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Maternal, pregnancy, and neonatal outcomes associated with surrogacy: a scoping review

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Abstract

Background Surrogacy is considered to be a method that allows infertile couples to have a child with the assistance of a third party, known as the surrogate mother. Two forms exist: traditional surrogacy, in which the surrogate provides the oocyte and is thus genetically related to the newborn, and gestational surrogacy, in which no genetic link is present. Over recent decades, the use of surrogacy has markedly increased, highlighting the need to evaluate its potential benefits and risks. This scoping review aims to summarize maternal, pregnancy, and neonatal outcomes reported in gestational surrogacy studies and to assess how these outcomes vary according to clinical protocols, including oocyte source and embryo transfer type.

Methods The review considered surrogate mothers and newborns as the population, clinical outcomes as the concept, and surrogacy arrangements as the context. Peer-reviewed studies reporting maternal, pregnancy, or neonatal outcomes were included regardless of design, sample size, or geographical setting. Studies limited to ethical, legal, or psychosocial aspects were excluded. A systematic search was conducted in PubMed, Scopus, and Web of Science. Two reviewers independently screened articles, extracted data, and charted outcomes such as pregnancy and live birth rates, miscarriage rates, and maternal complications. Disagreements were resolved by consensus.

Results From 2,077 articles identified, 19 studies met the inclusion criteria. Pregnancy rate ranged from 24.0% to 61.1%, while live birth rate from 15.8% to 55.5%. No major differences emerged between autologous and donor oocytes, nor between single and double embryo transfer. Miscarriage rates ranged from 3.0% to 17.6%, with minimal variation between fresh and frozen cycles for both autologous (10.5% and 9.8%) and donor oocytes (8.4% and 9.6%), and between fresh and frozen embryos transfers (10.9% and 12.3%). Gestational diabetes ranges from 0% to 27.8%, hypertensive disorder from 0% to 21.2%, and placenta previa from 0% to 4.9%. Preeclampsia showed substantial variability, ranging from 1.2% to 17.1%.

Conclusion This scoping review suggests that heterogeneous clinical protocols in gestational surrogacy may adversely affect maternal and neonatal health. Further research- particularly prospective, multicenter studies- is needed to better understand and characterize these outcomes.

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Keywords Gestational surrogacy, Pregnancy, Neonatal outcomes

Background

Surrogacy is considered an opportunity to have a child through the assistance of a third party, known as the surrogate mother, who is not part of the couple. In decades, there has been a notable increase in the use of Assisted Reproduction Technologies (ART) and surrogacy [1]. In the USA, in 2022, 4.7% of assisted reproductive embryo transfer cycles used gestational surrogacy ($n = 9734$ cycles) [1].

There are two types of surrogacies: traditional and gestational. In traditional surrogacy, the woman is both the gestational and genetic mother, as her egg is used to conceive the child. In gestational surrogacy (GS), the woman is only the gestational mother and not genetically related to the newborn [2]. The motivation for the use of surrogacy can be medical, psychological or social. Medical reasons include conditions such as: Absolute Uterine Factor Infertility—*AUFI* (i.e. Mayer-Rokitansky-Küster-Hauser syndrome or Asherman Syndrome) [3, 4], recurrent miscarriages, endometriosis, heart or kidney disease, possible severe isoimmunization Rh mother-fetus, previous hysterectomy, genetic disorders or healthy carrier status in intended parents, menopause, Turner syndrome, CAIS syndrome [1].

In 2022, the American Society for Reproductive Medicine (ASRM) established guidelines for selecting women for surrogacy. These criteria include age preferably between 21 and 45 years; at least one, full-term, uncomplicated pregnancy; no more than five previous deliveries or three deliveries via caesarean section. Additionally, the surrogate should be in a stable family environment with sufficient support to help her cope with the physical and emotional stress of pregnancy [5]. The selected women undergo thorough screening for sexually transmitted infections (STIs) or other infections that could be transmitted to the foetus. Psychological evaluation is conducted to examine the woman's emotional preparedness for supporting the pregnancy and delivery. Any lifestyle factors that could compromise the health of the child are excluded. According to the Practice Committee of the ASRM and to the Practice Committee for the Society for ARTs, single-embryo transfer is strongly recommended for all gestational carrier cycles due to the health risks associated with multiple gestations [6]. Deviation from these guidelines could be associated with increased rate of caesarean delivery, neonatal morbidity, and preterm birth [7]. However, despite adherence to these guidelines, the extent of potential risks to both the surrogate mother and fetus in the context of surrogacy remains insufficiently understood. The aim of this scoping review is to answer the question: among woman who have undergone the practice of GS what are the maternal, pregnancy and neonatal outcomes compared to women who have had natural own pregnancies, when applicable.

Methods

This scoping review was reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [8] and was registered on the Open Science Framework Portal (https://osf.io/t4p52/overview).

Objectives and PICOST definition

This scoping review aims to describe and analyze the maternal, pregnancy and neonatal outcomes related to the practice of GS. The research question was structured following the PI/ECOST framework (Population, Intervention/ Exposure, Comparison, Outcome, Setting/ Time/ Study design):

- Population: woman who have undergone the practice of GS.
- Intervention: practice of GS.
- Comparison: women who have had natural own pregnancies, when applicable.
- Outcome: maternal, pregnancy and neonatal outcomes.
- Setting/Time/ Study design: all.

Literature search

The literature search was conducted on PubMed, Scopus and Web of Science using key words such as "Surrogate Mothers"; Gestational Carriers"; "Gestational Mothers"; "Gestational Surrogacy"; "Intended Parents"; "Gestational Surrogate"; "Surrogate Motherhood"; "Gestational Carrier Pregnancies"; "Surrogacy". Initially, a search was conducted on Pubmed using MeSH terms, Boolean operators, and free text keywords. Afterwards, the string was adapted for use in Scopus and Web of Science. The search focused on articles published in peer-reviewed journals and written in English, with no additional restrictions related to publication date, study setting, geographic areas or other criteria.

The final search across all databases was performed on October 11th, 2024. Reference lists of all included articles were also screened to identify additional relevant studies. When full texts were not accessible online, the corresponding authors were contacted to obtain the complete manuscripts. A detailed search string is available in Supplementary Material 1.

Study selection and inclusion/exclusion criteria

All articles retrieved through the search strategy were imported into Rayyan QCRI [9], and duplicates were subsequently removed. The selection process involved two stages: (1) title and abstract screening and (2) full-text review. Two independent reviewers (MLDP and CMPC) assessed the titles and abstracts of the identified studies to select the relevant ones. Articles deemed potentially eligible were retrieved in full text and independently assessed for inclusion by the same reviewers. Articles meeting all inclusion criteria were incorporated into the review. Any disagreements were resolved through team discussions. All primary studies which investigated the outcomes of the practice of GS on woman and newborn health were considered pertinent. Studies that did not address the research question or presented findings only in abstract form were excluded. The study selection process was documented using a PRISMA flow diagram (Fig. 1).

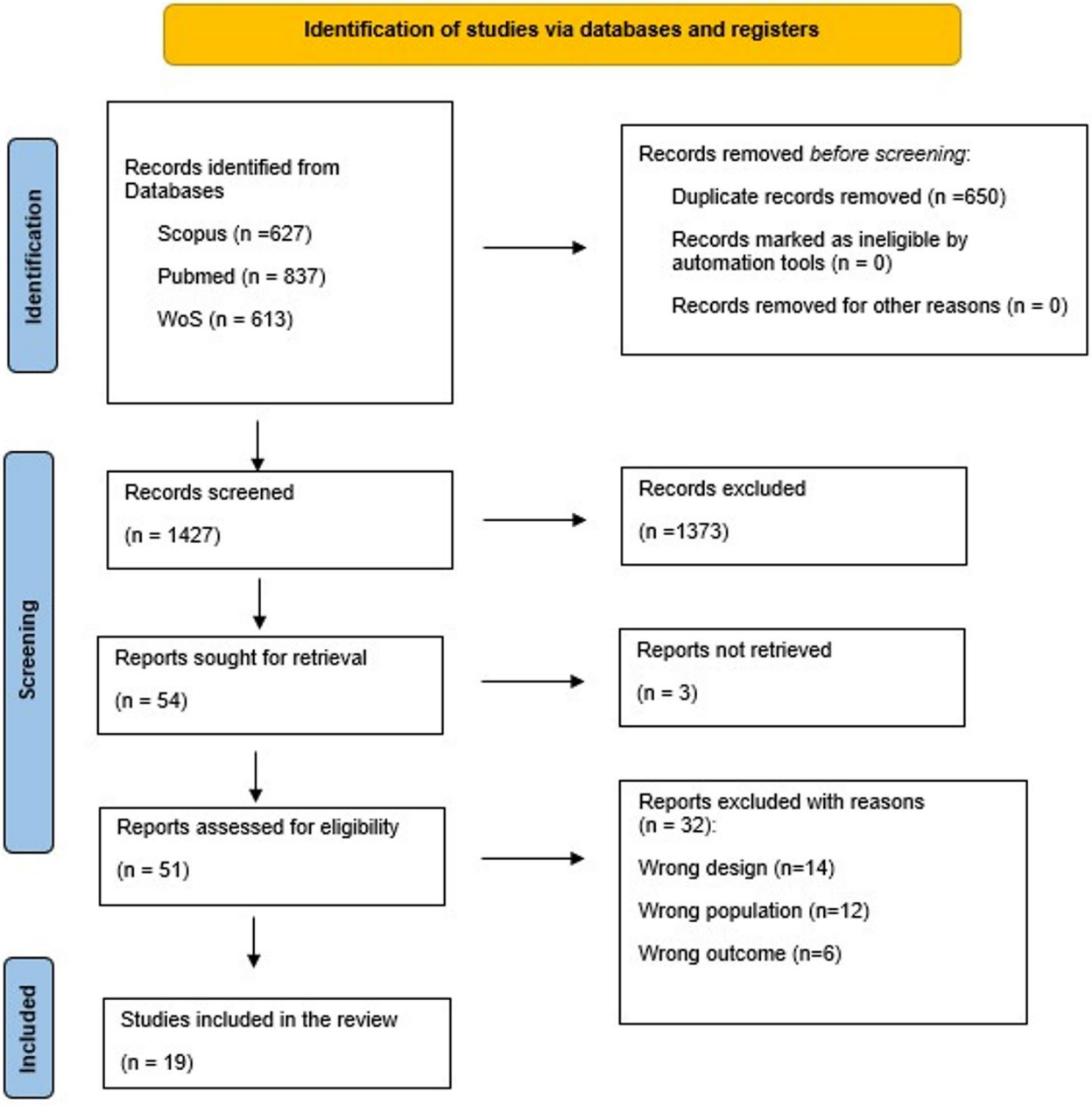

Fig. 1 Flowchart of the screening and selection process

Data extraction and synthesis

A standardized Excel spreadsheet was designed and used by the researchers (MLDP, GC, TP, DZ) who worked independently to record the following information: first author, year, country, study design, population, pregnancy rate, risk of neonatal morbidity, pre-term birth rate, caesarean rate, risk of pre-eclampsia, risk of hypertensive disorder of pregnancy, risk of obstetric morbidity, live birth rate (LBR), twin birth rate, multiple births rate, low birth weight rate, gestational age, miscarriage rate, risk of gestational diabetes, risk of placenta previa. For the purpose of data analysis, the studies were grouped into three categories based on the outcomes: 1) studies reporting pregnancy outcomes; 2) studies reporting maternal outcomes; 3) studies reporting neonatal outcomes. When possible, we included comparisons between surrogacy and unassisted pregnancy, reporting measures such as Relative Risks (RRs) or Odds Ratios (ORs).

In the pregnancy outcomes section embryo transfer (ET) details were highlighted as a critical step in gestational surrogacy. This process ensures that the surrogate carries the pregnancy without any genetic connection to the child, as the embryo is created using the gametes of the intended parents or donors. Success rates may vary based on factors such as embryo quality, egg donor age, and the overall health of the surrogate mother. Studies suggest that frozen-thawed embryo transfers (FET) achieve success rates comparable to fresh transfers. Consequently, this information was also collected when present.

Quality assessment

The included studies were assessed for methodological quality, based on their study design. The Newcastle–Ottawa scale was used to evaluate the following quality parameters: selection of study groups, comparability of study groups, and ascertainment of outcome, assigning scores ranging from 0 to 9. The overall quality of evidence was summarized by categorizing the articles into three groups, based on methodological quality: good (studies meeting at least 75% of the quality criteria), moderate (studies meeting 50%–74% of the quality criteria) and poor (studies meeting less than 50% of the quality criteria).

Results

Search strategy and characteristics of the included studies

Our search strategy identified a total of 2,077 articles. The results of the screening process are illustrated in Fig. 1, which ultimately led to the inclusion of 19 studies in this scoping review.

Table 1 shows the PI/ECOST, sample size and quality details of those included studies. Most of the them were conducted in the USA (11/19) [10, 11, 13, 15, 16, 20–26, 28] and Finland [12], Israel [14], Netherlands [17], Czech Republic [18], Russia [19] and Canada [27] with one study each. All included studies had a retrospective design, including cohort (17/19), case–control (1/19) and cross-sectional (1/19) studies. The reported data were collected between 1994 and 2021. The relationship between the commissioning couple and the GC was declared in 26.3% of cases. The smallest in-vitro fertilization (IVF) surrogacy sample included 28 cycles [12], while the largest encompassed 24,269 cycles [16]. Three articles analyzed the difference in clinical outcomes between IVF cycles using GCs and standard IVF cycles [11-14-18]. One article compared clinical outcomes between spontaneous pregnancies and IVF + GCs in the same woman, while another article compared the differences between unassisted conception, IVF and GS [27].

The quality assessment revealed that 94.7% of the studies had a good quality meeting more than 75% of the items on the rating scales, while 5.3% had a moderate quality.

Characteristics of surrogacy pregnancies

Detailed information on surrogacy pregnancy outcomes from the included studies is presented in Table 2 according to the following areas of interest: ET, pregnancy rate, delivery rate, LBR and multiple births rate, miscarriage.

Embryo transfer, pregnancy rate and delivery rate

The analyzed data showed number of embryos transferred per cycle between 1.66 ± 0.68 [20] to 4.1 ± 0.1 [10]. In some studies, the transfer involved fresh or frozen embryos [23-22-20], while others have used only frozen embryos [25-26-17]. The studies included both nulliparous and multiparous women. Among multiparous pregnancies, the average number of prior pregnancies ranged from 0.2 ± 0.6 [11] to 2.6 ± 2.0 [10]. In the study of Wang et al. the sample consisted of 29.1% nulliparous, 46.4% parous and 24.5% with unspecified parity [13]. Rumpik et al. report that in their sample 43.9% of women had one child, 39.0% had two children, and 17.1% had 3 or more children [18].

In Osmundsen et al., the average age for surrogate women was 29.6 in compared to 33.1 years for non-surrogate woman [25]. Velez et al. also analyzed the age in unassisted conception (30.2 yrs); in IVF (35.7 yrs) and in GC (33.4. yrs) groups [27].

Pregnancy-related outcomes

Pregnancy rate

The declared pregnancy rate varied as follows: 24.0% for Goldfarb et al., 55.9% for Peters et al., and 61.1% for Söderström-Anttila et al. No statistical differences were reported between fresh and vitrified donor eggs or between autologous and donor oocytes for several

Table 1 Characteristics of the studies included in the scoping review

Author, year	Country and data collection period	Study design	Population and setting	Sample size and study details	Comparison and related outcomes	QA score
Parkinson et al., 1999 [10]	USA, Oct.1989—Jan. 1997	Retrospective study	Non-commercial surrogate gestational pregnancy with IVF both in academic and private practice setting Oocytes were derived either in infertile women ($n=88$) or in oocyte donors ($n=24$). The oocytes were fertilized in vitro by the spermatozoa of the infertile husbands The commissioning parents were referred in several continents [Asia ($n=7$), Australia ($n=7$), Europe ($n=5$), South America ($n=5$), and North America ($n=64$, mainly California)]	95 IVF-surrogates who delivered 128 children 19 (20%) GCs were either relatives or close friends of the commissioning couple	Perinatal outcomes of pregnancies (both single and multiple) established after IVF-surrogacy were evaluated and compared to the outcomes of pregnancies that resulted in standard IVF reported by Brinsden and Rizk (1992)	9/9
Goldfarb et al., 2000 [11]	USA, 1984–1999	Retrospective study	Surrogate gestational pregnancy with IVF in a tertiary care and academic centre. Oocytes were derived in patients with different diagnosis of infertility: a) absence of uterus for hysterectomy (51 pts), b) congenital absence of uterus (15 pts), c) a variety of other (46 pts) The commissioning parents were in USA ($n=101$) and in abroad ($n=11$)	180 IVF surrogacy cycles in 112 couples. 158 transferred (16 cycles cancelled due to poor stimulation & 6 cycles with no embryos) to GCs 14 GCs were relatives of the commissioning couples	Individuals with congenital uterus absence had significantly more oocytes retrieved, fertilized, cleaved and transferable than patients who underwent hysterectomy	8/9
Söderström-Anttila et al., 2002 [12]	Finland, Jan. 1991-May 2001	Retrospective study	Non-commercial surrogate gestational pregnancy with IVF Oocytes derived either in infertile women ($n=27$), of whom 5 with vagina's and uterus' absence, or in oocyte donors ($n=1$) The 17 commissioning parents were referred in Finland ($n=13$), Sweden ($n=2$), Denmark ($n=1$), Norway ($n=1$). One couple commissioned 2 IVF surrogacies	28 IVF for 17 unpaid surrogacies 11/18 (61.1%) GCs were relatives of the commissioning couples	Not applicable	7/9
Wang et al., 2016 [13]	Australia, Jan. 2004-Dec. 2011	Retrospective population study	Surrogate gestational pregnancy with IVF Oocytes were derived in patients with different diagnosis of infertility or in oocytes donors ($n=12$,7.1%). Husband or partner's sperm was used in all intendent parent's cycles	557 surrogacy cycles including 169 intended parents' cycles and 388 GC cycles, with an average of 2.3 GC cycles per every intended parents'cycle 360/388 (92.8%) embryo transfer cycles: 248/360 (68.9%) single, 110 (30.6) double, 2/360 (0.5%) with more than embryos	Intendent parents' vs GC cycles	8/9
Machtinger et al., 2017 [14]	Israel, 1998–2016	Retrospective study	Surrogate gestational pregnancy with IVF in a tertiary, university affiliated medical centre Oocytes were derived in patients with different diagnosis of infertility: a) absence of uterus (either congenital or acquired) (21 pts), b) maternal disease with contraindication to conceptions (28 pts), c) recurrent IVF failure (3 pts)	52 intended mothers underwent 252 oocyte retrieval cycles. The embryos were transferred to 64 GCs in 212 IVF cycles. Of the 252 retrieval cycles, 132 were by the COH protocol, 62 by the modified natural cycle protocol, and 58 by the IVM protocol	COH vs MNC vs IVM	6/9

Table 1 (continued)

Author, year	Country and data collection period	Study design	Population and setting	Sample size and study details	Comparison and related outcomes	QA score
Woo et al., 2017 [15]	USA, Jan. 1990-Dec. 2014	Retrospective cohort study	Singleton live births achieved with the use of commissioned versus spontaneously conceived embryos carried by the same gestational surrogate (natural conception versus IVF in gestational surrogates) in 3 centres (2 surrogacy agencies and 1 university centre)	494 pregnancies of which 312 spontaneous and 182 in GS-IVF in 124 gestational surrogates	Natural conception vs IVF in GS	7/9
Murugappan et al., 2018 [16]	USA, 2004–2016	Retrospective cohort study	GC in ART For GS, oocytes were derived in patients with 4 different category of infertility (any uterine factor, exclusively male factor, unexplained infertility, and nonuterine female factor) or in oocytes donors. Husband or partner's sperm or donated sperm was used in intendent parent's cycles	A total of 1,337,721 cycles were analyzed, including 24,269 GC and 1,313,452 non-GC cycles. Donor oocytes were used in 143,947/1,313,452 (11.0%) of non-GC cycles and 11,279/24,269 (46.5%) of GC cycles	Clinical outcomes of IVF cycles with the use of GCs (GCs) vs with non-GC IVF cycles	9/9
Peters et al., 2018 [17]	Netherlands, Oct. 2006-Mar. 2017	Retrospective cohort study	Non-commercial surrogate gestational pregnancy with SET-IVF in a tertiary, university medical centre in a multidisciplinary team setting Husband or partner's sperm was used in all intendent parent's cycles Autologous oocytes were derived in patients with different diagnosis of infertility: a) absence of uterus (either congenital or acquired) (36 pts (60%)), b) maternal disease with contraindications to conceptions (10 pts (16.7%)), c) non-functioning uterus (14 pts (23.3%))	93 IVF/ICSI cycles initiated in 60 intended mothers, with subsequent 184 single fresh embryo transfers in 63 GCs (68.0% relatives and 31.7% with a genetic relationship with the commissioning couples)	GS in absence of the uterus vs maternal medical condition vs a non-functioning uterus	9/9
Rumpik et al., 2019 [18]	Czech Republic, 2004–2017	Retrospective cohort study	Non-commercial gestational surrogacy in the Czech Republic with a SET Oocytes were derived either in infertile women (49 without uterus or with uterine damage), 17 with medical conditions precluding pregnancy, 9 with repeated IVF or repeated pregnancy failure) or donors ($n=6$)	130 IVF cycles involving 75 intended mothers and 82 surrogate mothers (in 6/82 (7.3%) relatives (sisters) of the commissioning mothers)	Fresh vs frozen ET Cases of women without uterus or with uterine damage vs case of women with medical conditions precluding pregnancy vs cases of women with repeated IVF failure or repeated pregnancy failure	8/9
Rudenko et al., 2020 [19]	Russia, not specified	Retrospective case–control study	Immunomorphological features of the placenta in allogeneic pregnancy as the background for the development of obstetric complications	110 women: 89 cases whose pregnancy occurred as a result of IVF with a donor egg in a surrogate motherhood program (IVF-SM, $n=47$) or oocyte donation (IVF-DO, $n=42$) and 21 patients in whom pregnancy occurred as a result of IVF with their own egg (IVF-OE)	IVF-OE vs IVF-SM vs IVF-DO	7/9
Smith et al., 2021 [20]	USA, 2008–2018	Retrospective cohort study	GC pregnancies	836 GC	Not applicable	8/9
Swanson et al., 2021 [21]	USA, 2009–2018	Retrospective cross-sectional study	GC pregnancies	361 GC pregnancies	Not applicable	9/9

Table 1 (continued)

Author, year	Country and data collection period	Study design	Population and setting	Sample size and study details	Comparison and related outcomes	QA score
Swanson et al., 2020 [22]	USA, 2009–2018	Population-based retrospective study	GC pregnancies vs non-surrogate pregnancies	509.376 pregnancy of which: 361 GS-IVF, 563 IVF without GS-IVF, 567 Non-GC IVF pregnancies, non-GC pregnancies $n=509,015$, matched control pregnancies ($n=1800$)	Pregnancy outcomes of GS vs no GS	8/9
Namath et al., 2021 [23]	USA, 2009–2018	Retrospective cohort study	GC pregnancy outcomes in frozen embryo transfer	583 frozen ET, 427 SET e 156 DET.194 transfers with PGT-A and 389 cycles without PGT-A	SET vs DET PGT-A vs no PGT-A	8/9
Attawet et al., 2022 [24]	Australia, 2009–2016	Population-based retrospective study	Gestational surrogates who had at least one embryo transfer cycle in non-commercial surrogacy	170 embryo transfer cycles to 81 gestational surrogates and on behalf of 66 intended parents. 97.1% single embryo transfers	Not applicable	8/9
Osmundsen et al., 2023 [25]	USA, 2006–2016	Retrospective cohort study	Twin gestational surrogacy among ART pregnancies	249 Twin pregnancies: 36 GC and 213 non-GC	SM vs non-SM	8/9
Traub et al., 2024 [26]	USA, 2014–2020	Retrospective cohort study	ART cycles with an embryo transfer to a GC	40,177 ART cycles	Not applicable	8/9
Velez et al., 2024 [27]	Canada, 2012–2021	Retrospective cohort study	All singleton births at more than 20 wks' gestation: 846,124 (97.6%) were by unassisted conception, 16,087 (1.8%) by IVF, and 806 (0.1%) by gestational carriage	Unassisted conception: 846,124 (97.6%) IVF: 16,087 (1.8%), gestational carriage: 806 (0.1%)	Unassisted conception vs IVF vs gestational carriage	9/9
Kloos et al., 2024 [28]	USA, 2014–2015	Retrospective cohort study	1284 fresh transfer cycles to GC recipients of embryos resulting in fresh ($n=1119$) and vitrified/thawed ($n=165$) donor oocytes. Data in the Society for ART Clinic Outcome Reporting System database	1119 fresh and 165 vitrified/thawed donor oocytes for a total of 1284 transfer cycles	Fresh vs frozen donor oocytes in GC cycles	7/9

QA Quality Assessment according to New Castel and Ottawa scale, *ET* Embryo Transfer, *IVF* In Vitro Fertilization, *ET* Embryo Transfer, *SET* Single Embryo Transfer, *DET* Double Embryo Transfer, *GS* Gestational Surrogacy, *ART* Assisted Reproductive Technology, *NA* Not Available, *COH* Controlled Ovarian stimulation, *MNC* Modified Natural Cycle, *IVM* In Vitro Maturation, *SM* Surrogate Motherhood, *IVF-SM* IVF with a donor egg in a SM program, *IVF-OD* IVF with oocyte donation, *IVF-OE* Pregnancy occurred as a result of IVF with own egg, *PGT-A* Preimplantation Genetic Testing for Aneuploidy

pregnancy outcomes, including implantation, pregnancy rate and LBR [20-14-26-19].

Delivery rate

The highest delivery rate among the included studies was 55.5% per ET [12], while the lowest was 9.4%, which included 11.8% from modified natural cycle and 4.7% from in vitro maturation [14]. Rumpik et al. reported a rate of 32.3% [18].

Live birth

LBR reported in the analysed studies was heterogeneous: 15.8% for Goldfarb et al., and 55.5% for Söderström-Anttila et al.. Wang et al. found no differences between single embryo transfer (SET) and double embryo transfer (DET) (18.9% versus 19.1%). Woo et al. reported higher LBRs in GS-IVF (97.0%) compared to natural conception (88.8%) [15]. Murugappan et al. reported an overall LBR of 44.6% overall, with autologous oocytes yielding 41.0% in fresh cycles and 34.5% in frozen cycles, and donor oocytes yielding 59.3% in fresh cycles and 42.6% in frozen cycles [16]. Namath et al., found LBRs of 36.8% for Preimplantation Genetic Testing for Aneuploidy (PGT-A) SET and 64.5% for PGT-A DET compared to 36.7% for non-PGT-A SET and 48.0% for non-PGT-A SET DET [23].

Traub et al., reported 50.2% LBR for autologous oocytes and 58.2% for donor oocytes [26]. Finally, Attawet et al., documented cumulative LBRs of 23.5% after the first cycle increasing to 50.6% after the sixth cycle [24].

Multiple birth rate

The investigated studies did not report information to distinguish multiple deliveries from multiple births. The incidence of multiple births in surrogacy varied across studies and according to the number of ET. Parkinson et al., reported a rate of 22.7% (29/128), including 54 twins and 6 triplets after 5 multifetal reductions. A substantial decrease in multiple implantation rates was observed after the transfer of 6 embryos (9.1% twin gestations), most likely reflecting the infertility conditions of the commissioning mothers [10].

Table 2 Pregnancy outcomes details described in the studies included in the scoping review

Author, year	Embryo transferred details	Pregnancy rate	Delivery rate	Live Birth Rate	Multiple deliverable rate	Abortion
Parkinson et al., 1999 [10]	Mean ± SD per cycle: 4.1 ± 0.1	37.7%	NA	Not applicable	22.7% (29/128): 54 twins (27 pregnancies) and 6 triplets (2 pregnancies) were born following 5 multifetal reductions (3 quadruplet and 2 triplet pregnancies reduced to twins without complications. 53.8% and 7.7% of the twin and triplets' pregnancies respectively followed the transfer of five embryos. A substantial decrease in multiple implantation rates in the IVF-surrogates was observed after the transfer of 6 embryos (9.1% twin gestations), most likely reflecting the infertility conditions of the commissioning mothers	NA
Goldfarb et al., 2000 [11]	Mean ± SD per cycle: 3.2 ± 0.1 to each individual recipient 2–4 embryos transferred (range 1–6) per cycle	Overall pregnancy rate per cycle: 24% (38/158) Clinical pregnancy rate: 19.0% (30/158)	19.0% (30/158)	15.8% (25/158)	5.1% (7/138) (6 twins and 1 triplets)	4 miscarriages 1 ectopic pregnancy
Söderström-Anttila et al., 2002 [12]	16 fresh, 25 frozen/thawed	61.1% (11/18) 50.0% (8/16) per fresh ET, 15.9% (3/19) per frozen-thawed ET	55.5% (10/18)	55.5% (10/18)	5.5% (1/18) (1 twins)	5.5% (1/18) (1 miscarriage)
Wang et al., 2016 [13]	Mean per cycle: 1.8 91% cryopreserved 61% single-embryo transfer	26.4% (95/360) of which 27.4% (68/248) in SET and 24.5% (27/110) in DET ($p = 0.57$)	19.4% (70/360) of which 19.3% (48/248) in SET and 20.0% (22/110) in DET ($p = 0.89$)	18.9% (68/360) of which 18.9% (47/248) in SET and 19.1% (21/110) in DET ($p = 0.99$) 73/75 (97.3) number of live born babies (64/65 singleton and 9/10 twins)	7.1% (five twin deliveries and 65 singleton deliveries) of which 0% in SET and 22.7% in DET	6.9% (20/95)
Machtinger et al., 2017 [14]	Mean ± SD per cycle: 2.3 ± 0.7 for COH, 1.4 ± 0.5 for MNC, 2.3 ± 0.7 for IVM 42.4% (91/212) cryo preserved cycles	13.6% (29/212) of which 15.8% (24/152) in COH, 11.8% (2/17) in MNC and 7.0% (3/43) in IVM	9.4% (20/212) of which 11.8% (2/17) in MNC and 4.7% (2/43) in IVM	NA	NA	4.2% (9/212) of which 5.3% (8/152) in COH, 0% in MNC and 2.3% (1/43) in IVM
Woo et al., 2017 [15]	NA	Not applicable	Not applicable	97.0% (177/182) in GS-IVF vs 88.8% (277/312) in natural conception. 52/494 (71.3%) singleton live births of which 103 in GS-IVF and 249 in natural conception	33% in GS-IVF vs 1% in natural conception ($p < 0.001$)	3.0% in GS-IVF vs 10.9% in natural conception ($p = 0.01$) of which: 5 miscarriages in GS-IVF and 12 miscarriages, 21 elective abortions and 1 ectopic pregnancy in natural conception

Table 2 (continued)

Author, year	Embryo transferred details	Pregnancy rate	Delivery rate	Live Birth Rate	Multiple deliverable rate	Abortion
Murugappan et al., 2018 [16]	Data available only in fresh transfer Mean ± SD per cycle: 2.4 ± 1.1 and 2.1 ± 0.6 in case of autologous and donor oocyte respectively	In GS: 54.6% (11,926/21,829) of which 51.8% (3,403/6,574) and 44.6% (2,158/4,836) in fresh and frozen cycles for autologous oocyte and 68.0% (3,944/5,802) and 52.5% (2,421/4,617) in fresh and frozen cycles for donor oocyte	NA	44.6% (9,728/21,829) of which: 41.0% (2683/6,574) and 34.5% (1,661/4,836) in fresh and frozen cycles for autologous oocyte and 59.3% (3,423/5,802) and 42.6% (1,961/4,617) in fresh and frozen cycles for donor oocyte	15.6% (3,398/21,829) of which: *Twin births:* 14.9% (3263/21,829) of which 13.1% (859/2,683) and 7.9% (382/4,836) in fresh and frozen cycles for autologous oocyte and 25.1% (1,456/5,802) and 12.2% (561/4,617) in fresh and frozen cycles for donor oocyte *HOM births:* 135/21,829 (0.6%) of which 45/2,683 (1.7%) and 12/4,836 (0.2%) in fresh and frozen cycles for autologous oocyte and 51/5,802 (0.9%) and 561/4,617 (0.6%) in fresh and frozen cycles for donor oocyte	9.6% (2,097/21,829) *For autologous oocytes:* 10.5% (689/2,683) in fresh cycles; 9.8% (476/4,836) in frozen cycles *For donor oocytes:* 8.4% (487/5,802) in fresh cycles; and 9.6% (445/4,617) in frozen cycles
Peters et al., 2018 [17]	41 freshes, 40 cryopreserved	55.9% (52/93)	37.6% (35/93)	36.6% (34/93) One 22 wks gestation was interrupted for diagnosis of Down's syndrome combined with a severe cardiac anomaly	0%	18.3% (17/93) (5 spontaneous miscarriages, 12 biochemical pregnancies)
Rumpik et al., 2019 [18]	73 freshes, 57 cryopreserved	43.9% (57/130) of which 45.6% (34/73) and 40.4% (23/57) in fresh and frozen ET respectively ($p = 0.59$)	32.3% (42/130) of which: 35.6% (26/73) and 28.1% (16/57) in fresh and frozen ET respectively ($p = 0.45$)	32.3% (42/130)	2.3%	11.5% (15/130) of which: 10.9% (8/73) and 12.3% (7/57) in fresh and frozen ET respectively ($p = 1$)
Rudenko et al., 2020 [19]	Not applicable	Not applicable	42.6% (20/47)	Not applicable	Not applicable	57.4% (27/47) of which: 36.1% (17/47) in the 1st trimester and 21.3% (10/47) in 2nd trimester
Smith et al., 2021 [20]	Mean ± SD per cycle: 1.66 ± 0.68; 38.3% one cycle; 45.0% two cycles: 3.8% three cycles; 1.2% 4 four cycles; 0.5% ≥ 5 cycles; 11.2% Unknown	NA	NA	NA	22.3%	NA
Swanson et al., 2021 [21]	42.0% of SET in GS vs 60.0% of SETin non-GS	NA	NA	435	21.3%	NA
Swanson et al., 2020 [22]	Not applicable	NA	NA	NA	21.3% in GC pregnancies vs 1.7% in all other pregnancies vs 5.9% in matched controls vs 25.9% in non-surrogate IVF pregnancies Pairwise comparison of GC vs no GC: $p < 0.01$; $p < 0.01$ and $p = 0.11$ respectively	NA

Table 2 (continued)

Author, year	Embryo transferred details	Pregnancy rate	Delivery rate	Live Birth Rate	Multiple deliverable rate	Abortion
Namath et al., 2021 [23]	583 frozen ET cycles	NA	NA	*PGT-A:* 36.8% (60/163) SET; 64.5% (20/31); DET; $p=0.008$ *Non-PGT-A:* 36.7% (97/264) SET; 48.0% (60/125) DET; $p=0.05$	1.9% for SET vs 20.0% for DET	NA
Attawet et al., 2022 [24]	NA	30.9% ($n=25$)	NA	*Cumulative LBR ():* 23.5% (15.6–33.8) after 1st 50.6% (40.0–61.2) after the sixth cycle	2.4% (1/41) twin delivery (in multiple ET)	NA
Osmundsenet al, 2023 [25]	NA	NA	NA	NA	100% (all twin pregnancies)	NA
Traub et al., 2024 [26]	72.4% only 1 ET ($n=29,096$); 26.2% 2 ET ($n=10,507$); 1.4% more than 2 ET ($n=3574$)	*Biochemical pregnancy:* 69.5% Autologous oocytes: ($n=13,639$); 73.6% Donor oocytes ($n=15,679$) *Clinical pregnancy:* 69.0% Autologous oocytes ($n=11,702$); 67.3% Donor oocytes ($n=13,715$)	NA	50.2% Autologous oocytes ($n=9789$); 58.2% Donor oocytes ($n=11,860$)	11.4% Autologous oocytes ($n=1111$); 17.6% Donor oocytes ($n=2085$)	NA
Velez et al., 2024 [27]	NA	NA	NA	NA	0% (all single pregnancies)	NA
Kloos et al., 2024 [28]	1119 fresh and 165 frozen donor oocytes for a total of 1284 transfer cycles Mean ± SD ET: 1.6 ± 0.5 fresh; 1.5 ± 0.5 frozen	*Clinical pregnancy:* 54.6% Fresh ($n=611$); 54.5% Frozen ($n=90$); RR = 1.01 (0.82–1.24)	NA	47.7% Fresh ($n=534$); 46.1% Frozen ($n=76$); RR = 0.89 (0.70-.13)	36.1% Fresh ($n=193$); 23.7% Frozen ($n=18$); RR = 0.77 (0.47, 1.29)	*Biochemical pregnancy loss:* 5.9% Fresh ($n=66$); 10.3% Frozen ($n=17$) RR = 1.00 (0.46–2.19) *Clinical pregnancy loss:* 11.8% Fresh ($n=132$); 17.6% Frozen ($n=29$); RR = 1.13 (0.65–1.97)

SD Standard Deviation, *RR* Relative Risk presented with 95% Confidence Interval (CI) – RR (95% CI), *ET* Embryo Transfer, *IVF* In Vitro Fertilization, *SET* Single Embryo Transfer, *DET* Double Embryo Transfer, *GS* Gestational Surrogacy, *GC* Gestational Carrier, *NA* Not Available, *COH* Controlled Ovarian stimulation, *MNC* Modified Natural Cycle, *IVM* In Vitro Maturation, *HOM* High-Order Multiple, *SM* Surrogate Motherhood, *IVF-SM* IVF with a donor egg in a SM program, *IVF-OD* IVF with oocyte donation, *IVF-OE* Pregnancy occurred as a result of IVF with own egg, *PGT-A* Preimplantation Genetic Testing for Aneuploidy

Murugappan et al. reported 0.6% high-order multiple births in GS, with 1.7% and 0.2% in fresh and frozen cycles for autologous oocyte and 0.9% and 0.6% in fresh and frozen cycles for donor oocyte [16].

Miscarriage rate

Machtinger et al. found no differences among controlled ovarian stimulation (COH), modified natural cycle and in vitro maturation (5.3%, 0% and 2.3% respectively) [14]. Woo et al. reported, a miscarriage rate of 3.0% in GS-IVF and 10.9% in natural conception [15]. Murugappan et al., observed 9.6% overall, with 10.5% and 9.8% in fresh and frozen cycles for autologous oocytes and 8.4% and 9.6% in fresh and frozen cycles for donor oocytes [16]. Rumpik et al. reported a miscarriage rate of 11.5%, with10.9% and 12.3% for fresh and frozen ET [18]. Peters et al. documented a miscarriage rate of 18.3% including5 miscarriages and 12 biochemical losses [17], while Kloos et al. reported biochemical losses of 5.9% (fresh) and 10.3% (frozen), and clinical losses of 11.8% (fresh) and 17.6% (frozen) [28]. Wang et al., reported 6.9% (20/95) [13].

Surrogate mother's clinical and obstetrics outcomes

Table 3 presents the clinical and obstetrics outcomes related to GS. The age of surrogate mothers of the analyzed studies ranged from 22 to 52 years. The sample

Table 3 Surrogate mother's clinical and obstetrics outcomes details described in the studies included in the scoping review

Author, year	Pre-SG parity, mean ± SD except whereindicated	Surrogates maternal age, years Mean ± SD except were indicated	Surrogate gestational age, wks Mean ± SD except were indicated	Amniocentesis/Vaginal bleeding/ Gestational diabetes/PH/Antibiotic during labour	Placenta previa/Abruptio placentae	Pre-eclampsia /Eclampsia	Severe obstetric morbidity	Post-partum complications	Pre-term delivery < 37 wks, 34 and 32 wks	Caesarean section
Parkinson et al., 1999 [10]	2.6 ± 2.0 without obstetric complications, while providing no history of mental illnesses or postpartum depression	30.4 ± 4.7 yrs	38.7 ± 0.3 wks in singleton pregnancies 36.2 ± 0.4 in twins' pregnancies 35.5 in triplet pregnancies	*Amniocentesis:* NA *Vaginal bleeding:* 4.9 vs 3.7% in singleton and twins' pregnancies respectively *Gestational diabetes:* 1.6% vs 3.7% vs 0% in singleton, twin and triplet pregnancies respectively. HP: 4.9% vs 7.4% vs 0% in singleton, twin and triplet pregnancies respectively *Antibiotic during labour:* NA	4.9% vs 3.7% vs 0% in singleton, twin and triplet pregnancies respectively	NA	1 hysterectomy after caesarean section	Post-partum complication NOS: 1.6% vs 7.4% vs 0% in singleton, twin and triplet pregnancies respectively 5.2% (5/95) post-partum depression	11.5%, 20.4%, 100% respectively in singleton, twins and triples pregnancies 14.8%, 43.6% and 100% respectively of singleton, twins and triples pregnancies had a PTL	21.3% vs 59.3% vs 100% in singleton, twin and triplet pregnancies respectively In 4 cases Caesarean sections was performed for the delivery of the second infant following successful vaginal delivery of the first twin
Goldfarb et al., 2000 [11]	0.2 ± 0.6	34.4 ± 4.4 yrs	NA	*Amniocentesis*: NA Vaginal bleeding: NA Gestational diabetes: NA HP: NA Antibiotic during labour: NA	NA	NA	NA	NA	NA	NA
Söderström-Anttila et al., 2002 [12]	2.6 mean	36 yrs (range:29–52)	NA	*Amniocentesis*: NA Vaginal bleeding: NA Gestational diabetes: 11.1% (2/18) HP: 5.5% (1/18) Antibiotic during labour: NA	0	0	0	11.1% (2/18) post-partum depression	0 (0%)	70% (7/10)
Wang et al., 2016 [13]	29.1% Nulliparous 46.4% Parous 24.5 Not stated	< 30 yrs: 10.6% 30–34 yrs: 27.1% 35–39 yrs: 35.8% ≥ 40 yrs: 26.5%	NA	*Amniocentesis*: NA Vaginal bleeding: NA Gestational diabetes: NA HP: NA Antibiotic during labour: NA	NA	NA	NA	NA	21.9% (16/73) of which 12.8% in SET and 30.8% in DET ($p = 0.07$)	33/70 (47.1%)
Machtinger et al., 2017 [14]	1.8 ± 0.94 (range 0–4)	31.9 ± 4.0 yrs (range: 22–40)	NA	*Amniocentesis*: NA Vaginal bleeding: NA Gestational diabetes: NA HP: NA Antibiotic during labour: NA	NA	NA	NA	NA	NA	NA

Table 3 (continued)

Author, year	Pre-SG parity, mean ± SD except whereindicated	Surrogates maternal age, years Mean ± SD except were indicated	Surrogate gestational age, wks Mean ± SD except were indicated	Amniocentesis/Vaginal bleeding/ Gestational diabetes/PH/Antibiotic during labour	Placenta previa/Abruptio placentae	Pre-eclampsia /Eclampsia	Severe obstetric morbidity	Post-partum complications	Pre-term delivery < 37 wks, 34 and 32 wks	Caesarean section
Woo et al., 2017 [15]	NA	33.0 ± 4.7 yrs	For singleton live birth: 38.8 ± 2.1 wks in GS-IVF vs 39.7 ± 1.4 wks in natural conception	*Amniocentesis*: 6.8% for singleton live birth: in GS-IVF vs 0% in natural conception ($p < 0.001$) *Vaginal bleeding*: 2.9% for singleton live birth: 2.9% in GS-IVF vs 2.0% in natural conception ($p = 0.71$) *Gestational diabetes*: for singleton live birth: 6.8% in GS-IVF vs 1.2% in natural conception ($p = 0.01$) *HP*: for singleton live birth: 6.8% in GS-IVF vs 2.8% in natural conception ($p = 0.03$) *Antibiotic during labour:* for singleton live birth: 6.2% in G-IVF vs 0.5% in natural conception ($p = 0.02$)	For singleton live birth: 4.9% in GS-IVF vs 1.2% in natural conception ($p = 0.05$)	For singleton live birth: 1.9% in GS-IVF vs 1.2% in natural conception ($p = 0.59$)	Presence of of obstetrics complications specified in dedicated fields	Post-partum complications NOS: 19.4% in GS-IVF vs 0% in natural conception ($p = 0.009$)	For singleton live birth: 10.7% in GS-IVF vs 3.1% in natural conception ($p = 0.01$)	In emergency: 3.5% in GS-IVF vs 2.8% in natural conception ($p = 0.77$) Planned: 19.0% in GS-IVF vs 8.7% in natural conception ($p = 0.01$)
Murugappan et al., 2018 [16]	NA	NA	NA	*Amniocentesis*: NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	NA	NA
Peters et al., 2018 [17]	NA	mean: 35.3 yrs (range:27–44)	mean: 39.2 wks	*Amniocentesis*: NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* 20.6% (7/34) *Antibiotic during labour:* NA	NOS	0%	NA	52.9% Induced labour 23.5% post-partum haemorrhage (> 500 ml)	0%	3(34 (8.8%) due to new born position ($n = 2$) and induction fail ($n = 1$)
Rumpik et al., 2019 [18]	1 child in 36/82 (43.9%) 2 children in 32/82 (39.0%) 3 or more children (14 (17.1%)	< 30 yrs in 42/82 (51.2%) 30–35 yrs in 21/82 (25.6%) > 36 yrs in 20/82 (24.4%)	NA	*Amniocentesis*: NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	0%	0%	0%	NA
Rudenko et al., 2020 [19]	All surrogate mothers were multiparous	29.4 ± 3.2 yrs	37.1 ± 1.4 wks	*Amniocentesis*: NA Vaginal bleeding: NA Gestational *diabetes*: 2.1% *HP*: 6.4% *Antibiotic during* labour: NA	4.2% (2/47)	17.1% (5/47)	NA	NA	53.2% (25/47) of which: 10.6% (5/47) induced and 42.6% (20/47) spontaneous	NA

Table 3 (continued)

Author, year	Pre-SG parity, mean ± SD except whereindicated	Surrogates maternal age, years Mean ± SD except were indicated	Surrogate gestational age, wks Mean ± SD except were indicated	Amniocentesis/Vaginal bleeding/ Gestational diabetes/PH/Antibiotic during labour	Placenta previa/Abruptio placentae	Pre-eclampsia /Eclampsia	Severe obstetric morbidity	Post-partum complications	Pre-term delivery < 37 wks, 34 and 32 wks	Caesarean section
Smith et al., 2021 [20]	64.1% First-time GC ($n = 536$); 35.9% Repeat GC ($n = 300$)	33.92 ± 4.61	33 + 0 wks for in pre-term delivery; 36 + 6 wks for on term delivery	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	15.1%	61.5% with no history of CS and 38.5% of vaginal bleeding; 62.3% with history of 1 or more CSand 37.7%of vaginal bleeding
Swanson et al., 2021 [21]	0	30 (27–33) yrs in multifetal gestation; 31 (28.–35) yrs in singleton gestation	NA	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* 13% in multifetal gestation and 9.9% in singleton gestation *Antibiotic during labour:* NA	NA	0	1.7% total 2.6% in multifetal vs 1.4% in singleton	NA	*Birth < 37 wks:* 76.6% in multifetal vs 13.0% in singleton *Birth < 34 wks:* 29.9% in multifetal vs 3.5% in singleton *Birth < 32 wks:* 76.6% in multifetal vs 2.5% in singleton	52.0% in multifetal; 18.3% in singleton
Swanson et al., 2020 [22]	0	Median age (min–max): 31 (28–34) in GC; 38 (33–43) in non-GC	NA	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* 10.2% in GC vs 21.2% in non-GC IVF vs 5.8% in non-GC vs 8.5% in matched controls Reference standard: GC $OR_{non\text{-}GC\ IVF} = 0.42$ (0.28–0.6); $OR_{non\text{-}GC} = 1.84$ (1.31–2.59); $OR_{Matched\ controls} = 1.20$ (0.82–1.75)) *Antibiotic during labour:* NA	NA	0% in GC; 0.4% in non-GC IVF; 0.1 in non-GC; 0.3% in matched controls	1.7% in GC vs 5.5% in non-GC IVF vs 1.0% in non-GC vs 1.2% in matched controls with no statistical differences between groups	0	NA	25.5% in GC vs 60.0% in non-GC IVF vs 22.0% in non-GC vs 25.3% in matched controls with no statistical differences between groups except for GC vs non-CG IVF OR:0.22 (0.17–0.30)
Namath et al., 2021 [23]	NA	NA	SET 38 wks vs DET 36 wks; P < 0,001)	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	*Preterm*: 40.0% in DET vs 13.4% in SET ($p < .001$) *Very preterm*: 6.0% in DET vs 1.6% in ($p = 0.03$) *Extremely preterm*: 4% in DET vs 1.0% in SET	NA

Table 3 (continued)

Author, year	Pre-SG parity, mean ± SD except whereindicated	Surrogates maternal age, years Mean ± SD except were indicated	Surrogate gestational age, wks Mean ± SD except were indicated	Amniocentesis/Vaginal bleeding/ Gestational diabetes/PH/Antibiotic during labour	Placenta previa/Abruptio placentae	Pre-eclampsia /Eclampsia	Severe obstetric morbidity	Post-partum complications	Pre-term delivery <37 wks, 34 and 32 wks	Caesarean section
Attawet et al., 2022 [24]	*Previous pregnancy of > 20 wks:* 15.0.% Yes; 84.8% No	37.9 ± 6 yrs	4.9% 34 wks; 2.4% 35 wks; 7.3% 36 wks; 7.3% 37 wks; 39.0% 38 wks; 17.1% 39 wks; 19.5% 40 wks; 2.4% 41 wks	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	16.7%	39.0%
Osmundsenet al, 2023 [25]	Nulliparity (%) S 0 NS 78 (36.6) < .001 Term, range S 1–6 NS 0–4 < .001 Preterm, range S 0–2 NS 0–2 < .001	29.58 vs. 33.11 yrs in surrogate and NS respectively $p < 0.001$	0	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* 27.8% in GC vs 12.2% in non-GC ($p < .05$) *HP:* 0% in GC vs 7% in non-GC p = 0.21 *Antibiotic during labour:* NA	S 2 (5.6) NS 1 (0.5) $p = 0.08$	S 3 (8.3) NS 29 (13.6) $p = 0.54$	NA	NA	NA	NA
Traub et al., 2024 [26]	0: 14,453 (46.0); 1: 5737 (18.2); > = 210,949 (34.8)	< 30 13,472 (33.5); 30–34 14,063 (35.0); 35–39 9739 (24.2); >40 2903 (7.2)	Term-Autologous oocytes: 7314 (74.9); Donor oocytes:8484 (71.8). Preterm-Autologous oocytes:2136 (21.9); Donor oocytes:2878 (24.4). Very preterm-Autologous oocytes: 312 (3.2); Donor oocytes:459 (3.9)	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	Preterm-Autologous oocytes:2136 (21.9); Donor oocytes:2878 (24.4). Very preterm-Autologous oocytes: 312 (3.2); Donor oocytes:459 (3.9)	NA
Velez et al., 2024 [27]	Nulliparity: 42.1% in UC; 65.4% in IVF; 8.9% in GC	30.2 ± 5.1 in UC; 35.7 ± 4.7 in IVF; 33.4 ± 5.3 in GC	NA	*Pre-pregnancy diabetes:* 1.3% in UC; 2.0% in IVF; 1.7% in GC *HP:* GC vs UC wRR = 1.75 (1.46–2.10); GC vs IVF wRR = 1.37 (1.11–1.70)	< 6%	Severe preeclampsia or HELLP syndrome UC: 3552 (0.42 (0.41–0.43); IVF: 152 (0.94 (0.80–1.11]): GC: 15(1.86 [1.05–3.05])	*GC vs UC:* wRR = 3.30 (2.59- 4.20); *GC vs IVF:* wRR = 1.86 (1.36- 2.55)	Postpartum haemorrhage- UC: 3880 (0.46 [0.44–0.47]); IVF: 219 (1.36 [1.19–1.55]); GC: 19 (2.36 [1.43–3.66])	*< 37 wk:* GC vs UC wRR = 1.79 (1.46–2.20); GC vs IVF wRR = 1.27 (1.00–1.61) *< 32 wk:* GC vs UC wRR = 1.50 (0.86–2.64); GC vs IVF wRR = 1.02 (0.55–1.87)	*Elective:* GC vs UC wRR = 0.92 (0.79–1.07); GC vs IVF wRR = 0.79 (0.68–0.93 *In emergency:* GC vs UC wRR = 1.12 (0.90–1.39); GC vs IVF wRR = 0.91 (0.72–1.15)
Kloos et al., 2024 [28]	NA	31.6 ± 5.2 in fresh; 32.4 ± 5.4 in frozen	NA	*Amniocentesis:* NA *Vaginal bleeding:* NA *Gestational diabetes:* NA *HP:* NA *Antibiotic during labour:* NA	NA	NA	NA	NA	NA	NA

SD Standard Deviation, *RR* Relative Risk, *CI* Confidence Interval, *ET* Embryo Transfer, *IVF* In Vitro Fertilization, *SET* Single Embryo Transfer, *DET* Double Embryo Transfer, *GC* Gestational Carrier, *NA* Not Available, *COH* Controlled Ovarian stimulation, *MNC* Modified Natural Cycle, *IVM* In Vitro Maturation, *HOM* High-Order Multiple, Surrogate Motherhood, *IVF-SM* IVF with a donor egg in a SM program, *IVF-OD* IVF with oocyte donation, *IVF-OE* Pregnancy occurred as a result of IVF with own egg, *UC* Unassisted Conception, *HP* Hypertension during Pregnancy, *PGT-A* Preimplantation Genetic Testing for Aneuploidy

included nulliparous and multiparous women. Among multiparous pregnancies the average number of pre-surrogacy pregnancies ranged from 0.2 ± 0.6 [11] to 2.6 ± 2.0 [10].

Hypertension during pregnancy

Parkinson et al. reported hypertensive disorders in 4.9% of single, 7.4% of twin, and 0% of triplet surrogate pregnancies [10]. Woo et al. found higher rates in GS_IVF compared to natural conception (6.8% vs 2.8%, (p = 0.03)) [15]. In contrast, Swanson et al. showed gestational carriers were significantly less likely to develop hypertensive disorders compared to other IVF (10.2% versus 21.2%, OR 0.42, 95% CI 0.28–0.63), though their risk remained higher than the general birthing population and comparable to matched controls [21].

Antibiotic during labour

Preeclampsia/eclampsia

Woo et al., reported a low incidence in singleton gestational carrier compared to natural conception (1.9% vs 1.2% ($p = 0.59$)) [15]. In contrast, Rudenko et al., observed a higher rate of 17.1% [19], while Osmundsen et al. reported 8.3% in singleton and 13.6% ($p = 0.54$) in non-singleton pregnancies [25]. Velez et al. documented severe preeclampsia or HELLP syndrome with rates of 0.42 (95% CI 0.41–0.43) in unassisted conceptions, 0.94 (95% CI 0.80–1.11) in IVF, and 1.86 (95% CI 1.05–3.05) in GC [27].

Pre-implantation genetic testing

Namath et al. compared 194 cycles with Preimplantation Genetic Testing (PGT) and 389 cycles without, revealing no overall significant difference in LBRs (41.2% vs. 43.7%; $P = 0.9$) [23]. Stratification showed higher rates with DET: in the PGT-A group, SET yielded 36.8% and DET 64.5% ($p = 0.008$); in the non-PGT-A group, SET yielded 36.7% and DET 48.0% ($p = 0.05$). The highest rate (64.5%) was observed in PGT-A DET cycles. Traub et al. reported a widespread use of PGT (as high as 63.2%) [26].

Severe obstetric morbidity and postpartum complications

During pregnancy, GCs experienced higher postpartum haemorrhage and hypertensive disorder rates compared to unassisted and IVF conceptions (13.9% vs 5.7% vs 10.5% and 13.9% vs 6.6% vs 11.6% respectively) [27]. Swanson et al., reported transfusion requirements in 1.1% GC pregnancies vs 0.6% control pregnancies (OR 1.83,95% CI: 0.58–5.77) [21].

Pre-term delivery and caesarean section

Preterm delivery rates in gestational carrier pregnancies exceeded national averages. Smith et al. [20] reported 15.1%, while Velez et al. [27] observed a 1.79-fold higher risk compared to unassisted conceptions. Namath et al. (2021) found preterm birth rates of 13.4% following SET and 40.0% after DET. Caesarean section rates were also higher in gestational carrier pregnancies compared to unassisted and IVF conceptions underscoring elevated risks of preterm delivery and caesarean sections in this population. Other outcomes such as vaginal bleeding or use of antibiotics during labour are presented in Table 3.

Neonatal-related outcomes

Neonatal-related outcomes are reported in Table 4 according to the following area of interest: infants' malformations, weigh at birth, neonatal morbidity risk pre-implantations genetic test and other neonatal outcomes.

Infant malformations

Parkinson et al. reported a higher incidence of malformations in IVF surrogacy compared to standard IVF [10]. Minor malformations occurred in 4.9% of singleton surrogacy pregnancies, with none in twins or triplets, while standard IVF showed no minor malformations. Major malformations were absent in singleton and triplet pregnancies from IVF surrogacy but occurred in 7.4% of twin pregnancies. Conversely, standard IVF showed 2.9% major malformations in singleton pregnancies with none in twins or triplets.

Weight at birth

Ten studies reported data on birth weight, which varied based on the type of pregnancy and the number of foetuses [11–23- 22-13-14–25-27-17-21-20]. In singleton pregnancies, mean birth weights generally clustered around 3500 g, with values such as 3500 ± 700 g [10], 3498 g [12], and 3591 g [17]. Lower birth weights were reported in some studies, with values around 3303–3399 g depending on oocyte source and embryo transfer type [16]. The proportion of infants with low birth weight (LBW < 2500 g) ranged from 2.9% [17] to 26.6% in fresh cycles and 23.7% in frozen cycles [28]. LBW was more frequent in DET compared to SET (12.5% vs 3.8%, $p = 0.02$) [23].

Twin pregnancies showed lower birth weights, with reported values of 2700 ± 600 g [10] and 2900 g or 2400 g [12]. In triplet pregnancies, although data were limited, 83.3% of infants were appropriate for gestational age (AGA) [10]. Small for gestational age (SGA) rates were generally low, such as 2.4% [24].

In the only study that compared birth weight among GS and natural pregnancies, surrogacy singleton pregnancies had a higher incidence of LBW, reported at 7.8% vs 2.4% ($p = 0.02$) [15].

Table 4 Neonatal outcomes details described in the studies included in the scoping review

Author, year	Foetal and neonatal malformations /PGT-A & NIPT	Weight at birth, mean ± SD except whereindicated	Neonatal morbidity risk	Specific neonatal outcomes*	Foetal complications
Parkinson et al., 1999 [10]	*Minor malformations: IVF surrogates:* 4.9% vs 0% vs 0% in singleton, twin and triplet pregnancies *Only IVF*: 0% *Major malformations: IVF surrogates:* 0% vs 7.4% vs 0% in singleton, twin and triplet pregnancies *Only IVF:* 2.9% vs 0% vs 0% in singleton, twin and triplet pregnancies	3500 ± 700 g for singleton infants; 2700 ± 600 g for twins' infants 67.2%, 94.4% and 83.3% AGA respectively for singleton, twins and triplets' infants 32.8%, 3.7% and 0% LGA respectively for singleton, twins and triplets' infants	NA	*Apgar information:* NA for the whole study population except for 2 complicated cases *ICU:* 17 infants for a period of 4–30 days NA	NA
Goldfarb et al., 2000 [11]	NA	NA	NA	NA	NA
Söderström-Anttila et al., 2002 [12]	NA	Mean (min–max): 3498 g (2270–4650) for 10 singleton infants; 2900 g and 2400 for twins	NA	NA	0%
Wang et al., 2016 [13]	NA	LBW: 13.7% (10/73) of which 10.6% in SET; 19.2% in DET ($p = 0.31$)	NA	NA	0%
Machtinger et al., 2017 [14]	NA	NA	NA	NA	NA
Woo et al., 2017 [15]	NA	*For singleton live birth:* 7.8% in GS-IVF vs 2.4% in natural conception ($p = 0.02$)	NA	*Meconium for singleton live birth:* 1.0% in GS-IVF vs 3.1% in natural conception (p = 0.26)	0%
Murugappan et al., 2018 [16]	NA	*For singleton live birth in GS Autologous oocytes births:* 3303.9 ± 664.4 g in fresh cycles; 3374.1 ± 604.3 g in frozen cycles *Donor oocyte births:* 3347.1 ± 601.5 g in fresh; 3399.4 ± 631.1 g in frozen cycles	NA	NA	0%
Peters et al., 2018 [17]	0	3591 g (range: 2465–4550) LWB: 2.9% (1/34)	NA	NA	8.8% macrosomia; 2.9% Shoulder dystocia
Rumpik et al., 2019 [18]	NA	NA	0%	Absence of ICU and of meconium	0%
Rudenko et al., 2020 [19]	NA	Lower centile interval: 3,416 ± 3,394	NA	The majority had an Apgar ≥ 7 at 1 and 5 min after birth	NA
Smith et al., 2021 [20]	NA	NA	NA	NA	NA

Table 4 (continued)

Author, year	Foetal and neonatal malformations /PGT-A & NIPT	Weight at birth, mean ± SD except whereindicated	Neonatal morbidity risk	Specific neonatal outcomes*	Foetal complications
Swanson et al., 2021 [21]	NA	NA	51.7% in multifetal; 9.5% in singleton	*$Apgar_{5min}$ < 7:* 4.9% in multifetal; 1.1% in singleton *ICU:* 50.3% in multifetal; 8.8% in singleton *Respiratory distress syndrome with assisted ventilation for more than 6 h:* 21.8% (19.2% ventilation) in multifetal: 2.9% (2.8% ventilation) in singleton	0%
Swanson et al., 2020 [22]	NA	NA	NA	*ICU:* 0.6% in GC pregnancy vs 0.4% in non-GC IVF pregnancies vs 0.1% in non-GC vs 0.2% in matched controls	0%
Namath et al., 2021 [23]	NA	*Mean birth weight:* 3,468 g in SET vs. 2,945 g in DET; $p < .001$ *LBW:* 3.8% in SET vs 12.5% in DET; $p = 0.02$ *Very LBW:* 0.6% in SET vs 5% in DET; p = 0.08 *Extremely LBW:* SET 0.6%vs DET 3.8% p = 0.2	NA	NA	NA
Attawet et al., 2022 [24]	NA	5.0% LBW; 2.4% SGA	NA	NA	NA
Osmundsenet al, 2023 [25]	NA	NA	NA	NA	NA
Traub et al., 2024 [26]	63.2% used PGT-A	NA	NA	NA	NA
Velez et al., 2024 [27]	NA	NA	*Severe morbidity:* GC vs UC wRR = 1.20 (0.92–1.55); GC vs IVF wRR = 0.81 (0.61–1.08)	NA	NA
Kloos et al., 2024 [28]	NA	*Normal birthweight:* 62.2% fresh vs 66.7% frozen *LBW:* 26.6% fresh vs 23.7% frozen *High birthweight* 6.2% fresh vs 9.7% frozen	NA	NA	NA

SD Standard Deviation, *RR* Relative Risk, *wRR* Weighted RR, *CI* Confidence Interval, *PGT-A* Preimplantation Genetic Testing for Aneuploidy, *NIPT* Non-Invasive Prenatal Testing, *ET* Embryo Transfer, *IVF* In Vitro Fertilization, *SET* Single Embryo Transfer, *DET* Double Embryo Transfer, *GC* Gestational Carrier, *NA* Not Available, *COH*: Controlled Ovarian stimulation, *MNC* Modified Natural Cycle, *IVM* In Vitro Maturation, *SM* Surrogate Motherhood, *IVF-SM* IVF with a donor egg in a SM program, *IVF-OD* IVF with oocyte donation, *IVF-OE* Pregnancy occurred as a result of IVF with own egg. Normal birthweight: ≥ 2500 g and ≤ 3999 g. LBW: Low birthweight—< 2500 g. Very LBW: < 1500 g. Extremely LBW: < 1000 g. High birthweight: > 4000 g. SGA: Small for Gestational Age—weight < 10° centile

*The following specific neonatal outcomes were investigated: Apgar information, intensive care unit (ICU), hospitalization > 24 h, respiratory distress syndrome, assisted ventilation for more than 6 h, presence of meconium, breast feeding

Neonatal morbidity risk

Swanson et al. (2021) reported neonatal morbidity risks, defined as a composite of neonatal death, 5-min Apgar < 7, neonatal intensive care unit (NICU) admission, respiratory distress syndrome (RDS), assisted ventilation > 6 h, and seizure, in 51.7% of multifetal and 9.5% of singleton gestational carrier pregnancies. Velez et al. [27] found severe morbidity rates of 6.6% (GC), 5.9% (unassisted), and 8.9% (IVF), with weighted RRs of 1.20 (95% CI 0.92–1.55) for GC vs. unassisted and 0.81 (95% CI 0.61–1.08) for GC vs. IVF.

Other neonatal outcomes are presented in Table 4.

Discussion

This scoping review synthesizes evidence on surrogate pregnancies, focusing on maternal, pregnancy and neonatal outcomes. Studies show substantial variation in the number and type of embryos transferred, ranging from 1.66 ± 0.68 to 4.1 ± 0.1 per cycle [15-11], influenced by clinical protocols, oocyte source (autologous vs donor) and embryo status (fresh vs frozen). Murugappan et al. [16] and Machtinger et al. [14] highlight how these decisions significantly shape pregnancy rates and outcomes.

Gestational carrier cycles generally demonstrate a lower risk of early pregnancy loss compared with other ART cycles; however, spontaneous miscarriage rates still fall within expected ART ranges and remain slightly higher than in natural conceptions. Contributing factors include embryo quality, uterine receptivity and underlying parental genetic or medical conditions [16]. Importantly, embryos are often genetically unrelated to the surrogate mother [29].

Delivery rate data are limited and inconsistent, ranging from 9.4% [14] to 55.5% [12], likely reflecting differing surrogacy arrangements and clinic protocols. Recent studies suggest that live birth rates (LBR) in gestational surrogacy surpass those of other ART modalities, primarily due to the use of younger egg donors and high-quality embryos. Traub et al. [28] reported LBRs of 50–58% per embryo transfer, influenced by donor age and embryo quality. Donor age is critical: Hogan et al. [30] found cumulative live birth rates (CLBR) declining from 44.7% in donors < 30 years to 5.1% in donors ≥ 41 years; the likelihood of live birth was 40% lower for donors 38–40 years and 86% lower for donors ≥ 41 years.

In a series of 333 stimulation cycles, 178 pregnancies yielded 36 miscarriages (20.2%) [31], whereas Rudenko et al. reported a miscarriage rate of 57.4% [19]. Kloos et al. found no significant difference in miscarriage risk between pregnancies from fresh versus vitrified donor oocytes [28].

Multiple gestation remains an important concern due to associated morbidity. Soderstrom et al. reported a wide range of multiple pregnancy rates (2.6%–75%), reflecting differences in clinical practice and patient selection [12]. In a 10-year cohort from two military hospitals, 14.4% of ART-conceived twin gestations involved surrogates; surrogate mothers were younger (29.6 years vs 33.1 years in non-surrogates) and showed higher rates of gestational diabetes (27.8% vs 12.2%) [25].

Placenta previa and placental abruption rates appear low among IVF surrogates, with prevalences of 4.9%, 3.7% and 0% in singleton, twin and triplet pregnancies, respectively [10]. This has been attributed to the favourable uterine environments of gestational carriers. However, Woo et al. reported higher placenta previa rates in gestational surrogacy pregnancies conceived using intended-parent embryos compared with naturally conceived pregnancies of the surrogate (4.9% vs 1.2%, $p = 0.05$) [15], suggesting IVF-related factors may contribute to increased risk despite favourable uterine characteristics.

Evidence, though limited, indicates higher rates of gestational diabetes in surrogates compared with natural mothers, especially in twin pregnancies [15, 16, 20, 21, 23, 25]. Two studies also reported an increased risk of hypertensive disorders among gestational carriers relative to individuals carrying their own pregnancies [15, 16, 20, 21]. A recent JAMA Network Open meta-analysis confirmed higher odds of hypertensive disorders in gestational carrier pregnancies compared with both ART and non-ART conceptions [32].

A population-based study from Ontario including 863,017 singleton births reported that gestational carriers experienced markedly higher severe maternal morbidity (7.8%) compared with unassisted conceptions (2.3%) [27]. Postpartum haemorrhage (13.9% vs 10.5% in IVF and 5.7% in unassisted conceptions) and hypertensive disorders (13.9% vs 11.6% in IVF and 6.6% in unassisted conceptions) were also elevated [27]. These findings may reflect physiological stressors specific to surrogacy, ART-related influences, immunological mechanisms or differences in prenatal care, despite gestational carriers typically undergoing health screening [33].

Preterm birth risk is also elevated. Smith et al. reported a 15.1% preterm birth rate in gestational carrier pregnancies, exceeding national averages [20]. Preterm birth occurred predominantly among women with prior preterm delivery and was more common in singleton than multifetal pregnancies (76.7% vs 30.0%, $P < 0.001$) [20].

Caesarean section (CS) rates are consistently higher among gestational carriers compared with both IVF and unassisted conceptions. These rates appear independent of age, BMI and interpregnancy interval. Notably, VBAC rates among gestational carriers with a prior CS exceeded national averages, particularly among younger, leaner women [8].

Neonatal outcomes also demonstrate increased risks. Parkinson et al. reported minor malformations in 4.9% of singleton surrogacy births and major malformations in 7.4% of twin surrogacy births [10]. Rates of major birth defects in ART pregnancies (IVF 6.2%, IUI 5.0%) exceed those of natural conceptions (4.4%) [34], consistent with data from Luke et al. (2.0% for singletons, 3.5% for twins) [35]. Low birth weight (LBW) after surrogacy ranged from 2.9% [17] to 26.6% in fresh cycles and 23.7% in frozen cycles [28], with higher LBW following double-embryo transfer (DET) compared with single-embryo transfer (SET) (12.5% vs 3.8%; $p = 0.02$) [23]. Other ART cohorts have shown elevated LBW (8.7%) and very low birth weight (2.0%) rates [36], and Woo et al. found higher LBW in surrogacy than natural pregnancies [15]. This persists even when limiting analyses to singletons [37]. Consistent with broader ART evidence, both singleton [38] and twin [39] pregnancies after ART demonstrate higher neonatal morbidity.

NICU admissions also vary: in one study, 17 of 128 surrogacy infants required NICU care (4–30 days) [10], and another found significantly higher NICU use in multifetal versus singleton surrogacy pregnancies [21]. In a cohort of 34 surrogacy pregnancies, 8.8% of infants exhibited macrosomia and 2.9% experienced shoulder dystocia [17], consistent with ART-related outcomes in non-surrogacy cohorts [40].

This review has limitations: all included studies were retrospective, with substantial heterogeneity in populations and ART protocols. Long-term maternal and neonatal data remain scarce, and most studies originate from high-income settings, limiting generalization. Findings also cannot be directly compared with other ART contexts; future research should compare gestational surrogates with donor-egg recipients, who share similar reproductive and clinical characteristics. Such analyses may better clarify factors driving maternal and neonatal risks in surrogate pregnancies and support improved clinical counselling and management. Despite limitations, strengths include adherence to PRISMA-ScR guidelines, a comprehensive search strategy and systematic quality assessment.

Conclusion

In conclusion, the outcome of surrogate pregnancies is determined by the number of embryos transferred and the selection of future gestational mothers. However, the variability of the protocols, combined with the persistent risks of multiple gestation, gestational diabetes, hypertensive disorders and premature birth, represent a risk for the woman and the unborn child. Regarding neonatal outcomes, included studies suggest that there may be an increased incidence of LBW in multifetal and single pregnancies and an increased risk of neonatal morbidity especially for multifetal pregnancies.

Future research should prioritize prospective, multicenter studies comparing surrogate pregnancies to both IVF and natural conceptions, with a focus on long-term maternal and neonatal outcomes.

Abbreviations

GS	Gestational surrogacy
ART	Assisted reproductive technique
IVF	In vitro fertilization
ET	Embryo transfer
LBW	Low birth weight
SET	Single embryo transfer
DET	Dual embryo transfer
VBAC	Vaginal birth after caesarean
GDM	Gestational diabetes mellitus
NICU	Neonatal intensive care unit
AGA	Appropriate for gestational age
SGA	Small for gestational age
LBR:	Live birth rates
CLBR	Cumulative live birth rates
STIs	Sexually transmitted infections
PGT-A	Preimplantation Genetic Testing for Aneuploidy

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

DZ Conceived of the study. Carried out the design of the study, participated in the sequence alignment and drafted the manuscript. TP. Carried out the analysis and interpretation of data. Performed the statistical analysis. Helped to draft the manuscript. GC Helped to draft the manuscript. Participated in the design. CMC and ST Carried out the acquisition of data. Participated in the design. MLDP Gave final approval of the version to be published and revised the manuscript.

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Competing interests

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