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A predictive model for in vitro fertilization success: a retrospective cohort study from a tertiary clinic in Indonesia

Made Tangkas[1*], I Made Mahadinata Putra[1], Juwita Endarwati[2]

[1]Departement of Obstetrics and Gynecology, Faculty of Medicine, Universitas Mahasaraswati, Denpasar, Indonesia
[2]Department of Clinical Pathology, Faculty of Medicine, Universitas Mahasaraswati, Denpasar, Indonesia

*Correspondence to:
Made Tangkas; Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Mahasaraswati, Denpasar, Indonesia;
tangkas@unmas.ac.id

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ABSTRACT

Background: In vitro fertilization (IVF) remains one of the most effective assisted reproductive technologies for the management of infertility; however, its success rate varies widely across populations and clinical settings. In Indonesia, data-driven evaluations of IVF success predictors remain limited, and locally validated prognostic tools to support individualized counseling and treatment planning are scarce. This study aimed to identify factors associated with successful pregnancy outcomes among couples undergoing IVF at the WIN Infertility Clinic, Puri Bunda Hospital, Denpasar.

Methods: A retrospective cohort study with a case–control approach was conducted using secondary data from medical records of 243 infertile couples who underwent IVF cycles between January 2023 and December 2024. Clinical pregnancy confirmed by laboratory and ultrasound findings was classified as the success group (n = 100), while unsuccessful cycles constituted the control group (n = 143). Variables evaluated included female age, basal hormonal profile, ovulation induction protocol, number of embryos transferred, body mass index (BMI), infertility duration, and infertility status. Univariate and multivariate logistic regression analyses were performed to identify independent predictors, followed by the development of a predictive scoring model.

Results: The overall clinical pregnancy rate was 41.2%. Multivariate analysis demonstrated that four variables were independently associated with IVF success: female age (adjusted OR [aOR] 0.91; 95% CI 0.85–0.98; p = 0.012), number of embryos transferred (aOR 1.68; 95% CI 1.22–2.33; p = 0.001), normal BMI (aOR 2.00; 95% CI 1.12–3.59; p = 0.019), and duration of infertility (aOR 0.92; 95% CI 0.86–0.99; p = 0.041). A predictive scoring system derived from these factors demonstrated moderate discriminatory performance (AUC = 0.724).

Conclusion: Female age, number of embryos transferred, BMI, and infertility duration are significant independent predictors of IVF success at this center. The proposed scoring model may serve as a practical tool to support individualized patient counseling and optimize treatment planning in IVF programs.

Keywords: In Vitro Fertilization, Pregnancy Rate, Predictive Factors, Infertility, Logistic Models.
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INTRODUCTION

Infertility is defined as the inability to achieve a clinical pregnancy after at least 12 months of regular, unprotected sexual intercourse and represents a significant reproductive health problem worldwide.[1] This condition affects millions of couples and is associated with substantial physical, psychological, social, and economic consequences. In many societies, infertility may lead to emotional distress, marital strain, and reduced quality of life, underscoring its importance as both a medical and public health concern. In Indonesia, infertility prevalence is estimated to range from 12% to 15%, indicating a considerable burden among couples of reproductive age and reflecting an increasing demand for effective fertility services.[2]

Assisted Reproductive Technology (ART) has become a central component in the management of infertility, particularly for couples who do not respond to conventional medical or surgical treatments. Among available ART modalities, in vitro fertilization (IVF) is the most widely applied and extensively studied technique. Despite continuous advancements in ovarian stimulation protocols, embryo culture systems, and laboratory technologies, IVF outcomes remain suboptimal. Globally, the average clinical pregnancy rate per IVF cycle is reported to be approximately 30–35%, suggesting that a substantial proportion of treatment cycles still fail to result in pregnancy.[3]

The success of IVF is widely recognized as a multifactorial process influenced by an interplay of patient-related, clinical, and laboratory factors. Previous studies have consistently demonstrated that female age plays a pivotal role in determining IVF outcomes, mainly due to age-related declines in ovarian reserve and oocyte quality. Additional factors such as baseline

hormonal profiles, cause and duration of infertility, body mass index (BMI), ovarian stimulation protocols, and the number and quality of embryos transferred have also been shown to affect implantation and pregnancy rates significantly.[4,5] Furthermore, laboratory-related variables, including embryo culture conditions and embryologist expertise, contribute to variability in IVF success.

Despite the growing body of evidence, predictors of IVF success are not universally consistent across different populations and clinical settings. Differences in demographic characteristics, genetic background, lifestyle factors, clinical protocols, and institutional experience may result in heterogeneous outcomes between fertility centers. Consequently, predictive factors identified in one population may not be directly applicable to another, highlighting the need for locally generated data to support evidence-based clinical practice.

At WIN Infertility Clinic, Puri Bunda Hospital, Denpasar, the reported IVF success rate ranges between 30% and 35%, which is comparable to global averages. However, to date, no comprehensive evaluation has been conducted to identify clinic-specific factors associated with successful pregnancy following IVF. The absence of such data limits the ability of clinicians to accurately estimate prognosis, individualize treatment strategies, and provide optimal counseling to patients undergoing IVF. Therefore, this study aims to identify significant predictors of successful pregnancy among couples undergoing IVF at WIN Infertility Clinic, Puri Bunda Hospital, Denpasar.

METHODS

This study employed a retrospective cohort design with a case–control analytical approach. The study population comprised all infertile couples who underwent in vitro fertilization (IVF) cycles at the WIN Infertility Clinic, Puri Bunda Hospital, Denpasar, during the period from January 2023 to December 2024. Data were obtained from institutional medical records and laboratory databases. Initially, a total of 408 IVF cycles were identified. Cycles were excluded if medical records were incomplete, essential clinical or laboratory variables were missing, or if the cycle did not proceed to embryo transfer. After applying these exclusion criteria, 243 complete IVF cycles were eligible for inclusion in the final analysis. Participants were subsequently categorized into two groups based on treatment outcomes. The case group consisted of cycles that resulted in a successful pregnancy (n = 100), while the control group included cycles with unsuccessful outcomes (n = 143).

The primary outcome of this study was laboratory-confirmed pregnancy, defined as a positive serum β-human chorionic gonadotropin (β-hCG) level exceeding 50 IU/L following embryo transfer. This threshold was selected to ensure biochemical confirmation of implantation and minimize false-positive results. Independent variables analyzed in this study included demographic, clinical, and treatment-related factors. Demographic variables comprised female and male age at the time of IVF. Clinical variables included body mass index (BMI), duration of infertility, infertility status (primary or secondary), and baseline hormonal profiles consisting of estradiol, luteinizing hormone (LH), prolactin, and follicle-stimulating hormone (FSH). Treatment-related variables encompassed the ovulation induction protocol used (short protocol, long protocol, or frozen embryo transfer), as well as the number of embryos transferred per cycle.

BMI and basal hormone levels were categorized as normal or abnormal according to standardized laboratory reference ranges applied at the study center. All data were extracted using a standardized data collection form to ensure consistency and minimize information bias. Statistical analyses were performed using IBM SPSS Statistics version 29.0 for Windows. Descriptive statistics were used to summarize baseline characteristics of the study population, with continuous variables presented as means and standard deviations or medians and interquartile ranges, as appropriate, and categorical variables expressed as frequencies and percentages.

Univariate logistic regression analysis was initially conducted to assess the association between each independent variable and the primary outcome. Variables demonstrating a statistically significant association ($p < 0.05$) in univariate analysis were subsequently included in a multivariate logistic regression model to identify independent predictors of IVF success while controlling for potential confounding factors. A predictive scoring system was developed based on the regression coefficients derived from the final multivariate model. Model calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test, and discriminatory performance was assessed by calculating the area under the receiver operating characteristic curve (AUC). Statistical significance was defined as a two-tailed p-value of less than 0.05.

RESULTS

The overall clinical pregnancy rate was 41.2% (100/243). The majority of subjects had primary infertility (71.6%) and underwent the short ovulation induction protocol (81.1%). Most patients had normal basal hormone levels (Estradiol 93.8%, LH 80.7%, Prolactin 72.0%, FSH 74.1%) and normal BMI (61.3%). Univariate logistic regression identified female age (OR 0.92, p=0.008), number of embryos transferred (OR 1.65, p=0.002), categorized BMI (OR 1.89, p=0.021), duration of infertility (OR 0.93, p=0.032), and categorized FSH status (OR 1.94, p=0.034) as significantly associated with IVF success.

The multivariate logistic regression analysis was conducted to identify independent predictors of IVF success while controlling for potential confounding among variables and confirmed four independent predictors (**Table 1**). The final model included four statistically significant variables ($p<0.05$) that independently influenced the outcome. Female age and duration of infertility were negatively associated with success, while the number of embryos transferred and having a normal BMI were positively associated.

The model demonstrated good fit (Hosmer-Lemeshow p=0.312) and moderate discriminatory power (AUC=0.724), explaining approximately 21.4% of the variance in outcomes (Nagelkerke R^2=0.214).

The scoring system was developed

through a systematic transformation of the multivariate regression coefficients into a clinically practical tool. Step 1 was evaluating Coefficient Standardization. The β-coefficients were used as the foundation for point assignment. Continuous variables (age, infertility duration) were categorized based on clinical relevance and distribution analysis. In addition, categorical variables (BMI, embryo number) maintained their original groupings.

Step 2 was evaluating the point assignment algorithm. Points were assigned proportionally to the β-coefficients, with rounding to nearest integers for clinical usability (**Table 2**).

Step 3 was evaluating probability calibration. The total score ranges from -4 to +5. Using the logistic function $P = 1 / (1 + e^{-(\beta_0 + \Sigma\beta_i X_i)})$, where β_0 is the intercept (1.852), we calculated success probabilities for each score range such as: 1) Score ≤ 0: Probability <30% (Low success risk); 2) Score 1-2: Probability 30-60% (Medium success risk); and 3) Score ≥ 3: Probability >60% (High success risk).

The scoring system provides immediate bedside assessment without requiring complex calculations. For example, a 32-year-old patient (score -1) with normal BMI (score +1), transferring 3 embryos (score +2) and 2 years of infertility (score 0) totals 2 points, indicating a medium success probability (30-60%). The scoring system represents a balance between statistical rigor and clinical practicality, providing a foundation for shared decision-making and resource allocation in IVF treatment planning.

Table 1. Multivariate Logistic Regression Analysis of Factors Affecting IVF Success

Variable	β	Adjusted OR	95% CI	p
Intercept	1.852	-	-	0.038*
Female Age	-0.089	0.91	0.85-0.98	0.012*
Number of ET	0.521	1.68	1.22-2.33	0.001**
BMI category	0.693	2.00	1.12-3.59	0.019*
Duration of Infertility	-0.078	0.92	0.86-0.99	0.041*

OR: Odds-Ratio; CI: Confidence Interval; *Statistically significant if p-value is less than 0.05

Table 2. Scoring System for Predicting IVF Success

Variable	Category	Score
Female Age	≤30 yo	0
	31-35 yo	-1
	≥36 yo	-2
Number of ET	1	0
	2	1
	≥3	2
BMI	Normal	1
	Abnormal	0
Duration of Infertility	≤3 yo	0
	4-6 yo	-1
	≥7 yo	-2

DISCUSSION

This study provides a comprehensive analysis of factors influencing IVF success at a single infertility center in Bali, Indonesia. The overall clinical pregnancy rate of 41.2% aligns with global reports, which typically range between 35-40% for general populations.[4] Our multivariate analysis identified four independent predictors of IVF success: female age, number of embryos transferred, BMI, and duration of infertility. These findings corroborate and refine existing literature within the specific context of the Indonesian population.

The inverse relationship between female age and IVF success (aOR 0.91 per year) is a cornerstone of reproductive medicine, extensively documented in foundational textbooks and contemporary literature as well as preibous studies.[6-13] This decline is mechanistically linked to the progressive diminution of the primordial follicle pool and a concomitant increase in oocyte aneuploidy rates. Speroff & Fritz's *Clinical Gynecologic Endocrinology and Infertility* details the accelerated follicular atresia observed after age 35, leading to a quantifiable reduction in both ovarian reserve and oocyte quality.[14] Our findings are further substantiated by a recent multicenter analysis by Cimadomo et al., which demonstrated a significant, non-linear decrease in blastocyst euploidy rates with advancing female age, providing a direct cytogenetic explanation for the lower implantation and live birth rates.[5] This biological reality underscores the imperative for timely intervention in couples of advanced reproductive age.

The significant positive association between the number of embryos transferred and pregnancy likelihood (aOR 1.68) reflects the fundamental principle of increasing the probabilistic odds of implantation.[9] Pandian et al.'s Cochrane review established that transferring multiple embryos increases the chance of live birth compared to single embryo transfer.[6] However, this practice necessitates a critical risk-benefit analysis against the well-documented sequelae of multiple gestation, including preterm birth, low birth weight, preeclampsia, and gestational diabetes.[6,15] The global trend, guided by practice committees like ASRM and ESHRE, is shifting towards elective single embryo transfer (eSET) in favorable-prognosis patients to mitigate these maternal and neonatal risks.[15] This is particularly pertinent in the Indonesian healthcare landscape, where the economic and clinical burdens of multiple pregnancies are substantial. A previous study context concluded that while eSET

effectively reduces multiple pregnancy rates, its successful implementation requires rigorous patient selection based on age, embryo quality, and previous IVF history.[10]

Our finding that a normal BMI confers a two-fold increase in the odds of success (aOR 2.00) highlights the profound impact of metabolic and nutritional status on reproductive function. The pathophysiological pathways are multifactorial. In obesity, a state of chronic inflammation, insulin resistance, and hyperandrogenism can disrupt folliculogenesis, oocyte maturation, and endometrial receptivity, as detailed in the ASRM committee opinion on obesity and reproduction.[7,11] Conversely, underweight status, as discussed by Boutari et al., is associated with disruptions in the hypothalamic-pituitary-ovarian (HPO) axis, often leading to anovulation and impaired endometrial development due to insufficient energy availability.[12] These findings underscore pre-conception weight optimization as a foundational, modifiable, and cost-effective intervention prior to initiating IVF cycles.

The negative correlation between the duration of infertility and IVF success (aOR 0.92 per year) likely serves as a proxy for the increasing severity of underlying subfertility pathologies. A prolonged duration may indicate conditions such as advanced endometriosis (AFS Stage III-IV), severe tubal damage, or significant male factor infertility that are not fully circumvented by standard IVF protocols.[16] Furthermore, the psychological burden of long-term infertility, including chronic stress and depression, can independently negatively influence treatment outcomes, potentially through neuroendocrine pathways affecting the HPO axis.[13] Our results align with large international cohort studies and emphasize the critical importance of early evaluation and referral for infertile couples to improve their cumulative chances of success.

The predictive scoring model developed in this study, demonstrating moderate discriminatory power (AUC=0.724), offers a pragmatic tool for initial patient counseling and risk stratification in our clinical setting. While it provides a reasonable estimate, its predictive accuracy could be enhanced by incorporating more sensitive and dynamic biomarkers of ovarian reserve, such as Anti-Müllerian Hormone (AMH) and antral follicle count (AFC), which were not routinely available in this retrospective dataset.[5,17] A previous study reinforced the value of AMH, showing a strong correlation with oocyte yield in local populations, suggesting its potential for refining future local predictive models.[8] The present model represents a foundational step towards personalized reproductive medicine in Indonesia, allowing for more evidence-based prognostic discussions and tailored treatment planning.

This study's limitations are inherent to its retrospective design, including potential selection bias, unmeasured confounding variables, and reliance on data completeness from medical records. Significant prognostic factors such as specific infertility etiologies (e.g., endometriosis staging), comprehensive embryo quality grading (e.g., using time-lapse morphokinetics), sperm DNA fragmentation indices, and detailed lifestyle factors (e.g., smoking, specific dietary patterns) were not consistently available for analysis. As a single-center study, the generalizability of our findings to other Indonesian regions with differing patient demographics, ethnicities, and clinical protocols requires external validation. Future prospective, multi-center cohort studies incorporating comprehensive biomarker profiling, standardized embryo assessment, and endometrial receptivity assays are warranted to develop and validate more robust, multidimensional predictive models for IVF success in the diverse Indonesian population.

CONCLUSION

Female age, number of embryos transferred, BMI, and duration of infertility are significant independent factors influencing the success of IVF at WIN Infertility Clinic, Puri Bunda Hospital, Denpasar. The predictive scoring model derived from these factors offers a practical tool for clinicians to estimate patient-specific success probabilities, thereby improving counseling and personalizing treatment plans. Prospective, multi-center studies incorporating embryo quality and endometrial receptivity factors are recommended to validate and refine this model further.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study. The authors have no financial, personal, or institutional relationships that could have influenced the conduct, analysis, or reporting of the research.

ETHICS CONSIDERATION

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Commission of Mahasaraswati University, Denpasar (Approval Number: 03.0038/KEP-UnmasflX/2025). As this study used retrospective secondary data from medical records, the requirement for informed consent was waived by the ethics committee. All patient data were anonymized and handled confidentially to ensure privacy and data protection throughout the research process

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AUTHOR CONTRIBUTIONS

MT conceived and designed the study, supervised data collection, and contributed to data interpretation and manuscript drafting. IMMP participated in study design, data acquisition, and critical revision of the manuscript for important intellectual content. JE contributed to data analysis, interpretation of laboratory-related variables, and manuscript revision. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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