Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

How many oocytes are enough? An evidence-based counselling tool for women planning oocyte cryopreservation and those with oocytes already stored

Bulent Urman
Koç University
G. Ece Aksakal
geaksakal@gmail.com
Amerikan Hastanesi
Sinem Ertas
Amerikan Hastanesi
Irem Usta Korkut
Amerikan Hastanesi
Can Benlioglu
Koç University
Kayhan Yakın
Amerikan Hastanesi
Ayse Seyhan
Amerikan Hastanesi
Aylin Pelin Cil
Amerikan Hastanesi

Research Article

Keywords: oocyte cryopreservation, fertility preservation, counselling, cumulative live birth rate, oocyte yield, shared decision-making

Posted Date: November 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11750188/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Purpose.

Women considering planned oocyte cryopreservation ask how many mature oocytes they should store. The answer depends on age at retrieval, the number of mature oocytes stored, and the desired number of children, and cannot be reduced to a single target. We describe a browser-based calculator that presents published, age-stratified estimates of live birth and oocyte yield to support counselling.

Methods.

The calculator is a single HTML file that runs offline in any modern browser and stores no data. It presents three published live-birth models (Goldman, Cascante, and Namath) and age-specific oocyte-yield nomograms (Machtinger), conditions the estimates on the desired number of children, and substitutes observed yields for women with diminished ovarian reserve (Coccia). It also predicts ovarian response from anti-Müllerian hormone and antral follicle count and projects the effect of deferring a first cycle. Each estimate is linked to its source, and none is shown outside the range its source supports.

Results.

For stored oocytes, the calculator reports the probability of at least one, two, or three live births as a modelled (optimistic) to real-world (conservative) range, withholding the real-world estimate outside the derivation cohort. For a first cycle, it reports age-specific mature-oocyte yield distributions and the number of cycles likely to be required (Figs. 1–4).

Conclusions.

No single universal oocyte target describes the chance of a planned family. The calculator presents published estimates separately, with their assumptions and limits. It is a counselling aid, not an individual prediction, and should be updated and locally recalibrated as evidence accumulates.

Introduction

Planned oocyte cryopreservation, undertaken to preserve fertility against age-related decline, is increasingly common, and women who pursue it frequently ask a single practical question: how many mature oocytes should they store? The answer is not one number. The probability of a future live birth from stored oocytes depends on the woman’s age at retrieval, the number of mature oocytes stored, and the number of children she hopes to have, and these variables must be considered together.

A single oocyte target does not describe the probability of live birth. Counselling that reports only a number of eggs, or a single reassuring probability drawn from a population that may differ from the woman in front of the clinician, risks creating expectations that later prove wrong. Counselling should instead present the expected outcome, the assumptions on which it rests, and the uncertainty around it.

These decisions are often made under time pressure and are shaped by each woman's expectations and future family plans. Evidence-based, source-referenced estimates of whether a given number of stored oocytes is likely to be adequate support informed, shared decision-making and help the clinician avoid both false reassurance and unnecessary discouragement. We therefore developed a calculator that presents published, age-stratified estimates of live birth and oocyte yield for use in counselling before and after oocyte cryopreservation.

Materials and Methods

Implementation

The calculator is a single self-contained HTML file. It runs in any modern web browser without installation, a server, or an internet connection, and it retains no data outside the active session. It covers two settings: review of oocytes already stored, and planning before a first cycle.

Live-birth estimates

For stored oocytes, the calculator estimates the probability of at least one, two, or three live births from age at retrieval, the number of mature oocytes stored, and the desired number of children. It presents results from three age-stratified studies. Goldman et al. developed a model that estimates live birth from age and mature oocyte number [1]. Cascante et al. reported cumulative live birth after planned oocyte cryopreservation in women who returned to use their oocytes [2]. Namath et al. estimated the number of vitrified mature oocytes needed to obtain three euploid blastocysts by age group [3]. These estimates are presented separately because they use different populations and outcomes. The Goldman model is also used to show how the estimated probability changes with the desired number of children [1]. Cascante et al. report the cumulative probability of at least one live birth. For a target of two or three children, the real-world estimate is therefore obtained by scaling the Cascante rate by the corresponding conditional ratio from the Goldman model; this hybrid estimate is labelled as such, and the assumption on which it rests is stated.

Oocyte-yield estimates

For women planning a first cycle, the calculator estimates mature oocyte yield from age-specific nomograms derived from 400 healthy women undergoing a first elective cryopreservation cycle with a standardized protocol [4]. The nomograms report percentiles rather than a single average value, because

yield varies between women of the same age. The number of cycles likely to be required is calculated from the selected oocyte target and the expected yield range.

Predicted ovarian response

The calculator predicts the expected ovarian response from anti-Müllerian hormone and antral follicle count, classifying each marker as predicting a poor, normal, or high response using pooled thresholds from a systematic review and meta-analysis of 42 studies (antral follicle count below 6 or anti-Müllerian hormone below 1.0 ng/mL for a poor response; antral follicle count of 15 or more or anti-Müllerian hormone of 4.0 ng/mL or more for a high response) [5]. Each marker is first checked against conditions known to distort it — for example, recent combined oral contraceptive use, a transabdominal antral follicle count, measurement on a different assay, or raised body mass index — and a marker judged unreliable is set aside in favour of the other. The predicted response band in turn selects the yield percentile applied to the oocyte-yield estimate, so that a woman predicted to respond poorly is not counselled from the yield distribution of an unselected population.

Age-stratified reference

The calculator provides an age-stratified reference table that shows, for eight ages, the modelled per-oocyte live-birth probability and the number of mature oocytes required to reach a 50%, 70%, or 80% probability of the selected number of live births [1]. The table is recomputed for the chosen family size and highlights the row nearest the patient's age, giving an age-specific answer to the question of how many oocytes would be needed.

Effect of deferring cryopreservation

For a woman planning a first cycle, the calculator projects the effect of deferral by evaluating the same target at her current age and after delays of two and five years, reporting for each the mature oocytes required and the number of cycles likely to be needed [2, 4]. Because mature-oocyte yield per cycle and per-oocyte live-birth probability both decline with age, the projected number of cycles rises more steeply than either change alone; where a target cannot be reached within the range supported by the source cohort, the calculator reports that it is not quotable rather than extrapolating.

Data sources and source integrity

Each estimate in the calculator is linked to its source. Where a model parameter was not published, it was reconstructed and checked against the published values: the intercept of the Cascante model, whose slopes are published [2], and the age-specific per-oocyte live-birth probabilities used to implement the Goldman model [1]. Both are labelled as reconstructions in the interface. Surrogate outcomes are not presented as live-birth outcomes: Namath et al. used three euploid blastocysts as a target [3], and Pirtea

et al. reported a cumulative live birth rate of 92.6% after up to three consecutive frozen euploid single-embryo transfers in 4,429 women with an anatomically normal uterus [6]; this does not establish that three euploid blastocysts guarantee a live birth.

Diminished ovarian reserve

The yield nomograms were derived from healthy women and excluded those with conditions that could affect ovarian response [4], and they should not be applied directly to women with low ovarian reserve. The calculator uses the POSEIDON criteria to identify low-prognosis groups [7]. Below the POSEIDON thresholds (anti-Müllerian hormone below 1.2 ng/mL or antral follicle count below 5), the age-specific nomograms are withheld and the observed yield reported by Coccia et al. is substituted [8]. For anti-Müllerian hormone of 0.5 ng/mL or lower, the median yield of their diminished-reserve cohort is applied; between 0.5 and 1.2 ng/mL, a span between the medians of their diminished-reserve and comparison cohorts is reported. The limits of this evidence are stated with the estimate.

Model support and withholding

Prediction models may perform less well when applied to populations that differ from the development cohort. A systematic review and external validation found that many in vitro fertilization live-birth models had a high or unclear risk of bias and limited performance in external data [9], and McLernon et al. reported only moderate discrimination for models of cumulative live birth after in vitro fertilization [10]. The calculator therefore restricts each estimate to the age and oocyte ranges supported by its source; when an input falls outside a supported range, that estimate is not shown and the calculator explains which limit has been reached. For example, the real-world estimate is shown only for ages 28 to 42 years and for 6 to 27 mature oocytes, the range covered by the Cascante cohort [2].

Results

In internal verification, the implementation reproduced all nine probabilities published by Goldman et al. (at least one, two, or three live births with 20 mature oocytes at ages 34, 37, and 42 years) to within 1 percentage point, and the six published Cascante anchors to within 0.5 percentage points. For a woman reviewing stored oocytes, the calculator presents the modelled and real-world estimates side by side as a range. Figure 1 shows representative outputs for women planning one child. At 34 years with 10 mature oocytes, the modelled probability of at least one live birth is 68% and the real-world estimate is 49%; the range narrows with advancing age and falling oocyte number. When the inputs fall outside the derivation cohort, the real-world estimate is withheld: for a 44-year-old with three mature oocytes, only the modelled value (4%) is shown, and the calculator states why the real-world estimate is not given.

For a woman planning a first cycle, the calculator presents the expected mature-oocyte yield per cycle as an age-specific distribution (Fig. 2). The median yield falls from 15 mature oocytes at age 30 to 6 at age 40, and the spread at any one age is wide; at age 35, half of women obtain 7–16 mature oocytes and

90% obtain 4–28. Reporting the distribution rather than a single average makes the range of likely outcomes, and the number of cycles that may be required, explicit.

The calculator also shows how the desired number of children changes the target (Fig. 3). At age 34, 20 mature oocytes correspond to a modelled probability of 90% for at least one live birth, 66% for at least two, and 37% for at least three. Planning for more than one child therefore raises the number of oocytes required from the same stored cohort.

Alongside these estimates, the calculator reports the predicted ovarian response band for the markers entered — poor, normal, or high — which selects the yield percentile used, and an age-stratified reference of the mature oocytes required to reach a 50%, 70%, or 80% live-birth probability at the chosen family size. For a woman planning a first cycle, it projects the effect of deferral. To reach a 50% real-world cumulative live birth rate for one child, a 34-year-old would need about 11 mature oocytes, rising to about 21 if she defers to age 39; with the median yield falling from 11 to 7 mature oocytes per cycle over the same interval, the number of cycles likely to be required rises from about one to about three (Fig. 4). These outputs make the cost of delay explicit at the point of counselling.

Discussion

We developed a counselling calculator that replaces a single oocyte target with a range of published, age-specific estimates. Its contribution is not a new prediction model but the way existing evidence is assembled: three models with different populations and outcomes are shown side by side, each linked to its source, and none is extended beyond the range its source supports. It also covers both settings in which the question arises: women deciding whether and how many oocytes to freeze, and women with oocytes already in storage who wish to know what their cohort is likely to achieve. Because the implementation reproduces the published estimates on which it is built, differences between its outputs reflect differences between the source studies rather than errors of implementation. Because it runs offline and stores no data, it can be used at the point of counselling without data-protection concerns.

The gap between the modelled and the real-world estimate is itself informative. The Goldman model treats each mature oocyte as contributing independently to the chance of live birth [1] and is therefore an optimistic bound. The Cascante estimate comes from women who returned to use oocytes stored for planned cryopreservation [2] and incorporates losses at warming, fertilisation, embryo development and transfer that the model does not capture. Women who return are, however, a selected group, and real-world rates also depend on laboratory performance, transfer policy and length of follow-up. Neither estimate is the true value for an individual woman, and presenting both as a range conveys this uncertainty more honestly than either alone. The range narrows with advancing age and falling oocyte number (Fig. 1), where both sources agree that the prognosis is poor.

Three features address questions that a single target cannot. First, conditioning on the desired number of children shows that the same banked cohort supports a markedly lower probability of a second or third child (Fig. 3), a point rarely discussed at the time of freezing. Second, the deferral projection

combines two age-related declines, fewer mature oocytes per cycle and lower competence per oocyte, so the number of cycles required rises more steeply than either change alone suggests (Fig. 4). Making this explicit may help women who are deciding when, rather than whether, to freeze. Third, women with diminished ovarian reserve are not counselled from yield distributions derived in women with normal reserve; below the POSEIDON thresholds, observed yields from a diminished-reserve cohort are substituted [7, 8]. This matters in settings where planned cryopreservation is largely undertaken by women with low reserve, in whom an unselected yield distribution would overstate what one cycle can provide.

Withholding an estimate outside the supported range may appear to limit the usefulness of the tool, but it is deliberate. Prediction models for in vitro fertilization outcomes often perform less well in external populations [9, 10], and extrapolation beyond the age or oocyte range of the derivation cohort compounds this problem. In counselling, a statement that the evidence does not extend to a given patient is more useful than a number that implies a certainty the data do not support. For the same reason, the calculator labels reconstructed parameters and the one hybrid quantity it reports, so that the clinician can judge how much weight each figure should carry.

The calculator has several limitations. It is only as valid as its sources: the live-birth models were derived in cohorts from the United States and the yield nomograms in an Israeli cohort [1, 2, 4], and outcomes in other populations and laboratories may differ. Two parameters were reconstructed rather than taken directly from publications, although both reproduce the published values closely. The real-world estimate for more than one child combines an observed rate for the first child with a modelled ratio for subsequent children; this assumption is untested, because no planned-cryopreservation series has followed women to a second child from one banked cohort. The diminished-reserve yield comes from a single, relatively young cohort and is not conditioned on age [8], so it is likely to be optimistic in older women. The calculator does not account for other factors that may influence outcome, such as body mass index, polycystic ovary syndrome, endometriosis or male factor, and the euploid-blastocyst target is a surrogate rather than a live-birth outcome [3, 6]. Finally, the calculator has not been validated against outcomes in an independent cohort, and its effect on patient understanding and decision-making has not been studied.

Two steps follow. The first is external validation against local outcomes, including women who stored oocytes because of diminished reserve or advanced reproductive age and later returned to use them; such data would also allow local recalibration of the yield and survival parameters. The second is evaluation in clinical practice: whether presenting a range rather than a single figure improves patients' understanding, reduces decisional conflict, and changes decisions about the number of cycles or the timing of cryopreservation. Because the source literature is evolving rapidly, the parameters should be reviewed as new planned-cryopreservation cohorts with longer follow-up are published.

Conclusions

The number of mature oocytes needed for a planned family cannot be represented by a single universal target. The estimate depends on age at retrieval, the number of mature oocytes, the desired number of children, and the model used. The calculator presents published estimates separately, states their assumptions, and withholds results outside supported ranges.

Counselling should also include the potential benefits, the burden of treatment, cost, storage, and uncertainty. The decision to proceed may reflect personal values and circumstances that are not outcomes measured by the prediction models and are therefore not assigned numerical estimates. The calculator is a counselling aid; it does not predict an individual outcome with certainty.

The calculator should be updated as new evidence becomes available, including larger planned-cryopreservation cohorts, longer follow-up, and improved age-specific and ovarian-reserve-specific yield data. Because outcomes also vary between laboratories, the calculator records the source, assumptions, and version of each parameter, and any local recalibration should be based on appropriate local outcome data and reported clearly.

Declarations

Author Contribution

B.U. and A.P.C.: conception and design; G.E.A., S.E. C.B. and I.U.K.: literature screening and data collection; A.S. and K.Y.: manuscript drafting; B.U and A.P.C.: critical revision. All authors read and approved the final manuscript.

Data Availability

The calculator is available from the corresponding author upon reasonable request.

References

1. Goldman RH, Racowsky C, Farland LV, Munné S, Ribustello L, Fox JH. Predicting the likelihood of live birth for elective oocyte cryopreservation: a counseling tool for physicians and patients. Hum Reprod. 2017;32:853–9. https://doi.org/10.1093/humrep/dex008.
2. Cascante SD, Grifo JA, Licciardi F, Parra CM, Kelly A, Berkeley AS. The effects of age, mature oocyte number, and cycle number on cumulative live birth rates after planned oocyte cryopreservation. J Assist Reprod Genet. 2024;41:2979–85. https://doi.org/10.1007/s10815-024-03175-w.
3. Namath A, Flannagan K, Pirtea P, Toner JP, Devine K. The number of autologous, vitrified mature oocytes needed to obtain three euploid blastocysts increases with age. Fertil Steril. 2025;124:487–95. https://doi.org/10.1016/j.fertnstert.2025.04.023.

4. Machtinger R, Tuval A, Hammerman A, Maman E, Nahum R, Orvieto R, et al. Age-based oocyte yield in elective oocyte cryopreservation: a retrospective cohort study. Diagnostics (Basel). 2025;15:2278. https://doi.org/10.3390/diagnostics15172278.
5. Liu Y, Pan Z, Wu Y, Song J, Chen J. Comparison of anti-Müllerian hormone and antral follicle count in the prediction of ovarian response: a systematic review and meta-analysis. J Ovarian Res. 2023;16:117. https://doi.org/10.1186/s13048-023-01202-5.
6. Pirtea P, De Ziegler D, Tao X, Sun L, Zhan Y, Ayoubi JM, et al. Rate of true recurrent implantation failure is low: results of three successive frozen euploid single embryo transfers. Fertil Steril. 2021;115:45–53. https://doi.org/10.1016/j.fertnstert.2020.07.002.
7. Humaidan P, Alviggi C, Fischer R, Esteves SC. The novel POSEIDON stratification of 'Low prognosis patients in Assisted Reproductive Technology' and its proposed marker of successful outcome. F1000Res. 2016;5:2911. https://doi.org/10.12688/f1000research.10382.1.
8. Coccia ME, Gabbrielli B, Cutajar G, Piazzini F, Evangelisti P, Badolato L, et al. Fertility preservation in women with diminished ovarian reserve: evaluating the AMH criteria. J Assist Reprod Genet. 2025;43:865–72. https://doi.org/10.1007/s10815-025-03779-w.
9. Tian CH, Liu LY, Huang YF, Yang HJ, Lai YY, Li CL, et al. Clinical prediction models for in vitro fertilization outcomes: a systematic review, meta-analysis, and external validation. Hum Reprod. 2025;40:633–46. https://doi.org/10.1093/humrep/deaf013.
10. McLernon DJ, Raja EA, Toner JP, Baker VL, Doody KJ, Seifer DB, et al. Predicting personalized cumulative live birth following in vitro fertilization. Fertil Steril. 2022;117:326–38. https://doi.org/10.1016/j.fertnstert.2021.09.015.

Figures

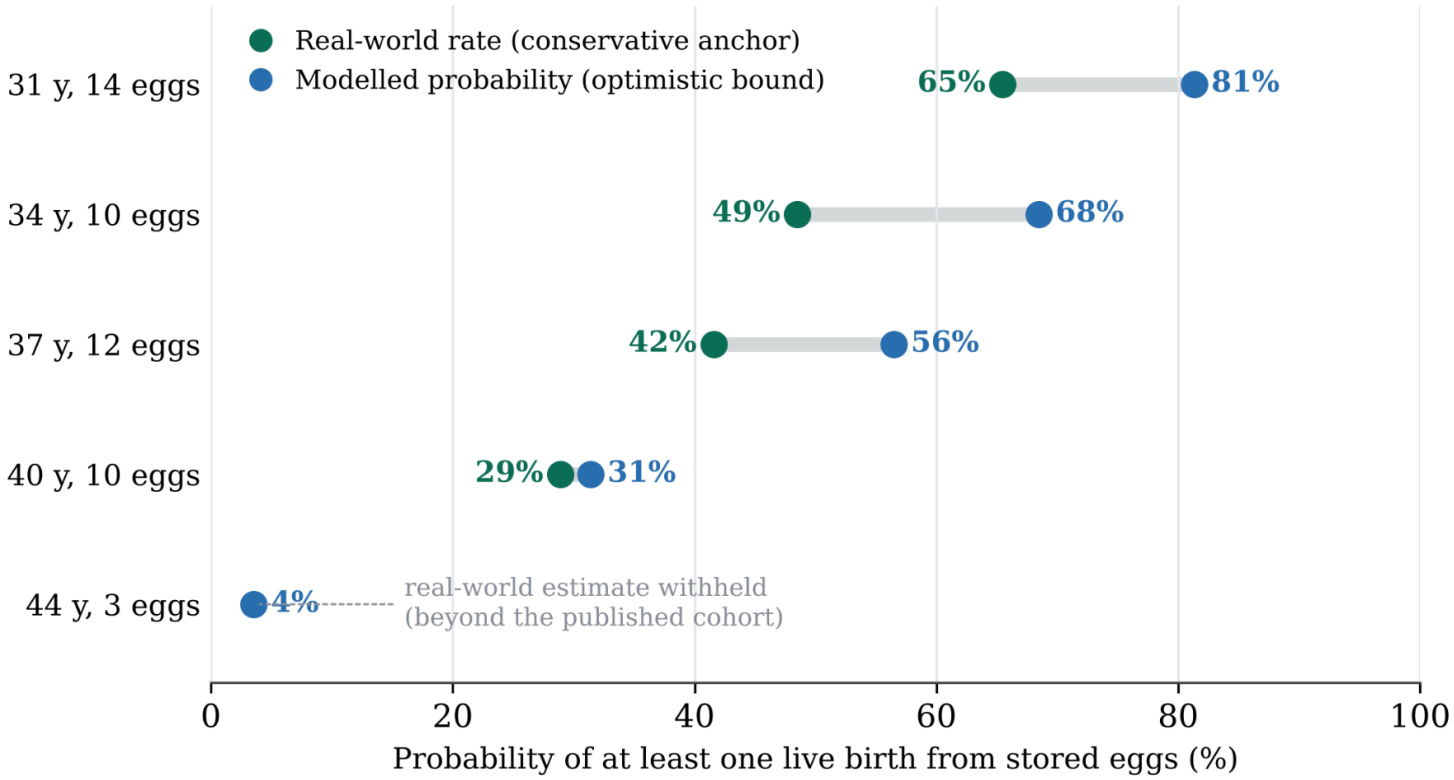

Figure 1

Representative calculator outputs for women planning one child. For each patient the tool shows a modelled probability of at least one live birth (Goldman et al. [1]) and, when the inputs lie within the derivation cohort, a real-world cumulative live birth rate (Cascante et al. [2]); the two are presented together as a range. For the 44-year-old with three mature oocytes the real-world estimate falls outside the published cohort and is withheld, and only the modelled value is shown. Values are illustrative and computed from the cited models

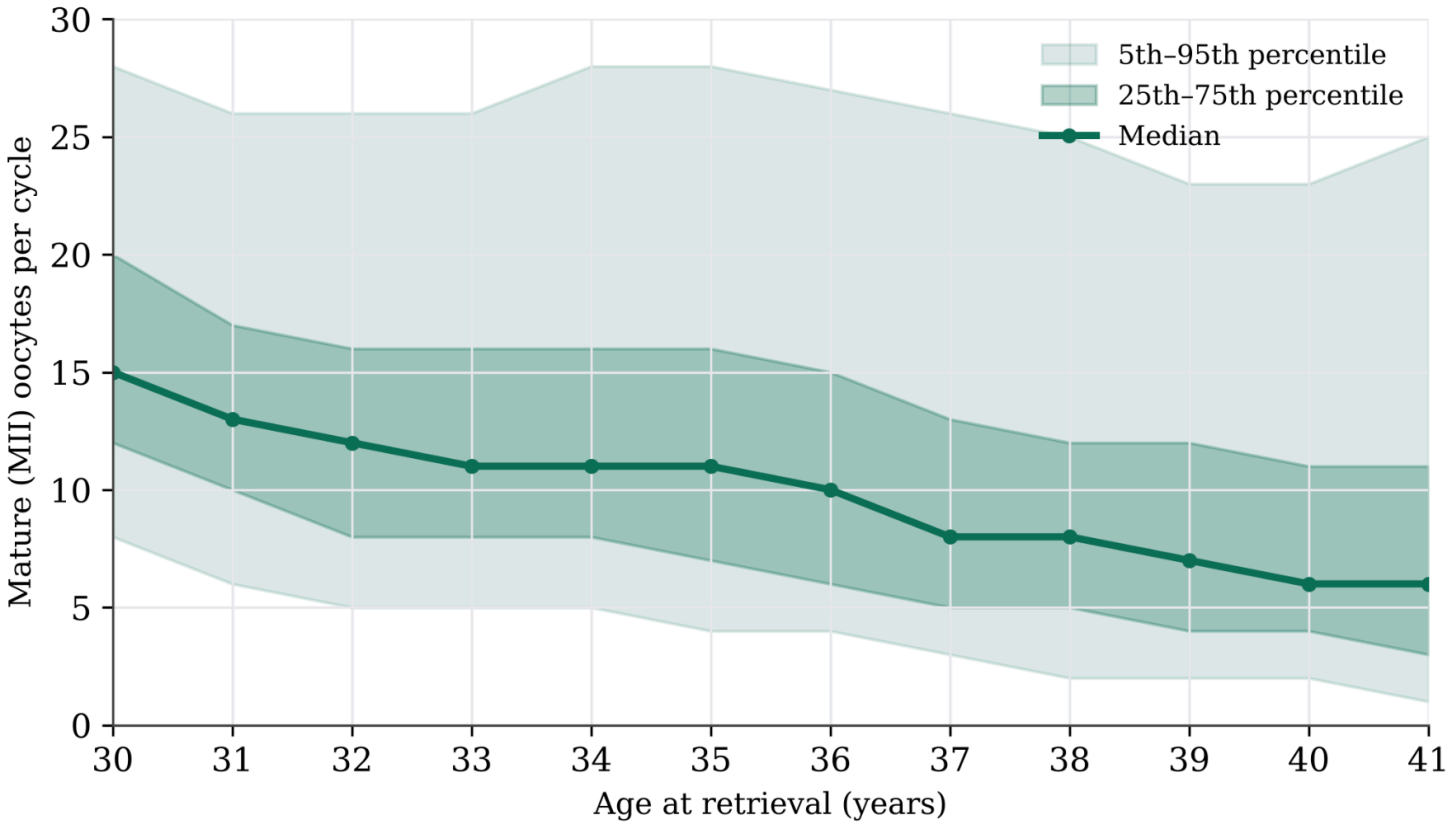

Figure 2

Expected number of mature (MII) oocytes per retrieval cycle by age, from the nomograms of Machtinger et al. [4]. The line is the median; the darker band shows the 25th–75th percentile and the lighter band the 5th–95th. At age 35, for example, half of women obtain 7–16 mature oocytes and 90% obtain 4–28, so yield is reported as a distribution rather than a single average. Values are taken from the cited source

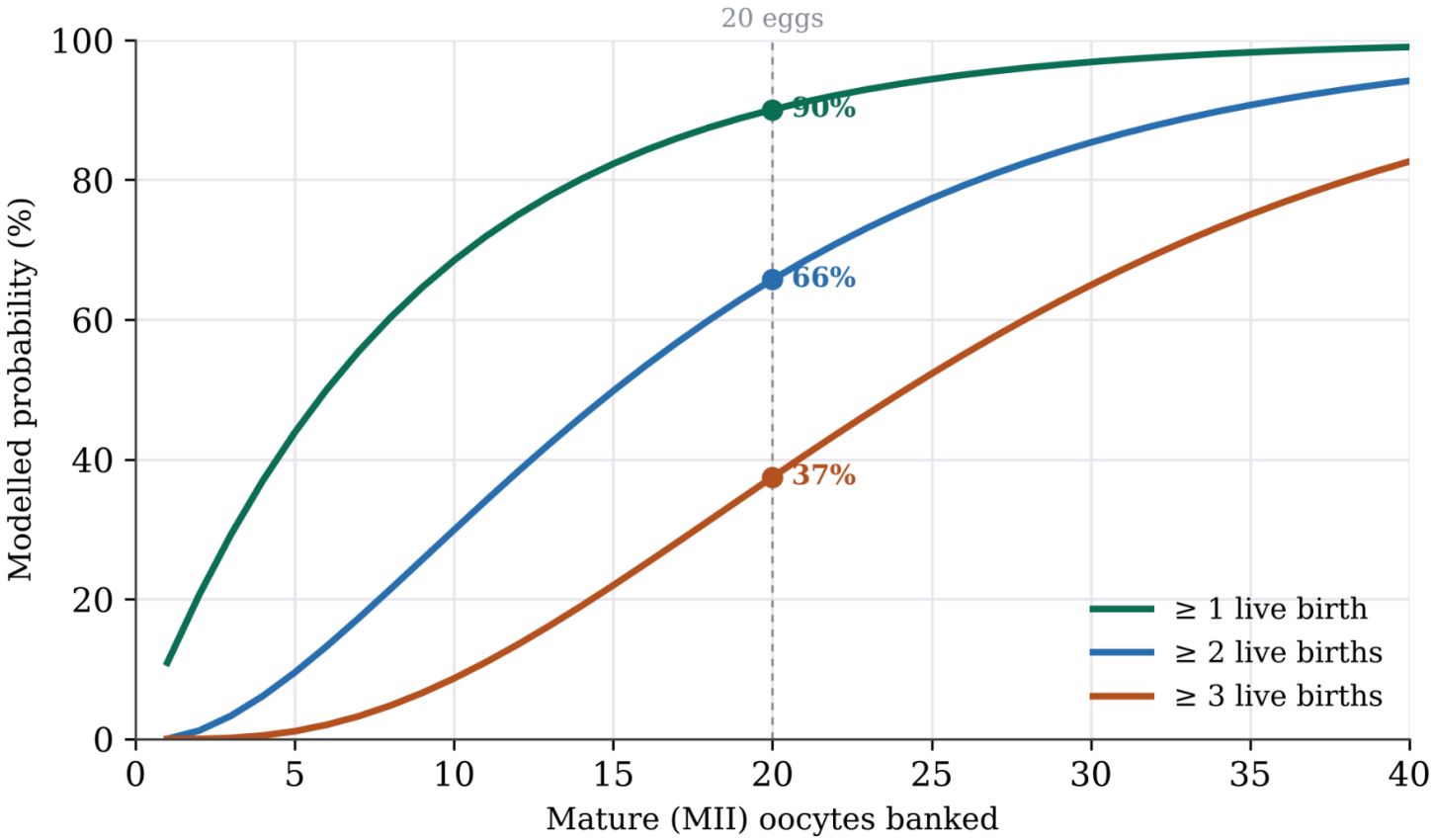

Figure 3

Effect of the desired number of children on the modelled probability at age 34 (Goldman et al. [1]). Curves show the probability of at least one, two, or three live births against the number of mature oocytes banked; at 20 mature oocytes the modelled probabilities are 90%, 66%, and 37%, respectively. Values are illustrative and computed from the cited model

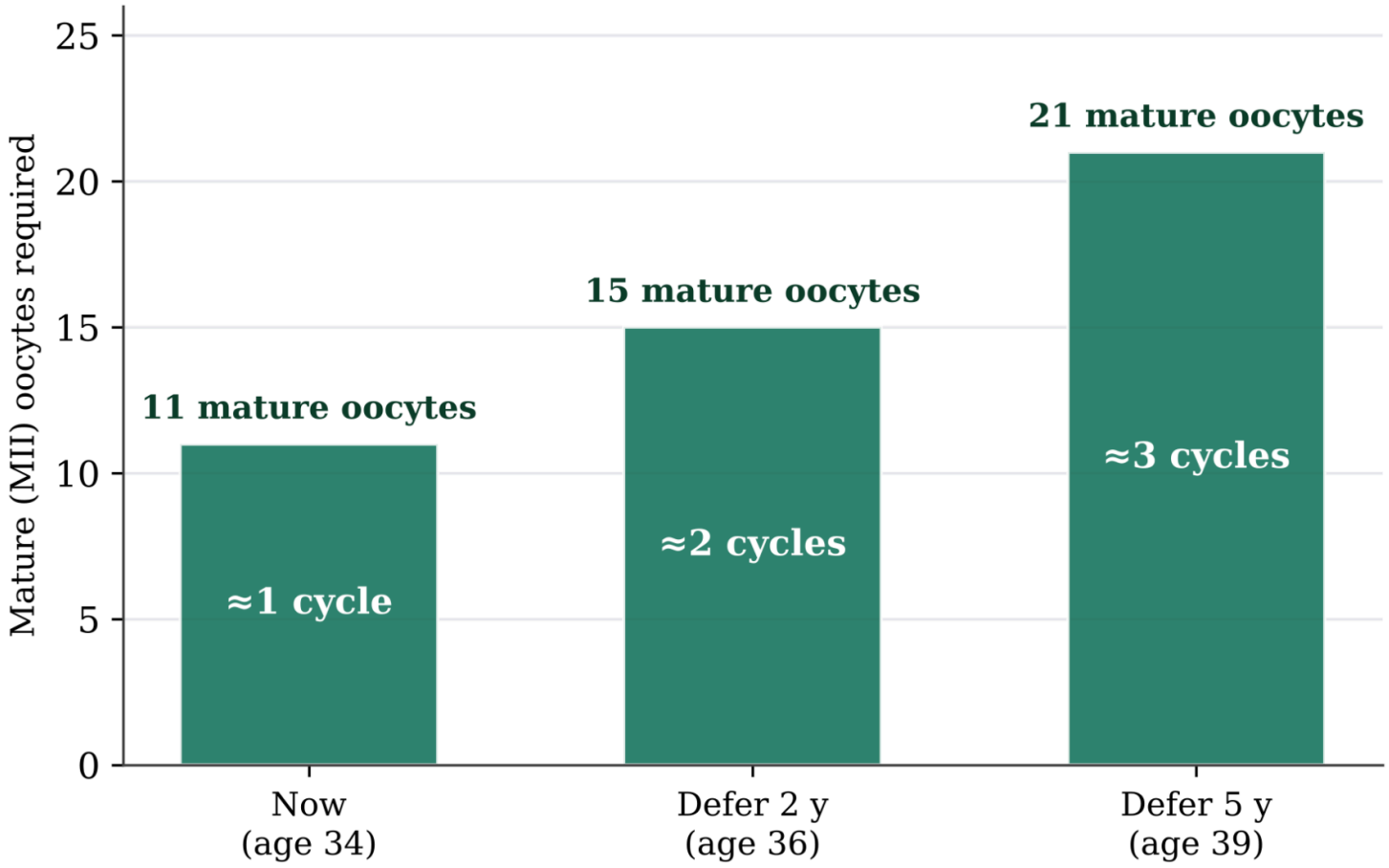

Figure 4

Projected effect of deferring a first cycle, for a woman aiming for a 50% real-world cumulative live birth rate for one child (target from Cascante et al. [2], yield from Machtinger et al. [4]). Proceeding at age 34 requires about 11 mature oocytes (about one cycle); deferring to age 36 or 39 raises the requirement to about 15 and 21 mature oocytes, and the number of cycles likely to be needed to about two and three, because mature-oocyte yield per cycle and per-oocyte live-birth probability both fall with age. Values are illustrative and computed from the cited models