A SART data cost-effectiveness analysis of planned oocyte cryopreservation versus in vitro fertilization with preimplantation genetic testing for aneuploidy considering ideal family size

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Objective: To determine the cost-effectiveness of planned oocyte cryopreservation (OC) as a strategy for delayed childbearing to achieve 1 or 2 live births (LB) compared with in vitro fertilization (IVF) and preimplantation genetic testing for aneuploidy (PGT-A) at advanced reproductive age.

Design: Decision tree model with sensitivity analyses using data from the Society for Assisted Reproductive Technology Clinical Outcome Reporting System and other clinical sources.

Setting: Not applicable.

Patient(s): A data-driven simulated cohort of patients desiring delayed childbearing with an ideal family size of 1 or 2 LB.

Intervention(s): Not applicable.

Main Outcome Measure(s): Probability of achieving ≥ 1 or 2 LB, average and maximum cost per patient, cost per percentage point increase in chance of LB, and population-level cost/LB.

Result(s): For those desiring 1 LB, planned OC at age 33 with warming at age 43 decreased the average total cost per patient from \$62,308 to \$30,333 and increased the likelihood of LB from 50% to 73% when compared with no OC with up to 3 cycles of IVF/PGT-A at age 43. For those desiring 2 LB, 2 cycles of OC at age 33 and warming at age 40 yielded the lowest cost per patient and highest likelihood of achieving 2 LB (\$51,250 and 77%, respectively) when compared withpursuing only 1 cycle of OC (\$75,373 and 61%, respectively), no OC and IVF/PGT-A with embryo banking (\$79,728 and 48%, respectively), or no OC and IVF/PGT-A without embryo banking (\$79,057 and 19%, respectively). Sensitivity analyses showed that OC remained cost-effective across a wide range of ages at cryopreservation. For 1 LB, OC achieved the highest likelihood of success when pursued before age 32 and remained more

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effective than IVF/PGT-A when pursued before age 39, and for 2 LB, 2 cycles of OC achieved the highest likelihood of success when pursued before age 31 and remained more effective than IVF/PGT-A when pursued before age 39.

Conclusion(s): Among patients planning to postpone childbearing, OC is cost-effective and increases the odds of achieving 1 or 2 LB when compared with IVF/PGT-A at a more advanced reproductive age. (Fertil Steril® 2022;■:■–■. ©2022 by American Society for Reproductive Medicine.)

Key words: Assisted reproductive technology (ART), cost-effectiveness, delayed childbearing, fertility preservation, oocyte cryopreservation

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The median age at first birth in the United States has risen from 22.7 in 1980 to 26.9 in 2018, driven partly by the shift in first births to women 35 years and older (1, 2). Given the well-established decline of female fertility and low success of conventional assisted reproductive technology (ART) in the setting of advanced reproductive age, postponing childbearing may lead to unanticipated consequences including unintended childlessness or secondary infertility (3–7).

Planned oocyte cryopreservation (OC) has become an increasingly common strategy for deferred reproduction (8). Technological advancements and proven efficacy led the American Society for Reproductive Medicine to remove the "experimental" label from OC in 2013 and deem it an "ethically permissible procedure" in 2018, paving the way for a dramatic 880% increase in OC cycles in the United States from 2010–2016 (9–11). Preliminary data from autologous vitrified warmed oocytes has indicated that the live birth rate (LBR) per transfer may be comparable to that of embryos derived from fresh oocytes, fueling its uptake for planned indications (12–19). According to one national survey, nearly 25% of reproductive-aged women have considered planned OC (20).

Despite widespread popularity and clinical use, many questions remain regarding the use and cost-effectiveness of planned OC for deferred reproduction. Several analyses have attempted to address these questions with most finding that OC may be cost-effective for at least a subset of patients planning to delay childbearing (21–24). These analyses have notably been limited by the use of single-center OC data and the inclusion of patients with infertility due to diminished ovarian reserve, which may not accurately reflect the population of patients seeking planned OC. It is unclear whether key differences exist between these populations. In addition, none of these analyses have incorporated the use of preimplantation genetic testing for aneuploidy (PGT-A), an important and now widely-used tool shown to improve the efficiency of ART among women of advanced reproductive age (25). Finally, no prior analysis has considered the effectiveness or cost-effectiveness of OC for achieving a second live birth (LB).

For these reasons, we conducted an updated analysis incorporating "real world" OC data from the Society for Assisted Reproductive Technology Clinical Outcomes Reporting System (SART-CORS) database. We evaluated the cost-effectiveness of OC as a strategy for deferred reproduction compared with no OC with in vitro fertilization (IVF)/PGT-A at advanced reproductive age. Strategies were modeled for patients desiring 1 or 2 LB. We hypothesized that OC would be more effective and cost-effective, and that these results would be more pronounced when considering a second LB.

METHODS

This study was reviewed by the Northwestern University institutional review board and deemed nonhuman subjects research.

Database

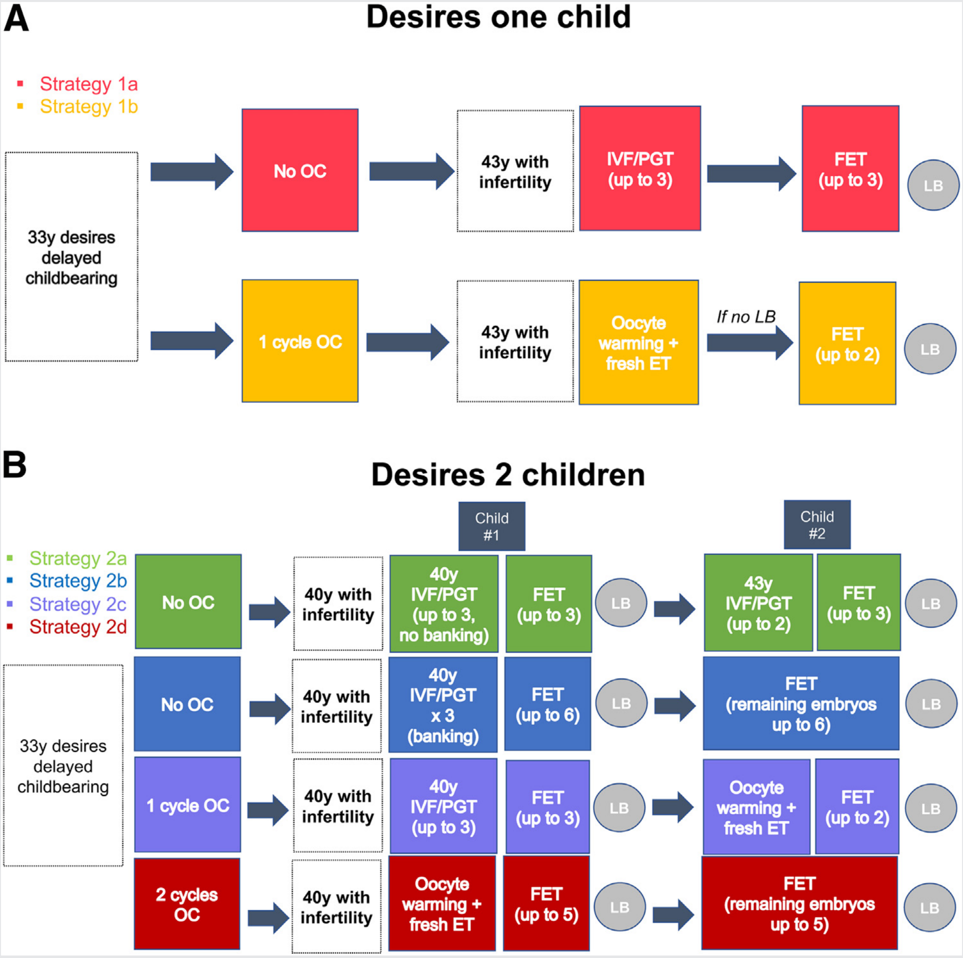
The data used for this study were obtained from the SART-CORS. Data were collected through voluntary submission, verified by SART, and reported to the Centers for Disease Control and Prevention (CDC) in compliance with the Fertility Clinic Success Rate and Certification Act of 1992 (Public Law 102-493). The Society for Assisted Reproductive Technology maintains Health Insurance Portability and Accountability Act-compliant business associates agreements with reporting clinics. In 2004, following a contract change with the CDC, SART gained access to the SART-CORS data system for the purposes of conducting research. In 2017, 82% of all ART clinics in the United States were SART members (26).

The data in the SART-CORS are validated annually with 7%–10% of clinics receiving on-site visits for chart review based on an algorithm for clinic selection. During each visit, data reported by the clinic were compared with information recorded in patients' charts. In 2019, records for 2,014 cycles at 34 clinics were selected randomly for full validation, along with 213 fertility preservation cycles selected for partial validation. The full validation included review of 1,300 cycles for which a pregnancy was reported. Nine of 11 data fields selected for validation had discrepancy rates of $\leq 5\%$ (26). The exceptions were the diagnosis field, which, depending on the diagnosis, had a discrepancy rate between 2.5% and 17.8%, and the start date, which had an 8.4% discrepancy rate. The deidentified dataset was transferred to ECF at Northwestern University in an encrypted file.

Infertility Treatment Strategies

Decision tree models were built to simulate the cost and success rate for a variety of strategies for delayed childbearing with a family size of either 1 or 2 LB. The strategies were modified from a prior cost-effectiveness analysis based on current practice patterns and recently published data reflecting an earlier age at cryopreservation and a more advanced

FIGURE 1



Schematic representation of treatment strategies for 1 child and 2 children. For 1 child (**A**), 2 strategies were modeled: no OC and in vitro fertilization with preimplantation genetic testing for aneuploidy (IVF/PGT) at 43 (strategy 1a) vs. oocyte cryopreservation (OC) at 33 and conception attempt at 43 (strategy 1b). For 2 children (**B**), 4 strategies were modeled: 2 without OC and 2 with OC. For no OC, strategies included IVF/PGT without embryo banking at 40 and, if successful, again at 43 for a second child (strategy 2a) vs. IVF/PGT with embryo banking at 40 (strategy 2b). For OC, strategies included OC at 33 with fresh IVF/PGT at 40 before oocyte warming (strategy 2c) vs. 2 cycles OC at 33 (strategy 2d).

Bakkensen. Cost-effectiveness of planned OC. Fertil Steril 2022.

age at return among those pursuing planned OC compared with previous estimates (24, 27, 28). In each strategy, a patient desires delayed childbearing and pursues no OC or 1 or 2 cycles OC at age 33. Patients desiring 1 LB attempt conception at age 43 for up to 6 months, whereas patients desiring 2 LB attempt conception at age 40. If unsuccessful, patients proceed along their respective treatment strategies (IVF/PGT-A vs. oocyte warming) as outlined in Figure 1.

Notably, patients desiring 2 LB have the option of pursuing IVF/PGT-A without embryo banking at age 40 for their first LB and, if successful, again at age 43 for their second LB (strategy 2a) vs. pursuing IVF/PGT-A x 3 cycles with embryo banking at age 40 and subsequent frozen embryo transfers (FET) to achieve 2 LB (strategy 2b). Patients desiring 2 LB who pursue 1 cycle OC at age 33 (strategy 2c) pursue up to 3 cycles of IVF/PGT-A at age 40 before warming banked oocytes, whereas those who pursue 2 cycles OC (strategy 2d) warm banked oocytes on presentation at age 40.

Model Inputs

Model parameter estimates and data sources are summarized in Supplemental Table 1. Most estimates were obtained from the 2007–2018 SART-CORS database. Data for 42,863 OC cycles derived only from 2014–2018, when SART-CORS began recording OC cycle-specific data.

The mean number of oocytes cryopreserved by age according to SART-CORS 2014–2018 is shown in Table 1. The number of usable embryos from oocyte warming cycles was calculated considering the probability of obtaining N oocytes from 1 or 2 OC cycles among 33-year-olds. Given previous studies citing lower oocyte survival and blastocyst conversion

TABLE 1

Mean number of oocytes cryopreserved by age among autologous oocyte cryopreservation cycles in the Society for Assisted Reproductive Technology Clinical Outcomes Reporting System Dataset 2014-2018

Age (y)	No. of OC cycles	No. oocytes cryopreserved per cycle (mean ± SD)
25	434	14.1 ± 9.8
26	391	14.5 ± 8.4
27	447	13.6 ± 8.4
28	527	14.2 ± 9.3
29	609	14 ± 8.8
30	863	14.1 ± 9
31	1,146	14.4 ± 8.7
32	1,576	13.2 ± 8
33	2,347	12.7 ± 7.9
34	3,623	12.6 ± 8.1
35	4,636	12 ± 7.8
36	4,793	11.3 ± 7.4
37	4,689	10.5 ± 7.2
38	4,205	9.9 ± 6.9
39	3,558	9 ± 6.6
40	2,360	8.1 ± 6.3
41	1,646	7.5 ± 5.9
42	1,051	6.8 ± 5.6

OC, oocyte cryopreservation.

Bakkensen. Cost-effectiveness of planned OC. Fertil Steril 2022.

rates among previously cryopreserved oocytes when compared with fresh oocytes, data from the California Cryobank – Donor Egg Bank USA (Generate Life Sciences, Los Angeles, CA) subsequently were used to estimate the blastocyst conversion rate per thawed/warmed oocyte (12–18). This database included outcomes from oocyte donors having undergone ovarian stimulation and oocyte retrieval at 47 centers with standardized methodology for donor recruitment and screening. According to 2020 data, 38% of 9,335 warmed donor oocytes from 1,376 cycles resulted in usable blastocysts.

The number of euploid embryos from IVF/PGT-A cycles was determined by multiplying the age-specific probability of obtaining any transferable embryos following fresh, autologous IVF by the probability of obtaining N euploid embryos per cycle according to data from 100,119 embryos from 21,657 couples tested with Natera Spectrum PGT-A (Natera Inc., Austin TX).

Age-specific probabilities of LB for fresh and frozen embryo transfer (ET) following oocyte warming were obtained from fresh and frozen autologous transfers in which embryos did not undergo PGT. The probability of LB following euploid FET was calculated among autologous FET cycles in which all embryos underwent PGT. Published estimates of pregnancy and loss rates were used to estimate the probability of LB after 6 months of unassisted attempted conception (29, 30).

Cost data for OC cycles, oocyte storage, oocyte warming cycles, IVF/PGT-A cycles, FET cycles, and embryo storage were 2021 self-pay prices obtained from 10 geographically diverse ART centers across the United States including academic and private centers from California, Georgia, Illinois, Missouri, New York, North Carolina, Oregon, and Pennsylvania (Supplemental Table 2). Median costs were used in the base model.

Model Structure

For strategies in which patients underwent OC, decision trees included 31 branches for all possible numbers of oocytes cryopreserved from 0 to ≥30; the probability of obtaining a given number of embryos did not vary appreciably above 30 oocytes.

When banked oocytes were warmed, trees included branches for obtaining 0, 1, 2, or ≥3 transferable embryos. Trees were structured to allow up to 3 ET at each “step” in a treatment strategy. For a patient with 12 banked oocytes, the probabilities of obtaining 0, 1, 2, or ≥3 transferable embryos were 0.3%, 2%, 8%, and 89%, respectively.

For IVF/PGT-A without embryo banking, the trees included branches for obtaining 0, 1, 2, or ≥3 euploid embryos. If the first IVF/PGT-A cycle did not produce at least 3 embryos and the resulting transfers were unsuccessful, up to 3 cycles of IVF/PGT-A were pursued until LB or up to 3 failed FET. For IVF/PGT-A with embryo banking, there were branches for 0, 1, 2, 3, 4, 5, or ≥6 euploid embryos. The tree included all necessary cycles (up to 3) to obtain banked embryos before including branches for ET. The probabilities of obtaining 0, 1, 2, or ≥3 euploid embryos for a 40-year-old were 47%, 26%, 14%, and 12%, respectively; for a 43-year-old, they were 77%, 17%, 4%, and 2%, respectively.

Outcomes

Outcomes for each treatment strategy included the probability of achieving at least 1 or 2 LB and the mean and maximum possible cost to an individual patient, regardless of whether LB was achieved. The cost per percentage point increase in success for achieving the desired number of LB was used to measure the incremental cost of any additional chance of success for each strategy compared with the referent no-OC strategy. This was calculated as the difference in mean individual cost between the 2 strategies divided by the difference in probability of success between those 2 strategies. To measure cost-effectiveness on a population scale, we calculated the population-level cost per LB. For 1 LB strategies, this was calculated as the mean cost divided by the probability of having a LB; for 2 LB strategies, it was calculated as the mean cost divided by the sum of the probability of having exactly 1 LB and 2 times the probability of having 2 LB. The population-level cost per LB can be interpreted as the expected total cost of a group of N patients undergoing a particular treatment strategy divided by the number of LB expected to occur among those N patients.

Sensitivity Analyses

To assess the impact of age at OC, we conducted 1-way sensitivity analyses comparing the likelihood of success and population-level cost per LB while varying age at OC. Additionally, we examined the effect of procedure cost by comparing the population-level cost per LB for each strategy while varying the cost of oocyte storage, OC cycles, and IVF/PGT-A cycles.

RESULTS

The outcomes for each strategy are summarized in Table 2. For 1 LB, OC at age 33 and warming at age 43 resulted in a higher chance of LB when compared with no OC with IVF/PGT-A at age 43 (73% vs. 50%). The OC strategy saved an average of $31,975 per individual and resulted in a $46,544 lower maximum cost to any individual. The OC resulted in a savings of $1,376 per percentage point increase in successful LB. When considered from a population level, OC resulted in a $82,591 reduction in cost per LB compared with no OC (Supplemental Table 2).

For 2 LB, OC was similarly cost-effective, with 2 cycles of OC at age 33 and warming at age 40 yielding the highest likelihood of LB and lowest cost by all measures compared with all other strategies. When compared with the referent strategy (no OC and IVF/PGT-A without banking at age 40 and 43), 2 cycles of OC resulted in a higher probability of at least 1 LB (94% vs. 76%) and markedly higher probability of at least 2 LB (77% vs. 19%). Two cycles of OC also reduced the average individual cost by $26,578 and the maximum individual cost by $81,926. When considering the likelihood of achieving 1 or 2 LB, 2 cycles of OC resulted in $1,441 and $458 reductions, respectively, in the cost per percentage point increase in success. This trend persisted on a population level, with 2 cycles OC achieving the lowest cost per LB of any strategy ($30,620, Supplemental Table 2).

Sensitivity analyses were used to examine the effect of age at OC on the effectiveness and cost-effectiveness of each strategy. For 1 LB, OC (strategy 1b) resulted in the highest probability of achieving at least 1 LB when pursued before age 32 and remained more effective than no OC until age at OC exceeded 39 years. Furthermore, OC resulted in a lower cost per LB across all ages analyzed (25–42 years; Figs. 2A, 2B). For 2 LB, 2 cycles of OC (strategy 2d) resulted in the highest probability of achieving 2 LB when pursued before age 31 and remained the most effective strategy until age at OC exceeded 39 years, at which point no OC followed by IVF/PGT-A with banking (strategy 2b) became more effective (Fig. 2C). Two cycles of OC resulted in the lowest cost per LB across all ages analyzed (25–39 years; Fig. 2D).

We similarly conducted sensitivity analyses comparing cost per LB while varying costs to assess the robustness of these findings (Supplemental Fig. 1A–F). For 1 LB, OC (strategy 1b) remained most cost-effective until the annual oocyte storage cost exceeded $6,632, the cost of an OC cycle exceeded $74,063, or the cost of an IVF/PGT-A cycle exceeded $7,314. When considering 2 LB, 2 cycles of OC (strategy 2d) remained more cost effective than the referent (strategy 2a) until annual oocyte storage costs exceeded $13,493, OC cycle costs exceeded $58,768, or IVF/PGT-A cycle costs exceeded $7,575. For 2 and 2 LB, the costs at which the OC strategies became less effective and less cost-effective exceeded the range of reported costs for all 3 model inputs.

DISCUSSION

Our results indicate that OC is a more effective and cost-effective strategy for delayed childbearing when compared with no OC and IVF/PGT-A at a more advanced age. Furthermore, by incorporating ideal family size into our analyses, we were able to establish clinically relevant cutoffs for patients and physicians considering OC. Notably, for a patient desiring one child, OC results in a higher likelihood of LB if pursued before age 39, with the highest chance of success achieved if pursued before age 32. For a patient desiring 2 children, 1 cycle of OC performed before age 37 and 2 cycles of OC before age 39 are more effective strategies than IVF/PGT-A at an advanced reproductive age, with the highest chance of success achieved if 2 cycles of OC are pursued before age 31. Importantly, strategies using OC remained cost-effective over a wide range of ages at OC, likely reflecting the high cost of PGT-A and the inefficiency of IVF at advanced reproductive age.

A key strength of our analysis over previously published studies is the use of “real world” data to inform our models. Van Loendersloot et al. (22) used a Markov model to estimate the cost-effectiveness of various strategies for deferred reproduction and found that OC at age 35 was cost-effective at an additional $24,600 per LB when compared with IVF at age 40. In the absence of OC data, they used cumulative LBR from 3 fresh cycles of IVF to approximate the LBR following 3 cycles of OC, without accounting for attrition from impaired oocyte survival or a potential reduction in blastocyst development rates (14, 15). Their model did not allow for unassisted conception attempts before oocyte warming, in sharp contrast with current practice and national guidance from the American Society for Reproductive Medicine (6). In a subsequent study, Hirshfeld-Cytron et al. (21) did allow for unassisted conception attempts before oocyte warming and adjusted for oocyte survival and found that OC at age 25 was not cost-effective compared with IVF at age 40 unless the cost of an IVF cycle exceeded $22,000. The age at OC in this model is not representative of typical use and is nearly a decade earlier than the mean age at which individuals currently pursue OC (21). In a subsequent analysis, Devine et el. (24) addressed these limitations and incorporated single-center OC data into their models, concluding that OC was cost-effective compared with IVF at age 40 provided oocytes were cryopreserved before age 38 years.

Our study has additional key advantages over those published previously. The first advantage involves the data used and our approach to estimating costs. We incorporated nationally representative data from nearly 43,000 OC cycles and accounted for regional variation in ART-related costs by incorporating median cost data from geographically distinct academic and private practices to set reasonable estimates for our base models. We derived cost estimates from self-pay pricing, which more faithfully represents costs as opposed to charges used in other studies. While we did not discount costs over time and while the cost of future fertility treatment may be difficult to predict, sensitivity analyses revealed the persistence of our findings over a wide range of OC, IVF/PGT-A, and storage costs, suggesting that our

TABLE 2

Probability of live birth and cost-effectiveness by delayed reproduction treatment strategy

Treatment strategy	Probability of ≥ 1 LB	Probability of 2 LB	Average individual cost	Maximum individual cost	Cost per percentage point increase in success, 1 LB	Cost per percentage point increase in success, 2 LB
Desires 1 child						
No OC + IVF/PGT	50%	0%	$62,308	$84,536	*Ref*	
OC	73%	0%	$30,333	$37,992	−$1,376	
Desires 2 children						
No OC + IVF/PGT without embryo banking	76%	19%	$79,057	$145,018	*Ref*	*Ref*
No OC + IVF/PGT with embryo banking	78%	48%	$79,728	$97,802	$278	$23
OC 1 cycle + IVF/PGT	93%	61%	$76,100	$122,528	−$176	−$71
OC 2 cycles	94%	77%	$52,479	$63,092	−$1,441	−$458

See Figure 1 and methods for a detailed description of each treatment strategy. Negative cost per percentage point increase in live birth reflects a net cost savings. OC, oocyte cryopreservation; IVF/PGT, in vitro fertilization with preimplantation genetic testing for aneuploidy; LB, live birth; *Ref*, referent strategy.

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conclusions would be unlikely to change despite anticipated changes in costs over time.

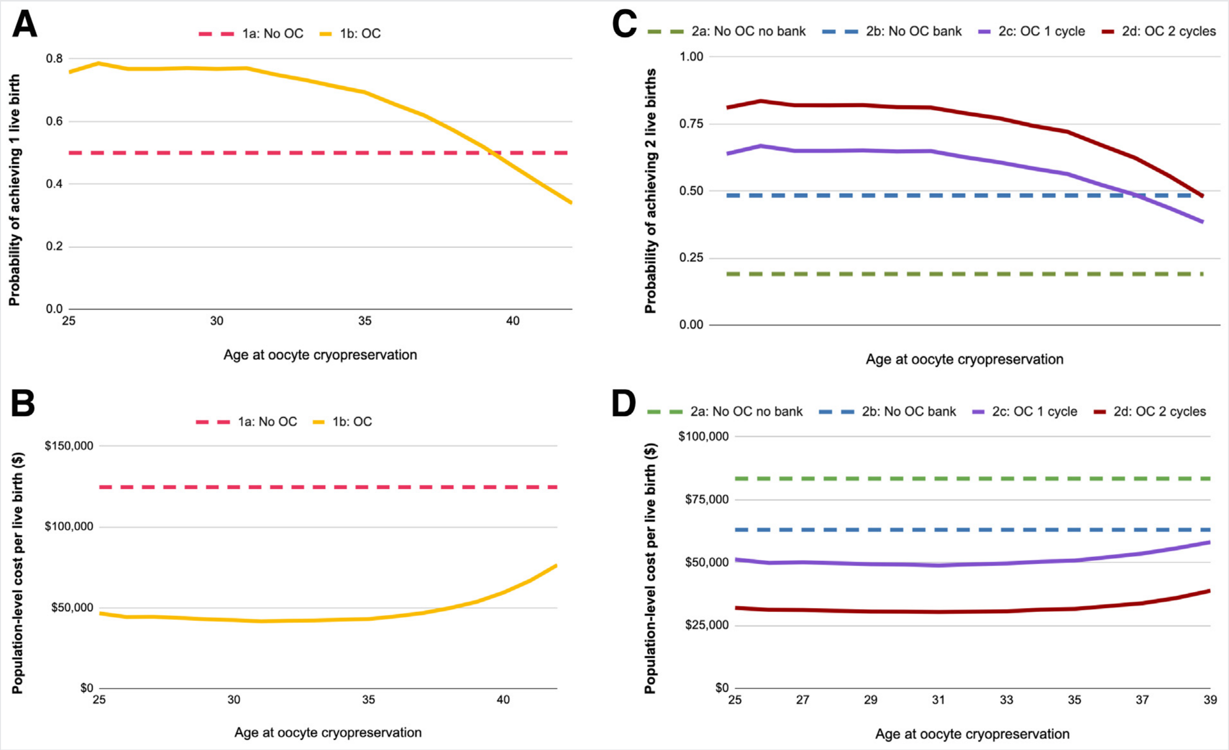
Second, we accounted for a later age at which patients began attempting pregnancy. Although the aforementioned studies modeled childbearing delayed until age 40, recently published planned OC data suggest that patients pursuing OC defer childbearing beyond age 40. One study showed a mean age of oocyte thaw/warming of 41.8 years, and another showed that patients did not return until age 43.9 years (27,28). This difference is significant given the marked increase in chromosomal aneuploidy and corresponding decrease in LBR following IVF between the ages 40 and 44 years (7, 31, 32).

The third advantage of our study is the incorporation of PGT-A. Preimplantation genetic testing for aneuploidy is one of the only available tools with the potential to increase the efficiency of IVF among women of advanced reproductive age (25). In this analysis, our models allowed for up to 3 euploid FET based on data showing that <5% of patients fail to achieve a clinical pregnancy after 3 euploid transfers (33). While PGT-A in younger patients remains controversial, PGT-A in patients ≥38 years has been shown to increase LBR per ET given increased rates of aneuploidy with advancing age (34). Furthermore, PGT-A use in the United States has increased dramatically in recent years, with just 13% of ART cycles using PGT-A in 2014 compared with 32% of cycles in 2017, and nearly one-quarter of ART clinics performing PGT-A in >50% of all cycles in 2017 (35, 36). While some clinicians advocate for more limited use of PGT-A given the low likelihood of obtaining transferrable embryos among patients of advanced age with diminished ovarian reserve and, therefore, may view its inclusion in our models as a limitation, we believe the inclusion of PGT-A mirrors widespread current practice patterns and adds to the clinical applicability of our findings (37).

The final and most notable advantage of our study is the inclusion of 2 LB as a potential endpoint. Although the achievement of any LB traditionally has been considered the desired outcome of ART, national survey data indicate that just 4% of Americans consider ≤1 children to be an ideal family size, with most considering 2 or 3 children to be ideal (47% and 26% of respondents, respectively) (38). The use of OC to achieve a larger family size has been described, and long-term follow-up of patients having undergone planned OC has shown that many patients return to use their cryopreserved oocytes in the setting of secondary infertility (28, 39). This important benefit of OC has not been explored in previous cost-effectiveness analyses.

Our study has several limitations. The SART-CORS database does not account for clinic-level effects or clustering, which may bias the data toward larger, high volume centers and render our results less generalizable to smaller or lower volume clinics. While we were able to incorporate OC data from the SART-CORS database, it is important to note that the number of oocytes anticipated may be overestimated due to selection bias as patients who ultimately underwent OC may have a more favorable prognosis than all-comers at a given age. There also were insufficient linked warming cycles to allow for meaningful incorporation of oocyte warming data. Autologous oocyte thaw/warming outcomes among individuals who use oocytes vitrified for nonelective reasons appear to closely approximate those of fresh cycles when analyzed on a per transfer basis, but this approach lacks important metrics, such as oocyte survival and blastocyst formation rates, which have been lower in some studies (12–18). To address these challenges for warming cycles among patients who return to use frozen oocytes, we used data from California Cryobank – Donor Egg Bank USA that included oocyte warming data from nearly 10,000 oocytes from over 1300 cycles. It is important to acknowledge that while this blastocyst formation rate is similar to that previously reported among autologous frozen-thawed oocytes from patients <35 years old, outcomes from donor oocytes may be more favorable than autologous warming cycles (14, 19). As such, the current analysis should be updated with autologous warming outcomes among planned OC cycles as these data become available.

FIGURE 2



Sensitivity analyses comparing likelihood of success and population-level cost-effectiveness between treatment strategies for 1 and 2 live births while varying age at oocyte cryopreservation: (**A**) Probability of achieving at least 1 live birth; (**B**) Population-level cost per live birth among strategies to achieve 1 live birth; (**C**) Probability of achieving at least 2 live births; (**D**) Population-level cost per live birth among strategies to achieve 2 live births. See Figure 1 and methods for a detailed description of each treatment strategy.

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To maintain the necessary simplicity in our models, we also omitted some treatments and made certain assumptions that warrant discussion. For example, we did not incorporate the use of ovulation induction or intrauterine insemination as first-line therapies for infertility before proceeding with oocyte warming or IVF at age 40. However, given the low rates of success with these therapies relative to IVF at age 40, their exclusion is unlikely to impact our results (40). We also did not include the costs of managing nonviable pregnancies. This omission is unlikely to meaningfully alter our findings, as miscarriage rates for euploid embryos among older patients are not significantly different than those from untested embryos among women <35 years (25, 41–43). Furthermore, our models incorporated a uniform estimate of pregnancy loss following unassisted conceptions, which may have underestimated the rate of pregnancy loss among older patients, thereby overestimating the cost-effectiveness of the no OC strategies. We also assumed that patients desiring delayed childbearing would attempt conception at rather advanced ages of 43 and 40 years on the basis of recently published data among those having undergone planned OC; however, the exact duration of delay will vary for each patient and should be carefully considered in the course of patient counseling (28). Additionally, our models did not address the likelihood of returning to use cryopreserved oocytes, which may limit the external validity of our findings. Although it has been suggested that women who pursue OC at a younger age may be less likely to use these oocytes, emerging data show a higher rate of return than previously published. In a retrospective study of 231 patients who underwent planned OC between 2005–2009, Blakemore et al. (28) found that 38.1% of patients returned to thaw/warm their oocytes within 10–15 years of follow-up, and that the “return” and “no use” rates were similar across women of all ages at cryopreservation (28, 44). As more long-term oocyte thaw/warming data emerge, models should incorporate these data to address the critical issue of oocyte use.

Finally, this analysis was conducted from the patient perspective, and therefore did not incorporate costs to the health care sector or to society at large such as lost productivity, absence from work, or social service utilization. Because these considerations are less relevant to individual patients and clinicians counseling patients on OC, they were omitted from the analysis.

In conclusion, patients are increasingly delaying childbearing and relying on ART for family building. This analysis modeled real-world data and showed that OC was a cost-effective strategy for delayed childbearing across a wide range of ages at cryopreservation, OC resulted in an increased likelihood of achieving 1 or 2 LB when pursued before age 39 relative to IVF/PGT-A at a more advanced age, and the likelihood of achieving 1 or 2 LB was highest when OC was pursued before ages 32 or 31, respectively. Collectively, these results support the cost-effectiveness of planned OC and may guide individualized decision-making among patients and clinicians in determining the optimal age at which to pursue OC considering ideal family size.

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