AJPM FOCUS
INCLUSIVITY IN PEOPLE, METHODS, AND OUTCOMES
RESEARCH ARTICLE

Group B Streptococcus Screening and Treatment Adherence in Pregnancy: A Retrospective Cohort Study and Opportunities for Improvement

Donna A. Santillan, PhD,[1] Alexander J. Hubb, MD,[2,3] Taryn E. Nishimura, BS,[1] Sandra R. Rosenfeld-O'Tool, MD,[4,5] Kathleen J. Schroeder, MD,[4,6] Jona M. Conklin, MD,[1,7] Alexandra E. Karras, BS,[1] Serena B. Gumusoglu, PhD,[1] Debra S. Brandt, PhD,[1] Emily Miller, PhD,[8,9] Stephen K. Hunter, MD, PhD,[1] Mark K. Santillan, MD, PhD[1]

Introduction: Pregnancy is a time of increased healthcare screening, and past adherence to evolving guidelines informs best practices. Although studies of Group B *Streptococcus* guideline adherence have focused primarily on treatment of Group B *Streptococcus* carriers, this study broadly evaluated long-term adherence to both Group B *Streptococcus* screening and treatment guidelines. Adherence was evaluated across provider types (obstetrics and gynecology, certified nurse midwives, and family medicine).

Methods: We conducted a retrospective cohort study. Demographic and clinical information were extracted from all prenatal care and delivery patients at a single institution in a single year. Vancomycin prescriptions in pregnancy were tracked for 10 years to determine long-term adherence. *Adherence* was defined as no deviation from 2010 Group B *Streptococcus* screening and treatment guidelines.

Results: Adherence occurred in 89% (1,610/1,810) of patients. Reasons for deviations from guidelines could not always be determined. There was no significant difference in maternal age, race, prenatal provider type, provider type at delivery, gestational age at delivery, delivery mode, or whether antibiotic sensitivities were performed between compliant and noncompliant groups. Significant differences in adherence were found between obstetric clinics (high-risk obstetrics clinic, maternal–fetal medicine fellows clinic, continuity of care clinic, and faculty private clinic) ($p<0.0001$) and between the faculty family medicine clinic and resident family medicine clinic ($p=0.001$). Vancomycin prescription practice did not change significantly over the10-year period.

Conclusions: High rates of adherence to Group B *Streptococcus* screening and treatment guidelines in pregnancy have positive implications for reducing antibiotic resistance. Given evolving guidelines, there is a need to periodically evaluate adherence and to re-educate providers about standard practices and best documentation practices.

From the [1]Department of Obstetrics and Gynecology, University of Iowa Hospitals & Clinics, Iowa City, Iowa; [2]Carver College of Medicine, University of Iowa Hospitals & Clinics, Iowa City, Iowa; [3]Department of Obstetrics & Gynecology, Saint Louis University School of Medicine, St. Louis, Missouri; [4]Department of Family Medicine, University of Iowa Hospitals & Clinics, Iowa City, Iowa; [5]Department of Family Medicine, University of New Mexico Hospital, Albuquerque, New Mexico; [6]Department of Family Medicine, Northwestern Medicine Central DuPage Hospital, Wheaton, Ilinois; [7]MercyOne Perinatal Center, Perinatal Center of Iowa, Des Moines, Iowa; [8]College of Nursing, The University of Iowa, Iowa City, Iowa; and [9]UCHealth, Loveland, Colorado

Address correspondence to: Donna A. Santillan, PhD, Department of Obstetrics & Gynecology, The University of Iowa, 200 Hawkins Drive, Iowa City IA 52242. E-mail: donna-santillan@uiowa.edu.

2773-0654/$36.00
https://doi.org/10.1016/j.focus.2022.100028

INTRODUCTION

The coronovirus disease 2019 pandemic and efforts to reduce healthcare burden and cost as well as bundling of care costs by insurers have emphasized the need to streamline care and implement effective screening and treatment protocols.[1] Pregnancy is a time of particularly high healthcare consumption, with an average of 12−14 prenatal visits and up to 13 screenings recommended by the Centers for Disease Control and Prevention (CDC).

Pregnancy-specific guidelines for the screening and treatment of Group B *Streptococcus* (GBS), the most common cause of early-onset neonatal sepsis and meningitis, were originally issued by CDC in 1996. GBS is a significant cause of maternal complications and infant mortality but is readily treated with antibiotics.[2,3] GBS screening guidelines have evolved in response to concerns over antibiotic resistance and public health trends, with updates published in 2002, 2010, and 2019. Adherence to the updated guidelines is a measurable objective to ensure high-quality care across providers.

Preventive efforts to identify and treat GBS, when implemented properly, have resulted in a dramatic decline in GBS infections. However, screening adherence has been shown to be poor in recent studies and reviews.[4−7] Because of challenges in implementation, it is imperative to determine whether screening is compliant with guidelines. Furthermore, racial disparities in disease prevalence have been observed.[8] Thus, an in-depth study is necessary to identify which patients are most at risk for improper screening.

Before the issuance of initial CDC GBS prenatal treatment/screening guidelines in 1996, roughly 7,500 cases of neonatal GBS disease occurred annually in the U.S.[9] Without intrapartum antibiotic prophylaxis, the incidence of invasive GBS disease in infants of women who are colonized with GBS is 1%−2%.[10] Guidelines regarding the prevention of neonatal GBS disease were revised and reissued by CDC in 2002 and again in 2010.[11,12] Key updates from the 2010 revision included recommendations on screening protocols with polymerase chain reaction technology, guidance for antibiotic prophylaxis in the setting of threatened preterm labor, and clarification of appropriate specimen processing and intrapartum antibiotic prophylaxis in the setting of penicillin allergy.

Declines in GBS disease have been noted where updated guidelines were implemented.[2,3,13−15] Despite gains, GBS remains the leading cause of neonatal morbidity and mortality in the U.S.[16] In general, the 2010 CDC guidelines recommended universal screening of women at 35−37 weeks of gestation who were (1) not previously identified as positive for GBS bacteriuria during pregnancy and (2) without a previous child affected by a GBS infection during the neonatal period. Early studies on adherence to CDC guidelines for GBS prophylaxis showed suboptimal screening rates.[16−19] Consequences of improper implementation of CDC guidelines include maternal infection, fetal infection, antibiotic resistance, and potential adverse antibiotic events, making this a significant public health concern.[20,21]

Recently, penicillin-tolerant strains of GBS have been identified. This is significant because penicillin is the first-line agent for treatment. Resistance to other antibiotics has also been documented.[20,22] Recent studies have suggested opportunities for improving antibiotic sensitivity testing and selection in the setting of resistance.[23−26] For example, as clarified in GBS screening and treatment guidelines, erythromycin and clindamycin are the first choices for treatment of penicillin-resistant GBS; vancomycin can be utilized if susceptibilities to erythromycin and clindamycin are unknown. However, previous retrospective studies of vancomycin use done at other academic centers have identified improper administration of intrapartum vancomycin in up to 94% of patients.[23] Overuse of vancomycin is a concern for several reasons, including antibiotic resistance and hypersensitivity reactions.[27] Improved GBS screening and treatment guideline adherence may decrease these adverse outcomes, which was a goal of recent guideline updates.

To our knowledge, no other study has measured adherence to 2010 CDC guidelines for screening and treatment of GBS at a large institution across provider types and compared outcomes between providers for all women who delivered at the institution, including those who were GBS negative. This study is therefore a novel contribution to the field. We also examined adherence in association with cohort characteristics to determine whether there were specific traits more associated with deviations from care guidelines. In addition, we examined the appropriate use of vancomycin in GBS-positive pregnant women from 2009 to 2019.

By identifying deficits in adherence to guidelines and evaluation of continued antibiotic use as well as disparities across patient demographics, we hope to find specific areas to target for improvement as professional guidelines continue to evolve.[28] This will reduce the burden of GBS−related disease and thus improve maternal and fetal outcomes. More broadly, this will also improve our understanding of issues facing the implementation of new screening and treatment guidelines, both within and without pregnancy.

METHODS

Study Population

In this retrospective cohort study, we performed an electronic query of the medical record system at the University of Iowa Hospitals and Clinics (UIHC), to identify eligible patients. STROBE reporting guidelines were followed.

The protocol was reviewed and approved by the University of Iowa IRB. A waiver of consent was granted by the institution because this was a minimal risk study, which would have been impracticable to conduct without a waiver of consent. Participant identifiers were removed from the data set before analysis.

Inclusion criteria. Criteria for inclusion were pregnant women who delivered their child(ren) in 2012 at the UIHC and received most of their prenatal care at UIHC. Cohort groups were comprised patients cared for by (1) general Obstetrics and Gynecology faculty, (2) maternal–fetal medicine specialists, 3) certified nurse midwives, and 4) family medicine faculty. Additional cohorts seen by residents in obstetrics and gynecology and family medicine were also examined.

Exclusion criteria. Excluded from the review were nonpregnant women, women aged <18 years, prisoners, wards of the court, women with a documented refusal of GBS screening and/or treatment, and women who transferred to UIHC for delivery or late in pregnancy. Also excluded were women with intrauterine fetal demise, delivery of nonviable infants (defined as gestational age <24 weeks), and women with children with lethal anomalies because guidelines do not call for screening or treatment in these cases.

Measures

To determine adherence, chart extraction to a standardized form was performed by trained research team members. Training involved a minimum of 20 chart extractions, which were reviewed for accuracy by the study's principal investigator and contributing maternal–fetal medicine specialist (DAS and MKS). Data were deidentified and managed using REDCap, a password-protected electronic data capture tool hosted at UIHC.[29]

The following information was recorded and analyzed in relation to guideline adherence: whether GBS testing was performed, gestational age at testing, membrane rupture before delivery (if delivered through cesarean section), and whether GBS status was known at the time of delivery. Penicillin allergies were documented on the basis of patient reports. Allergy type was further classified as *severe* (defined as anaphylaxis), *mild* (defined as non-anaphylaxis), or unknown.

GBS-positive was defined as any amount of GBS colonies identified in the urine culture and from the vaginal/rectal swab. In penicillin-allergic patients who were also GBS-positive, we recorded whether antibiotic sensitivity testing was performed. For patients with documented GBS bacteriuria, we recorded colony count; if treatment occurred and, if so, what antibiotics were used for treatment; and whether a subsequent negative urine culture was obtained. We also determined whether and when preterm labor and/or preterm premature rupture of membranes (PPROM) occurred. We noted whether a woman or her other children were previously affected by GBS.

The non-adherence cohort was comprised of cases with any of the following deviations from the guidelines: no screening performed, improperly timed screening performed and/or unnecessary screening performed, non-administration of antibiotics, improper type and/or dose of antibiotic administration per CDC guidelines for GBS, or lack of antibiotic sensitivity testing for penicillin-allergic women. Only treatment performed by UIHC staff was considered for adherence; for example, transfer patients who were previously given inappropriate antibiotics were not considered non-adherent. Patients with no deviations from the guidelines were placed into the adherence cohort.

Statistical Analysis

Maternal information was recorded and analyzed as independent variables versus the dependent variable of guideline adherence, including age at delivery, self-reported race as listed in the electronic health record (Epic), gestational age at delivery, route of delivery, prenatal provider/clinic type, and provider type at delivery. Missing data were excluded from analyses and verified to be missing by at least 2 team members.

Data were analyzed to determine whether the proper screening was followed during outpatient prenatal care and/or inpatient admission. Statistical comparisons were performed through SigmaPlot (version 12) between the non-adherence and adherence cohorts. For continuous variables, comparisons were performed using Student's *t* tests. For categorical variables, chi-square analyses were performed. The association between adherence as the dependent variable and potential confounders was evaluated through logistic regression.

Continued Antibiotic Stewardship

Vancomycin use in pregnancy (2009−2019) was determined by UIHC medical record query. Aggregate use was normalized to annual pregnant patients. This measure served as a surrogate for continued guideline adherence and antibiotic stewardship.

RESULTS

Results from 1,810 pregnancies were included. We excluded 24 pregnancies owing to known lethal anomalies or intrauterine fetal demises. There were no statistically significant differences between the adherent and non-adherent cohorts in maternal age, race, prenatal provider type, provider type at delivery, mode of delivery, or whether antibiotic sensitivities were performed. Patients were predominantly White (71.4%), delivered vaginally (68.1%) at term (38.15 weeks±3.19), received prenatal care from a physician who completed a residency in obstetrics and gynecology (61.3%), had their delivery attended by an obstetrician/gynecologist (75.4%), and underwent GBS testing at UIHC (85.5%) (Table 1). Regarding GBS status, 23% of patients were positive by urine culture or vaginal/rectal swab. A total of 5% of all patients were defined as GBS-positive on the basis of the urine culture. Only 32 of 90 bacteriuric samples (36%) had a colony count ≥10,000.

Strict adherence to screening and treatment protocols, that is, without 1 deviation, occurred in 89% (1,610 of 1,810) of all included patients, whereas 2.6% were

Table 1. Cohort Characteristics

Characteristics	Total cohort (N=1,810)	Number missing data	Adherence cohort (*n*=1,610)	Nonadherence cohort (*n*=200)	*p*-value
Maternal age at delivery (years)	28.9±5.5	29	28.9±5.5	29.06±6.0	0.69
Race		0			0.17
White	1,292 (71.4)		1,162 (89.9)	130 (10.1)	
Asian	111 (6.1)		102 (91.9)	9 (8.1)	
Black	96 (5.3)		81 (84.4)	15 (15.6)	
Hispanic	166 (9.2)		142 (85.5)	24 (14.5)	
Native American	11 (0.7)		9 (81.8)	2 (18.2)	
Other	89 (4.9)		76 (85.4)	13 (14.6)	
Declined to answer	45 (2.5)		38 (84.4)	7 (15.5)	
Gestational age at delivery (weeks)	38.15±3.19	13 (0.7)	38.21±3.12	37.68±3.68	0.04
Mode of delivery		10[a] (0.55)			0.06
Vaginal	1,232 (68.1)		1,103 (89.5)	129 (10.5)	
Cesarean section before ROM	355 (19.6)		308 (86.8)	47 (13.2)	
Cesarean section with ROM	213 (11.8)		180 (84.5)	33 (15.5)	
Operative vaginal delivery		0 (0)			0.71
Yes	86 (4.8)		78 (90.7)	8 (9.3)	
No	1,146 (63.3)		1,025 (89.4)	121 (10.6)	
Type of operative vaginal delivery		0 (0)			0.34
Vacuum	74 (4.1)		68 (91.9)	6 (8.1)	
Forceps	12 (0.7)		10 (83.3)	2 (16.7)	
Prenatal provider type		5 (0.3)			0.14
Obstetrician	1,110 (61.3)		999 (90.0)	111 (10.0)	
Family medicine	204 (11.3)		179 (87.7)	25 (12.3)	
Certified nurse midwife	307 (17)		266 (86.6)	41 (13.4)	
Transfer/shared care	184 (10.2)		158 (85.9)	26 (14.1)	
Clinic type within obstetrics		0 (0)			<0.001
High-risk obstetrics	237 (13.1)		195 (82.3)	42 (17.7)	
High-risk fellows clinic	40 (2.2)		37 (92.5)	3 (7.5)	
Continuity clinic (resident)	179 (9.9)		157 (87.7)	22 (12.3)	
Private	654 (36.1)		613 (93.7)	41 (6.3)	
Clinic type within family medicine		8 (0.4)			0.01
Continuity clinic (resident)	133 (7.3)		109 (82.0)	24 (18.0)	
Private	63 (3.5)		62 (98.4)	1 (1.6)	
Provider at delivery[b]		0 (0)			0.21
Obstetrician	1,365 (75.4)		1,223 (89.6)	142 (10.4)	
Family medicine	184 (10.2)		162 (88.0)	22 (12.0)	
Certified nurse midwife	271 (15)		233 (86.0)	38 (14.0)	
Location of test		183 (10.1)			0.90
UIHC	1,548 (85.5)		1,404 (90.7)	144 (9.3)	
Non-UIHC provider	79 (4.4)		72 (91.1)	7 (8.9)	

Note: The *n* for each group is shown. Where appropriate, the percentage follows in parentheses. For continuous variables, the mean±SD is shown.
[a]The missing mode of delivery represents the cesarean section in which it was not documented when ROM occurred.
[b]Several deliveries were attended by >1 provider type.
ROM, Rupture of membranes; UIHC, University of Iowa Hospitals and Clinics.

untested for GBS within 5 weeks of delivery (including cases of missing or conflicting documentation) (Table 2). In cases with multiple GBS swab tests (*n*=48), as in preterm labor and PPROM, 3 tests were inappropriate given a pre-existing positive test result (6.25%). Of the 105 patients with PPROM, GBS cultures were completed before delivery for 46. A total of 40 patients were swabbed owing to PPROM, of whom 38 had GBS-prophylaxis antibiotics started (95%). Of these 38, 4 patients were found not to be in labor, and GBS antibiotics were discontinued before 48 hours for 3 (75%).

There were 111 patients admitted for preterm labor, 64 of whom were tested for GBS; 27 received antibiotics for GBS prophylaxis. A total of 40 patients had GBS culture results available before delivery.

Because UIHC is the only academic tertiary medical center in Iowa and services a large rural population, the patient population shares prenatal care between UIHC and local providers across the state. For patients with GBS status documented beyond UIHC, we examined their actual results in the medical record. These patients were not included in our assessment of non-

Table 2. Adherence to the GBS Guidelines

Independent variables	Total cohort (N=1,810)	Number missing data	Adherence cohort (*n*=1,610)	Nonadherence cohort (*n*=200)	*p*-value
Number of GBS swabs obtained		19			<0.0001
0	172		126 (73.3)	46 (26.7)	
1	1,571		1,452 (92.4)	119 (7.6)	
2	44		12 (27.3)	32 (72.3)	
3	4		2 (50)	2 (50)	
Gestational age at first swab (weeks) when >1 swab was obtained	30.50±4.48	0	28.01±4.61	31.54±4.12	0.02
Gestational age of the last swab (weeks) if 1 or multiple swabs were obtained	35.55±2.28	0	35.50±2.16	36.03±3.24	0.05
Negative swab <5 weeks of delivery		40			<0.0001
Yes	1,236		1,151 (93.1)	85 (6.9)	
No	33		18 (54.5)	15 (45.5)	
Not applicable	501		406 (81.0)	95 (19.0)	
GBS swab between 35 and 37 weeks		20			<0.0001
Yes	1,301		1,237 (95.1)	64 (4.9)	
No	152		78 (51.3)	74 (48.7)	
Not applicable	337		277 (82.2)	60 (17.8)	
GBS bacteriuria		28			<0.0001
Yes	94		66 (70.2)	28 (29.8)	
No	1,688		1,524 (90.3)	164 (9.7)	
Average colony count if bacteriuric	20,000 (average)	0	24,222.2±32,749.5	17,555.6±28,200	0.33
Patient allergic to penicillin		20			0.02
Yes	133		110 (82.7)	23 (17.3)	
No	1,657		1,481 (89.4)	176 (10.6)	
Type of penicillin allergy		22			<0.0001
Unknown	5		0 (0)	5 (100)	
Mild	23		11 (47.8)	12 (52.2)	
Anaphylaxis	83		79 (95.2)	4 (4.8)	
Swab sent for sensitivities					0.74
Yes	66		55 (83.3)	11 (16.7)	
No	42		36 (85.7)	6 (14.3)	
GBS status known at delivery		19			<0.0001
Yes	1,568		1,430 (91.2)	138 (8.8)	
No	223		162 (72.6)	61 (27.4)	
GBS result		132			0.014
Negative	1,296		1,187 (91.6)	109 (8.4)	
Positive	382		334 (87.4)	48 (12.6)	
Preterm labor		29			<0.0001
Yes	111		85 (76.6)	26 (23.4)	
No	1,670		1,497 (89.6)	173 (10.4)	
Gestational age at preterm labor (weeks)	31.63±4.01		31.60±3.88	31.82±5.34	0.91
PPROM		29			0.02
Yes	105		86 (81.9)	19 (18.1)	
No	1,676		1,496 (89.3)	180 (10.7)	
Gestational age at PPROM (weeks)	31.99±4.59 4.59	0	31.92±4.65	32.32±4.56	0.73
Scheduled cesarean section		20			0.083
Yes	31		24 (77.4)	7 (22.6)	
No	527		464 (88.0)	63 (12.0)	

GBS, Group B *Streptococcus*; PPROM, preterm premature rupture of membranes.

adherence, although results were missing in 20 of 79 patients (25%).

No difference in guideline adherence was observed by patient age (p=0.69), race (p=0.06), or mode of delivery (p=0.06) nor by prenatal provider type (p=0.14) or the type of provider attending the delivery (p=0.21). There were adherence differences observed by clinic type for both obstetricians (p<0.001) and family medicine physicians (p=0.01). A difference was also observed for gestational age at delivery, with the non-adherence cohort delivering earlier than the adherence cohort (37.68±3.68 weeks vs 38.21±3.12 weeks, p=0.04).

Penicillin allergy was noted in 7% of all patients, of whom 87% had a recorded allergy severity (mild or severe). Of these, 14% had a severe allergy.

To reveal the effect of independent variables on adherence, a multiple logistic regression model was constructed with guideline adherence as the

Table 3. Results of Logistic Regression Analysis of Variables Associated With Guideline Adherence

Independent variable	Categories	OR	95% CI	*p*-value
Prenatal provider type	Obstetrician (ref) Family medicine Certified nurse midwife Transfer/shared care	0.959	0.822, 1.118	0.591
Maternal age at delivery	Years	0.985	0.957,1.014	0.298
Maternal race	White (ref) Asian Black Hispanic Native American Other Declined to answer	0.939	0.855, 1.031	0.298
Gestational age at delivery	Gestational weeks	0.916	0.860, 0.976	0.006
Mode of delivery	Vaginal (ref) Cesarean section before ROM Cesarean section with ROM	0.852	0.602, 1.207	0.368
Was GBS status known at delivery?	Yes (ref)/no	5.425	3.222, 9.133	<0.001
GBS status	Yes (ref)/no	0.628	0.434, 0.910	0.014
GBS bacteriuria	Yes (ref)/no	0.121	0.068, 0.215	<0.001
PPROM	Yes (ref)/no	0.976	0.515, 1.851	0.940

Note: Ref groups are indicated in the table.
GBS, Group B *Streptococcus*; PPROM, preterm premature rupture of membranes; ROM, Rupture of membranes.

dependent variable and the following independent variables: (1) prenatal provider type, (2) maternal age at delivery, (3) maternal race, (4) gestational age at delivery, (5) mode of delivery, (6) whether GBS status was known at the time of delivery, (7) GBS status, (8) GBS bacteriuria, and (8) whether the patient experienced PPROM. Prenatal provider type, maternal age, maternal race, mode of delivery, and PPROM did not remain significantly associated with adherence given this logistic regression analysis (Table 3). Gestational age at delivery, knowledge of GBS status, and GBS status remained significantly associated with adherence. These data suggest that the largest driver of adherence was whether GBS status was known at delivery (OR=5.425, CI=3.222, 9.133, $p<0.001$).

We investigated the long-term changes in overall vancomycin use in pregnancy from 2009 to 2019 as a measure of continued adherence. By plotting annual pregnant patients seen normalized to deliveries, we determined the stability of prescription practices (a stable slope indicates unchanged practice). With guideline updates, vancomycin use during pregnancy decreased marginally (slope= −0.0004) (Figure 1). Vancomycin use continued to decrease in 2019 (0.022 pregnant patients per delivery in 2009 vs 0.013 in 2019).

DISCUSSION

This study contributes to an existing literature on adherence to CDC guidelines for prevention of perinatal GBS-related morbidity by adding a more nuanced understanding of adherence across guideline updates. Most previous studies have addressed adherence to treatment or screening in high-risk patients. However, without identifying all GBS-positive patients, it is impossible to determine global treatment adherence.

Previous studies have reported varying degrees of adherence. One 6-month audit of adherence to antibiotic administration for GBS based on risk-based assessment identified that 56% received appropriate GBS prophylaxis,[30] whereas a 2015 Brazilian study reported GBS status annotation in only 48.6% of patients. Furthermore, 25% of mothers were not informed of their GBS status before delivery.[31] Previous studies in a setting more comparable with UIHC have not evaluated adherence to the most recent guidelines or across provider types[32] or have focused exclusively on GBS-positive or complicated pregnancy cases, reporting poor adherence (<84% of patients, with 22% receiving unintended antibiotics).[33] Considering this gap and limited previous information on adherence across all pregnancies at large and U.S.−based providers, this study provides a valuable contribution.

This study also explored the differences across provider types, clinic types, patient demographics, and pregnancy characteristics to help identify those at greater risk of receiving guideline-incongruent care. An improved understanding of these characteristics and their associations with GBS guidelines will support moves to address and target pregnancy-related healthcare disparities.

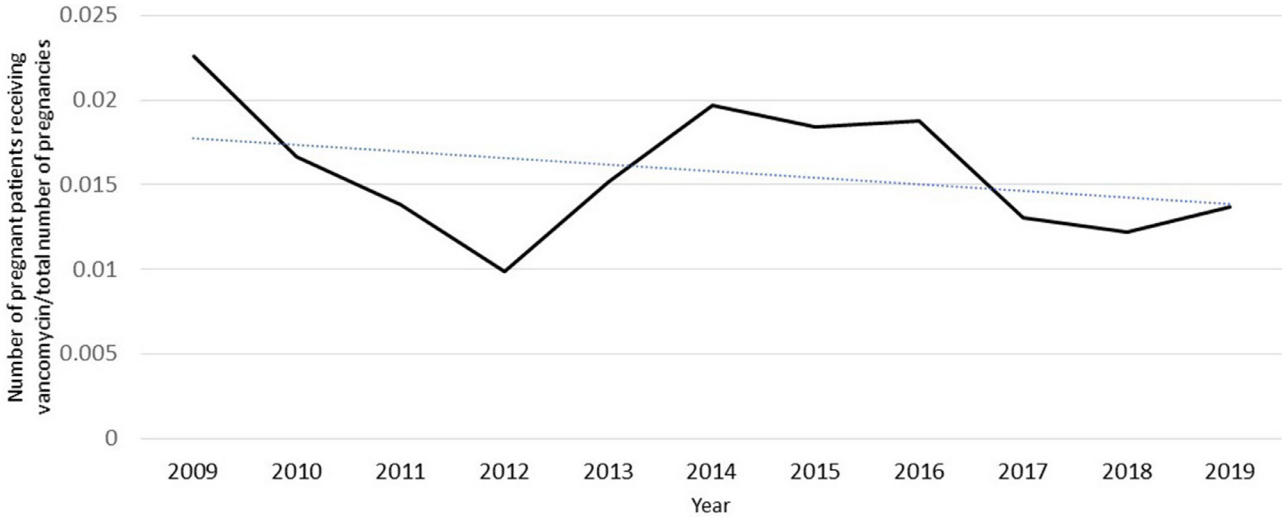

Figure 1. Use of vancomycin during pregnancy by year. The number of women receiving vancomycin (normalized to the number of pregnancies per year) is shown for the years 2009 through 2019. The use of vancomycin has remained steady.

Limitations

This study is limited by its sampling from only 1 large, tertiary care facility in Iowa. Given this setting in a Midwestern academic medical center in a rural state, results may not be generalizable across the U.S. or internationally. Future studies will need to be performed in diverse clinical populations and settings to determine whether our findings generalize. Furthermore, our strict definition of *guideline adherence* (defined as no deviation) may not fully address the nuances of appropriate clinical decision making. For instance, obstetric providers who care for more complicated, comorbid patients who are at an increased risk for early delivery could require earlier GBS screening before the 35−37-week gestation recommended by CDC guidelines. Although this study would code these early screenings as non-adherent, they may in fact be medically appropriate. Furthermore, we did not assess whether non-adherence occurred owing to patient behaviors, such as a lack of proper prenatal care or non-adherence, or individual provider preferences. In general, it was often difficult to discern from medical record documentation the precise reason for non-adherence. Patient and provider differences across clinics may explain the differences in guideline adherence between clinics within specialties reported in this study. Our results show a need for improved documentation as it relates to GBS screening practices, which might be addressed by enhanced provider education in documentation as well as healthcare systems requiring more complete documentation related to GBS screening and treatment.

Overall, adherence was high across all provider types. Within the obstetrics and family medicine settings, provider types did differ with regard to their adherence, with residents showing the lowest rates of adherence. Future studies should evaluate the effectiveness of educational programs for improving resident adherence. Differences between prenatal and delivery provider types were non-significant, suggesting good continuity of practice standards. We attribute this to shared continuing education at UIHC, including grand rounds and postgraduate courses for faculty, fellows, and residents. Despite the limited diversity of the study population, maternal age and race were not associated with differences in adherence. Demographic similarities between patients who did and did not receive compliant care also indicate that a high quality of care is provisioned to all patients, not just select populations.

An increased emphasis on antibiotic stewardship at our institution may also have increased adherence. Furthermore, the relatively stable and rare use of vancomycin in pregnancy, even given guideline updates, suggests consistent care to avoid overuse. The ongoing antibiotic stewardship program at UIHC may bolster continued and consistent caution around avoiding the inappropriate use of antibiotic regimens. Similar programs targeted at clinics and providers with high levels of inappropriate antibiotic use, across specialties and care settings, may prove fruitful.[34]

Our surveillance identified potential areas to target for improvement. These areas include proper documentation of outside test results and reasons for non-adherence, especially when early testing is performed. This work will serve as a baseline against which the efficacy of future educational interventions may be assessed. Findings of non-adherence, particularly at large institutions,

may also support new innovations in the prevention of perinatal GBS disease, such as the development of a GBS vaccine. Furthermore, our findings suggest that, particularly among medical residents, improved education around documentation and screening and treatment guidelines is needed to ensure the completeness of medical records and guidelines adherence. Our results show that this is an area requiring continued emphasis in training programs and across medical systems.

CONCLUSIONS

Adherence with all aspects of updated GBS screening and treatment guidelines was high at a tertiary academic medical center 1 year after implementation. Guidelines were broadly implemented and adhered to across multiple specialties and levels of training. Notably, there was no evidence of inequities by patient age or race in GBS guideline adherence. Differences in adherence were detected between clinic types. Reasons for deviations from the protocol and/or a lack of GBS screening were not always well documented. Following the usage of antibiotics in the same obstetrical practices indicated continued adherence to key aspects of updated GBS screening and treatment guidelines in pregnancy. It is critical to fully evaluate all aspects of screening and treatment guidelines to identify areas for improvement.

ACKNOWLEDGMENTS

The authors wish to thank members of the Santillan laboratory for helpful discussion and contributions.

The funders of this study had no role in the study design; collection, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication. The protocol was reviewed and approved (IRB Number 201207778) by the University of Iowa IRB.

Research reported in this publication was supported by the National Center For Advancing Translational Sciences of the NIH (UL1TR002537).

Declarations of interest: none.

CREDIT AUTHOR STATEMENT

Donna A. Santillan: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Writing — original draft. Alexander J. Hubb: Data curation, Investigation, Writing — review and editing. Taryn E. Nishimura: Data curation, Investigation, Writing — review and editing. Sandra Rosenfeld-O'Tool: Data curation, Investigation, Supervision, Validation, Writing — review and editing. Kathleen J. Schroeder: Data curation, Investigation, Writing — review and editing. Jona M. Conklin: Data curation, Investigation, Methodology, Writing — review and editing. Alexandra E. Karras: Visualization, Writing — review and editing. Serena B. Gumusoglu: Formal analysis, Visualization, Writing — review and editing. Debra S. Brandt: Investigation, Supervision, Validation, Writing — review and editing. Emily Miller: Data curation, Investigation, Writing — review and editing. Stephen K. Hunter: Conceptualization, Formal analysis, Methodology, Supervision. Mark K. Santillan: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Writing — original draft.

REFERENCES

1. Peahl AF, Howell JD. The evolution of prenatal care delivery guidelines in the United States. *Am J Obstet Gynecol.* 2021;224(4):339–347. https://doi.org/10.1016/j.ajog.2020.12.016.
2. Schuchat A. Group B streptococcus. *Lancet.* 1999;353(9146):51–56. https://doi.org/10.1016/S0140-6736(98)07128-1.
3. Zaleznik DF, Rench MA, Hillier S, et al. Invasive disease due to group B Streptococcus in pregnant women and neonates from diverse population groups. *Clin Infect Dis.* 2000;30(2):276–281. https://doi.org/10.1086/313665.
4. Berikopoulou MM, Pana A, Liakopoulou-Tsitsipi T, Vlahos NF, Papaevangelou V, Soldatou A. Poor adherence to the screening-based strategy of group B streptococcus despite colonization of pregnant women in Greece. *Pathogens.* 2021;10(4):418. https://doi.org/10.3390/pathogens10040418.
5. Jury I, Thompson K, Hirst JE. A scoping review of maternal antibiotic prophylaxis in low- and middle-income countries: comparison to WHO recommendations for prevention and treatment of maternal peripartum infection. *Int J Gynaecol Obstet.* 2021;155(3):319–330. https://doi.org/10.1002/ijgo.13648.
6. Pangerl S, Sundin D, Geraghty S. Group B streptococcus screening guidelines in pregnancy: a critical review of compliance. *Matern Child Health J.* 2021;25(2):257–267. https://doi.org/10.1007/s10995-020-03113-z.
7. Kolkman DGE, Rijnders MEB, Wouters MGAJ, Dommelen PV, de Groot CJM, Fleuren MAH. Adherence to three different strategies to prevent early onset GBS infection in newborns. *Women Birth.* 2020;33(6):e527–e534. https://doi.org/10.1016/j.wombi.2019.12.004.
8. Hamdan L, Vandekar S, Spieker AJ, et al. Epidemiological trends of racial differences in early- and late-onset Group B streptococcus disease in Tennessee. *Clin Infect Dis.* 2021;73(11):e3634–e3640. https://doi.org/10.1093/cid/ciaa1511.
9. Zangwill KM, Schuchat A, Wenger JD. Group B streptococcal disease in the United States, 1990: report from a multistate active surveillance system. *MMWR CDC Surveill Summ.* 1992;41(6):25–32. PMID: 1470102.
10. Eichenwald EC. Perinatally transmitted neonatal bacterial infections. *Infect Dis Clin North Am.* 1997;11(1):223–239. https://doi.org/10.1016/s0891-5520(05)70350-0.
11. Verani JR, McGee L, Schrag SJ. Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention (CDC). Prevention of perinatal group B streptococcal disease—revised guidelines from CDC, 2010. *MMWR Recomm Rep.* 2010;59(RR−10):1–36.
12. Schrag S, Gorwitz R, Fultz-Butts K, Schuchat A. Prevention of perinatal group B streptococcal disease. Revised guidelines from CDC. *MMWR Recomm Rep.* 2002;51(RR−11):1–22. accessed 11/16/2020 https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5111a1.htm.
13. Heath PT, Schuchat A. Perinatal group B streptococcal disease. *Best Pract Res Clin Obstet Gynaecol.* 2007;21(3):411–424. https://doi.org/10.1016/j.bpobgyn.2007.01.003.
14. Phares CR, Lynfield R, Farley MM, et al. Epidemiology of invasive group B streptococcal disease in the United States, 1999−2005. *JAMA.* 2008;299(17):2056–2065. https://doi.org/10.1001/jama.299.17.2056.
15. Schrag SJ, Zywicki S, Farley MM, et al. Group B streptococcal disease in the era of intrapartum antibiotic prophylaxis. *N Engl J Med.* 2000;342(1):15–20. https://doi.org/10.1056/NEJM200001063420103.

16. Centers for Disease Control and Prevention (CDC). Perinatal group B streptococcal disease after universal screening recommendations −United States, 2003−2005. *MMWR Morb Mortal Wkly Rep*. 2007;56 (28):701–705. accessed 11/16/2020 https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5628a1.htm.
17. Centers for Disease Control and Prevention (CDC). Adoption of perinatal group B streptococcal disease prevention recommendations by prenatal-care providers−Connecticut and Minnesota, 1998. *MMWR Morb Mortal Wkly Rep*. 2000;49(11):228–232. accessed 11/16/2020 https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4911a2.htm.
18. Van Dyke MK, Phares CR, Lynfield R, et al. Evaluation of universal antenatal screening for group B streptococcus. *N Engl J Med*. 2009;360 (25):2626–2636. https://doi.org/10.1056/NEJMoa0806820.
19. Goins WP, Talbot TR, Schaffner W, et al. Adherence to perinatal group B streptococcal prevention guidelines. *Obstet Gynecol*. 2010;115 (6):1217–1224. https://doi.org/10.1097/AOG.0b013e3181dd916f.
20. Pearlman MD, Pierson CL, Faix RG. Frequent resistance of clinical group B streptococci isolates to clindamycin and erythromycin. *Obstet Gynecol*. 1998;92(2):258–261. https://doi.org/10.1016/s0029-7844(98)00155-0.
21. Back EE, O'Grady EJ, Back JD. High rates of perinatal group B Streptococcus clindamycin and erythromycin resistance in an upstate New York hospital. *Antimicrob Agents Chemother*. 2012;56(2):739–742. https://doi.org/10.1128/AAC.05794-11.
22. Andrews JI, Diekema DJ, Hunter SK, et al. Group B streptococci causing neonatal bloodstream infection: antimicrobial susceptibility and serotyping results from SENTRY centers in the Western Hemisphere. *Am J Obstet Gynecol*. 2000;183(4):859–862. https://doi.org/10.1067/mob.2000.108839.
23. Peláez LM, Gelber SE, Fox NS, Chasen ST. Inappropriate use of vancomycin for preventing perinatal group B streptococcal (GBS) disease in laboring patients. *J Perinat Med*. 2009;37(5):487–489. https://doi.org/10.1515/JPM.2009.090.
24. Critchfield AS, Lievense SP, Raker CA, Matteson KA. Group B Streptococcus prophylaxis in patients who report a penicillin allergy: a follow-up study. *Am J Obstet Gynecol*. 2011;204(2):150.e1–150.e8. https://doi.org/10.1016/j.ajog.2010.08.063.
25. Shore EM, Yudin MH. Choice of antibiotic for group B streptococcus in women in labour based on antibiotic sensitivity testing. *J Obstet Gynaecol Can*. 2012;34(3):230–235. https://doi.org/10.1016/S1701-2163(16)35183-0.
26. Paccione KA, Wiesenfeld HC. Guideline adherence for intrapartum group B streptococci prophylaxis in penicillin-allergic patients. *Infect Dis Obstet Gynecol*. 2013;2013:917304. https://doi.org/10.1155/2013/917304.
27. Sivagnanam S, Deleu D. Red man syndrome. *Crit Care*. 2003;7 (2):119–120. https://doi.org/10.1186/cc1871.
28. Prevention of Group B streptococcal early-onset disease in newborns: ACOG committee opinion, number 797. *Obstet Gynecol*. 2020;135(2): e51–e72. https://doi.org/10.1097/AOG.0000000000003668.
29. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research Electronic Data Capture (REDCap)−a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377–381. https://doi.org/10.1016/j.jbi.2008.08.010.
30. McIlwaine K, Kneebone K, Barkehall-Thomas A, Wallace EM. Compliance with a risk factor-based intrapartum prophylaxis program for neonatal group B streptococcal disease. *Aust N Z J Obstet Gynaecol*. 2006;46(3):199–201. https://doi.org/10.1111/j.1479-828X.2006.00565.x.
31. de Mello DS, Tsunechiro MA, Mendelski CA, Pierre SA, Silva AR, Padoveze MC. Group B Streptococcus: compliance with the information in prenatal card records and knowledge of pregnant women. *Am J Infect Control*. 2015;43(4):400–401. https://doi.org/10.1016/j.ajic.2014.12.026.
32. Faro S, Brehm B, Smith F, et al. Screening for group B streptococcus: a private hospital's experience. *Infect Dis Obstet Gynecol*. 2010;2010: 451096. https://doi.org/10.1155/2010/451096.
33. Chandran L, Navaie-Waliser M, Zulqarni NJ, et al. Compliance with group B streptococcal disease prevention guidelines. *MCN Am J Matern Child Nurs*. 2001;26(6):313–319. https://doi.org/10.1097/00005721-200111000-00008.
34. St Louis J, Okere AN. Clinical impact of pharmacist-led antibiotic stewardship programs in outpatient settings in the United States: a scoping review. *Am J Health Syst Pharm*. 2021;78(15):1426–1437. https://doi.org/10.1093/ajhp/zxab178.