we chose an inclusive definition of guideline-based antibiotics and included any drug or class of drugs that have been described in published guidelines. Finally, we recognize the fact that just because guidelines do not recommend antibiotics does not necessarily mean that antibiotics are of no benefit in some scenarios. Administrative data is unlikely to capture some clinical scenarios in which antibiotics may be warranted. Clearly antibiotic prophylaxis has been poorly studied for many gynecologic procedures, including after complications, and would benefit from more rigorous prospective trials.

The widespread misuse of perioperative antibiotics for gynecologic surgery suggests that strategies to better align practice patterns with evidence-based recommendations are urgently needed. While most quality initiatives have focused on promoting an intervention, reducing unnecessary treatments could substantially decrease medical waste and lower costs.³⁷ Prior studies have demonstrated moderate success for pay for performance initiatives and public reporting of data.³⁸ Similarly, educational interventions, formalized protocol implementation, and clinical decision support tools linked to electronic order entry have all been proposed to reduce unnecessary testing and treatments.^{39–41}

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Figure 1. Use of antibiotics for patients undergoing (A) antibiotic-appropriate procedures and (B) antibiotic-inappropriate procedures.

Table 1

Patterns of Antibiotic Use Among Patients Who Underwent Gynecologic Procedures for Which Antibiotics are Recommended

	No Antibiotics		Inappropriate Antibiotic		Multivariable RR of Not Receiving Antibiotic	
	n	(%)	n	(%)	P *	
	57,901	(10.6)	12,451	(2.3)		
<i>Age (years)</i>					<0.001	
<40	14,161	(9.5)	3723	(2.5)		Referent
40–49	27,909	(11.0)	5639	(2.2)		0.99 (0.97–1.01)
50–59	9898	(11.2)	1859	(2.1)		0.97 (0.94–1.00)
60–69	3564	(11.3)	718	(2.3)		0.96 (0.92–1.00)*
70	2369	(11.5)	512	(2.5)		0.94 (0.89–1.00)
<i>Year of diagnosis</i>					<0.001	
2003	8323	(12.0)	317	(4.5)		Referent
2004	8270	(11.7)	2432	(3.5)		0.94 (0.91–0.97)*
2005	6935	(9.8)	1965	(2.8)		0.78 (0.76–0.81)*
2006	8095	(10.0)	1996	(2.5)		0.73 (0.70–0.75)*
2007	8467	(10.9)	1306	(1.7)		0.80 (0.77–0.83)*
2008	7916	(10.3)	862	(1.1)		0.77 (0.74–0.80)*
2009	8165	(10.1)	650	(0.8)		0.74 (0.71–0.77)*
2010	1730	(9.3)	113	(0.6)		0.67 (0.64–0.71)*
<i>Race</i>					<0.001	
White	34,274	(9.6)	8183	(2.3)		Referent
Black	10,098	(12.2)	1862	(2.3)		1.07 (1.04–1.10)*
Hispanic	3251	(12.3)	501	(1.9)		1.16 (1.10–1.21)*
Other/unknown	10,278	(13.0)	1905	(2.4)		1.10 (1.06–1.14)*
<i>Marital status</i>					<0.001	
Married	31,489	(9.7)	7617	(2.3)		Referent
Single	9582	(11.5)	1765	(2.1)		1.02 (0.99–1.04)
Unknown	16,830	(12.3)	3069	(2.3)		1.03 (1.01–1.06)*
<i>Insurance status</i>					<0.001	
Commercial	45,066	(10.7)	9543	(2.3)		Referent
Medicare	5063	(11.0)	1138	(2.5)		1.03 (0.99–1.07)
Medicaid	4410	(10.1)	1060	(2.4)		1.02 (0.99–1.06)
Uninsured	1659	(10.2)	289	(1.8)		1.03 (0.97–1.08)
Unknown	1703	(9.0)	421	(2.2)		1.04 (0.99–1.10)
<i>Area of residence</i>					<0.001	
Metropolitan	53,433	(11.3)	10,033	(2.1)		Referent
Non-metropolitan	4468	(6.0)	2418	(3.3)		0.74 (0.66–0.83)*

	No Antibiotics		Inappropriate Antibiotic		<i>P</i> *	Multivariable RR of Not Receiving Antibiotic
	n	(%)	n	(%)		
<i>Elixhauser comorbidity index</i>					<0.001	
0	25,861	(10.4)	6112	(2.5)		Referent
1	16,938	(10.8)	3347	(2.1)		1.00 (0.98–1.02)
2	8158	(11.0)	1467	(2.0)		0.98 (0.96–1.01)
3	6944	(10.8)	1525	(2.4)		0.97 (0.94–0.99) *
<i>Region</i>					<0.001	
Eastern	14,291	(25.7)	642	(2.1)		Referent
Midwest	12,626	(11.2)	642	(1.2)		0.41 (0.38–0.46) *
South	24,463	(8.4)	8042	(2.8)		0.36 (0.33–0.39) *
West	6521	(7.7)	1398	(1.7)		0.33 (0.30–0.37) *
<i>Hospital teaching status</i>					<0.001	
Teaching	27,785	(13.9)	4468	(2.2)		Referent
Non-teaching	30,116	(8.7)	7983	(2.3)		0.75 (0.70–0.81) *
<i>Beds</i>					<0.001	
<400	30,286	(10.3)	7283	(2.5)		Referent
400–600	13,287	(9.1)	3285	(2.2)		0.75 (0.70–0.81) *
>600	14,328	(13.6)	1883	(1.8)		1.11 (1.01–1.21) *
<i>Hospital volume</i>					<0.001	
Lowest quartile	14,277	(9.7)	3857	(2.6)		Referent
Second quartile	17,174	(12.4)	3356	(2.4)		1.18 (1.09–1.28) *
Third quartile	15,276	(10.9)	3327	(2.4)		1.01 (0.92–1.09)
Highest quartile	11,174	(9.4)	1911	(1.6)		0.94 (0.85–1.03)
<i>Physician volume</i>					<0.001	
Lowest quartile	18,177	(13.7)	2501	(1.9)		Referent
Second quartile	15,345	(11.1)	2820	(2.0)		0.88 (0.82–0.95) *
Third quartile	11,944	(8.8)	3531	(2.6)		0.72 (0.65–0.79) *
Highest quartile	10,836	(8.4)	3396	(2.6)		0.59 (0.52–0.66) *
Unknown	1599	(17.2)	203	(2.2)		0.92 (0.67–1.25)
<i>Procedure</i>					<0.001	
Abdominal hysterectomy	32,685	(11.6)	6716	(2.4)		Referent
Vaginal hysterectomy	11,651	(9.5)	3039	(2.5)		0.90 (0.88–0.93) *
Laparoscopic hysterectomy	13,565	(9.8)	2696	(1.9)		0.99 (0.97–1.02)

* *P*-value derived from chi square tests comparing appropriate antibiotics, inappropriate antibiotics, and no antibiotics for each class variable.

Table 2

Patterns of Antibiotic Use Among Patients Who Underwent Gynecologic Procedures for Which Antibiotics are Not Recommended

	No Antibiotics		Antibiotic		<i>P</i>	Multivariable RR of Receipt of Any Antibiotic
	<i>n</i>	(%)	<i>n</i>	(%)		
	293,845	(59.8)	197,226	(40.2)		
<i>Age (years)</i>					<0.001	
<40	151,111	(60.9)	96,973	(39.1)		Referent
40–49	81,708	(60.2)	54,100	(39.8)		0.96 (0.95–0.97)
50–59	37,978	(61.6)	23,712	(38.4)		0.91 (0.90–0.93)
60–69	13,724	(52.8)	12,288	(47.2)		0.94 (0.92–0.96)
70	9324	(47.9)	10,153	(52.1)		0.97 (0.94–1.00)
<i>Year of diagnosis</i>					<0.001	
2003	43,319	(66.6)	21,763	(33.4)		Referent
2004	37,309	(63.3)	21,671	(36.7)		1.06 (1.04–1.08)
2005	35,648	(60.5)	23,325	(39.6)		1.12 (1.10–1.15)
2006	39,282	(59.3)	27,1019	(40.8)		1.17 (1.15–1.20)
2007	37,262	(58.1)	26,899	(41.9)		1.20 (1.17–1.22)
2008	42,907	(57.1)	32,183	(42.9)		1.25 (1.23–1.28)
2009	47,038	(56.8)	35,768	(43.2)		1.30 (1.28–1.33)
2010	11,080	(56.3)	8598	(43.7)		1.32 (1.29–1.36)
<i>Race</i>					<0.001	
White	194,682	(61.0)	124,544	(39.0)		Referent
Black	39,033	(55.6)	31,130	(44.4)		1.02 (1.01–1.04)
Hispanic	15,294	(53.6)	13,251	(46.4)		1.01 (0.99–1.04)
Other/unknown	44,836	(61.3)	28,301	(38.7)		0.98 (0.97–1.00)
<i>Marital status</i>					<0.001	
Married	156,892	(59.7)	105,809	(40.3)		Referent
Single	64,395	(59.3)	44,188	(40.7)		1.01 (1.00–1.02)
Unknown	72,558	(60.6)	47,229	(39.4)		1.00 (0.99–1.01)
<i>Insurance status</i>					<0.001	
Commercial	202,873	(58.7)	142,704	(41.3)		Referent
Medicare	21,445	(52.0)	19,796	(48.0)		1.00 (0.97–1.02)
Medicaid	52,032	(70.4)	21,868	(29.6)		0.93 (0.92–0.95)
Uninsured	7978	(55.6)	6372	(44.4)		0.97 (0.94–0.99)
Unknown	9517	(59.5)	6486	(40.5)		0.99 (0.96–1.02)
<i>Area of residence</i>					<0.001	
Metropolitan	255,438	(59.2)	176,112	(40.8)		Referent
Non-metropolitan	38,407	(64.5)	21,114	(35.5)		0.94 (0.90–0.98)
<i>Elixhauser comorbidity index</i>					<0.001	
0	180,884	(63.2)	105,539	(36.9)		Referent

		No Antibiotics		Antibiotic		Multivariable RR of Receipt of Any Antibiotic
		n	(%)	n	(%)	P
	1	62,532	(57.8)	45,726	(42.2)	1.05 (1.03–1.06)
	2	26,250	(55.2)	21,281	(44.8)	1.07 (1.05–1.09)
	3	24,179	(49.5)	24,680	(50.5)	1.12 (1.10–1.13)
<i>Region</i>						<0.001
	Eastern	44,229	(72.3)	16,909	(27.7)	Referent
	Midwest	75,250	(68.0)	35,485	(32.0)	1.12 (1.07–1.18)
	South	141,687	(55.4)	114,159	(44.6)	1.59 (1.53–1.66)
	West	32,679	(51.6)	30,673	(48.4)	1.66 (1.58–1.74)
<i>Hospital teaching status</i>						0.81
	Teaching	111,966	(59.8)	75,216	(40.2)	Referent
	Non-teaching	181,879	(59.9)	122,010	(40.2)	1.08 (1.05–1.11)
<i>Beds</i>						<0.001
	<400	159,144	(60.8)	102,495	(39.2)	Referent
	400–600	72,668	(57.9)	52,800	(42.1)	1.07 (1.04–1.10)
	>600	62,033	(59.7)	41,931	(40.3)	1.08 (1.03–1.12)
<i>Hospital volume</i>						<0.001
	Lowest quartile	67,727	(60.4)	44,390	(39.6)	Referent
	Second quartile	72,310	(60.2)	47,819	(39.8)	0.96 (0.92–0.99)
	Third quartile	69,886	(58.3)	50,023	(41.7)	0.95 (0.91–0.98)
	Highest quartile	83,922	(60.4)	54,994	(39.6)	0.98 (0.94–1.01)
<i>Physician volume</i>						<0.001
	Lowest quartile	67,483	(55.1)	54,910	(44.9)	Referent
	Second quartile	67,660	(59.3)	46,352	(40.7)	0.92 (0.89–0.95)
	Third quartile	74,907	(62.9)	44,264	(37.1)	0.85 (0.81–0.88)
	Highest quartile	77,690	(61.6)	48,340	(38.4)	0.87 (0.83–0.92)
	Unknown	6105	(64.5)	3360	(35.5)	1.00 (0.88–1.14)
<i>Procedure</i>						<0.001
	Laparoscopic oophorectomy	20,938	(43.4)	27,365	(56.7)	Referent
	Open oophorectomy	8707	(18.6)	38,015	(81.4)	1.46 (1.44–1.49)
	Laparoscopic cystectomy	15,710	(55.1)	12,803	(44.9)	0.80 (0.78–0.81)
	Open cystectomy	2881	(26.7)	7926	(73.3)	1.31 (1.28–1.35)
	Laparoscopic tubal ligation	77,580	(77.7)	22,271	(22.3)	0.47 (0.46–0.48)
	Dilation and curettage	155,239	(70.7)	64,208	(29.3)	0.57 (0.56–0.58)
	Myomectomy	12,790	(34.2)	24,638	(65.8)	1.11 (1.09–1.13)