

The use of bubble charts in analyzing the global second-stage cesarean delivery rates: a systematic review



Lin Tai Linus Lee, MRCOG; Christopher Pak Hey Chiu, MRCOG; Man Kee Teresa Ma, MRCOG; Lee Ting Kwong, MRCOG; Man Wai Catherine Hung, MRCOG; Yuen Yee Yannie Chan, MRCOG; Eunice Joanna Wong, MBBS; Theodora Hei Tung Lai, MRCOG; Oi Ka Chan, MSc; Po Lam So, MMedSc; Wai Lam Lau, FRCOG; Tak Yeung Leung, MD; On behalf of the Hong Kong College of Obstetricians and Gynaecologists Research Group

OBJECTIVE: This study aimed to systematically review the worldwide second-stage cesarean delivery rate concerning pre-second-stage cesarean delivery and assisted vaginal birth rates.

DATA SOURCES: PubMed, Medline Ovid, EBSCOhost, Embase, Scopus, and Google Scholar were queried from inception to February 2023, with the following terms: “full dilatation,” “second stage,” and “cesarean,” with their word variations. Furthermore, an additional cohort of 353,434 cases from our recently published study was included.

STUDY ELIGIBILITY CRITERIA: Only original studies that provided sufficient information on the number of pre-second-stage cesarean deliveries, second-stage cesarean deliveries, and vaginal births were included for the calculation of different modes of delivery. Systemic reviews, meta-analyses, or case reports were excluded.

METHODS: Study identification and data extraction were independently performed by 2 authors. Selected studies were categorized on the basis of parity, study period, and geographic regions for comparison.

RESULTS: A total of 25 studies were included. The overall pre-second-stage cesarean delivery rate, the second-stage cesarean delivery rate, and the second-stage cesarean delivery—to—assisted vaginal birth ratio were 17.94%, 2.65%, and 0.19, respectively. Only 5 studies described singleton, term, cephalic presenting pregnancies of nulliparous women, and their second-stage cesarean delivery rates were significantly higher than those studies with cohorts of all parity groups (4.50% vs 0.83%; $P < .05$). In addition, the second-stage cesarean delivery rate showed a secular increase across 2009 (0.70% vs 1.05%; $P < .05$). Moreover, it was the highest among African studies (5.14%) but the lowest among studies from East Asia and South Asia (0.94%). The distributions of second-stage cesarean delivery rates of individual studies and subgroups were shown with that of pre-second-stage cesarean delivery and assisted vaginal birth using the bubble chart.

CONCLUSION: The overall worldwide pre-second-stage cesarean delivery rate was 17.94%, the second-stage cesarean delivery rate was 2.65%, and the second-stage cesarean delivery—to—assisted vaginal birth ratio was 0.19. The African studies had the highest second-stage cesarean delivery rate (5.14%) and second-stage cesarean delivery—to—assisted vaginal birth ratio (1.88), whereas the studies from East Asia and South Asia were opposite (0.94% and 0.11, respectively).

Key words: cesarean delivery, full dilatation, second stage

From the Department of Obstetrics and Gynaecology, Pamela Youde Nethersole Eastern Hospital, Chai Wan, Hong Kong (Dr Lee); Department of Obstetrics and Gynaecology, The Chinese University of Hong Kong, Shatin, Hong Kong (Dr Chiu, Ms Chan, and Prof Leung); Department of Obstetrics and Gynaecology, Queen Elizabeth Hospital, Yau Ma Tei, Hong Kong (Dr Ma); Department of Obstetrics and Gynaecology, Tuen Mun Hospital, Tuen Mun, Hong Kong (Drs Kwong and So); Department of Obstetrics and Gynaecology, Kwong Wah Hospital, Kowloon, Hong Kong (Drs Hung and Lau); Department of Obstetrics and Gynaecology, Princess Margaret Hospital, Lai Chi Kok, Hong Kong (Dr Chan); Department of Obstetrics and Gynaecology, United Christian Hospital, Kwun Tong, Hong Kong (Dr Wong); Department of Obstetrics and Gynaecology, Queen Mary Hospital, Pok Fu Lam, Hong Kong (Dr Lai)

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This study (identification number: CRD42022380627) was registered on the International Prospective Register of Systematic Reviews on December 12, 2022.

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Corresponding author: Tak Yeung Leung, MD. tyeung@cuhk.edu.hk

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AJOG Global Reports at a Glance

Why was this study conducted?

The incidence of second-stage cesarean delivery (ssCD) rate has been increasing worldwide. However, it is influenced by the cesarean delivery (CD) rate performed before the second stage of labor and the assisted vaginal birth (AVB) rate. Hence, we conducted a systematic review and applied the bubble charts to compare the global ssCD rate concerning the other modes of birth.

Key findings

Among the 25 studies identified, the overall pre-ssCD (pssCD) rate was 17.94%, the ssCD rate was 2.65%, and the ssCD-to-AVB ratio was 0.19. The nulliparous women were at a higher risk of ssCD (4.50%). The African studies showed higher ssCD rates (5.14%) and ssCD-to-AVB ratios (1.88), whereas the studies from East Asia and South Asia showed the opposite (0.94% and 0.11, respectively).

What does this add to what is known?

There are significant differences in the incidence of ssCD among geographic regions, and their relationships with their corresponding pssCD rates and AVB rates are differentiated with the bubble chart.

Introduction

According to a recent World Health Organization report, the cesarean delivery (CD) rate tripled from approximately 7% in 1990 to 21% in 2018.¹ In particular, the increasing trend in the second-stage CD (ssCD) rate has become a medical and legal concern.^{2–5} Most ssCDs are indicated for term, cephalic presenting pregnancies, in which instrumental delivery has failed or is anticipated to be difficult. Although a difficult assisted vaginal birth (AVB) may cause significant neonatal complications, such as subgaleal hemorrhage, and maternal complications, such as postpartum hemorrhage and pelvic floor injury,^{6–9} ssCD for a deeply engaged fetal head is also associated with a higher rate of maternal complications, such as urinary bladder injuries, uterine tear, and postpartum hemorrhage,^{10–12} and neonatal complications, such as neonatal skull fracture and intracranial bleeding.^{13–15} Furthermore, as it takes time to arrange ssCD, a delay in childbirth may also increase the risk of neonatal hypoxic-ischemic encephalopathy, especially when there is coexisting fetal distress.^{10,12,16,17} Moreover, recent studies suggest that ssCD is associated with a higher rate of preterm birth in subsequent

pregnancies.^{18,19} Hence, the decision on the mode of delivery during a complicated second stage of labor poses a great challenge to obstetricians. Whichever mode of delivery is chosen, any consequent poor perinatal outcome may also lead to litigation.⁵

On one hand, obstetricians want to prevent a potentially complicated instrumental vaginal birth,^{20–22} and on the other hand, it is also important to avoid an unnecessary but high-risk ssCD. However, the best way to present and interpret the figure and the optimal ssCD rate remains to be determined,²³ as it is influenced by multiple factors, such as parity, gestational age, fetal presentation, number of fetuses, and the obstetrical practice of a unit. The simplest way to express the ssCD rate is as a proportion of the total number of births. However, comparing such figures between different units may be misleading, as 1 unit may have a lower threshold of performing elective CD (eICD) or emergency CD (emCD) before reaching the second stage of labor (which collectively is grouped as pre-ssCD [pssCD]), so that the proportion of ssCD may be lower. In contrast, the ssCD rate may be high if a unit has a preference for ssCD instead of attempting instrumental vaginal birth. Hence, the ssCD rate should be interpreted in light of the pssCD rate and the

AVB rate.²⁴ Recently, we have demonstrated that the relationship of the 3 modes of birth can be more clearly illustrated using bubble charts.^{24,25} By plotting the ssCD rate (y-axis) against the pssCD (pssCD) rate (x-axis) and showing the ssCD-to-AVB ratio by the size of the bubble, the obstetrical practice can also be compared between different units.

Objectives

This study aimed to systematically review the worldwide incidence of ssCD concerning the pssCD and AVB rates and to use a bubble chart for comparison between different studies and geographic regions.

Materials and Methods**Eligibility criteria, information sources, and search strategy**

This study was a systematic review of the ssCD rates reported in the literature. The systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The study was registered on the International Prospective Register of Systematic Reviews database (identification number: CRD42022380627). The following search engines were used to perform the literature search from the inception of databases to February 17, 2023: PubMed, Medline Ovid, EBSCOhost, Embase, Scopus, and Google Scholar. The key words used for the literature review included “full dilatation,” “second stage,” and “cesarean,” with their word variations. The search was limited to published articles in human studies written in English. A full search strategy was listed in detail in [Supplementary Document 1](#).

Study selection

The selected articles were reviewed by 2 reviewers (T.Y.L. and O.K.C.) independently. Disputes were resolved by discussion. We included only original studies that provided sufficient information on the number of pssCD, ssCD, and vaginal birth. The total number of birth (T) is the sum of pssCD, ssCD, and vaginal birth. The number of births that reached the second stage of labor (ssB) was the sum of ssCD and all vaginal births. These were the basic and essential information to

TABLE 1
Definition and abbreviation of different modes of births and rates

Terms	Description	Abbreviation or formula
Modes of birth		
eICD	Planned CDs that were performed as scheduled	eICD
emCD	Included unplanned CD before the onset of labor, during the first stage of labor, and during the second stage of labor	emCD
ssCD	CD performed during the second stage of labor	ssCD
pssCD	All eICDs plus those emCDs performed before the second stage of labor	pssCD = eICD + emCD performed before the second stage of labor
UVB	Spontaneous vaginal birth without the need of instrumental intervention	UVB
AVB	Vaginal birth requiring instrumental intervention (eg, forceps and vacuum extraction)	AVB
Total number of births	The sum of all modes of deliveries	T = pssCD + ssCD + UVB + AVB
Total number of births during the second stage of labor	The sum of UVBs and AVBs plus ssCD	ssB = UVB + AVB + ssCD
Rates		
pssCD per total number of births	All CDs that were performed before the second stage of labor per total births	pssCD/T
ssCD per total number of births	All CDs that were performed during the second stage of labor per total births	ssCD/T
ssCD per births during the second stage of labor	All ssCDs per all cases reaching the second stage of labor	ssCD/ssB
ssCD-to-AVB ratio	The ratio of ssCD to AVB	ssCD/AVB

AVB, assisted vaginal birth; CD, cesarean delivery; eICD, elective cesarean delivery; emCD, emergency cesarean delivery; pssCD, pre-second-stage cesarean delivery; ssB, all births during the second stage of labor; ssCD, second-stage cesarean delivery; UVB, unassisted vaginal birth.

Lee. Assessment of the global incidences of second-stage cesarean delivery using a bubble chart. *Am J Obstet Gynecol Glob Rep* 2024.

calculate the pssCD rate per total births (pssCD/T) and the ssCD rate per number of birth that had reached the second stage (ssCD/ssB), as described in our previous article and summarized in Table 1.²⁴ pssCD/T and ssCD/ssB were shown, respectively, on the x-axis and y-axis of a bubble chart. If the articles also provided the numbers of unassisted vaginal birth and AVB, we also calculated the ssCD-to-AVB ratio, which was presented as the size of the bubble in the bubble chart.²⁴ Systemic reviews, meta-analyses, or case reports were excluded. If there were more than 1 publication from the same unit, their data were crosschecked to avoid duplication of data. If so, only the one with the most representable data was chosen. Moreover, we included our recently published study, which fulfilled the inclusion criteria for this systematic review.²⁴

Data extraction

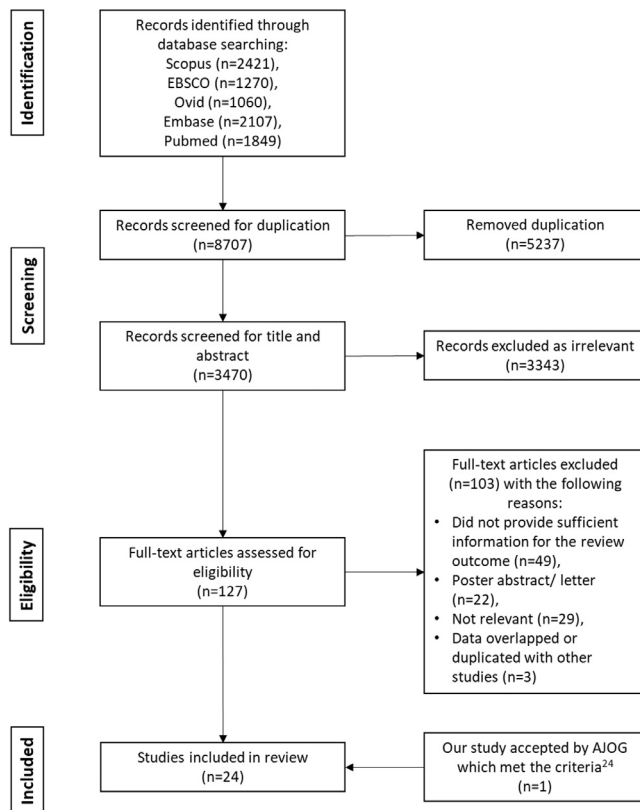
Data from each article were extracted by 1 reviewer (T.Y.L) and were checked by a second reviewer (O.K.C.). Information about their publication dates, the countries and the years that their subjects were recruited, singleton or multiple pregnancies, term or preterm pregnancies, cephalic or noncephalic pregnancies, and parity were recorded. Although we focused on the mode of delivery of singleton, term, cephalic presenting pregnancies (group A [all parities] and Group B [nulliparous patients only]), we also looked into those cohorts that did not specify these criteria (group C). For each group, we applied the bubble chart to plot individual articles' ssCD/ssB (Y-axis) against their corresponding pssCD/T (X-axis). Their ssCD/AVB was expressed by the diameter of the bubble. If ssCD/AVB was not available,

then the bubble was replaced by a cross. To investigate the secular trend, the included articles were divided based on their study periods (before 2009 vs thereafter, according to our previous publication).²⁴ Moreover, we looked into any variation between geographic regions.

Assessment of risk of bias

The risk of bias was evaluated using the Joanna Briggs Institute (JBI) Prevalence Critical Appraisal Tool by 2 reviewers (T. Y.L. and O.K.C) independently.²⁶ The JBI critical assessment tool consists of 9 questions. The risk of bias in each included study was categorized according to the total score as high (0–3), moderate (4–6), and low (7–9). In case of disagreement between the 2 reviewers, a third reviewer (L.T.L.L.) assessed the case, and consensus was finally drawn among them.

FIGURE 1
The PRISMA flowchart



AJOG, American Journal of Obstetrics & Gynecology; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

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Data synthesis

Statistical analysis was performed using SPSS Statistics for Windows (version 22.0; IBM Corporation, Armonk NY). The results were presented using descriptive statistics. Categorical data were expressed as numbers and percentages. The chi-square test was used to compare the difference in proportion between different study periods, geographic regions, and parity subgroups. Moreover, posthoc pairwise comparison was performed to compare within units. A *P* value of <.05 was considered statistically significant.

Results

Study selection and characteristics

A total of 127 articles were identified after full-text articles assessment for eligibility, of which 103 were excluded for various reasons: 49 articles did not provide

sufficient information for the review outcome, 22 articles were poster abstracts or letters, 29 articles were irrelevant, and 3 articles^{27–29} were excluded as their data respectively overlapped with that of other 3 included studies (coming from the same studies unit and study periods) (Figure 1).^{30–32} Together with our recently published article,²⁴ a total of 25 articles from 17 countries provided sufficient information for the calculation of pssCD/T and the ssCD/ssB. The size of their cohorts ranged from 2151 to 420,459, and the total number of subjects was 1,512,303. Moreover, 5 of the articles did not include information on eCD.^{31,33–36}

In addition, 17 articles provided information on ssCD-to-AVB ratio. The characteristics and the data of these 25 articles are listed respectively in Tables 2 and 3 and shown with a bubble chart (Figure 2).^{2,3,23,24,30–50}

Risk of bias of included studies

The quality assessment of these 25 studies is listed in Supplemental Table. The risk of bias in the included studies was considered between low (*n*=21) and moderate (*n*=4).

Synthesis of results

Among these 25 articles, the overall pssCD rate, the ssCD rate, and the ssCD-to-AVB ratio were 17.94%, 2.65%, and 0.19, respectively. Only 9 articles focused on singleton, term, cephalic presenting pregnancies. Moreover, 5 of the articles consisted of a mixture of both nulliparous and multiparous subjects, but none of the articles provided separate information according to parity except Hung et al.²⁴ These 5 articles were grouped under group A (Table 3), and its bubble chart is shown in Figure 2, A.^{2,3,23,24,30–50} The average pssCD/T of these 5 articles was 18.20% (reported range, 9.06%–30.26%). Their average ssCD/ssB was 0.83% (range, 0.19%–2.76%), whereas their average ssCD-to-AVB ratio was 0.09 (range, 0.05–0.28; available in 4 of 5 articles).

Group B consisted of 4 articles that also focused on singleton, term, cephalic presenting pregnancies as group A but of nulliparous subjects only.^{30,33,34,36} As the article by Hung et al.²⁴ in group A also provided separate data for different parity, their nulliparous subgroup was also extracted and tabulated in group B (Table 3), and the bubble chart of group B is shown in Figure 2, B.^{2,3,23,24,30–50} Their average pssCD/T was 15.10% (reported range, 10.97%–32.59%). Their average ssCD/ssB was 4.50% (range, 0.79%–6.46%), whereas their ssCD-to-AVB ratio was 0.18 (range, 0.05–0.63).

Group C consists of the other 16 articles that did not exclude multiple pregnancies, preterm births, and noncephalic pregnancies.^{2,3,32,38–50} All of them had a mixture of nulliparous and multiparous subjects, except the study of Fyfe et al,⁴¹ which focused on nulliparous women only. Their average pssCD/T was 21.67% (range, 12.83%–43.59%), their average ssCD/ssB was 1.65% (range, 0.56%–6.66%), and their average ssCD-to-AVB ratio was 0.27 (range, 0.04–1.82; available in 9

TABLE 2

The background characteristics of the 25 included studies based on our literature search

Author	Country	Study period	Number of units	Denominators in calculating CD rate				Remarks
				Singleton	Term	Cephalic	Parity	
Group A								
Halscott et al ³¹	United States	2002–2008	19	Yes	Yes	Yes	All parities	Excluded eICD
Hung et al ²⁴	Hong Kong	2009–2018	8	Yes	Yes	Yes	All parities	—
Liu et al ³⁵	China	2007–2016	1	Yes	Yes	Yes	All parities	Excluded eICD
Rahim et al ²³	United Kingdom	2017–2018	6	Yes	Yes	Yes	All parities	—
Thuillier et al ³⁷	France	2013–2015	1	Yes	Yes	Yes	All parities	—
Group B								
Cong et al ³⁰	Australia	1989–2015	1	Yes	Yes	Yes	Nulliparous	—
Edmonds et al ³³	United States	2006–2011	1	Yes	Yes	Yes	Nulliparous	Excluded eICD
Hagiwara et al ³⁴	Japan	2014–2018	1	Yes	Yes	Yes	Nulliparous	Excluded eICD
Hung et al ²⁴	Hong Kong	2009–2018	8	Yes	Yes	Yes	Nulliparous	Extracted from Hung et al ²⁴ in group A
Wood and Tang ³⁶	Canada	1992–2018	122	Yes	Yes	Yes	Nulliparous	Excluded eICD, included >35 wk
Group C								
Asırcıoğlu et al ³⁸	Turkey	2008–2011	1	No	No	No	All parities	Only ssCD cases were specified term pregnancies
Belay et al ³⁹	Ethiopia	2012	3	No	No	No	All parities	
Eze et al ⁴⁰	Nigeria	2012–2016	1	No	No	No	All parities	Only ssCD cases were specified singleton, term, cephalic pregnancies
Fyfe et al ⁴¹	Australia	2004–2008	Multicenter	No	Yes	No	Nulliparous	
Giacchino et al ⁴²	United Kingdom	2010–2018	1	No	No	No	All parities	
Gurney et al ⁴³	United Kingdom	2014–2018	1	No	No	No	All parities	
Gurung et al ⁴⁴	Nepal	2013–2017	1	No	No	No	All parities	Only ssCD cases were specified singleton, term, cephalic pregnancies
Keepanasseril et al ⁴⁵	India	2014–2016	1	No	No	No	All parities	
Lipschuetz et al ⁴⁶	Israel	2003–2015	1	Yes	No	No	All parities	
Loudon et al ²	United Kingdom	1992–2001	1	No	No	No	All parities	
Malik et al ⁴⁷	India	2018–2019	1	No	No	No	All parities	
Nolens et al ³²	Uganda	2014–2015	1	No	No	No	All parities	
Pearson and MacKenzie ⁴⁸	United Kingdom	1976, 1986, 1996, 2006	1	No	No	No	All parities	
Radha et al ⁴⁹	Singapore	2009	1	No	No	No	All parities	
Rashid et al ⁵⁰	Malaysia	2010–2015	1	Yes	No	No	All parities	
Unterscheider et al ³	Ireland	2006–2008	1	No	No	No	All parities	Only ssCD cases were specified singleton, term, cephalic pregnancies

Group A indicates studies that focused on singleton, term, cephalic pregnancies of all parities. Group B indicates studies that focused on singleton, term, cephalic pregnancies of nulliparous patients only. Group C indicates studies that had not excluded preterm, noncephalic presenting, or multiple pregnancies.

CD, cesarean delivery; eICD, elective cesarean delivery; ssCD, second-stage cesarean delivery.

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TABLE 3
The numbers and rates of each mode of delivery of the 25 included studies based on our literature search.

Author	Total births	Different modes of births Numbers and rate per total births							Different modes of birth during the second stage of labor Rate per ssB			
		Births before the second stage of labor			Births during the second stage of labor				UVB	AVB	ssCD	ssCD/AVB
		eICD	emCD before the second stage of labor	pssCD = eICD + emCD before the second stage of labor	UVB	AVB	ssCD	ssB = UVB + AVB + ssCD				
								ssB %	ssB %	ssB %	Ratio	
Group A												
Halscott et al ³¹	136,491 (22.80)	Excluded	21,215 (15.54)	21,215 (15.54)	112,746 (82.60)	2308 (1.69)	222 (0.16)	115,276 (84.46)	97.81	2.00	0.19	0.10
Hung et al ²⁴	353,434 (59.04)	29,239 (8.27)	41,062 (11.62)	70,301 (19.89)	250,908 (70.99)	30,765 (8.70)	1460 (0.41)	283,133 (80.11)	88.62	10.87	0.52	0.05
Liu et al ³⁵	71,709 (11.98)	Excluded	6498 (9.06)	6498 (9.06)	57,050 (79.56)	6359 (8.87)	1802 (2.51)	65,211 (90.94)	87.49	9.75	2.76	0.28
Rahim et al ²³	28,867 (4.82)	3797 (13.15)	4937 (17.10)	8734 (30.26)	15,469 (53.59)	4171 (14.45)	493 (1.71)	20,133 (69.74)	76.83	20.72	2.45	0.12
Thuillier et al ³⁷	8165 (1.36)	1324 (16.22)	900 (11.02)	2224 (27.24)	NS	NS	109 (1.33)	5941 ^a (72.26)	—	—	1.83	—
Group A total	598,666 (100.00)	34,360 (5.74)	74,612 (12.46)	108,972 (18.20)	436,173 (72.86)	43,603 (7.28)	4086 (0.68)	489,694 (81.80)	89.07	8.90	0.83	0.09
Group B												
Cong et al ^{30,b}	19,099 (3.05)	1030 (5.39)	2142 (11.22)	3172 (16.61)	11,604 (60.76)	3790 (19.84)	533 (2.79)	15,927 (83.39)	72.86	23.80	3.35	0.14
Edmonds et al ^{33,b}	4483 (0.72)	Excluded	492 (10.97)	492 (10.97)	3322 (74.10)	411 (9.17)	258 (5.76)	3991 (89.03)	83.24	10.30	6.46	0.63
Hagiwara et al ^{34,b}	2151 (0.34)	Excluded	701 (32.59)	701 (32.59)	1234 (57.37)	189 (8.79)	27 (1.26)	1450 (67.41)	85.10	13.03	1.86	0.14
Hung et al ^{24,b}	180,496 (28.80)	4102 (2.27)	29,432 (16.31)	33,534 (18.58)	119,912 (66.43)	25,884 (14.34)	1166 (0.65)	146,962 (81.42)	81.59	17.61	0.79	0.05

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(continued)

TABLE 3

The numbers and rates of each mode of delivery of the 25 included studies based on our literature search. (continued)

Author	Total births	Different modes of births Numbers and rate per total births							Different modes of birth during the second stage of labor Rate per ssB				
		Births before the second stage of labor				Births during the second stage of labor			UVB	AVB	ssCD	ssCD/AVB	
		eICD	emCD before the second stage of labor	pssCD = eICD + emCD before the second stage of labor	UVB	AVB	ssCD	ssB = UVB + AVB + ssCD					
									n/T (%)	n/T (%)	n/T (%)	n/T (%)	n/T (%)
Wood and Tang ^{36,b}	420,459	Excluded	56,730	56,730	239,942	101,803	21,984	363,729					
	(67.09)		(13.49)	(13.49)	(57.07)	(24.21)	(5.23)	(86.51)	65.97	27.99	6.04	0.22	
Group B total	626,688	5132	89,497	94,629	376,014	132,077	23,968	532,059					
	(100.00)	(0.82)	(14.28)	(15.10)	(60.00)	(21.08)	(3.82)	(84.90)	70.67	24.82	4.50	0.18	
Group C													
Asıcıoğlu et al ³⁸	39,027	3713	3519	7232	NS	NS	298	31,795 ^a					
	(8.35)	(9.51)	(9.02)	(18.53)			(0.76)	(81.47)	—	—	0.94	—	
Belay et al ³⁹	3238	118	791	909	NS	NS	97	2329 ^a					
	(0.69)	(3.64)	(24.43)	(28.07)			(3.00)	(71.93)	—	—	4.16	—	
Eze et al ⁴⁰	9260	NS	NS	1334	7362	200	364	7926					
	(1.98)			(14.41)	(79.50)	(2.16)	(3.93)	(85.59)	92.88	2.52	4.59	1.82	
Fyfe et al ^{41,b}	2902	195	545	740	1405	613	144	2162					
	(0.62)	(6.72)	(18.78)	(25.50)	(48.41)	(21.12)	(4.96)	(74.50)	64.99	28.35	6.66	0.23	
Giacchino et al ⁴²	34,757	3844	4781	8625	22,111	3181	840	26,132					
	(7.44)	(11.06)	(13.76)	(24.82)	(63.62)	(9.15)	(2.42)	(75.18)	84.61	12.17	3.21	0.26	
Gurney et al ⁴³	24,756	2278	3181	5459	16,527	2631	107	19,265					
	(5.30)	(9.20)	(12.85)	(22.05)	(66.76)	(10.63)	(0.43)	(77.82)	85.79	13.66	0.56	0.04	
Gurung et al ⁴⁴	40,860	7527	10,284	17,811	NS	NS	200	23,049 ^a					
	(8.74)	(18.42)	(25.17)	(43.59)			(0.49)	(56.41)	—	—	0.87	—	
Keepanasseril et al ⁴⁵	33,106	1371	4413	5784	NS	NS	321	27,322 ^a					
	(7.08)	(4.14)	(13.33)	(17.47)			(0.97)	(82.53)	—	—	1.17	—	
Lipschuetz et al ⁴⁶	123,628	9232	10,212	19,444	94,344	8076	1764	104,184					
	(26.45)	(7.47)	(8.26)	(15.73)	(76.31)	(6.53)	(1.43)	(84.27)	90.56	7.75	1.69	0.22	

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(continued)

TABLE 3

The numbers and rates of each mode of delivery of the 25 included studies based on our literature search. (continued)

Author	Total births	Different modes of births Numbers and rate per total births							Different modes of birth during the second stage of labor Rate per ssB			
		Births before the second stage of labor			Births during the second stage of labor				UVB	AVB	ssCD	ssCD/AVB
		eICD	emCD before the second stage of labor	pssCD = eICD + emCD before the second stage of labor	UVB	AVB	ssCD	ssB = UVB + AVB + ssCD				
									n/T (%)	n/T (%)	n/T (%)	n/T (%)
Loudon et al ²	38,683 (8.28)	5240 (13.55)	3390 (8.76)	8630 (22.31)	22,727 (58.75)	6868 (17.75)	458 (1.18)	30,053 (77.69)	75.62	22.85	1.52	0.07
Malik et al ⁴⁷	17,167 (3.67)	NS	NS	4672 (27.22)	12,209 (71.12)	176 (1.03)	110 (0.64)	12,495 (72.78)	97.71	1.41	0.88	0.63
Nolens et al ³²	13,152 (2.81)	NS	NS	3611 (27.46)	8642 (65.71)	342 (2.60)	557 (4.24)	9541 (72.54)	90.58	3.58	5.84	1.63
Pearson and MacKenzie ⁴⁸	22,998 (4.92)	1581 (6.87)	1369 (5.95)	2950 (12.83)	NS	NS	272 (1.18)	20,048 ^a (87.17)	—	—	1.36	—
Radha et al ⁴⁹	11,253 (2.41)	1095 (9.73)	2391 (21.25)	3486 (30.98)	7007 (62.27)	650 (5.78)	110 (0.98)	7767 (69.02)	90.22	8.37	1.42	0.17
Rashid et al ⁵⁰	42,456 (9.08)	1854 (4.37)	6086 (14.33)	7940 (18.70)	NS	NS	257 (0.61)	34,516 ^a (81.30)	—	—	0.74	—
Unterscheider et al ³	10,202 (2.18)	NS	NS	2665 (26.12)	NS	NS	136 (1.33)	7537 ^a (73.88)	—	—	1.80	—
Group C total	467,445 (100.00)	38,048 (8.14)	50,962 (10.90)	101,292 (21.67)	192,334 (41.15)	22,737 (4.86)	6035 (1.29)	366,121 (78.32)	52.53	6.21	1.65	0.27

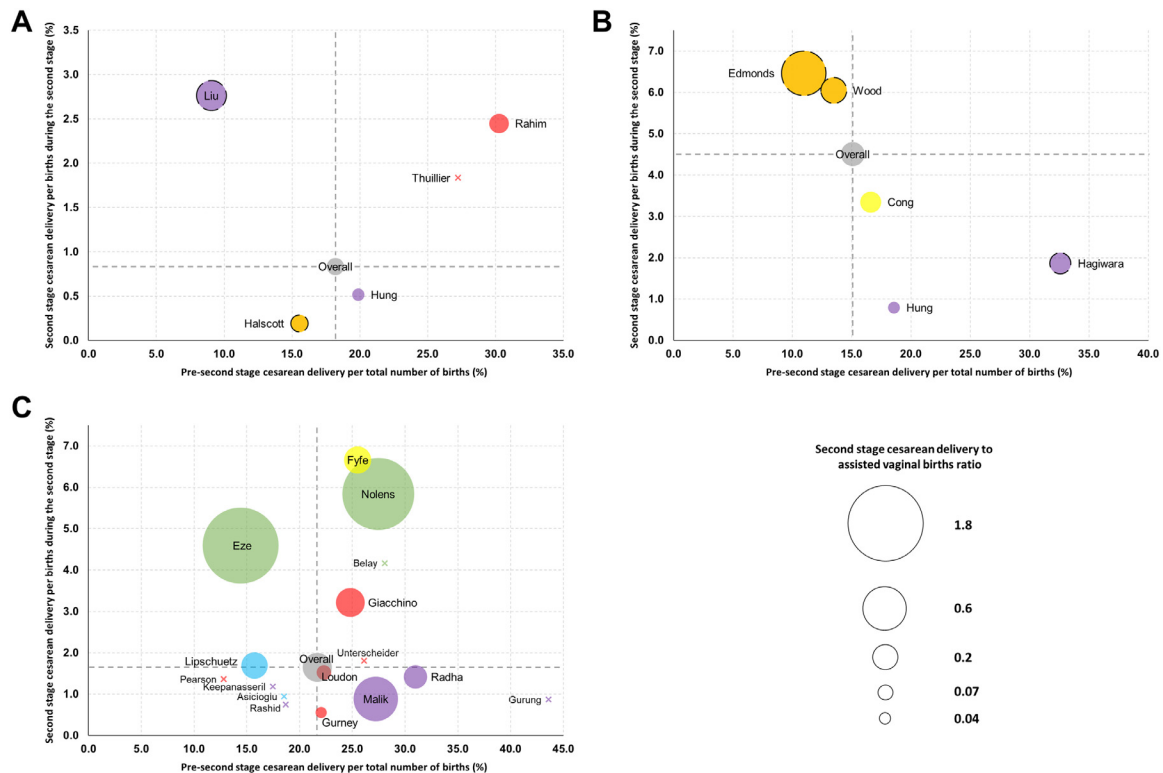
Group A indicates studies that focused on singleton, term, cephalic pregnancies of all parities. Group B indicates studies that focused on singleton, term, cephalic pregnancies of nulliparous patients only. Group C indicates studies that had not excluded preterm, noncephalic presenting, or multiple pregnancies.

AVB, assisted vaginal birth; eICD, elective cesarean delivery; emCD, emergency cesarean delivery; NS, not specified in the reference; pssCD, pre-second-stage cesarean delivery; ssB, all births during the second stage of labor; ssCD, second-stage cesarean delivery; UVB, unassisted vaginal birth.

^a Calculated using the sum of vaginal birth and ssCD; ^b Nulliparous only.

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FIGURE 2
The bubble chart showing the rates of different modes of delivery



A, Group A consists of studies focusing on singleton, term, cephalic presenting pregnancies of all parities. **B**, Group B consists of studies focusing on singleton, term, cephalic presenting pregnancies of nulliparous patients. **C**, Group C consists of studies that have not specified the number of fetuses, gestation, or presentation. The “x” symbol indicates that information on AVB is not available for calculation of the ssCD—to—AVB ratio. For articles that had excluded elective CD, their bubbles were circled with dotted lines. The green color indicates African studies. The yellow color indicates Australian studies. The blue color indicates East Mediterranean studies. The purple color indicates East Asia or South Asia studies. The orange color indicates North America studies. The red color indicates Western Europe studies.

AVB, assisted vaginal birth; CD, cesarean delivery; ssCD, second-stage cesarean delivery.

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articles) (Table 3; Figure 2, C).^{2,3,23,24,30}

Overall, group B had a significantly lower pssCD/T but higher ssCD/ssB rates than the other 2 groups ($P < .05$).

In 5 of the 25 included articles, the study period was before 2009,^{2,3,31,41,48} and 14 articles started in or after 2009.^{23,24,32,34,37,39,40,42–45,47,49,50} In the remaining 6 articles, their study periods crossed over 2009,^{30,33,35,36,38,46} and their published data were not stratified by years of births (Table 2).^{2,3,23,24,30–50} Hence, we could only compare the 5 studies completed before 2009 with the 14 studies that started thereafter. Overall, the pssCD/T (17.13% vs 22.74%; $P < .05$) and ssCD/ssB (0.70% vs 1.05%; $P < .05$) were increased with time (Table 4; Figure 3).^{2,3,23,24,30–50}

In terms of geographic distribution, 8 articles came from East or South Asia,^{24,34,35,44,45,47,49,50} 7 articles were from Western Europe,^{2,3,23,37,42,43,48} 3 articles were from North America,^{31,33,36} 3 articles were from Africa,^{32,39,40} and 2 articles were from Australia.^{30,41} There was 1 study from Israel and 1 study from Turkey (and they were grouped under the East Mediterranean region).^{38,46} However, no study originated from other Middle East countries, Eastern Europe, or South America. There were significant differences in the pssCD/T and ssCD/ssB rates between different regions (Table 5; Figure 4).^{2,3,23,24,30–50} Studies originating from Africa had the highest ssCD/ssB (5.14%), and its pssCD/T was also the highest (22.82%); hence, its bubble is

located in the upper right quadrant of the bubble chart. The bubble of the East Mediterranean region is at its opposite (left lower quadrant). The East or South Asian countries had the lowest ssCD/ssB (0.94%) but had a higher pssCD/T. Therefore, its bubble is at the right lower quadrant together with that of Western Europe, while the bubble of North America is at their opposite (left upper quadrant). The ssCD/ssB was below 1% in 7 studies, of which 4 were from East or South Asia,^{24,44,47,50} 2 were from Western countries,^{31,43} and 1 was from Turkey.³⁸ The ssCD/ssB was between 1.00% and 3.99% in 12 studies^{2,3,23,30,34,35,37,42,45,46,48,49} and more than 4.0% in the remaining 6 studies, of which 3 were from Africa^{32,39,40} and the

TABLE 4
The numbers and rates of each mode of delivery of the 25 included studies based on our literature search stratified by study periods

Variable	Total births	Different modes of births Numbers and rate per total births							Different modes of birth during the second stage of labor Rate per ssB			
		Births before the second stage of labor			Births during the second stage of labor							
		eICD	emCD before the second stage of labor	pssCD = eICD + emCD before the second stage of labor	UVB	AVB	ssCD	ssB = UVB + AVB + ssCD	UVB	AVB	ssCD	ssCD/AVB
Before 2009 ^{2,3,31,41,48}	211,276	7016	26,519	36,200	136,878	9789	1232	175,076				
	(13.97%)	(3.32)	(12.55)	(17.13)	(64.79)	(4.63)	(0.58)	(82.87)	78.18	5.59	0.70	0.13
In or after 2009 ^{23,24,32,34,37,39,40,42–45,47,49–50}	622,622	52,447	79,527	141,591	341,469	42,305	5052	480,999				
	(41.17)	(8.42)	(12.77)	(22.74)	(54.84)	(6.79)	(0.81)	(77.25)	70.99	8.80	1.05	0.12
Across 2009 ^{30,33,35,36,38,46}	678,405	13,975	79,593	93,568	406,262	120,439	26,639	584,837				
	(44.86)	(2.06)	(11.73)	(13.79)	(59.88)	(17.75)	(3.93)	(86.21)	69.47	20.59	4.55	0.22
Total	1,512,303	73,438	185,639	271,359	884,609	172,533	32,923	1,240,912				
	(100.00)	(4.86)	(12.28)	(17.94)	(58.49)	(11.41)	(2.18)	(82.05)	71.29	13.90	2.65	0.19

Comparison between study periods:

pssCD rate (pssCD/T): across 2009 < before 2009 < in or after 2009 ($P < .05$).

ssCD rate (ssCD/ssB): before 2009 < in or after 2009 < across 2009 ($P < .05$).

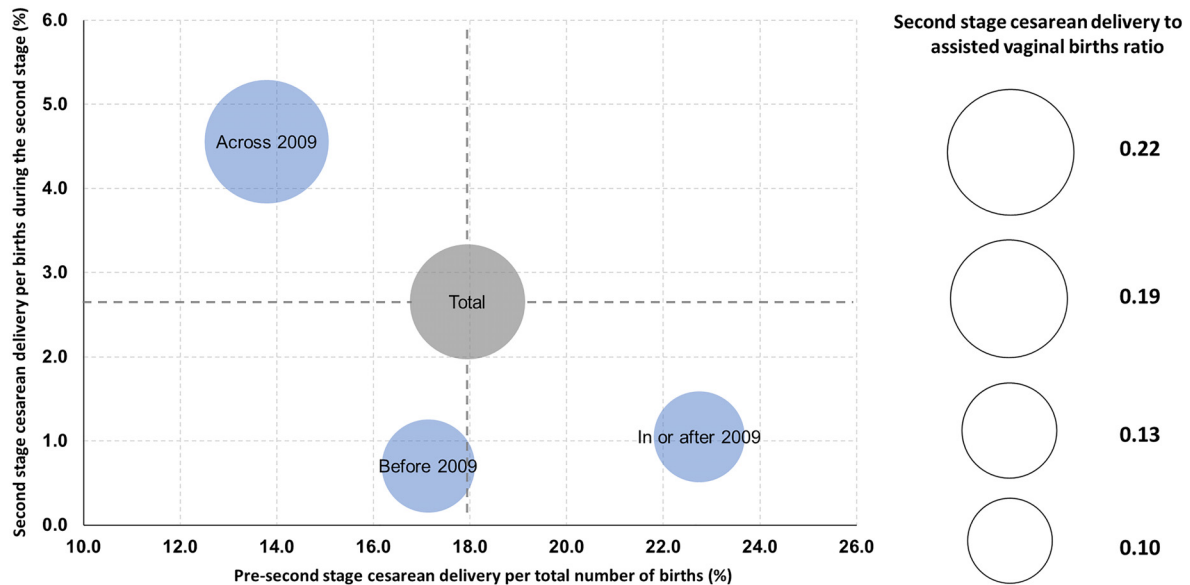
AVB rate (AVB/ssB): before 2009 < in or after 2009 < across 2009 ($P < .05$).

AVB, assisted vaginal birth; eICD, elective cesarean delivery; emCD, emergency cesarean delivery; pssCD, pre-second-stage cesarean delivery; ssB, all births during the second stage of labor; ssCD, second-stage cesarean delivery; UVB, unassisted vaginal birth.

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FIGURE 3

The bubble chart showing the pre-ssCD and ssCD rates and the ssCD-to-assisted vaginal birth ratio of the studies grouped by their study periods



CD, cesarean delivery; ssCD, second-stage cesarean delivery.

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other 3 were from Western countries but focused on nulliparous women only (Table 3).^{33,36,41}

In addition, the overall ssCD-to-AVB ratio was the lowest in the East or South Asian region (0.11) and the highest in Africa (1.88) (Table 5; Figure 4).^{2,3,23,24,30-50} Among the 17 studies that had ssCD-to-AVB ratio available, only 3 had ssCD-to-AVB ratio below 0.1, including our Hong Kong cohort²⁴ and 2 British cohorts.^{2,43} Moreover, 10 studies were between 0.10 and 0.29,^{23,30,31,34-36,41,42,46,49} but 4 studies fell into the extreme range of 0.63 to 1.82, of which 2 were from Africa,^{32,40} 1 was from India,⁴⁷ and 1 was from the United States.³³

Comment

Principal findings

This was a systematic review on the worldwide incidence of ssCD and the use of a bubble chart to graphically show the relationship among ssCD/ssB, pssCD/T, and ssCD-to-AVB ratio between different geographic regions. Although ssCD is of increasing concern medically and legally, not many articles have addressed specifically the incidence of ssCD. Only 25 articles provided sufficient information to

calculate both the ssCD and pssCD rates, with just 9 of them specifically focusing on singleton term pregnancies and the other 16 studies not completely excluding multiple pregnancies, noncephalic presenting pregnancies, or preterm births. Furthermore, 5 of these 9 articles excluded cases delivered by eLCD. Overall, nulliparous women had a lower pssCD rate but had a higher ssCD rate. It seems that both the ssCD and pssCD rates increased across 2009. African units reported the highest ssCD and pssCD rates and the highest ssCD-to-AVB ratio, whereas East and South Asian units had the lowest ssCD rate and ssCD-to-AVB ratio. However, caution must be taken when interpreting these results.

Comparison with existing literature

First, we found a great variation in the pssCD rate ranging from 9.06% to 43.59%. As 5 articles excluded eLCD cases from their reports,^{31,33-36} the distribution of pssCD rates was skewed downward (ie, leftward on the bubble charts in Figure 2, A and B). There are pros and cons of including eLCD in the calculation of the pssCD rate. In units where eLCD on maternal request was not allowed or

the threshold to decide eLCD is high, the number of eLCD is expected to be low, and the exclusion of them would not affect the overall pssCD rate much. In contrast, when the proportion of eLCD is high, the exclusion of them from the calculation of pssCD rate may lead to a biased result in assessing the relationship between pssCD rate and ssCD rate.²⁴ As the obstetrical practice and the reporting methods varied greatly between units and geographic regions, we decided to keep pssCD/T as the sum of the eLCD and emCD performed before the onset or during the first stage of labor and tabulate the individual eLCD and emCD rates for readers to interpret. In Figure 2, we also distinguished the bubbles of those studies that excluded eLCD by a dotted outline. Regardless of whether eLCD is included in the pssCD rate or not, the calculation of ssCD/ssB and ssCD-to-AVB ratio are not affected, and nulliparous patients had a higher risk of having CD during the second stage of labor.²⁴

Second, Loudon et al² was the first to address an increase in the ssCD rate, which was about 0.94% in their British cohort in 1993 but 2.05% in 2001. The ssCD-to-AVB ratio also increased from

TABLE 5
The numbers and rates of each mode of delivery of the 25 included studies based on our literature search stratified by geographic regions

Variable	Total births	Different modes of births Numbers and rate per total births							Different modes of birth during the second stage of labor Rate per ssB													
		Births before the second stage of labor			Births during the second stage of labor																	
		eICD	emCD before the second stage of labor	pssCD = eICD + emCD before the second stage of labor	UVB	AVB	ssCD	ssB = UVB + AVB + ssCD	UVB	AVB	ssCD	ssCD/AVB										
													Proportion in group (%)	n/T (%)	n/T (%)	n/T (%)	n/T (%)	n/T (%)	n/T (%)	n/T (%)	ssB %	ssB %
Africa ^{32,39,40}	25,650	118	791	5854	16,004	542	1018	19,796														
	(1.70)	(0.46)	(3.08)	(22.82)	(62.39)	(2.11)	(3.97)	(77.18)	80.84	2.74	5.14	1.88										
Australia ^{30,41}	22,001	1225	2687	3912	13,009	4403	677	18,089														
	(1.45)	(5.57)	(12.21)	(17.78)	(59.13)	(20.01)	(3.08)	(82.22)	71.92	24.34	3.74	0.15										
East Mediterranean ^{38,46}	162,655	12,945	13,731	26,676	94,344	8076	2062	135,979														
	(10.76)	(7.96)	(8.44)	(16.40)	(58.00)	(4.97)	(1.27)	(83.60)	69.38	5.94	1.52	0.26										
East or South Asia ^{24,34,35,44,45,47,49,50}	572,136	41,086	71,435	117,193	328,408	38,139	4287	454,943														
	(37.83)	(7.18)	(12.49)	(20.48)	(57.40)	(6.67)	(0.75)	(79.52)	72.19	8.38	0.94	0.11										
North America ^{31,33,36}	561,433	0	78,437	78,437	356,010	104,522	22,464	482,996														
	(37.12)	(0)	(13.97)	(13.97)	(63.41)	(18.62)	(4.00)	(86.03)	73.71	21.64	4.65	0.21										
Western Europe ^{2,3,23,37,42,43,48}	168,428	18,064	18,558	39,287	76,834	16,851	2415	129,109														
	(11.14)	(10.73)	(11.02)	(23.33)	(45.62)	(10.00)	(1.43)	(76.66)	59.51	13.05	1.87	0.14										
Total	1,512,303	73,438	185,639	271,359	884,609	172,533	32,923	1,240,912														
	(100.00)	(4.86)	(12.28)	(17.94)	(58.49)	(11.41)	(2.18)	(82.05)	71.29	13.90	2.65	0.19										

Comparison between regions:

pssCD rate (pssCD/T): Western Europe ~ Africa > East or South Asia > Australia > East Mediterranean > North America ($P < .05$).

ssCD rate (ssCD/ssB): Africa > North America > Australia > Western Europe > East Mediterranean > East or South Asia ($P < .05$).

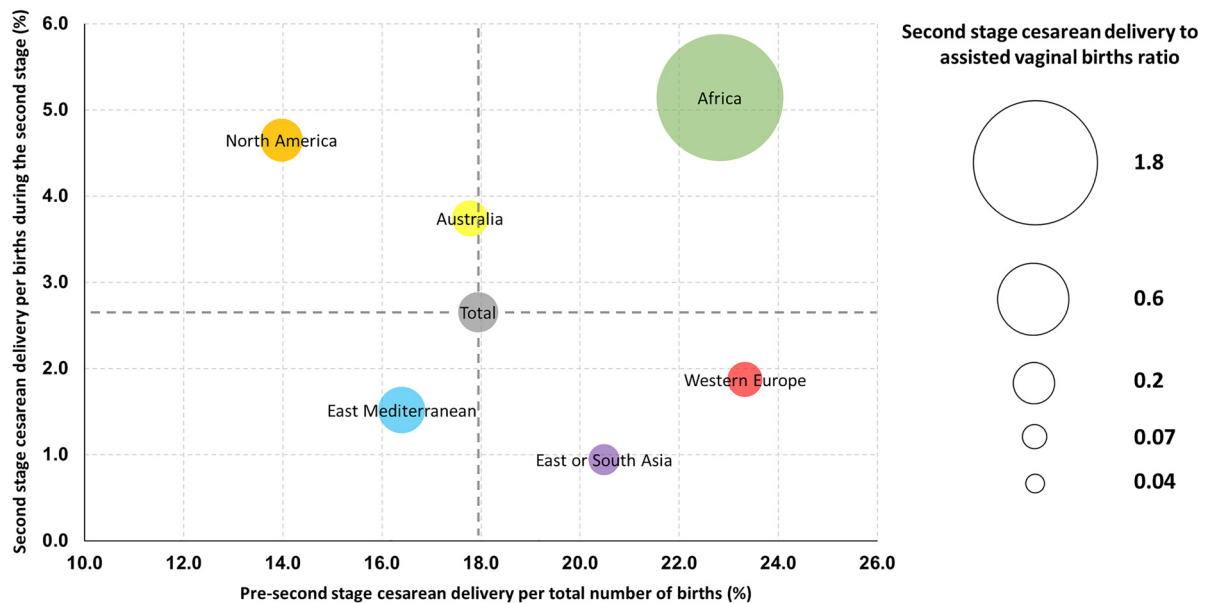
AVB rate (AVB/ssB): Australia > North America > Western Europe > East or South Asia > East Mediterranean > Africa ($P < .05$).

AVB, assisted vaginal birth; eICD, elective cesarean delivery; emCD, emergency cesarean delivery; pssCD, pre-second-stage cesarean delivery; ssB, all births during the second stage of labor; ssCD, second-stage cesarean delivery; UVB, unassisted vaginal birth.

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FIGURE 4

The bubble chart showing the pre-ssCD and ssCD rates and the ssCD-to-assisted vaginal birth ratio stratified of the included studies grouped by geographic distribution



CD, cesarean delivery; ssCD, second-stage cesarean delivery.

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0.05 to 0.10.² The Irish study by Unterscheider et al³ also showed a doubling increase of the ssCD rate from 0.9% in 2006 to 1.8% in 2008. Although the data from these 2 studies represented Western Europe before 2009, our global systematic review also showed an increase in ssCD rate from 1.05% before 2009 to 0.99% thereafter, as shown in the bubble chart in Figure 3. The limitation of our comparison is that the study period of our 6 included articles crossed over 2009 and their overall ssCD rate was even higher at 4.55%. It is unknown whether the actual increase could be even higher.

Third, there is a wide variation in the CD rate between different geographic regions as shown in the bubble chart in Figure 4. In particular, the East and South Asian countries seemed to have an overall low ssCD rate, and 4 of the 7 articles that had ssCD rate below 1% were Asian in origin. However, it is noteworthy that the pssCD rates were high in 2 of these 4 Asian reports. It was 27.22% in the Indian cohort of Malik et al⁴⁷ and 43.59% in the Nepal cohort of Gurung et al.⁴⁴ These figures indicate

that their low ssCD rates were a trade-off for a high pssCD rate. In contrast, the other 2 Asian reports, namely, our Hong Kong study²⁴ and Malaysian study of Rashid et al,⁵⁰ and other 3 non-Asian studies that also achieved a low ssCD rate of <1%, namely, the British study by Gurney et al,⁴³ the American study by Halscott et al,³¹ and the Turkish study by Asıcıoğlu et al,³⁸ had similarly lower pssCD rate of approximately 20%. Furthermore, the ssCD-to-ABV ratio was as low as 0.05 in our Hong Kong study²⁴ and the British study⁴³ and was 0.10 in the US study³¹ (the Malaysian and Turkish studies did not report their ssCD-to-ABV ratio). Their low ssCD-to-ABV ratio indicates that they achieved high successful rates in instrumental delivery, which may have contributed to their low ssCD rates.

In contrast, the overall pssCD rate and ssCD rate were the highest in the African region. In particular, all 3 African studies showed a high ssCD rate, with 5.84% in a Ugandan report,³² 4.59% in a Nigerian report,⁴⁰ and 4.16% in an Ethiopian report.³⁹ The former 2 studies also reported the highest ssCD-

to-ABV ratio of 1.63 and 1.82, respectively (the third study did not report ssCD-to-ABV ratio). The authors attributed this to the underutilization of instrumental delivery in their units. In a public health study on the use of AVB in low-income countries published in 2017, only 6% of 10,000 health centers in sub-Saharan Africa practiced instrumental delivery regularly, and the lack of training and equipment were the main causes.⁵¹ It is also noteworthy that, in 3 Western studies, the ssCD rate was reported to be 6.66% in Australia by Fyfe et al,⁴¹ 6.46% in the United States by Edmonds et al,³³ and 6.04% in Canada by Wood et al.³⁶ Their high ssCD rates were probably related to their solely nulliparous subjects. In contrast to the 3 African studies, their ssCD-to-ABV ratios were relatively lower (0.22–0.63) with smaller bubble sizes shown in Figure 2.

Our systematic review shows a wide variation in ssCD rate and ssCD-to-ABV ratio, which is influenced by multiple factors. Nonetheless, there is still room for improvement. Modification of obstetrical practice may help to reduce

the pssCD and ssCD rates. For example, in a randomized controlled trial comparing extending the second-stage period by 1 more hour to the usual practice, Gimovsky et al⁵² demonstrated a significant reduction of ssCD rate from 43.2% to 19.5%. Similar improvements after modification of practice were also shown by 2 observational studies. Thuillier et al³⁷ compared their pssCD rate and ssCD rate before and after the implementation of the American College of Obstetricians and Gynecologists guideline updated in 2014, in which the definition of active labor was changed from 4-cm to 6-cm cervical dilation and the arrest of the second stage of labor was changed from lack of progress for 3 hours to 4 hours. Both their pssCD and ssCD rates were reduced from 27.83% to 26.61% and from 2.11% to 1.55%, respectively.³⁷ Furthermore, the practice of manual rotation of the fetal head to the occipital anterior position during the second stage of labor may help to reduce the risk of AVB or the need for ssCD.^{22,53,54}

Strength and limitations

As mentioned above, the included studies are heterogeneous as there is a lack of standardization in reporting the ssCD rate, with stratification according to parity, gestation, and the number of fetuses. Furthermore, the information on eICD and AVB were incomplete in some studies. These made our comparisons between different units, time, and geographic regions less precise. However, our results provided a global overview of this matter.

Conclusion and implications

Among the 25 studies identified, the overall pssCD rate was 17.94%, the ssCD rate was 2.65%, and the ssCD-to-AVB ratio was 0.19. The African studies had the highest ssCD rate (5.14%) and the ssCD-to-AVB ratio (1.88), whereas the studies from East Asia and South Asia were opposite (0.94% and 0.11, respectively). The nulliparous women were at a higher risk of ssCD (4.50%). The bubble chart facilitated the comparison of the ssCD rate concerning the rates of pssCD and AVB. ■

CRedit authorship contribution statement

Lin Tai Linus Lee: Conceptualization, Data curation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Christopher Pak Hey Chiu:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Man Kee Teresa Ma:** Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Lee Ting Kwong:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Man Wai Catherine Hung:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Yuen Yee Yannie Chan:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Eunice Joanna Wong:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Theodora Hei Tung Lai:** Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Oi Ka Chan:** Data curation, Formal analysis, Project administration, Validation, Writing – review & editing. **Po Lam So:** Conceptualization, Data curation, Supervision, Writing – review & editing. **Wai Lam Lau:** Conceptualization, Data curation, Supervision, Writing – review & editing. **Tak Yeung Leung:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.xagr.2024.100312.

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