Jeon *et al. Reproductive Health (2025) 22:88*
https://doi.org/10.1186/s12978-025-02030-0

Reproductive Health

RESEARCH

Open Access

Lifestyle factors and health outcomes associated with infertility in women: A case-control study using National Health Insurance Database

Boyoung Jeon[1*], Taeuk Kang[2*] and Sung Wook Choi[3]

Abstract

Background Approximately one in six people is experiencing infertility at some point in their lives. In response, health insurance coverage for infertility treatments has been strengthened. However, studies examining lifestyle factors that affect infertility remain lacking, highlighting the need to generate objective evidence to address infertility issues using national-level datasets.

Methods The General Healthcare Screening Program dataset from National Health Insurance Service database was employed in this study to examine infertility and childbirth among women aged 22–49 years. In 2020, 25,333 women with infertility and 73,759 women who had given birth were initially identified. After applying propensity score matching for age, Charlson Comorbidity Index score, and income level, the final study population included 24,325 women with infertility and 24,325 women who with childbirth. Employing a case–control study design, lifestyle factors (drinking, smoking, and physical activity) and health checkup outcomes (underweight, overweight, hypertension, diabetes, kidney function, anemia, and menstrual disorders) were assessed in this study. Statistical analyses included chi-squared tests, t-tests, and logistic regression.

Results This study revealed significant risk factors for infertility: two high-risk lifestyle factors, including heavy drinking and smoking, and five health conditions, comprising underweight, hypertension, diabetes, kidney function loss, and menstrual disorders. Conversely, being overweight, not engaging in vigorous physical activity, and anemia were negatively associated with infertility.

Conclusions These findings underscore the need for lifestyle modifications and personalized preconception care to improve fertility outcomes.

Trial registration Not available.

Keywords Infertility, Childbirth, Lifestyle, Health checkup, Case–control study

*Correspondence:
Boyoung Jeon
jeon.boyoung26@gmail.com
Taeuk Kang
ethan.kang@sungshin.ac.kr
Full list of author information is available at the end of the article

Background

The World Health Organization (WHO) reports that 17.5% of people, or approximately one in six, experience infertility at some point in their lives [1]. The prevalence of infertility is particularly increasing in developing countries in South Asia, the Middle East, and North Africa [2]. In Republic of Korea, 36.3% of mothers are now aged over 35, a figure that rises yearly, while the number of infertile couples wishing to have children continues to grow [2]. In 2023, 86,965 male and 156,247 female patients with infertility were recorded in Korea, with infertility cases rising by an average of 1.2% annually between 2018 and 2023 [3], total expenditures on female infertility care more than doubled over the same 5-year period [4]. The 2021 National Family and Fertility Survey found that 17.2% of married Korean women had experienced infertility, a figure that climbs to one in three among women aged ≥ 35 years [5]. At the same time, the number of women who received assisted-reproductive-technology (ART) procedures rose from 66,547 in 2019 to 75,075 in 2023 [6]. These trends are unfolding against an unprecedented demographic backdrop—the nation's total fertility rate fell to an all-time global low of 0.72 births per woman in 2023 [7]. The coexistence of rapidly increasing infertility care needs and the world's lowest fertility rate highlights an urgent public-health priority: identifying modifiable factors that can enhance natural conception and improve ART outcomes.

Infertility is defined as a reproductive disease in women or men who fail to conceive despite having regular sexual intercourse for more than 12 months [3]. To support the infertile couples, National Health Insurance (NHI) coverage for ART and other infertility treatments began in October 2017, initially limited to women under the age of 45 years with household incomes ≤ 180% of the median income (e.g., a monthly income of $465 for a two-person household). Subsequently, in response to social demands and the worsening low birthrate, the age limit was removed in 2019, and by 2024, income-based eligibility was also eliminated [8]. Under the updated NHI benefit package effective January 2024, infertility treatment support has been expanded and eligibility criteria simplified. In vitro fertilization (IVF), now combining fresh and frozen embryo cycles into a single category, is covered for up to 20 cycles, and intrauterine insemination (IUI) remains covered for up to five attempts. Eligibility has been broadened to include all individuals experiencing infertility—including unmarried persons—and income criteria have been abolished [9]. Previously, coverage was capped at nine fresh-embryo IVF cycles, seven frozen-embryo IVF cycles, and five IUI attempts, with any additional procedures paid entirely out-of-pocket; under that scheme [10].

Despite the rise of ART cases, infertility treatments can be medically invasive and may lead to health complications, alongside psychological stress, anxiety, and depression [11]. Recent research highlights the importance of preconception lifestyle, care, and population-wide approaches in shaping research and policy [12, 13]. According to the WHO and Centers for Disease Control and Prevention (CDC), preconception care includes interventions provided before pregnancy to improve the health of women and couples, ultimately improving pregnancy outcomes and the health of future children [14, 15]. This approach mainly targets women planning to conceive, showing that a healthy preconception lifestyle boosts fertility, supports successful pregnancies, and benefits the health of future generations [16].

Among patients with infertility, unexplained infertility accounts for about 10% of cases, while male and female factors each account for about 40% [3]. Systematic literature reviews indicate several risk factors for infertility, including modifiable lifestyle choices such as poor nutrition, lack of physical activity, smoking, alcohol consumption, drug misuse, sleeping patterns, and physiological factors such as genetic abnormalities, hormonal imbalances, congenital genital malformations, and infections also play a role in infertility [17, 18].

Despite the growing importance of infertility and its treatments, comprehensive national-level data on the causes of infertility remain insufficient. Given the comprehensive and nationally representative nature of the Korean NHI database, using the database is critical, as East Asian populations exhibit distinct dietary, lifestyle, and reproductive behaviors compared to Western cohorts, underscoring the need for region-specific insights and tailored preconception recommendations [19]. Therefore, this study aims to identify lifestyle factors related to infertility, with a focus on modifiable factors that can be improved through lifestyle management. The analysis compared women with childbirth experience (control group) and women diagnosed with infertility (case group) using the representative Korean NHI dataset.

Methods

Study settings and data sources

The National Health Insurance Service (NHIS) database was employed in this study. The NHIS includes health insurance claims from medical institutions, data from the General Healthcare Screening Program (GHSP), enrollee information, health coverage type, NHI contributions, and death records. The NHIS offers the GHSP to all citizens aged ≥ 20 years every 2 years [20]. The GHSP is conducted in accordance with national health checkup guidelines for early disease diagnoses.

It includes screenings for obesity (height, weight, waist circumference), visual impairment (visual acuity), hearing impairment (hearing), hypertension (blood pressure (BP)), kidney disease (urine protein, serum creatinine, and glomerular filtration rate (GFR)), anemia (hemoglobin), diabetes (fasting blood sugar (FBS)), liver disease, pulmonary tuberculosis, chest X-ray, and oral health [21]. Anonymized data from the NHIS database were provided under strict confidentiality guidelines, and this secondary analysis was approved by the Korea National Institute for Bioethics Policy (IRB number: P01-202208–01–025).

Definition of case group and control group

The case group was women diagnosed with infertility for the first time in 2020, while the control group comprised women with childbirth in 2020. To select the study participants, we first extracted data on all women aged 20–49 years as of 2018. Because assisted-reproductive-technology (ART) procedures—fresh-embryo IVF, frozen-embryo IVF, and intra-uterine insemination—were first reimbursed by the Korean National Health Insurance in October 2017, the corresponding fee codes were consistently recorded in claims data from 2018 onward. We therefore began identifying cases with the 2018 data year, when these infertility-specific service codes became reliably available in the NHIS dataset. Women with a history of pregnancy or childbirth between 2002 and 2017 were excluded.

In this study, infertility was defined as at least two outpatient visits or hospitalization with a first-time female infertility diagnosis (three-character ICD-10 code N97) in 2020. The N97 umbrella comprises seven sub-categories—N97.0 anovulatory, N97.1 tubal, N97.2 uterine, N97.3 cervical, N97.4 male-factor–associated, N97.8 other specified, and N97.9 unspecified infertility. To maximize capture, we reviewed up to five principal diagnosis codes recorded on each claim.

The control group was women with childbirth, which were restricted to those who gave birth for the first time in 2020 and had no prior infertility diagnosis between 2018 and 2021. Childbirth was categorized using the following medical diagnosis codes: O80 (single spontaneous delivery), O81 (forceps or vacuum extraction delivery), O82 (Cesarean delivery), O83 (other assisted single delivery), and O84 (multiple delivery).

Study participants

Based on these codes, 25,333 women with infertility and 73,759 women with childbirth were included in the study. To enhance comparability between both groups, propensity score matching was applied using age (as a continuous variable), Charlson Comorbidity Index (CCI) scores (0, 1, or ≥ 2), and a proxy for income level, represented by health insurance premium quartiles. The CCI is a validated summary score that captures a patient's chronic-disease burden by assigning weights (1, 2, 3, or 6) to 17 predefined conditions—including myocardial infarction, diabetes, renal disease, and malignancy—and summing them [22]. Higher scores indicate more severe multimorbidity and are strongly associated with long-term mortality risk; in this study we categorized CCI as 0, 1, or ≥ 2 to reflect none, mild, and moderate-to-severe comorbidity, respectively. We then constructed data for 48,650 women, with 24,325 and 24,325 in the infertility and childbirth groups, respectively (Fig. 1). A comparative analysis was then performed to examine differences in health behaviors and lifestyle habits between the two groups.

Definition of outcome (risky lifestyle and health checkup results) variables

In this study, GHSP records from 2018–2019 were used to assess various high-risk lifestyle factors and health checkup outcomes. As the GHSP is conducted biennially, and if a woman has more than one record, the most recent results from the health checkup were used. The outcome variables for risky lifestyle include drinking habits (non/moderate or heavy drinking) and smoking status (non-smoking or past/current smoking). It was used to evaluate physical activity levels, categorizing them as moderate ($\geq$ 3 times per week) or vigorous ($\geq$ once per week). For health checkup outcomes, body mass index (BMI) was categorized, ranging from underweight (< 18.5 kg/m^2), normal (18.5–22.9 kg/m^2), pre-obesity (23–24.9 kg/m^2), or obesity ($\geq$ 25 kg/m^2). Hypertension was classified as normal or hypertensive (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg). Diabetes was diagnosed based on FBS levels (normal < 125 mg/dl or diabetic ≥ 125 mg/dl). Kidney function was evaluated using e-GFR, with normal function defined as ≥ 90 ml/min and reduced function as < 90 ml/min. Proteinuria, indicating possible kidney damage, was recorded if present (trace or more). Anemia was defined as hemoglobin levels < 12 g/dl, with normal levels being ≥ 12 g/dl.

Menstrual disorders were described based on diagnoses from 2018–2019 for N91 (absent, scanty, or rare menstruation), N92 (excessive, frequent, or irregular menstruation), N93 (other abnormal uterine and vaginal bleeding), and N94 (pain and other conditions related to the female genital organs and menstrual cycle), using health insurance claims data from all medical records, including outpatient visits, hospitalizations, and emergency department visits, according to the Korean Standard Classification of Diseases (KCD) codes.

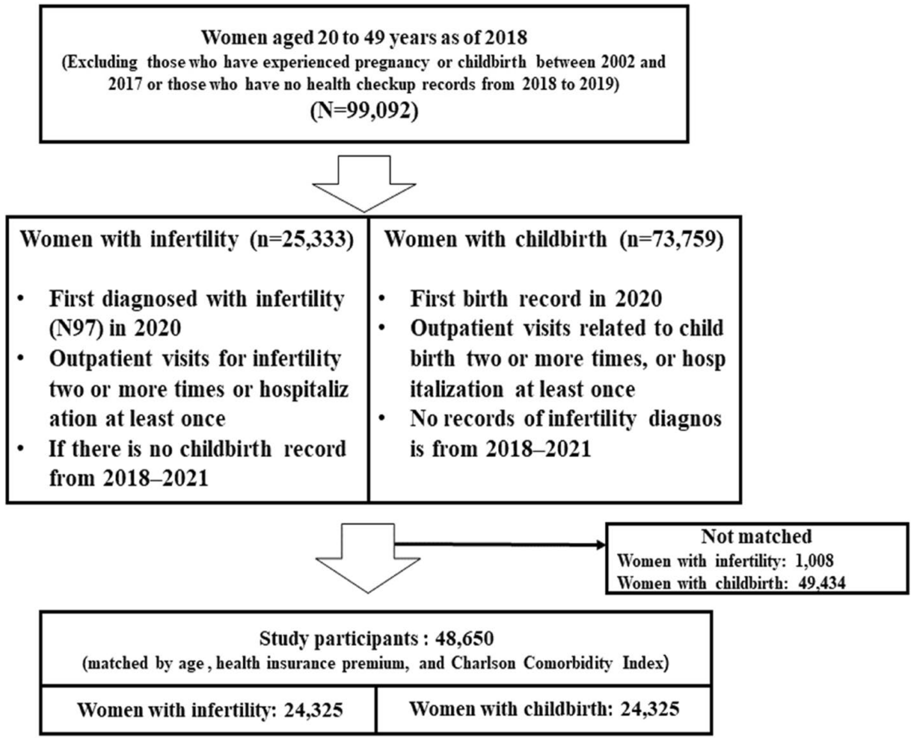

Fig. 1 Flowchart of study participants

Definition of other explanatory variables

The explanatory variables include age group (22–29, 30–34, 35–39, 40–44, and 45–49 years old), income level (1 st, 2nd, 3rd, and 4 th quartile), health insurance status (the dependent, employer, employee, and medical aid), CCI score (0, 1, and ≥ 2), and residential area (capital area (Seoul/Incheon/Gyeonggi Do), and other provinces).

Statistical analysis

Before and after matching, general characteristics were compared between women with infertility and those with childbirth using the chi-squared test and t-test. In the matched sample, lifestyle risk factors (heavy drinking, current/past smoking, being underweight or overweight, and lack of moderate/vigorous physical activity), health checkup results (hypertension, diabetes, kidney disease, proteinuria, anemia), and menstrual disorders were compared. Employing a case–control study design, the odds ratio of exposure to these risk factors in women with infertility were estimated compared to those who had given birth (Fig. 2). Multivariate logistic regression analyses were conducted for each outcome variables. To show the effect of case group, all of the explanatory variables (age group, income level, health insurance status, CCI score, and residential area) were adjusted in the logistic regression models. Data were analyzed using SAS Enterprise Guide 7.1 (SAS Institute, Cary, NC, USA).

Results

Before matching, the study included 25,333 women with infertility and 73,759 women with childbirth in 2020. After matching, the sample consisted of 24,325 women with infertility and 24,325 women with childbirth. Before matching, the average age of women with infertility and those with childbirth was 35.9 and 32.9 years, respectively, with a higher proportion of women over 35 years among the infertile group. Women with infertility also had a higher proportion in the highest income quartile (4 th income quartile) and were more likely to be employed than women with childbirth. Additionally, more women with infertility had CCI scores of ≥ 2 and lived in capital areas compared to those with childbirth. After matching, the average age of both groups was 34.6 years, and no differences were observed in income level or CCI score. However, in the matched group, a higher proportion of women with infertility were employed and lived in capital areas compared to women with childbirth (Table 1).

In Table 2, we compared lifestyle factors between women with infertility and women with childbirth. High-risk health behaviors, including heavy drinking, current/past smoking, being underweight or overweight, and lack

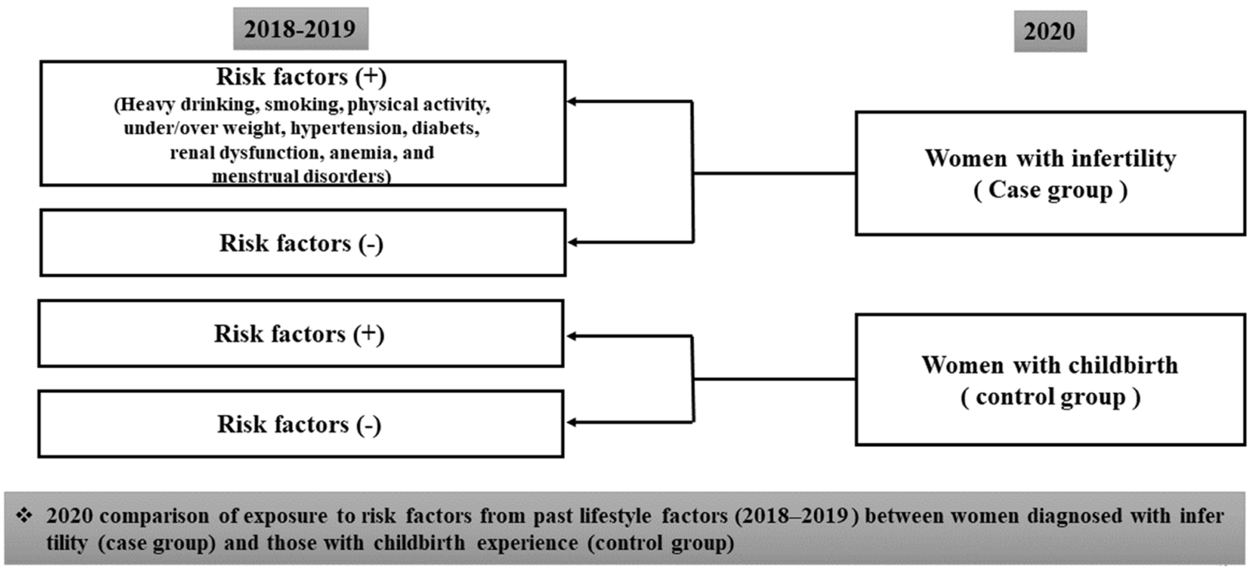

Fig. 2 Case–control study design

Table 1 General characteristics of study participants

		Before matching			After matching		
		Women with infertility (*N* = 25,333)	Women with childbirth (*N* = 73,759)	*p*-value	Women with infertility (*N* = 24,325)	Women with childbirth (*N* = 24,325)	*p*-value
		% or mean(SD)	% or mean(SD)		% or mean(SD)	% or mean(SD)	
Age continuous variable[a]		35.9 (4.8)	32.9 (3.9)	<.0001	34.6 (4.4)	34.6 (4.3)	0.354
Age group	22–29	11.0	19.7	<.0001	11.5	11.5	0.002
	30–34	40.0	48.2		41.6	41.6	
	35–39	30.3	26.4		31.5	31.8	
	40–44	15.6	5.5		14.5	14.5	
	45–49	3.2	0.2		0.9	0.6	
Income level[a]	1 st quartile	14.0	13.6	<.0001	13.6	13.7	0.933
	2nd quartile	25.2	27.8		25.3	25.4	
	3rd quartile	38.1	39.0		38.7	38.8	
	4 th quartile	22.8	19.6		22.4	22.2	
Health insurance status	The dependent	19.1	22.6	<.0001	18.7	24.4	<.0001
	Employer	4.7	3.2		4.2	3.8	
	Employee	75.9	74.0		76.9	71.5	
	Medical aid	0.3	0.2		0.2	0.3	
CCI score[a]	0	78.8	81.0	<.0001	79.3	78.9	0.144
	1	12.4	12.1		12.5	12.4	
	≥ 2	8.7	6.8		8.3	8.7	
Residential area	Capital area	59.1	53.7	<.0001	59.2	54.3	<.0001
	Other Provinces	40.9	46.3		40.8	45.7	
Total		100.0	100.0	100.0	100.0	100.0	100.0

[a] Age, income level, and CCI score were used for propensity score matching

Table 2 Comparison of health lifestyles and checkup results between women with infertility and childbirth

		Women with infertility (N = 24,325)	Women with childbirth (N = 24,325)	p-value
		% or mean(SD)	% or mean(SD)	
Drinking habits	Non/moderate drinking	55.9	60.9	<.0001
	Heavy drinking	44.1	39.1	
Smoking	Never smoking	89.8	91.6	<.0001
	Current/past smoking	10.2	8.4	
Moderate physical activity	≥ 3 times a week	28.1	28.1	0.195
	< 3 times a week	71.9	71.9	
	Missing	0.02	0.05	
Vigorous physical activity	≥ Once a week	39.6	35.4	<.0001
	< Once a week	60.4	64.5	
	Missing	0.02	0.05	
BMI (continuous)	BMI (kg/m^2)	22.0(3.7)	22.2(3.5)	0.354
BMI classification	Underweight (< 18.5 kg/m^2)	11.2	9.4	<.0001
	Normal (18.5–22.9 kg/m^2)	59.6	58.8	
	Pre-obesity (23–24.9 kg/m^2)	12.6	14.8	
	Obesity (≥ 25 kg/m^2)	16.6	17.0	
Hypertension	Normal	97.5	98.0	0.000
	Hypertension (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg)	2.5	2.0	
Diabetes	Normal (FBS < 125 mg/dl)	85.0	86.7	<.0001
	Diabetes (FBS ≥ 125 mg/dl)	15.0	13.3	
Kidney disease	Normal (e-GFR ≥ 90 ml/min)	66.6	71.2	<.0001
	Reduced kidney function (e-GFR < 90 ml/min)	33.4	28.8	
Proteinuria	Negative	92.0	92.7	0.004
	Reduced kidney function (trace or more)	6.8	6.3	
	Missing	1.2	1.0	
Anemia	Normal [HGB ≥ 12 g/dl]	91.6	88.0	<.0001
	Anemia (< 12 g/dl)	8.4	12.0	
Menstrual disorders Diagnosis	None	61.3	64.1	<.0001
	Present (diagnoses N91, N92, N93, N94)	38.7	35.9	
Total		100.0	100.0	

of moderate/vigorous physical activity, were analyzed. Women with infertility had higher rates of heavy drinking (44.1% vs. 39.1%) and current/past smoking (10.2% vs. 8.4%). No difference was observed in the proportion of women who engaged in moderate physical activity more than 3 times per week. However, women with infertility participated more in vigorous physical activity (39.6% vs. 35.4%). When comparing health checkup results, women with infertility had higher rates of being underweight (11.2% vs. 9.4%), hypertension (2.5% vs. 2.0%), diabetes (15.0% vs. 13.3%), loss of kidney function (33.4% vs. 28.8%), proteinuria (6.8% vs. 6.3%), and menstrual disorders (38.7% vs. 35.9%). The only condition less prevalent in women with infertility compared to women with childbirth was anemia (8.4% vs. 12.0%).

In Table 3, we compared exposure to risky lifestyle factors between women with infertility and women with childbirth. Women with infertility had higher odds of heavy drinking (aOR: 1.23, 95% CI: 1.18–1.27) and past/current smoking (aOR: 1.28, 95% CI: 1.20–1.36) than women with childbirth. Women with infertility were also less likely to avoid vigorous physical activity than women with childbirth (aOR: 0.84, 95% CI: 0.81–0.88).

When comparing the health checkup outcomes, women with infertility had higher odds of being underweight (aOR: 1.17, 95% CI: 1.10–1.25) but lower odds of being overweight (aOR: 0.92, 95% CI: 0.89–0.96) compared to women with childbirth. Additionally, women with infertility were more likely to be diagnosed with hypertension (aOR: 1.27, 95% CI: 1.12–1.43), diabetes (aOR: 1.17, 95% CI: 1.11–1.23), and kidney function loss (aOR: 1.25, 95% CI: 1.20–1.30). However, women with infertility had a lower incidence of anemia than women with childbirth (aOR: 0.67, 95% CI: 0.63–0.71). They were

Table 3 Comparison of high-risk lifestyle exposure between women with infertility and those with childbirth

High-risk lifestyles (Outcome variables)	Category	Estimated coefficient	Adjusted OR	(95% CI)	
Drinking habits: Heavy drinking[1)]	**Women with childbirth**	**Reference**			
	Women with infertility	0.204*	1.23	(1.18,	1.27)
Smoking: Past/current smoking[1)]	Women with childbirth	Reference			
	Women with infertility	0.243*	1.28	(1.20,	1.36)
Less engaging in moderate physical activity: < 3 times a week[2)]	Women with childbirth	Reference			
	Women with infertility	−0.014	0.99	(0.95,	1.03)
Less engaging in vigorous physical activity: < Once a week[3)]	Women with childbirth	Reference			
	Women with infertility	−0.170*	0.84	(0.81,	0.88)

1) *n* = 48,650, 2) *n* = 43,635, 3) *n* = 43,632

* $p < 0.001$, Logistic regression analyses were performed using high-risk lifestyles as the outcome variables. The results are adjusted for age group, income level, health insurance status, CCI score, and residential area

also more likely to be diagnosed with menstrual disorders 2 years before their infertility was diagnosed compared to women with childbirth (aOR: 1.14, 95% CI: 1.10–1.19) (Table 4).

Discussion

This study aimed to identify key factors influencing female infertility using lifestyle and health checkup result data from the nationwide GHSP dataset. To achieve this, we matched and analyzed women with infertility and those who had given birth by controlling for similarities between the two groups, such as age, CCI, and income level. The matching approach was used to consider the relationship between age, female reproductive ability, and economic status. The risk factors that increased the likelihood of infertility included two unhealthy lifestyle behaviors, heavy drinking, and current/past smoking, along with five concerning health checkup outcomes: underweight (BMI < 18.5), hypertension, diabetes, kidney function loss, and menstrual disorders. In contrast, being overweight, not participating in high-intensity physical activity, and having anemia were negatively associated with infertility.

Before matching, the average age of women with infertility was higher than that of women who had given birth (35 vs. 32.9 years). This finding aligns with previous study findings showing that aging negatively affects female reproductive ability, particularly in egg maturation and

Table 4 Comparison of high-risk health checkup results between women with infertility and those with childbirth

High-Risk Lifestyle (Outcome variables)	Category	Estimated coefficient	Adjusted OR	(95% CI)	
Underweight (< 18.5 kg/m^2)[1)]	Women with childbirth	Reference			
	Women with infertility	0.160*	1.17	(1.10,	1.25)
Pre-obesity or above (≥ 23 kg/m^2)[2)]	Women with childbirth	Reference			
	Women with infertility	−0.081*	0.92	(0.89,	0.96)
Hypertension diagnosis (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg)[3)]	Women with childbirth	Reference			
	Women with infertility	0.237*	1.27	(1.12,	1.43)
Diabetes diagnosis (FBS ≥ 125 mg/dl)[3)]	Women with childbirth	Reference			
	Women with infertility	0.156*	1.17	(1.11,	1.23)
Reduced kidney function (e-GFR < 90 ml/min)[3)]	Women with childbirth	Reference			
	Women with infertility	0.219*	1.25	(1.20,	1.30)
Proteinuria: Trace or more)[3)]	Women with childbirth	Reference			
	Women with infertility	0.058	1.06	(0.99,	1.14)
Anemia (hemoglobin levels < 12 g/dl)[3)]	Women with childbirth	Reference			
	Women with infertility	−0.398*	0.67	(0.63,	0.71)
Menstrual disorders)[3)]	Women with childbirth	Reference			
	Women with infertility	0.134*	1.14	(1.10,	1.19)

Note. 1) n=33,807, 2) n=43,647, 3) n=48,650 = 48,650. *$p < 0.001$. Logistic regression analyses were performed using high-risk health checkup results as the outcome variables. The results are adjusted for age group, income level, health insurance status, CCI score, and residential area ovulation [23]. After matching, women with infertility still showed a higher risk of unhealthy lifestyle behaviors and adverse health checkup results. They had higher odds of heavy drinking and current/past smoking. Consistent with our findings, a previous meta-analysis indicates a decrease in fecundability for every 12.5 g/day increase in alcohol consumption [23]. In the GHSP dataset, heavy drinking is assigned to examinees who score ≥ 8 on the AUDIT questionnaire—equivalent to at least monthly binge drinking or weekly high-risk intake; the physician then delivers brief counselling during the same visit [24]. Because this classification is questionnaire-based, some misreporting is possible, so our estimates should be interpreted with caution. Similar to previous study findings, current/past smoking was positively associated with infertility. Smoking decreases ovarian function by affecting gonadotropin levels in current smokers/former smokers, and it is related to primary infertility in women [25, 26].

When comparing exposure to high-risk health checkup outcomes, being underweight (BMI < 18.5) was positively associated with infertility. A previous study found that women with a BMI < 17 are at high risk of infertility owing to an increased likelihood of ovulation disorders [11]. However, inconsistent with previous study findings, our study showed that being overweight (BMI ≥ 23) was negatively associated with infertility. Furthermore, overweight women have a higher incidence of menstrual dysfunction, anovulation, subfecundity, and infertility. They also face increased risks of miscarriage, pregnancy complications, and poor reproductive outcomes [27]. The discrepancy in our findings may be influenced by the definition of "women with childbirth." Since the definition of women who had given birth included those with first childbirth in 2020 and at least two outpatient visits or one hospitalization (O80-O84), the measured BMI could be higher than their usual pre-pregnancy weight. However, women with infertility were more likely to engage in Vigorous physical activities. Excessive or overly intense physical activity is related to menstrual irregularities and reduced reproductive ability, suggesting that moderate physical activity may be more beneficial than excessive exercise [25, 28].

Women with infertility were more likely to be diagnosed with hypertension and diabetes compared to women who had given birth. A history of underlying conditions, including hypertension, diabetes, and thyroid disorders, is associated with infertility [29]. A history of infertility is associated with a 20% greater risk of developing diabetes compared to women without infertility, even after adjusting for age and lifestyle factors [30]. However, the relationship between infertility and hypertension remains unclear. No significant increase in hypertension risk has been observed among women with infertility, except for those with infertility caused by tubal disease, who showed a higher risk of hypertension [31, 32]. Women diagnosed with kidney function loss are also more susceptible to infertility. Chronic kidney disease affects fertility in both sexes, with women experiencing reduced ovarian reserve, anovulatory cycles, and pregnancy complications owing to endocrine abnormalities [33]. Hypertension, diabetes, and kidney function loss are often related to dietary habits, particularly carbohydrate intake. High consumption of carbohydrates with a high glycemic index increases the risk of infertility and is associated with ovulatory disorders. The quality of carbohydrates in the diet directly influences the risk of ovulation-induced infertility [11,34,35,36].

Anemia is less common in women with infertility compared to women who have given birth. Iron deficiency is a frequent issue associated with unexplained infertility [37]. Abnormal uterine bleeding, a condition that can lead to iron deficiency anemia, is caused by various factors classified under the PALM-COEIN system: polyp, adenomyosis, leiomyoma, malignancy, and hyperplasia and coagulopathy, ovulatory dysfunction, endometrial issues, iatrogenic factors, and conditions not otherwise classified [38]. Since the control group consisted of women who had given birth, and anemia is the most common hematologic condition during pregnancy, the findings of this study align with expectations, showing lower anemia rates in women with infertility [39].

Women with infertility were more likely to be diagnosed with menstrual disorders than women who had given birth. Hormonal imbalances, such as hypothyroidism and hyperprolactinemia, are common causes of infertility and can lead to irregular menstrual cycles, abnormal uterine bleeding, dysmenorrhea, and weight fluctuations. Recognizing normal menstrual patterns is essential for accurate diagnosis and effective treatment [40, 41].

This study has some limitations. First, family factors, such as the duration of marriage and infertility in the husband, were not considered. Second, psychological factors, including stress, anxiety, and depression, alongside employment and educational levels were not considered. Although the GHSP includes a depression (PHQ-9) module, during our study period it was offered only once every 10 years at ages 20, 30, 40, 50, 60, and 70; consequently, most women in our 22–49 year cohort had no recent screening record. From 2025 onward, the mental-health module will be administered biennially for young adults (22–34 years), but those data were not yet available for this analysis [42]. Third, the exact quantity and frequency of alcohol consumption or smoking were not measured, so the specific high-risk levels could not be determined. Fourth, infertility status was ascertained from administrative claims: although we required N97 in any of the first five diagnosis slots on ≥ 2 outpatient claims (or one inpatient claim) to improve specificity, some misclassification is still possible, and the 12-month clinical criterion may not always be met. Fifth, our case definition included all ICD-10 N97–coded infertility subtypes without stratifying by etiology (e.g., tubal, anovulatory, uterine), so heterogeneity in underlying causes may confound associations. Sixth, menstrual disorders were identified using broad N91–N94 codes but were not subclassified or adjusted for specific gynecological illnesses, which could also influence infertility risk. Finally, the retrospective design of this case–control study prevents establishing clear temporal relationships between the identified risk factors and female infertility. For example, the unexpected results regarding overweight, vigorous physical activity, and anemia may be due to the timing of measurement. While the most recent results from 2018–2019 were used, women with childbirth in 2020 may have had a higher likelihood of being overweight or anemic if they underwent the health screening during pregnancy.

Despite these limitations, this study's strengths include the use of a large, nationally representative GHSP–NHIS linkage, objective health-screening measures, comprehensive assessment of multiple modifiable risk factors, and a matched case–control design—together filling a critical gap in Korean infertility research.

Conclusions

Using nationally representative GHSP–NHIS data and a matched case–control design, we comprehensively analyzed lifestyle factors and health behaviors associated with infertility in Korean women. Seven modifiable risk factors emerged—heavy drinking, current/past smoking, underweight, hypertension, diabetes, kidney function loss, and menstrual disorders. Focusing on pre-conception lifestyle optimization and tailored counselling can improve fertility outcomes. These results give practical direction to clinicians and policymakers developing targeted pre-conception interventions.

Abbreviations

ART	Assisted reproductive technology
BMI	Body mass index
CCI	Charlson comorbidity index
CDC	Centers for disease control and prevention
GHSP	General Healthcare Screening Program
FBS	Fasting blood sugar
KCD	Korean standard classification of diseases
IVF	In vitro fertilization
IUI	Intrauterine insemination
NHIS	National Health Insurance Service
WHO	World Health Organization

Acknowledgements
Not applicable.

Authors'contributions
BJ, TK, and SWC contributed to the design of the work. BJ acquired the data. SWC, BJ, and TK contributed to the interpretation of data. BJ and SWC contributed to the drafting of the manuscript. BJ and TK critically reviewed the manuscript for intellectual content. BJ and TK supervised the study. All authors reviewed the manuscript.

Funding
This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. RS-2022-NR074434). The NRF and MSIT were not involved in study conceptualization and design, data analysis, interpretation of the results, or paper submission.

Data availability
The study has been approved by National Health Insurance Service because the data can be used within a limited period instead of receiving the entire dataset. Currently, access to the raw data is restricted, but the use of summarized data is available upon request.

Declarations

Ethics approval and consent to participate
This study was exempt from approval by the Korea National Institute for Bioethics Policy (IRB number: P01-202208–01-025).

Consent for publication
Not applicable. The earlier version of this study presented at the Korean Association of Health Economics and Policy Conference in May 24, 2024. The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration by another publisher.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Health and Medical Information, Myongji College, 134, Gajwa-Ro, Seodaemun-Gu, Seoul 03656, Republic of Korea. [2]School of Bio-Health Convergence, College of Natural Sciences, Sungshin Women's University Woonjung Green Campus, Seoul, Republic of Korea. [3]M Fertility Center, 407, Teheran-Ro, Gangnam-Gu, Seoul 06162, Republic of Korea.

Received: 5 October 2024 Accepted: 8 May 2025
Published online: 21 May 2025

References
1. World Health Organization. 1 in 6 people globally affected by infertility. News release Geneva, Switzerland. 4 April 2023. URL: https://www.who.int/news/item/04-04-2023-1-in-6-people-globally-affected-by-infertility 2023.
2. Statistics Korea. Birth Statistics of 2023. Press Release of Statistics Korea. Aug 28, 2024. [Press release]. https://kostat.go.kr/boardDownload.es?bid=204&list_no=432388&seq=1
3. Health Insurance Review & Assessment Service. Analysis of Infertility and Assisted Reproductive Treatment Medical Services. May 25, 2023. [Press Release]. https://www.hira.or.kr/bbsDummy.do?pgmid=HIRAA020041000100&brdScnBltNo=4&brdBltNo=10880&pageIndex=1&pageIndex2=1
4. Health Insurance Review & Assessment Service. Analysis of infertility and assisted-reproductive-technology medical services [Press release]. https://www.hira.or.kr. 2023, May 25.
5. Korea Institute for Health and Social Affairs. 2021 National survey on family and fertility. https://www.kihasa.re.kr. 2021.
6. Health Insurance Review & Assessment Service. National statistics on assisted-reproductive-technology procedures (2019–2023). OpenData HIRA Portal. https://opendata.hira.or.kr. 2024.
7. Statistics Korea. Birth statistics, 2023 (Press Release No. 2024–79). https://kostat.go.kr. 2024.

8. Ministry of Health and Welfare. Expansion of Support for Infertility Treatment. Press Release of the Ministry of Health and Welfare. Feb 06, 2024. URL: https://www.mohw.go.kr/boardDownload.es?bid=0027&list_no=1480190&seq=2. 2024.
9. Ministry of Health and Welfare. 2024 Government Support Dramatically Expanded to Ensure Happiness in Pregnancy, Childbirth, and Parenting. January 5, 2024. URL: https://www.mohw.go.kr/board.es?mid=a10503010100&bid=0027&act=view&list_no=1479667&tag=&nPage=2
10. Health Insurance Review & Assessment Service, Korea Institute for Health and Social Affairs. Infertility guidebook. 2022. https://22762276.nmc.or.kr/nmc/cmmn/file/fileDown.do?menuNo=1600012&atchFileId=14c675b3b05e446293a4df38a0429a7a&fileSn=1&bbsId=
11. Sharma A, Shrivastava D. Psychological problems related to infertility. Cureus. 2022;14(10):e30320. https://doi.org/10.7759/cureus.30320.
12. M'hamdi HI, Sijpkens MK, de Beaufort I, Rosman AN, Steegers EA. Perceptions of pregnancy preparation in women with a low to intermediate educational attainment: a qualitative study. Midwifery. 2018;59:62–67.
13. Boedt T, Vanhove AC, Vercoe MA, Matthys C, Dancet E, Fong SL. Preconception lifestyle advice for people with infertility. Cochrane Database of Systematic Reviews. 2021;4(4):CD008189. https://doi.org/10.1002/14651858.CD008189.pub3.
14. Brooks C, Supramaniam PR, Mittal M. Preconception health in the well woman. Obstet Gynaecol. 2022;24(1):58–66.
15. Johnson K, Posner SF, Biermann J, Cordero JF, Atrash HK, Parker CS, et al. Recommendations to improve preconception health and health care—United States. Morb Mortal Wkly Rep. 2006;55(4):1–23.
16. Hoek, J., Steegers-Theunissen, R., Sinclair, K., Schoenmakers, S. The Science of Preconception. In: Shawe, J., Steegers, E., Verbiest, S. (eds) Preconception Health and Care: A Life Course Approach. Springer, Cham. 2020: 21-34. https://doi.org/10.1007/978-3-030-31753-9_3.
17. Deyhoul N, Mohamaddoost T, Hosseini M. Infertility-related risk factors: a systematic review. Int J Womens Health Reprod Sci. 2017;5(1):24–9.
18. Emokpae MA, Brown SI. Effects of lifestyle factors on fertility: practical recommendations for modification. Reproduction and Fertility. 2021;2(1):R13–26.
19. Lee J, Choo C, Moon K, Lyu S, Kim H, Lee J, et al. Risk Factors for Infertility in Korean Women. J Korean Med Sci. 2024;39(10): e85.
20. National Health Insurance Service. Health screening information. National Health Insurance Service. In: National Health Insurance Service, editor. 2022. https://www.nhis.or.kr/static/alim/paper/oldpaper/202205/sub/01.html.
21. Korea Disease Control and Prevention Agency. General Healthcare Screening Program. Access: September 17. 2024. URL: https://health.kdca.go.kr/healthinfo/biz/health/gnrlzHealthInfo/gnrlzHealthInfo/gnrlzHealthInfoView.do?cntnts_sn=5295. 2024.
22. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation Journal of Chronic Diseases, .40(5):373–83.
23. Fan D, Liu L, Xia Q, Wang W, Wu S, Tian G, et al. Female alcohol consumption and fecundability: a systematic review and dose-response meta-analysis. Sci Rep. 2017;7(1):13815.
24. Korea Disease Control and Prevention Agency. "Alcohol." National Health Information Portal. Korea Disease Control and Prevention Agency, n.d. https://health.kdca.go.kr/healthinfo/biz/health/gnrlzHealthInfo/gnrlzHealthInfo/gnrlzHealthInfoView.do?cntnts_sn=5297. Accessed 1 May 2025. 2025.
25. Musa S, Osman S. Risk profile of Qatari women treated for infertility in a tertiary hospital: a case-control study. Fertility Research and Practice. 2020;6:1–17.
26. Parizadeh D, Momenan AA, Amouzegar A, Azizi F, Hadaegh F. Tobacco smoking: findings from 20 years of the Tehran Lipid and Glucose Study. Int J Endocrinol Metab. 2018;16(4 Suppl):e84738. https://doi.org/10.5812/ijem.84738.
27. Zheng L, Yang L, Guo Z, Yao N, Zhang S, Pu P. Obesity and its impact on female reproductive health: unraveling the connections. Front Endocrinol. 2024;14:1326546.=
28. Kim MY, Han K. The Effect of Infertile Women's Lifestyle on the Number of Their Childbirth in 2 Years. Journal of Health Informatics and Statistics. 2021;46(3):309–14.
29. Deshpande PS, Gupta AS. Causes and prevalence of factors causing infertility in a public health facility. Journal of human reproductive sciences. 2019;12(4):287–93.
30. Tobias DK, Gaskins AJ, Missmer SA, Hu FB, Manson JE, Buck Louis GM, et al. History of infertility and risk of type 2 diabetes mellitus: a prospective cohort study. Diabetologia. 2015;58:707–15.
31. Farland LV, Wang YX, Gaskins AJ, Rich-Edwards JW, Wang S, Magnus MC, et al. Infertility and risk of cardiovascular disease: a prospective cohort study. J Am Heart Assoc. 2023;12(5): e027755.
32. Farland LV, Grodstein F, Srouji SS, Forman JP, Rich-Edwards J, Chavarro JE, et al. Infertility, fertility treatment, and risk of hypertension. Fertil Steril. 2015;104(2):391–7.
33. Kuczera P, Więcek A, Adamczak M. Impaired fertility in women and men with chronic kidney disease. Advances in Clinical and Experimental Medicine. 2022;31(2):187–95.
34. Silvestris E, Lovero D, Palmirotta R. Nutrition and female fertility: an interdependent correlation. Front Endocrinol. 2019;10:346.
35. Aoun A, El Khoury V, Malakieh R. Can nutrition help in the treatment of infertility? Preventive nutrition and food science. 2021;26(2):109.
36. Skoracka K, Ratajczak AE, Rychter AM, Dobrowolska A, Krela-Kaźmierczak I. Female fertility and the nutritional approach: the most essential aspects. Adv Nutr. 2021;12(6):2372–86.
37. Holzer I, Ott J, Beitl K, Mayrhofer D, Heinzl F, Ebenbauer J, et al. Iron status in women with infertility and controls: a case-control study. Front Endocrinol. 2023;14:1173100.
38. Donnez J, Carmona F, Maitrot-Mantelet L, Dolmans M-M, Chapron C. Uterine disorders and iron deficiency anemia. Fertil Steril. 2022;118(4):615–24.
39. James AH. Iron deficiency anemia in pregnancy. Obstet Gynecol. 2021;138(4):663–74.
40. Meneses K, Holland AC. Current evidence supporting fertility and pregnancy among young survivors of breast cancer. J Obstet Gynecol Neonatal Nurs. 2014;43(3):374–81.
41. Berga, S.L. The Menstrual Cycle and Related Disorders. In: Petraglia, F., Fauser, B. (eds) Female Reproductive Dysfunction . Endocrinology. Springer, Cham. 2020: 23-37. https://doi.org/10.1007/978-3-030-14782-2_2.
42. Ministry of Health and Welfare. Expansion of biennial mental-health screening for young adults in the National Health Check-up [Press release]. https://www.mohw.go.kr/board.es?mid=a10503000000&bid=0027&list_no=1483375&act=view. 2025.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.