

Machine learning prediction of usable blastocyst yield in hp-hMG-only ICSI cycles: A multicenter retrospective analysis

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OBJECTIVE

Use machine learning to accurately predict the number of usable blastocysts in HP-hMG-only ICSI cycles based on data available on the day of oocyte retrieval

KEY TAKEAWAYS

- 1
- HP-hMG (Menopur)-only ICSI cycles achieved usable blastocysts across evaluated age groups, supporting age-specific blastulation-rate benchmarking
- 2
- Machine learning predicted usable blastocyst yield with reliable accuracy in an independent multicenter test cohort
- 3
- Consistent predictive performance across age groups supports post-retrieval counseling and clinical decision-making, with prospective validation needed

Abbreviations
2PN, 2 pronuclei (fertilization); AFC, antral follicle count; AI, artificial intelligence; AMH, anti-Müllerian hormone; ART, assisted reproductive technology; BMI, body mass index; CR, complete response; E2, estradiol; HP-hMG, highly purified human menopausal gonadotropins; ICSI, intracytoplasmic sperm injection; IVF, in vitro fertilization; MAE, mean absolute error; MII, metaphase II (mature oocyte); P4, progesterone; R2, co-efficient of determination.

References
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BACKGROUND

- The number of usable blastocysts is a key outcome in IVF, reflecting treatment efficacy and serving as an important predictor of pregnancy outcomes.¹
- Blastocyst yield varies substantially and depends on multiple patient and clinical variables.²
- Few models are available to forecast the usable blastocyst cohort in ART cycles, and their predictive accuracy remains limited.³

METHODS

- Objective:** To create a machine learning model that accurately predicts usable blastocyst number
- Data source:** retrospective data collected on 3,955 HP-hMG-only ICSI cycles from clinics in Asia, Europe, and North America (Figure 1)
- Model development:** 974 cycles with complete records for total oocytes, MII oocytes, 2PN fertilization, and usable blastocysts
- Input parameters:** maternal age, BMI, AFC, trigger day E2 and P4, follicle counts, starting HP-hMG dose, oocytes retrieved, MII oocytes
- Model evaluation:** independent test set of 272 cycles
- Predictive performance** evaluated as the coefficient of determination (R2) and Mean Absolute Error (MAE)

RESULTS

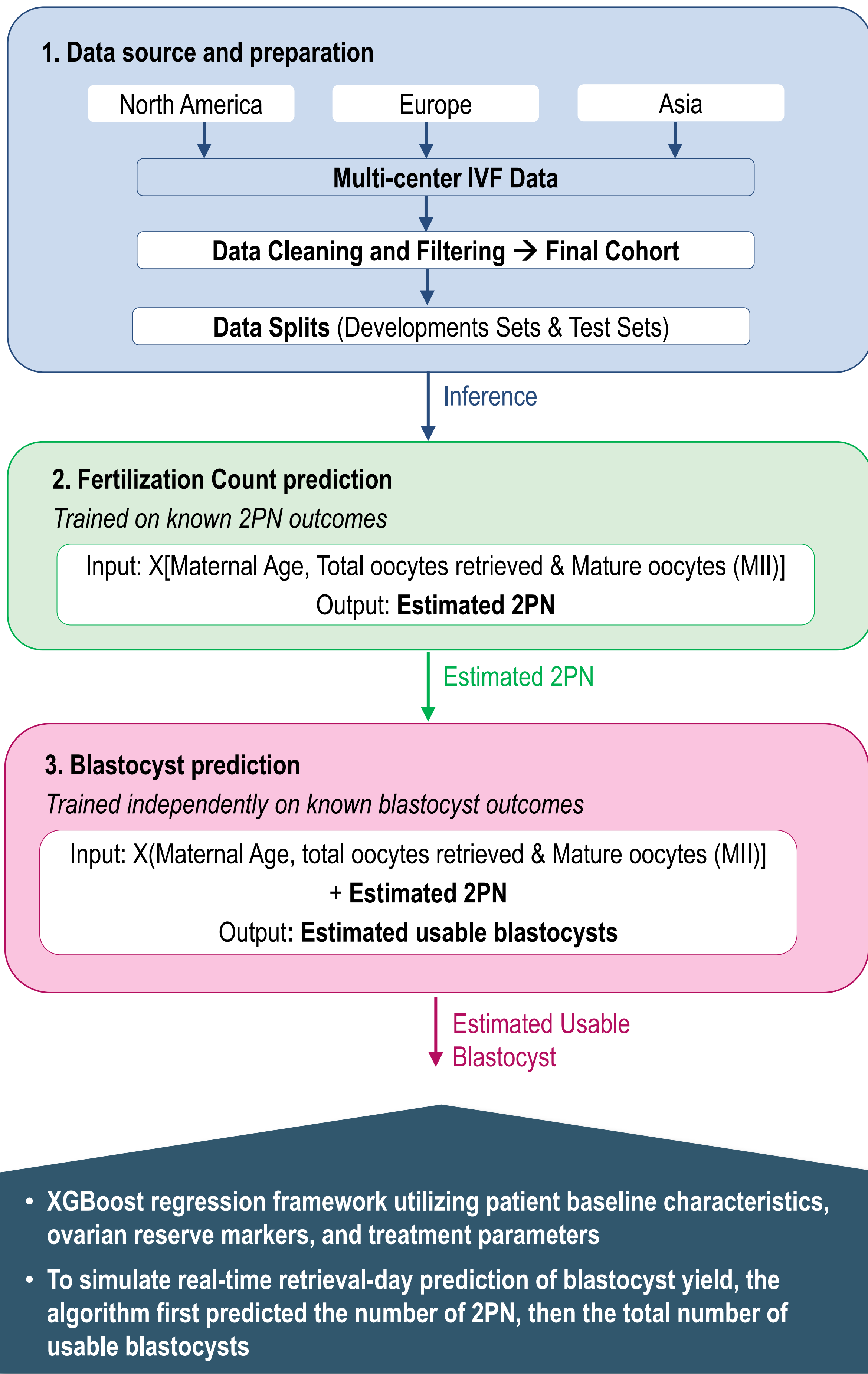
Independent test cohort (n=272 cycles)

- Robust overall predictive performance for the number of usable blastocysts (R2=0.50, MAE=1.35)
- Mean number of blastocysts: 2.56

Additional subgroup analysis by maternal age (Table 1)

- The number of oocytes decreases with increasing maternal age, along with the absolute number of blastocysts.
- The blastulation rate also declines with age, potentially reflecting age-related defects in oocyte or embryo competence.
- Consistent absolute difference in blastocyst yield ratios (0.02-0.04) across all age groups reflects a slight but stable underestimation in blastocyst yield
- MAE decreased as age increased: 1.66 (30–34 years), 1.42 (35–39 years), 1.14 (40–42 years), and 0.95 (43–45 years)

FIGURE 1 Methods



Sensitivity analysis (n=345 cycles without complete MII data)

- Showed similar predictive accuracy, with an absolute difference in yield ratios of 0.01–0.03

TABLE 1 Model Predictive Accuracy by Patient Age (N=253 patients)

Age (years)*	n	Oocytes	MI	2PN	Blastocysts	Blastulation rate†	Blastocyst prediction†
30-34	40	13.30±7.17	9.93±5.32	7.55±4.48	3.95±3.21	0.29±0.17	0.26±0.07
35-39	81	9.95±6.83	7.06±5.01	5.10±3.65	2.59±2.64	0.26±0.22	0.22±0.07
40-42	82	8.72±5.33	6.70±4.26	4.77±3.08	1.93±1.83	0.22±0.20	0.20±0.09
43-45	50	7.96±4.49	6.22±3.60	4.36±2.72	1.60±1.44	0.21±0.18	0.18±0.05

*Analysis excluded patients <30 years (n=16) and >45 years (n=3) due to small sample sizes.

†Mean of per-cycle usable blastocyst-to-oocyte yield ratios.

Blastocyst yield was consistent and primarily driven by age

CONCLUSION

- In HP-hMG (Menopur)-only ICSI cycles, usable blastocysts were achieved across evaluated age groups, with blastulation-rate trends providing an age-specific benchmark
- Machine learning predicted usable blastocyst number with moderate-to-robust accuracy in an independent test cohort
- Consistent prediction performance across age groups supports reliable post-retrieval benchmarking, personalized counseling, and clinical decision-making; prospective validation in broader patient populations is needed to confirm clinical implementation