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REVIEW ARTICLE

Clinical Risk Factors Associated With Late-Onset Invasive Group B Streptococcal Disease: Systematic Review and Meta-Analyses

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Background. Group B streptococcal (GBS) infection remains one of the most significant causes of late-onset sepsis and meningitis (LOGBS) among young infants. However, transmission routes and risk factors for LOGBS are not yet fully understood.

Methods. We conducted systematic reviews on clinical risk factors previously reported in the literature (prematurity, low birth weight [<2500 g], antenatal colonization, multiple-gestation pregnancy, maternal age <20 years, male infant sex, intrapartum fever, prolonged rupture of membranes) and meta-analyses to determine pooled estimates of risk.

Results. We included 27 articles, reporting 5315 cases. Prematurity (odds ratio [OR] 5.66; 95% confidence interval [CI]: 4.43–7.22), low birth weight (OR 6.73; 95% CI: 4.68–9.67), maternal colonization (2.67; [2.07–3.45]), and multiple-gestation pregnancies (OR 8.01; 95% CI: 5.19–12.38) were associated with an increased risk of LOGBS.

Conclusions. Prematurity/low birth weight and maternal colonization are major risk factors for LOGBS. Future GBS vaccine studies should try to establish the optimal time for vaccination during pregnancy to protect preterm infants.

Keywords. Group B *Streptococcus*; *Streptococcus agalactiae*; risk; neonatal sepsis.

Group B streptococcus (GBS) is the leading cause of sepsis and meningitis in neonates and young infants in most countries [1]. In 2015, it was estimated that there were at least 319 000 infants <90 days of age with invasive GBS disease (iGBS disease) worldwide, of whom 205 000 infants had early-onset Group B streptococcal disease (EOGBS, occurring in infants aged <7 days) and 114 000 late-onset Group B streptococcal disease (LOGBS, occurring in infants aged 7–89 days) [1]. A high proportion of LOGBS cases presents with meningitis that often results in neurodevelopmental impairment, further increasing the burden of iGBS disease [2, 3]. Despite intrapartum antibiotic prophylaxis (IAP) the incidence of LOGBS has not been reduced [2, 4] and is even rising in some countries [5–8]. Maternal GBS vaccination could be an effective method to prevent EOGBS and LOGBS [1]. However, compared to EOGBS, risk factors for LOGBS are less well understood and have not been systematically reviewed. Addressing this gap could help identify vaccine targetable risk factors and recognize the most vulnerable infants to inform GBS vaccine research priorities and policy decisions.

This study aimed to provide a comprehensive and systematic literature review and meta-analyses to assess the association between LOGBS and previously reported clinical and epidemiological risk factors.

METHODS

Search Strategy

The review protocol was registered with the PROSPERO database (Registration number CRD42021253749). We searched Medline, Embase, and Cochrane Library databases for studies published until 1 December 2020 with no language restrictions (full search available in Supplementary Table 1). We identified additional studies by searching the reference lists of included studies and reviews.

Study Selection and Data Collection

We included observational studies that reported risk factors for iGBS disease (case-control studies, retrospective and prospective cohort studies). The cohort studies were surveillance studies conducted to estimate the national or regional incidence of iGBS disease. Case reports, case series, and reviews were excluded. We included all previously reported clinical risk factors

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for LOGBS and EOGBS [9]. We included studies that reported LOGBS cases (7–89 days of age at the onset of infection episode) and excluded studies with a non-representative sample (eg, studies containing only very high-risk groups like preterm infants) or a non-appropriate comparison group (no denominator data for risk factors). We included only cases with GBS isolated from a normally sterile site (blood, cerebrospinal fluid [CSF], joint fluid, peritoneal fluid). The most comprehensive report was included if more than 1 study was published on the same patients.

Two review authors (K. K., H. D.) independently scanned the abstract, title, or both, of every record retrieved to determine which studies should be assessed further. We investigated all potentially relevant articles as full text and resolved any discrepancies through consensus. For studies that fulfilled eligibility criteria, 2 review authors (K. K., H. D.) independently abstracted key data on maternal colonization in pregnancy (defined as a positive vaginal, rectal, or rectovaginal swab by culture or polymerase chain reaction [PCR] on at least 1 occasion from 35 weeks of gestation until birth), maternal colonization at the time of LOGBS diagnosis, preterm birth (delivery at <37 weeks of gestation), low birth weight (LBW <2500 g), multiple-gestation pregnancy, maternal age <20 years, infant sex, human immunodeficiency virus (HIV) exposure, GBS detected in mother's breast milk at the time of LOGBS diagnosis, maternal intrapartum fever (temperature ≥38°C during labor), and prolonged rupture of membranes (PROM ≥18 hours before delivery). We used published aggregate data, not individual participant data. When the existing published data included cases isolated from non-sterile sites or with an age of onset ≥90 days, we contacted the original researchers to ask for a summary of cases that met our inclusion criteria. We collected data on the number of preterm births, LBW, multiple births, and sex ratio in the study population, either from the reports included in the articles or from the publicly available national statistics services and previously published systematic reviews that used these data sets [10–13]. For national surveillance studies, the number of live births for the whole population for that period was used as the denominator. For studies reporting cases from multi-site surveillance programs, regional data were used as the denominator. When population data were not available for the entire duration of the study, a midpoint year was used. Due to a lack of population-wide studies on maternal GBS colonization, we used the pooled estimates of GBS colonization prevalence by country from a systematic review conducted in 2015 [14].

Quality Assessment

Two review authors (K. K., M. M.) assessed the risk of bias of each included study independently by using a modified Newcastle-Ottawa scale (NOS) (Supplementary Table 2). We resolved any disagreements by consensus.

Statistical Analyses

We performed a meta-analysis to calculate weighted odds ratios (OR) with 95% confidence intervals (CIs) across studies and pooled risk of LOGBS for the following parameters: (i) preterm birth, (ii) GBS colonization in pregnancy, (iii) LBW, (iv) multiple-gestation pregnancy, (v) maternal age <20 years, (vi) intrapartum fever, (vii) PROM, and (viii) infant sex. Data on HIV exposure were collected, but the synthesis of these data has recently been done [15]. Data about the other clinical risk factors (maternal colonization and isolation of GBS in breast milk at the time of LOGBS diagnosis) were disparate and could not be pooled. We summarized data with a random-effects model, using the Mantel-Haenszel method and the DerSimonian-Laird approach to estimate the variance of the distribution of true effect sizes (τ^2). We assessed between-study heterogeneity by using the I^2 statistic. Heterogeneity was further explored with subgroup analyses and meta-regression for variables where an association with a higher risk of LOGBS was found. We compared studies based on the study design, World Health Organization (WHO) regions, high-income countries (HIC) versus low- and middle-income countries (LMIC), presence versus absence of IAP policy, length of study, and year of publication. The subgroup pooled estimates were calculated with a mixed-effect model, without a common estimate of τ^2 across subgroups [16]. Meta-regression was performed using a mixed-effect model with continuous and categorical moderators [16]. The R^2 index was used to quantify the percentage of variation explained by the model [16]. Sensitivity analyses were performed to explore the influence of excluding studies that used a different definition of LOGBS (7–179 days of age) or studies that only reported sepsis or meningitis cases. We assessed publication bias by using funnel plots for analyses with more than 9 included studies and tested for funnel plot asymmetry using Egger's test. We considered Egger test *P*-value less than .05 to implicate publication bias [17]. Statistical analyses were done with R studio (version 3.6.3) using the packages "meta," "metafor," and "dmetar" [16].

RESULTS

Study Selection

From a total of 14 468 articles identified through the literature search, we assessed 104 full manuscripts and identified 27 articles that met the inclusion criteria [2, 3, 5, 6, 18–40] (Figure 1).

Study Characteristics

We included 27 studies with a total of 5315 cases of LOGBS among 30 487 773 live births. The median incidence of LOGBS was 0.21 cases/1000 live births (range 0.06–1.18). Of the included studies, 13 (48%) were prospective cohort studies, 9 (33%) retrospective cohort studies, and 5 (19%) case-control studies (Table 1 and Supplementary Table 3).

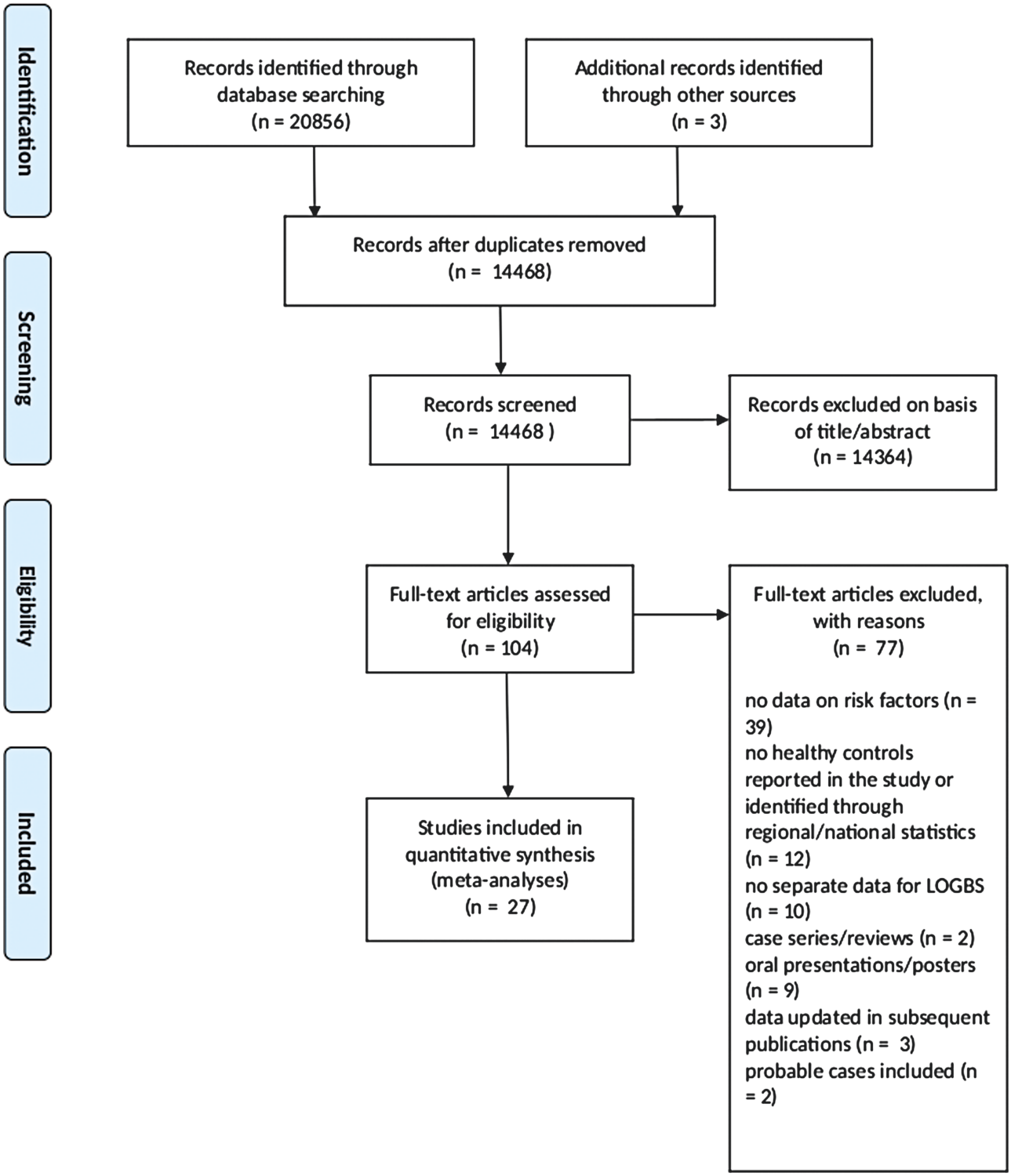

Figure 1. Data search and included studies for risk factor for LOGBS. Abbreviation: LOGBS, late-onset group B streptococcal disease.

Thirteen (48%) articles were from Europe, 6 (22%) from the Western Pacific region, 5 (19%) from North America, and 3 (11%) from Sub-Saharan Africa. Quality was moderate to high (defined as NOS score >5) for all the included studies (Supplementary Table 4).

Outputs From Meta-analyses

The OR of LOGBS in preterm infants compared to those born ≥ 37 weeks was 5.66 (95% CI: 4.43–7.22), with considerable heterogeneity among the 22 studies included (I2: 92%) (Figure 2). An additional analysis was performed

Table 1. Characteristics of Included Studies

Reference	Country	Start of Data Collection	End of Data Collection	Income	Region	Design	Setting	IAP Policy	Definition LOGBS	LOGBS clinical entity	Capture of Cases
Berardi et al 2013 [18]	Italy	2003.01	2010.12	HIC	Europe	Prospective cohort	Multi-centre	Both	>6 days <90 days	Both	CRC
Dangor et al 2015 [3]	South Africa	2012.11	2014.02	LMIC	Africa	Case control	Multi-centre	Risk based	>6 days <90 days	Both	NA
Dangor et al 2016 [19]	South Africa	2005	2014	LMIC	Africa	Prospective cohort	Single centre	Risk based	>6 days <90 days	Both	CRC
Fluegge 2006 [20]	Germany	2001.04	2003.03	HIC	Europe	Prospective cohort	National surveillance	Both	>6 days <90 days	Both	CRC
Frigati et al 2015 [21]	South Africa	2010.01	2011.12	LMIC	Africa	Retrospective cohort	Multi-centre	Risk based	>6 days <90 days	Both	LS
Giannoni et al 2016 [22]	Switzerland	2011.09	2015.02	HIC	Europe	Prospective cohort	Multi-centre	Universal screening	>6 days <90 days	Only LOS	LS
Guan et al 2018 [23]	China	2011.01	2014.12	HIC	Western Pacific	Retrospective cohort	Multi-centre	No	>6 days <90 days	Both	LS
Heath et al 2004 [24]	UK	2000.02	2001.02	HIC	Europe	Prospective cohort	National surveillance	No	>6 days <90 days	Both	CRC
Ireland et al 2014 [25]	Australia	2002.01	2011.12	HIC	Western Pacific	Case control	Multi-centre	Policy changed during study	>2 days <90 days	Both	NA
Jordan et al 2008 [26]	USA	2003	2005	HIC	Americas	Prospective cohort	Multi-centre	Universal screening	>6 days <90 days	Both	LS
Joubrel et al 2015 [27]	France	2007.01	2012.12	HIC	Europe	Prospective cohort	National surveillance	Both	>6 days <90 days	Both	LS
Juncosa-Morros et al 2014 [28]	Spain	1996	2010	HIC	Europe	Retrospective cohort	Multi-centre	Policy changed during study	>6 days <90 days	Both	LS
Ko et al 2015 [29]	Australia	2005.07	2008.06	HIC	Western Pacific	Prospective cohort	National surveillance	Risk based	>6 days <90 days	Both	CRC
Lin et al 2003 [30]	USA	1995.07	2000.06	HIC	Americas	Case control	Multi-centre	Risk based	>6 days <180 days	Both	NA
Matsubara et al 2013 [31]	Japan	2004.01	2010.12	HIC	Western Pacific	Retrospective cohort	Multi-centre	Policy changed during study	>6 days <90 days	Both	CS
Matsubara et al 2017 [32]	Japan	2011.01	2015.12	HIC	Western Pacific	Retrospective cohort	Multi-centre	Policy changed during study	>6 days <90 days	Both	CS
Mynarek et al 2021 [33]	Norway	1996	2012	HIC	Europe	Retrospective cohort	National surveillance	Risk based	>6 days <90 days	Both	CRC
Nanduri et al 2019 [2]	USA	2006	2015	HIC	Americas	Prospective cohort	Multi-centre	Universal screening	>6 days <90 days	Both	LS
Neto 2007 [34]	Portugal	2001.04	2005.03	HIC	Europe	Prospective cohort	National surveillance	Policy changed during study	>6 days <90 days	Both	CS
O'Sullivan et al 2019 [5]	UKROI	2014.04	2015.04	HIC	Europe	Prospective cohort	National surveillance	Risk based	>6 days <90 days	Both	CRC
Óladóttir et al 2011 [35]	Iceland	1975	2006	HIC	Europe	Retrospective cohort	National surveillance	Policy changed during study	>6 days <90 days	Both	LS
Pintye et al 2016 [36]	USA	1992.00	2011.00	HIC	Americas	Case control	Multi-centre	Policy changed during study	>6 days <90 days	Both	NA

Table 1. Continued

Reference	Country	Start of Data Collection	End of Data Collection	Income	Region	Design	Setting	IAP Policy	Definition LOGBS	LOGBS clinical entity	Capture of Cases
Romain et al 2018 [6]	France	2001.01	2014.12	HIC	Europe	Prospective cohort	National surveillance	Both	>6 days <90 days	Only Men-ingitis	CRC
Schuchat et al 1990 [37]	USA	1982.01	1983.12	HIC	Americas	Retrospective cohort	Multi-centre	No	>6 days <180 days	Both	LS
Trijbels-Smeulders et al 2007 [38]	Netherlands	1997	2001.	HIC	Europe	Prospective cohort	National surveillance	Policy changed during study	>6 days <90 days	Both	CRC
Vergadi et al 2018 [39]	Greece	1995.01	2016.12	HIC	Europe	Retrospective cohort	Multi-centre	No	>6 days <90 days	Both	LS
Ying et al 2019 [40]	China	2011.01	2016.12	HIC	Western Pacific	Case control	Single centre	No	>6 days <90 days	Both	NA

Abbreviations: CS, clinical surveillance; CRC, Capture-Recapture; HIC, high income country; IAP, intrapartum antibiotic prophylaxis; LMIC, low-middle income country; LOGBS, late-onset group B streptococcal disease; LOS, late-onset sepsis; LS, laboratory surveillance; NA, not applicable; USA, United States of America; UK, United Kingdom; UKROI, United Kingdom and Republic of Ireland.

using birth <34 weeks as a cutoff when data were available. The OR of LOGBS for infants born <34 weeks compared to those born ≥ 34 weeks was 19.70 (95% CI: 15.25–25.45) among 3 studies included (I2: 0%) (Supplementary Figure 1). The OR of LOGBS in all infants with LBW compared to birth weight >2500*g* was 6.73 (95% CI: 4.68–9.67) with considerable heterogeneity among fourteen studies included (I2: 95%) (Figure 3). The OR of LOGBS in all infants born to mothers colonized with GBS antenatally compared to those born to mothers not colonized with GBS was 2.67 (95% CI: 2.07–3.45), with substantial heterogeneity among 12 studies included (I2: 66%) (Figure 4). The OR of LOGBS in multiple births compared to singletons was 8.01 (95% CI: 5.19–12.38), with considerable heterogeneity among ten studies included (I2: 72%) (Figure 5).

PROM and intrapartum fever were not associated with an increased risk of LOGBS. The OR was 1.49 (95% CI: .94–2.36) and 1.06 (95% CI: .14–8.18), respectively (Supplementary Figures 2 and 3). There was no difference in risk of LOGBS between male and female infants (OR: 1.02 [95% CI: .92–1.13]; I2: 20%) (Supplementary Figure 4). Similarly, maternal age <20 years was not associated with an increased risk of LOGBS (OR: 1.86 [95% CI: .74–4.68]; I2: 78%) (Supplementary Figure 5).

Subgroup Analyses and Meta-regression

For prematurity and LBW, studies from Africa/LMIC had lower pooled estimates than the other geographic areas and HIC (Supplementary Table 5). Also, single-center studies had lower pooled estimates than multi-center or national studies, whereas comparison according to study design and IAP policy showed no significant difference (Supplementary Table 5). A meta-regression analysis showed that WHO region, classification of countries based on economic resources and classification of the studies based on the number of participating sites, accounted for a small to moderate proportion of heterogeneity for prematurity (R^2: 46%, 59%, 52%, respectively); and LBW (R^2: 35%, 30%, 64%), but none for colonization (R^2: 0%, 4%, 0%) and multiple gestations (R^2: 0%). A meta-regression analysis with publication year, duration of the study and NOS score as continuous predictors showed that these factors did not influence the studies' effect size for any risk factor (R^2: 0%).

Sensitivity Analyses

When we excluded studies that reported cases up to 6 months of age (very-late-onset GBS disease), the OR was similar to the primary analysis for prematurity (OR: 5.90 [95% CI: 4.58–7.60]), LBW (OR: 7.07 [95% CI: 4.88–10.24]), antenatal colonization (OR: 2.65 [95% CI: 2.02–3.48]), multiple gestation pregnancies (OR: 8.12 [95% CI: 5.07–12.99]), PROM (OR: 1.32 [95% CI: .82–2.12]), intrapartum fever

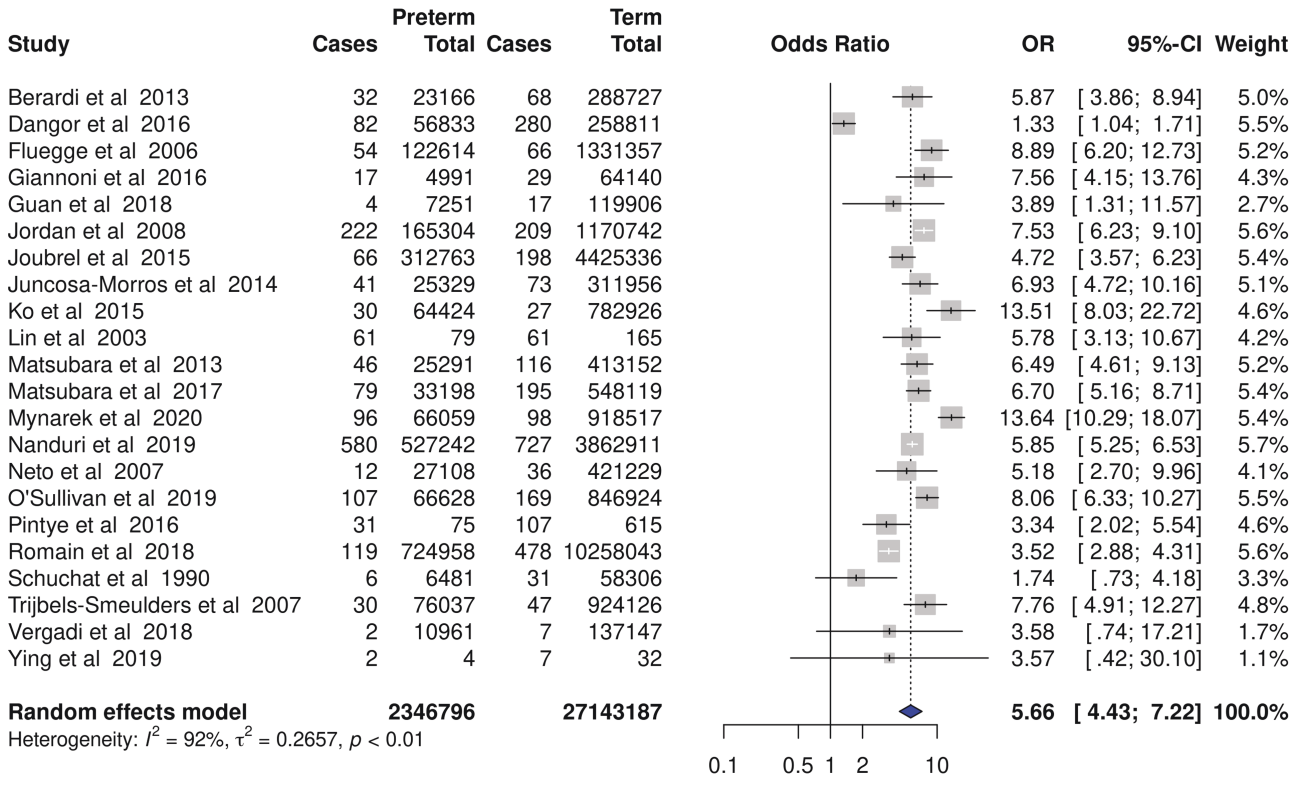

Figure 2. Forest plot of meta-analysis of risk of LOGBS for prematurity. Abbreviations: CI, confidence interval; LOGBS, late-onset group B streptococcal disease.

(OR: 1.77 [95% CI: .09–34.65]), infant sex (OR: 1.01 [95% CI: .91–1.12]), and maternal age (OR: 1.29 [95% CI: .33–4.98]). Similarly, when we excluded studies that only reported sepsis or meningitis cases, the pooled estimate did not differ from the primary analysis for prematurity (OR: 5.74 [95% CI: 4.42–7.45]), maternal colonization (OR: 2.60 [95% CI: 1.94–3.49]), and infant sex (OR: 1.05 [95% CI: .94–1.17]). For the rest, primary analyses did not include studies only reporting sepsis or meningitis; therefore, sensitivity analyses were not needed.

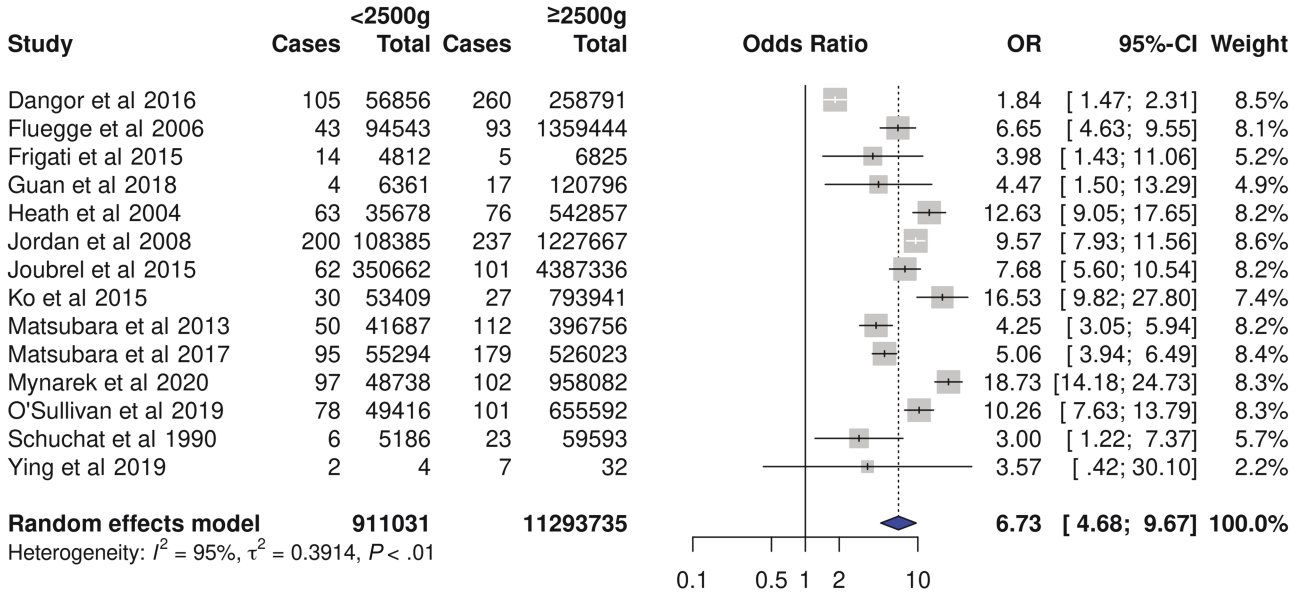

Figure 3. Forest plot of meta-analysis of risk of LOGBS for LBW. Abbreviations: CI, confidence interval; LBW, low birth weight; LOGBS, late-onset Group B streptococcal disease.

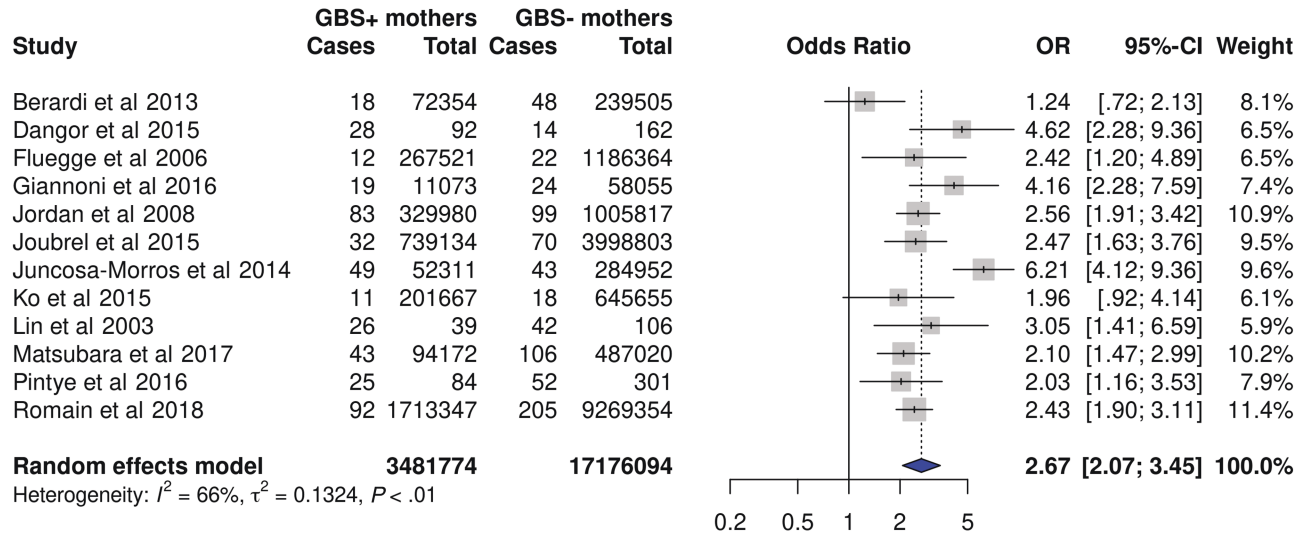

Figure 4. Forest plot of meta-analysis of risk of LOGBS for antenatal GBS colonization. Abbreviations: CI, confidence interval; GBS, Group B *Streptococcus*; LOGBS, late-onset group B streptococcal disease.

Assessment of Reporting Biases

Eggers' test did not indicate the presence of funnel plot asymmetry for prematurity, LBW, colonization, multiple-gestation pregnancies, and infant sex (Supplementary Figure 6).

DISCUSSION

This systematic review and meta-analyses show that the risk of LOGBS is higher in preterm and LBW infants, infants born to mothers colonized with GBS in pregnancy, and multiple gestation pregnancies. Our findings are consistent with previous reviews that identified prematurity and maternal GBS colonization as risk factors for EOGBS [41]. In contrast, we did not demonstrate any association between LOGBS and other intrapartum risk factors, such as maternal fever and PROM [41], confirming that intra-amniotic infection does not have any connection to LOGBS.

Premature and LBW infants are known to have increased susceptibility to infections due to immature immune responses, low placental antibody transfer, increased gut permeability, and the risk of nosocomial transmission during their prolonged hospitalization. Prematurity is also characterized by disturbances of microbiome development associated with frequent use of antibiotics, formula feeding and reduced contact with the maternal microbiome that might disturb the adaptation of GBS to its neonatal host environment [42]. Our sub-analysis of LOGBS risk in infants <34 weeks showed that very preterm infants are at higher risk. This is in keeping with the previous finding of increasing risk for each week of decreasing gestation [30].

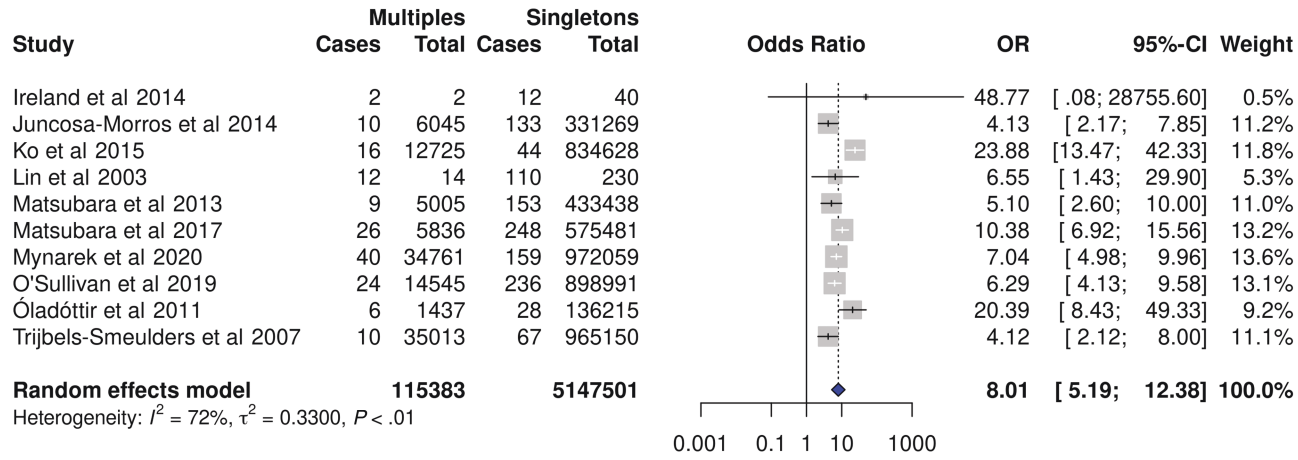

Figure 5. Forest plot of meta-analysis of risk of LOGBS for multiple gestation pregnancies. Abbreviations: CI, confidence interval; LOGBS, late-onset group B streptococcal disease.

In addition, our results suggest a strong association between LOGBS and maternal colonization during pregnancy. Because GBS screening results were only recorded in mothers who reached 35 weeks of pregnancy, prematurity is unlikely to have accounted for the effect of maternal GBS colonization on LOGBS risk. The transmission routes underpinning this observation, however, are not fully understood. The time infants get colonized with GBS is highly variable. Longitudinal colonization studies of mother-infant pairs showed that approximately 20–25% of infants born to mothers colonized with GBS became colonized with the same strain by 2 months of age, despite adequate IAP, and negative GBS screening at birth [43]. It seems that GBS can persist at mucosal surfaces even after adequate therapy and cause delayed infant acquisition through nursing (eg, via contaminated hands) and possibly breastfeeding, although the latter remains controversial [44]. It is important to note that only a small proportion of colonized infants will develop iGBS disease. There are likely other virulence factors (eg, adhesins) and host defenses (eg, anti-capsular polysaccharide-specific antibodies) that may modify the risk of LOGBS in the presence of maternal GBS colonization [45].

In contrast, the association of multiple-gestation pregnancies with increased risk of LOGBS is likely confounded by prematurity and LBW, although we could not adequately test this due to the use of aggregate data for this review. However, a previous review of the clinical risk factors of EOGBS showed that multiple-gestation pregnancies are not an independent risk factor, with LBW accounting for the excess risk in twins [41]. It is important to note that we compared rates of LOGBS in multiple-gestation pregnancies and singletons. Due to the use of aggregate data, we did not assess the risk of LOGBS for an infant with a twin sibling with iGBS disease (EOGBS or LOGBS), which is known to be significantly raised, since the multiples have the same mother, thus the same potential exposure to GBS colonization either vertically or horizontally [46].

Our findings might have important implications for designing GBS vaccine trials. A vaccine administered during pregnancy could substantially reduce the LOGBS disease burden through passively transferred antibodies [1]. However, to do so would require the persistence of protective concentrations of antibodies in infants until at least 3 months of age. Given that three-quarters of LOGBS cases occur within the first 8 weeks (median 34 days, interquartile range: 20–49 days) [2], it is plausible that vaccine-induced antibodies with a half-life between 39 and 46 days [47] would protect most infants. However, optimal transfer (and persistence) of antibodies may be a particular challenge for protecting preterm/LBW infants who are at high risk of both EOGBS and LOGBS. This is because the placental transfer of immunoglobulin G (IgG) antibody is optimal in the third trimester of pregnancy so that infants born prematurely may not have had a chance to receive protective concentrations. This will, however, be strongly influenced by the timing of vaccination during pregnancy. Several recent studies on maternal vaccination against pertussis support the efficacy of early vaccination in protecting preterm infants. Kent et al showed that preterm infants whose mothers were immunized from 28 weeks had higher antibody concentrations compared to preterm infants born to unvaccinated mothers [48]. Eberhardt et al reported higher antibody concentrations in both term and preterm infants when mothers were vaccinated in the second compared to third trimester [49]. Also, vaccine effectiveness data from the United Kingdom suggested that extending the vaccination window down to 16 weeks gestation reduced hospitalized pertussis cases in preterm infants [50]. Therefore, studies seeking to define the optimal window for GBS vaccination to protect preterm and term infants should be prioritized.

This study has some limitations. First, under-ascertainment of cases is a common problem with invasive infant disease incidence studies [1]. However, many of the included surveillance studies mitigated the problem of under-reporting by using Capture-Recapture methods to ascertain cases, where both reference laboratories and clinical surveillance data were used (Table 1). Second, most studies were from HIC; therefore, the estimated risks might not be generalizable. Subgroup analyses suggested that the OR for prematurity and LBW were lower in LMIC. This difference was driven by higher rates of LOGBS among term infants compared to HIC, whereas the incidence of disease among preterm/LBW infants was similar in LMIC and HIC. This might be explained by comorbidities such as exposure to HIV, or other clinical risk factors in early life that have not been captured in this review (eg, malnutrition). Third, we could not adjust for multiple risk factors since we used aggregate data. Although 3 case-control studies reported adjusted OR for different sets of covariates [30, 36, 37], we used the unadjusted OR from these studies to compare the effect sizes across all studies. Therefore, the pooled estimates are subject to possible confounding due to other factors influencing LOGBS risk. For the same reasons, it was not possible to assess the relationship between the risk of LOGBS and gestation or birth weight as continuous variables. Instead, we did a sub-analysis using a cutoff of 34 weeks that showed a higher risk in more preterm infants. We chose this threshold because it was the most common subgroup of preterm infants reported in the included studies. Limited availability of national or regional data on the prevalence of very preterm (28–32 weeks) or extremely preterm (<28 weeks) infants did not allow for further comparisons. Similarly, there were insufficient data available to perform a sub-analysis for very low birth weight (VLBW <1500*g*) or extremely low birth weight (ELBW <1000*g*) infants. Fourth, subgroup analyses and meta-regression did not provide a convincing explanation for the observed variation between the results of the studies. Finally, we did not identify enough eligible studies to estimate the risk of horizontal transmission through breast milk or non-maternal caregivers. Aside from vertical

transmission risks, evidence regarding horizontal transmission risk factors to inform preventive strategies is currently limited.

CONCLUSION

Overall, our study shows that prematurity/low birth weight and maternal colonization with GBS are major risk factors for LOGBS. To fully understand and ultimately prevent LOGBS, we need (i) well-conducted colonization studies that use genome sequencing and include breast milk samples and specimens from other family members (not restricted to mothers), (ii) mechanistic studies of the role of virulent strains in driving LOGBS, and (iii) globally collaborative sero-epidemiological studies of the role of maternally derived antibodies in protecting infants from GBS acquisition and LOGBS. Answering these questions would be key to developing novel strategies to control LOGBS.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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Dovato
dolutegravir/lamivudine

EVIDENCE SUPPORTS THE HIGH BARRIER TO RESISTANCE OF DOVATO UP TO 5 YEARS[1-3]

CONFIDENCE IN DOVATO ACROSS TREATMENT SETTINGS[4–9]

Treatment-naïve resistance rates, with up to **3 years of evidence**[5–7]

0% (n=0/1,885)*,[4] **REAL-WORLD EVIDENCE**

0.1% (n=1/953)**,†,‡,§,5–7 **RANDOMISED CONTROLLED TRIALS**

Treatment-experienced resistance rates, with up to **5 years of evidence**[1–3]

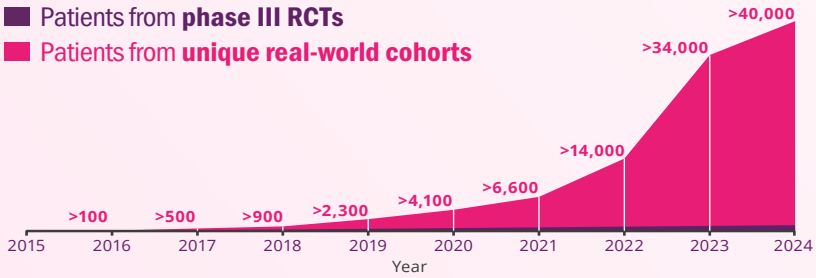
0.03% (n=10/35,888)*,[4] **REAL-WORLD EVIDENCE**

0% (n=0/615)||,¶,#,8,9 **RANDOMISED CONTROLLED TRIALS**

>300,000 PEOPLE LIVING WITH HIV HAVE BEEN TREATED WITH DOVATO GLOBALLY[10]

DOVATO is supported by a wealth of evidence, with the outcomes of **>40,000** people living with HIV captured within clinical trials and real-world evidence, including those with:[4–9,11,12]

- **NO PRIOR TREATMENT EXPERIENCE**[13]
- **NO BASELINE RESISTANCE TESTING**[13]
- **HIGH BASELINE VIRAL LOAD** (>100,000 copies/mL and even >1M copies/mL)[6,13]
- **LOW CD4 + COUNT** (≤200 cells/mm³)[13]



IS IT TIME TO RECONSIDER THE VALUE OF THE 2ND NRTI?

LEARN MORE

DOVATO is indicated for the treatment of Human Immunodeficiency Virus type 1 (HIV-1) infection in adults and adolescents above 12 years of age weighing at least 40 kg, with no known or suspected resistance to the integrase inhibitor class, or lamivudine.[13]

Adverse events should be reported. Reporting forms and information can be found at **https://yellowcard.mhra.gov.uk/** or search for MHRA Yellowcard in the Google Play or Apple App store. Adverse events should also be reported to GSK on 0800 221441

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ABBREVIATIONS

3TC, lamivudine; **CD4,** cluster of differentiation 4; **DTG,** dolutegravir; **FDA,** United States Food and Drug Administration; **FTC,** emtricitabine; **HIV,** human immunodeficiency virus; **ITT-E,** intention-to-treat exposed; **NRTI,** nucleoside/nucleotide reverse transcriptase inhibitor; **RCT,** randomised controlled trial; **RNA,** ribonucleic acid; **TAF,** tenofovir alafenamide fumarate; **TDF,** tenofovir disoproxil fumarate; **XTC,** emtricitabine.

FOOTNOTES

*Data extracted from a systematic literature review of DTG+3TC real-world evidence. Overlap between cohorts cannot be fully excluded.

**The reported rate reflects the sum-total of resistance cases calculated from GEMINI I and II (n=1/716, through 144 weeks), STAT (n=0/131, through 52 weeks), and D2ARLING (n=0/106, through 24 weeks).[5–7]

†GEMINI I and II are two identical 148-week, phase III, randomised, double-blind, multicentre, parallel-group, non-inferiority, controlled clinical trials testing the efficacy of DTG/3TC in treatment-naïve patients. Participants with screening HIV-1 RNA ≤500,000 copies/mL were randomised 1:1 to once-daily DTG/3TC (n=716, pooled) or DTG + TDF/FTC (n=717, pooled). The primary endpoint of each GEMINI study was the proportion of participants with plasma HIV-1 RNA <50 copies/mL at Week 48 (ITT-E population, snapshot algorithm).[13]

‡STAT is a phase IIIb, open-label, 48-week, single-arm pilot study evaluating the feasibility, efficacy, and safety of DTG/3TC in 131 newly diagnosed HIV-1 infected adults as a first line regimen. The primary endpoint was the proportion of participants with plasma HIV-1 RNA <50 copies/mL at Week 24.[6]

§D2ARLING is a randomised, open-label, phase IV study designed to assess the efficacy and safety of DTG/3TC in treatment-naïve people with HIV with no available baseline HIV-1 resistance testing. Participants were randomised in a 1:1 ratio to receive DTG/3TC (n=106) or DTG + TDF/XTC (n=108). The primary endpoint was the proportion of participants with plasma HIV-1 RNA <50 copies/mL at Week 48.[7] Results at week 24 of the study.

||The reported rate reflects the sum-total of resistance cases calculated from TANGO (n=0/369, through 196 weeks) and SALSA (n=0/246, through 48 weeks).[8,9]

¶TANGO is a randomised, open-label, trial testing the efficacy of DOVATO in virologically suppressed patients. Participants were randomised in a 1:1 ratio to receive DOVATO (n=369) or continue with TAF-containing regimens (n=372) for up to 200 weeks. At Week 148, 298 of those on TAF-based regimens switched to DOVATO. The primary efficacy endpoint was the proportion of subjects with plasma HIV-1 RNA ≥50 copies/mL (virologic non-response) as per the FDA Snapshot category at Week 48 (adjusted for randomisation stratification factor).[8,13]

#SALSA is a phase III, randomised, open-label, non-inferiority clinical trial evaluating the efficacy and safety of switching to DTG/3TC compared with continuing current antiretroviral regimens in virologically suppressed adults with HIV. Eligible participants were randomised 1:1 to switch to once-daily DTG/3TC (n=246) or continue current antiretroviral regimens (n=247). The primary endpoint was the proportion of subjects with plasma HIV-1 RNA ≥50 copies/mL at Week 48 (ITT-E population, snapshot algorithm).[9]

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