Prevalence, Serotype Distribution, and Antimicrobial Resistance of *Streptococcus agalactiae* Among Pregnant Women in Greece: A Retrospective Study

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Article

Prevalence, Serotype Distribution, and Antimicrobial Resistance of *Streptococcus agalactiae* Among Pregnant Women in Greece: A Retrospective Study

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Abstract

Background: *Streptococcus agalactiae* (group B *Streptococcus*, GBS) remains a leading cause of invasive infections in pregnant women, fetuses, and neonates. Universal screening at 36-37 weeks of gestation followed by intrapartum antibiotic prophylaxis is essential to prevent adverse outcomes. However, data on GBS serotype distribution are limited in several regions, including Greece. This study aimed to determine the prevalence, serotype distribution, and antimicrobial susceptibility of GBS isolates among pregnant women in Greece. **Methods**: Vaginal and rectal swabs were collected from pregnant women undergoing routine GBS screening between January 2021 and December 2025. Samples were processed using selective enrichment broth and cultured on blood agar and chromogenic media. Identification was based on standard microbiological methods, CAMP test, and VITEK2 system. Antimicrobial susceptibility testing and macrolide-lincosamide-streptogramin B (MLS_B) phenotyping were performed. Serotyping was conducted using a commercial latex agglutination assay. **Results**: Among 941 women screened, 118 (12.5%) were colonized with GBS. The most prevalent serotypes were III (29.7%), V (18.6%), Ib (14.4%), IX (10.2%), Ia (9.3%), and II (9.3%). All isolates were susceptible to penicillin. Resistance to erythromycin and clindamycin was observed in 29.7% and 22.9% of isolates, respectively. The predominant MLSB phenotype was constitutive (cMLSB, 78.4%), followed by inducible (iMLSB, 13.5%), L (5.4%), and M (2.7%) phenotypes. **Conclusions**: GBS colonization was detected in 12.5% of pregnant women, with serotype III predominating, underscoring its clinical relevance due to its association with invasive neonatal disease. Although penicillin remains fully effective, the observed resistance to macrolides and lincosamides, primarily mediated by the $cMLS_B$ phenotype, raises concerns regarding alternative therapies.

Keywords: *Streptococcus agalactiae*; GBS; pregnancy; serotypes; antimicrobial resistance; MLSB phenotypes

1. Introduction

Streptococcus agalactiae (Lancefield group B streptococcus, GBS) is a commensal bacterium colonizing the gastrointestinal and genitourinary tracts. It is a leading cause of morbidity and mortality in neonates and young infants worldwide [1–3]. To reduce neonatal disease, the American College of Obstetricians and Gynecologists recommends universal culture-based screening of pregnant women using vaginal and rectal samples collected between 36 0/7 and 37 6/7 weeks of gestation, followed by intrapartum antibiotic prophylaxis (IAP) for colonized individuals [4].

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Despite these measures, GBS remains a significant clinical concern worldwide. The global prevalence of maternal GBS colonization is estimated at approximately 18%, with regional variation ranging from 15.2% to 20.8% in Europe, 22% in North America, 11% in Asia, and 18.2% in Africa [5]. Vertical transmission occurs in nearly 50% of colonized mothers; however, invasive disease develops in only 1-2% of exposed neonates [4]. Transmission rates and disease burden vary across geographic regions, highlighting the importance of local epidemiological data.

Penicillin remains the first-line agent for the prevention and treatment of GBS infections, with sustained susceptibility reported globally. However, increasing resistance to alternative agents, particularly erythromycin and clindamycin, is of growing concern [6]. These antibiotics are commonly used in penicillin-allergic patients and, although chemically different, share overlapping mechanisms of action against Gram-positive organisms. Resistance to these antimicrobials can be expressed as resistance to 14- (erythromycin) and 15- (azithromycin) membered macrolides only (M phenotype), resistance to lincosamides (clindamycin) only (L phenotype), while cross-resistance to macrolides, lincosamides and streptogramin B, identified as MLS_B phenotype, can be constitutive ($cMLS_B$) or inducible ($iMLS_B$) [7]. Monitoring these resistance patterns is essential for guiding appropriate clinical management and prevention strategies for GBS infection.

Although screening and intrapartum antibiotic prophylaxis have significantly reduced early-onset GBS disease, the emergence of antimicrobial resistance and the limitations of antibiotic-based prevention strategies have prompted interest in alternative approaches, particularly maternal vaccination [8]. In this context, characterization of circulating GBS serotypes is critical for vaccine development and implementation.

GBS is classified into ten serotypes (Ia, Ib, II-IX) based on capsular polysaccharide composition [2,9]. Among these, serotypes Ia, Ib, II, III, and V account for the vast majority of isolates from colonized pregnant women and invasive neonatal disease [5,10]. Notably, certain serotypes, particularly serotype III, are associated with hypervirulent clones and increased disease severity [11,12].

In this study, we aimed to evaluate the prevalence, serotype distribution, and antimicrobial susceptibility profiles of *S. agalactiae* isolates obtained from pregnant women in Greece.

2. Materials and Methods

Specimen Collection and Processing

This study included 941 pregnant women screened for GBS colonization at 36 0/7 – 37 6/7 weeks of gestation between January 2021 and December 2025 in a maternity university hospital in Athens, Greece. All consecutive vaginal and rectal swab specimens collected from pregnant women presenting for GBS screening were evaluated in the clinical laboratory. Specimens were inoculated into Todd Hewitt broth supplemented with antibiotics (bioMerieux SA, Marcy-l'Etoile, France) and incubated at 37°C for 24 hours. Subcultures were performed on 5% sheep blood agar (Bioprepare, Keratea-Attiki, Greece) and chromogenic culture medium Liofilchem® Chromatic™ Strepto B (Liofilchem®, Roseto d'Abruzzi, Italy), followed by an additional 24-hour incubation.

GBS Identification and Antimicrobial Susceptibility Testing

Suspected colonies were identified as GBS based on colony morphology, Gram staining, catalase test, bile-esculin test and confirmed by CAMP test and with the rapid identification system I-dOne (Alifax S.r.l, Polverara, Italy) based on ATR-FTIR (Attenuated Total Reflection – Fourier Transform Infrared) spectroscopy. The definitive identification and antimicrobial susceptibility testing was carried out using the automated system VITEK2 (Biomerieux, Marcy l'Etoile, France).

Resistance to erythromycin and clindamycin was further tested with the standardized double-disk diffusion test (D-zone test) using erythromycin (15 μg) and clindamycin (2 μg) disks placed 12-15 mm apart edge to edge. Phenotypes were identified as: M when intermediate sensitivity or resistance to erythromycin and sensitivity to clindamycin was detected, L phenotype when intermediate sensitivity or resistance to clindamycin and sensitivity to erythromycin was observed,

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cMLSB (constitutive mechanism of resistance to macrolides, lincosamides and streptogramin B) phenotype when resistance to erythromycin and either resistance or intermediate sensitivity to clindamycin were determined and, finally, iMLSB (inducible resistance to macrolides, lincosamides and streptogramin B) phenotype when intermediate sensitivity or resistance to erythromycin and flattening of the zone of inhibition around clindamycin proximal to the erythromycin disk (D shape halo) was visible [7]. Reference strain *S. agalactiae* ATCC 13813 was used as control.

GBS Serotype Identification

Serotyping was performed with a latex agglutination assay targeting capsular polysaccharides (Immulex™ *Streptococcus*-B Kit (SSI Diagnostica A/S, Hillerød, Denmark). As reference strain and positive control the CultiControl™ *Streptococcus agalactiae* ATCC® 13813™ (Liofilchem srl, Roseto d'Abruzzi, Italy) was used.

Ethical Approvement

The study was approved by the Institutional Ethics Committee of Aretaieion University Hospital (no. 625/20-11-2024). Informed consent was waived as GBS testing was part of routine clinical care. All data were anonymized prior to analysis.

3. Results

3.1. Demographics and Maternal GBS Colonization Rate

A total of 941 pregnant women between 36 0/7 and 37 6/7 weeks of gestation, aged 22-45 years, were screened for GBS colonization during the study period. *S. agalactiae* was isolated from 118 women, corresponding to an overall colonization rate of 12.5%.

3.2. Serotype Distribution

The distribution of the 118 GBS isolates is shown in Figure 1. Serotype III was the most prevalent (35/118, 29.7%), followed by serotype V (22/118, 18.6%), Ib (17/118, 14.4%), IX (12/118, 10.2%), Ia (11/118, 9.3%), and II (11/118, 9.3%). Less frequently detected were serotypes IV (6/118, 5.1%), VI (3/118, 2.5%), and VIII (1/118, 0.9%). No isolates with unknown serotype were identified, while serotype VII was not detected.

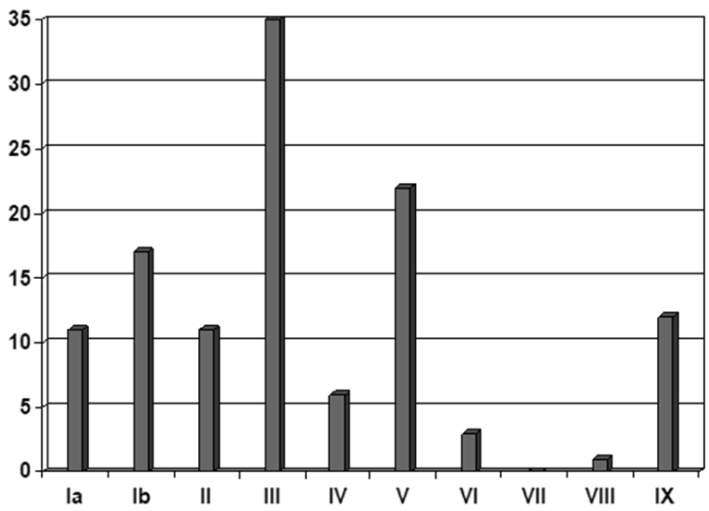

Figure 1. Serotype distribution (n) in 118 GBS strains isolated from pregnant women.

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3.3. Antimicrobial Susceptibility

All isolates were susceptible to penicillin and vancomycin. Resistance to erythromycin and clindamycin was observed in 29.7% and 22.9% of isolates, respectively, while resistance to tetracycline was markedly high (90.7%) (Table 1).

Among the 118 isolates, 37 (31.4%) exhibited resistance to erythromycin and/or clindamycin and were further characterized. The D-zone test revealed that 29 isolates (78.4%) expressed the constitutive MLSB (cMLSB) phenotype, 5 (13.5%) the inducible MLSB (iMLSB) phenotype, 2 (5.4%) the L phenotype, and 1 (2.7%) the M phenotype.

Co-resistance to erythromycin, clindamycin, and tetracycline was detected in 27 isolates (22.9%), primarily among those of serotypes III, followed by serotypes V, Ib, IX, II, and Ia (Table 1).

Table 1. Antimicrobial resistance among identified GBS serotypes.

Antibiotics	Ia (n=11)	Ib (n=17)	II (n=11)	III (n=35)	IV (n=6)	V (n=22)	VI (n=3)	VII (n=0)	VIII (n=1)	IX (n=12)	Total (n=118)
Penicillin	0	0	0	0	0	0	0	0	0	0	0 (0%)
Erythromycin	2	3	2	18	1	5	0	0	1	3	35 (29.7%)
Clindamycin	1	3	2	14	0	5	0	0	1	1	27 (22.9%)
Tetracycline	8	15	9	33	5	21	3	0	1	12	107 (90.7%)
Levofloxacin	0	0	0	2	0	1	0	0	0	0	3 (2.5%)
Vancomycin	0	0	0	0	0	0	0	0	0	0	0 (0%)

4. Discussion

In the present study, the maternal GBS colonization rate was 12.5%. This finding is consistent with previous reports from Greece, where colonization rates have ranged from 6.6% to 18.4% [13–15], as well as with data from south-western Greece (12%) [16]. Compared to global estimates, our rate is slightly lower than the overall prevalence of 18% reported in a large meta-analysis, which also highlighted regional variability, with Europe showing rates between 15.2% and 20.8% [5].

GBS serotyping is based on the capsular polysaccharide (CPS), a major virulence factor that facilitates immune evasion and persistence within the host [2,9,17]. To date, ten serotypes have been identified [18]. In our cohort, nine of the ten known serotypes were detected, with Ia, Ib, II, III, V, and IX being the most prevalent. This distribution aligns with global data, where serotypes Ia, Ib, II, III, and V account for approximately 98% of isolates [5], and are dominant in both Europe and North America [17].

Data on GBS serotype distribution in Greece remain limited. In our study, serotype III predominated, followed by V, Ib, IX, Ia, and II. This differs from earlier Greek reports in which serotype I was most common [13], suggesting temporal shifts in circulating strains. More recent findings from Greece and other countries support the predominance of serotype III [19–21], although geographic variation persists, as illustrated by the high prevalence of serotype V in Poland [22].

The predominance of serotype III is of particular concern due to its strong association with invasive neonatal disease. Serotypes I-V account for approximately 97% of invasive infections, with serotype III alone responsible for a substantial proportion of early- and late-onset disease, as well as the majority of meningitis cases [10,17,23,24]. In our study, nearly 30% of isolates belonged to serotype III, consistent with global trends [5], and this serotype was also associated with increased antimicrobial resistance.

Serotype IX, the most recently characterized serotype [9], was identified in 10.2% of isolates in our study. Although still underreported globally, similar rates have been described in London [21], while higher prevalence has been noted in Ghana and Sweden [25,26]. Its implication in severe infections, including ultra-late-onset sepsis, further highlights its clinical relevance [27].

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We did not detect serotype VII, while serotypes VI and VIII were rare. This pattern is consistent with reports from Europe and North America, where these serotypes account for less than 5% of isolates, in contrast to significantly higher rates reported in Africa [28–30].

Penicillin remains the first-line agent for GBS prophylaxis and treatment, with universal susceptibility reported over decades [4,6]. Our findings confirm continued susceptibility among all isolates, in agreement with previous studies from Greece [13,19]. Nevertheless, sporadic reports of reduced susceptibility underscore the need for ongoing surveillance [7,31].

In contrast, resistance to alternative agents, particularly macrolides and lincosamides, is increasing globally. In our study, resistance rates were 29.7% for erythromycin and 22.9% for clindamycin, reflecting a rising trend compared to earlier Greek data [13,19,32]. Similar variability has been reported internationally, with resistance rates differing widely across regions [22,28,33]. Phenotypic analysis revealed that the majority of resistant isolates exhibited the cMLSB phenotype, consistent with previous findings [19,22]. These trends limit the reliability of macrolides and lincosamides as alternative therapies and reinforce current recommendations favoring other agents such as cefazolin or vancomycin [4].

Tetracycline resistance was highly prevalent (90.6%), consistent with global reports and previous local data [19,22,28,33]. This resistance is well established and attributed to widespread dissemination of resistance genes, particularly tetM [6,7].

The emergence of multidrug-resistant (MDR) strains represents an additional concern. In our cohort, 22.9% of isolates were resistant to erythromycin, clindamycin, and tetracycline, predominantly among serotypes III and V. Comparable findings have been reported in Greece and elsewhere, although rates vary substantially [19,22].

The judicious use of intrapartum antimicrobial prophylaxis is essential to balance prevention of neonatal disease against the risk of promoting antimicrobial resistance. Accurate identification of colonized women, combined with susceptibility testing, is critical to guide appropriate therapy. Continuous epidemiological surveillance, including serotype distribution, is also essential for informing preventive strategies and supporting the development of effective vaccines [17].

This study has certain limitations. The relatively small sample size and single-center design may limit the generalizability of our findings. Larger, multicenter studies are needed to better characterize the epidemiology of GBS colonization, serotype dynamics, and resistance patterns in Greece.

5. Conclusions

GBS remains a significant colonizer of pregnant women worldwide, with notable geographic variability in prevalence and serotype distribution. In this study, the colonization rate was considerable, and serotype III was the predominant type, reinforcing its clinical importance due to its association with invasive neonatal disease. Increasing resistance to erythromycin and clindamycin observed in our isolates is consistent with global trends and raises concerns regarding the effectiveness of alternative therapies. These findings highlight the importance of continued surveillance of antimicrobial susceptibility patterns and adherence to current guidelines favoring penicillin where appropriate. Ongoing monitoring of circulating GBS strains is essential for optimizing prophylactic and therapeutic strategies. Furthermore, detailed knowledge of serotype distribution will be critical for the development and implementation of future serotype-specific vaccines.

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Informed Consent Statement: Informed consent was waived as GBS testing was part of routine clinical care in pregnant women.:

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

GBS	Group B *Streptococcus*
CAMP	Christie-Atkins-Munch-Petersen
ATR-FTIR	Attenuated Total Reflection-Fourier Transform Infrared spectroscopy
MLS_B	Macrolide-lincosamide-streptogramin B
MDR	Multidrug-resistant

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