

The Relationship Between Smoking Habits and Sperm Quality in Men of Reproductive Age

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Abstract. Male infertility is a health problem influenced by various lifestyle factors, including smoking habits, which expose individuals to toxic substances and free radicals that may disrupt spermatogenesis. Such disruptions can lead to abnormalities in sperm parameters, including concentration, morphology, and motility, thereby contributing to male infertility. This study aimed to analyze the relationship between smoking habits and sperm quality among men of reproductive age at a reproductive health clinic in Cirebon, Indonesia, in 2024. An analytical observational study with a cross-sectional design was conducted. The sample consisted of men aged 20–45 years who underwent semen analysis during the study period. Subjects with a history of anatomical or reproductive hormonal disorders, as well as those receiving hormone therapy or medications that could affect sperm quality, were excluded. Smoking habits were determined based on smoking status recorded in medical records. Sperm quality was assessed using laboratory data on sperm concentration, morphology, and motility, which were categorized as normal or abnormal. Data were analyzed using the Chi-square test. Of the 140 subjects, 86 (61.42%) were non-smokers, and 79 (56.42%) had abnormal sperm quality. Statistical analysis showed no significant association between smoking habits and sperm quality ($p = 0.592$). These findings indicate that smoking habits were not significantly associated with sperm quality in the studied population. Further studies incorporating more detailed assessments of smoking exposure, such as smoking duration and the number of cigarettes consumed per day, are recommended to better evaluate potential risks.

Keywords: *male fertility, sperm quality, smoking.*

A. Introduction

Infertility is a reproductive health disorder affecting men and women, characterized by the inability to achieve pregnancy after 12 months or more of regular, unprotected sexual intercourse. Infertility affects millions of individuals worldwide.[1] The World Health Organization (WHO) reports that one in six people of reproductive age experiences infertility during their lifetime, and in Indonesia approximately 10–15% of couples of reproductive age experience infertility, with about one-third of cases attributed to male factors.[1], [2], [3] This condition is primarily associated with impaired sperm production, including decreased concentration, motility, and abnormal morphology.[1]

Various factors contribute to male infertility, ranging from general factors such as age and frequency of sexual intercourse to specific factors including pretesticular and posttesticular disorders, hormonal disturbances, immunological reactions, and environmental exposures.[1], [2] Among environmental factors, smoking has been shown to have a significant effect on male fertility and is associated with reduced sperm quality.[4] Although the adverse effects of smoking on health, particularly on the male reproductive system, have been widely recognized, smoking remains prevalent worldwide.[5] In 2020, a survey conducted by the World Health Organization (WHO) reported that 22.3% of the global population used tobacco, with a higher prevalence among men (36.7%). Tobacco use represents one of the greatest global public health threats, causing approximately 8 million deaths annually. All forms of tobacco use are harmful, and there is no safe level of exposure to tobacco. Cigarette smoking remains the most commonly used form of tobacco consumption.[6] The prevalence of smoking in Indonesia is high, reaching 64.7% among men according to the Global Adult Tobacco Survey (GATS) 2021.[7]

Cigarette smoke contains more than 7,000 chemical compounds, including free radicals, carbon monoxide, nitrogen oxides, benzopyrene, and heavy metals such as cadmium.[8], [9] These substances generate excessive reactive oxygen species (ROS), leading to oxidative stress, DNA damage, impaired Sertoli and Leydig cell function, and disruption of spermatogenesis. Decreased semen volume, sperm count, abnormal morphology, and reduced motility have been reported in previous studies.[2] In addition, smoking has been shown to reduce testosterone and luteinizing hormone (LH) levels, both of which play an essential role in sperm production.[10]

Several previous studies conducted in Indonesia and other countries have reported an association between smoking and decreased sperm quality. A study conducted in North Sumatra in 2015 demonstrated that smokers experienced reduced semen volume, motility, and sperm morphology.[11] Similarly, a study in Karachi, Pakistan in 2018 found that smoking was associated with a decreased sperm count and increased morphological abnormalities.[4] However, other studies have reported no significant association, indicating that findings across different populations remain inconsistent.[12]

Permata Bunda Syariah Clinic, Cirebon, is a clinic providing reproductive and fertility health services with a relatively high number of male patients. This condition makes the clinic a relevant setting to reassess the relationship between smoking habits and sperm quality in the local population. Furthermore, the increasing use of electronic cigarettes over the past decade, particularly among adolescents and young adults, has made this topic increasingly important to be re-examined.¹¹

This study was conducted to analyze the relationship between smoking habits and sperm quality among men of reproductive age undergoing semen examination at Permata Bunda Syariah Clinic, Cirebon, in 2024. The findings are expected to contribute to the development of reproductive health education and infertility prevention strategies, thereby supporting promotive and preventive efforts in male reproductive health.

B. Method

This study employed an analytical observational design with a cross-sectional approach. The study population consisted of male patients who underwent semen analysis at Permata Bunda Syariah Clinic, Cirebon, Indonesia, in 2024. Data collected included smoking status (smoker or non-smoker) and semen analysis parameters, namely sperm motility, morphology, and concentration, assessed according to the World Health Organization (WHO) 2010 criteria.

Sampling was conducted using a non-probability purposive sampling technique. Inclusion criteria were men aged 20–45 years who underwent semen analysis at Permata Bunda Syariah Clinic during 2024. Exclusion criteria included patients with anatomical or hormonal disorders of the reproductive system, as well as those receiving hormonal therapy or medications that could affect sperm quality.

Based on the two-proportion formula, the minimum required sample size was 100 subjects, with 50 subjects in each group. A total of 140 subjects who met the inclusion criteria were included in this study. The independent variable was smoking habits (smoker or non-smoker), while the dependent variable was sperm quality, assessed based on sperm motility, morphology, and concentration according to WHO 2010 standards and categorized as normal or abnormal. Data analysis included univariate analysis to describe frequency distributions and bivariate analysis using the Chi-square test to evaluate the association between smoking habits and sperm quality.

The study was initiated with proposal preparation, followed by ethical approval from the Health Research Ethics Committee of Universitas Islam Bandung (No. 119/KEPK-Unisba/IX/2025) and data collection permission. Secondary data were obtained from medical records, including smoking status and semen analysis results. Data were processed through editing, coding, entry, and cleaning stages prior to analysis. The final stage involved interpreting the results and comparing them with findings from previous studies.

C. Result and Discussion

This study was conducted among men of reproductive age who attended Permata Bunda Syariah Clinic, Cirebon, Indonesia, in 2024. Of a total of 218 male patients of reproductive age registered during the study period, 140 subjects met the inclusion criteria and did not meet any exclusion criteria. Therefore, the final sample size of this study was 140 subjects.

Table 1 presents the distribution of smoking habits among the study subjects. The majority of subjects were non-smokers, accounting for 86 patients (61.42%), while 54 patients (38.57%) reported smoking habits.

Table 1 Distribution of Smoking Habits among Men of Reproductive Age at Permata Bunda Syariah Clinic, Cirebon, 2024

Smoking Habits	Number of Patients	Frequency (%)
Non-smoker	86	61.42 %
Smoker	54	38.57 %
Total	140	100%

The distribution of sperm quality among the study subjects is shown in Table 2. Based on the table, 79 patients (56.42%) had abnormal sperm quality, while 61 patients (43.57%) had normal sperm quality.

Table 2 Distribution of Sperm Quality among Men of Reproductive Age at Permata Bunda Syariah Clinic, Cirebon, 2024

Sperm Quality	Number of Patients	Frequency (%)
Normal	61	43.57 %
Abnormal	79	56.42 %
Total	140	100%

Table 3 presents the association between smoking habits and sperm quality. Among non-smokers, 47 patients (54.65%) had abnormal sperm quality, while 39 patients (45.35%) had normal sperm quality. In the group of smokers, 32 patients (59.26%) had abnormal sperm quality and 22 patients (40.74%) had normal sperm quality.

Although differences in percentages were observed between the two groups, the Chi-square test showed a p-value of 0.592, indicating that there was no statistically significant association between smoking habits and sperm quality in the study population. These findings suggest that smoking habits were not significantly associated with sperm quality among men of reproductive age in this study.

Table 3 Association between Smoking Habits and Sperm Quality among Men of Reproductive Age at Permata Bunda Syariah Clinic, Cirebon, 2024

Smoking Habits	Normal Sperm Quality		Abnormal Sperm Quality		Total		P value
	N	%	N	%	N	%	
Non-smoker	39	45.35	47	54.65	86	61.42	0.592
Smoker	22	40.74	32	59.26	54	38.57	

This study was conducted at Permata Bunda Syariah Clinic, Cirebon, in 2024 to analyze the relationship between smoking habits and sperm quality among men of reproductive age. The results showed that smoking habits were not significantly associated with sperm quality in the study population.

Based on the findings of this study, the majority of male patients undergoing semen analysis were non-smokers, while only 38.57% reported smoking habits. This proportion is considerably lower than the prevalence of smoking among Indonesian men reported by the Global Adult Tobacco Survey (GATS) 2021, which reached 64.7%. Furthermore, data from *The Tobacco Atlas 2025* indicate an even higher prevalence of smoking among Indonesian men, at 71.2%. These findings suggest that the infertile male population attending this clinic tends to have a lower prevalence of smoking compared with the general male population.[7], [13] A similar pattern was observed in a study conducted at an infertility clinic in Saudi Arabia, where only 34.8% of patients were smokers.[14] One possible explanation for the relatively low proportion of smokers in this study is the increased awareness of patients regarding the adverse effects of smoking on reproductive health, leading some individuals to avoid smoking or to quit smoking prior to undergoing semen examination.

The findings of this study also indicate that the majority of men of reproductive age had abnormal sperm quality, which is consistent with a meta-analysis conducted in Sumatra (2020) and a study in West Lampung (2015) reporting that approximately one-third of infertility cases in Indonesia are attributable to male factors.[2], [3] Sperm quality assessment in this study was based on the WHO 2010 guidelines used in the study clinic, which emphasize three main parameters: concentration, motility, and morphology.[15] In the present study, sperm concentration was the parameter with the highest proportion of abnormal findings, followed by abnormalities in motility, while all morphology parameters were within the normal category. These findings suggest that impaired sperm quality in the study population primarily occurred in terms of sperm concentration.

This study demonstrated that smoking habits were not significantly associated with sperm quality. This finding differs from a study conducted in Bengkulu City in 2022, which reported a significant association between smoking habits and sperm motility.[16] Further explanation suggests that this relationship may be explained through several biological mechanisms. Cigarette smoke contains more than 4,000 harmful chemical compounds, including nicotine, carbon monoxide, cadmium, and free radicals, which can increase oxidative stress in testicular tissue and seminal fluid. This excessive production of free radicals leads to a reduction in antioxidant levels, thereby increasing the risk of damage to sperm cell membranes and mitochondria, which play a critical role in energy production for sperm motility. In addition, exposure to free radicals and toxic components of cigarette smoke may induce sperm DNA fragmentation and disrupt the structural integrity of the sperm head, midpiece, and tail, ultimately reducing the sperm's ability to move progressively. In that study,

smoking behavior was assessed in greater detail, including smoking duration and the number of cigarettes consumed per day factors that are biologically relevant to oxidative stress and sperm function. Cigarette smoke contains numerous toxic substances and free radicals, such as nicotine, carbon monoxide, cadmium, and reactive oxygen species, which increase oxidative stress, reduce antioxidant capacity, and cause damage to sperm membranes, mitochondria, and DNA, ultimately impairing sperm motility and integrity.[16]

Similarly, a study conducted in Surabaya in 2024 reported that increased daily cigarette consumption was associated with decreased sperm quality, particularly among heavy smokers.[17] This association may be explained through biological damage mechanisms induced by exposure to toxic components of cigarette smoke on the male reproductive system. Cigarette smoke contains two types of free radicals, namely tar-phase and gas-phase radicals, both of which are highly reactive and capable of inducing oxidative stress in testicular tissue and seminal fluid. The excessive production of these free radicals exceeds the body's antioxidant capacity, leading to oxidative imbalance that affects sperm cell membranes, mitochondria, and DNA structure. In addition, heavy metals such as cadmium and lead present in cigarette smoke may accumulate in the testes and disrupt spermatogenesis through the induction of inflammatory responses and increased reactive oxygen species (ROS) production. The resulting damage includes sperm DNA fragmentation, chromosomal abnormalities, and morphological alterations of the sperm head, midpiece, and tail, all of which play a critical role in progressive sperm motility. That study employed a more detailed classification of smoking exposure, including categories of light, moderate, and heavy smokers, smoking duration, and age groups. Sperm quality assessment was also more comprehensive, encompassing parameters such as pH, viscosity, volume, concentration, motility, morphology, viability, and liquefaction time.[17] These findings indicate that more detailed measurements of smoking exposure and semen parameters may reveal associations that are not evident when simpler classifications are applied.

In contrast, a study conducted in Purwokerto in 2022 reported no significant association between smoking habits and sperm quality, including concentration, motility, and morphology.[12] The study explained that the absence of a significant association may be influenced by the presence of other, more dominant factors in determining sperm quality, particularly semen leukocyte concentration. In a study conducted in Purwokerto in 2022, semen leukocyte levels were shown to have a strong and statistically significant association with sperm quality, with a mean leukocyte concentration of 0.36 ± 0.42 million/mL, and demonstrated significant correlations with sperm concentration, motility, and morphology. Semen leukocytes act as a major endogenous source of reactive oxygen species (ROS) through the activation of polymorphonuclear cells and macrophages in seminal plasma, thereby increasing oxidative stress beyond the antioxidant capacity of spermatozoa. This condition leads to lipid peroxidation of the sperm membrane, mitochondrial dysfunction in the sperm tail, and sperm DNA fragmentation, which directly reduce progressive motility, impair sperm maturation, and increase morphological abnormalities. Consequently, this mechanism may exert a more dominant effect on sperm damage than cigarette smoke exposure itself, resulting in smoking habits appearing to have no significant impact on semen analysis parameters. That study categorized smoking habits using a simple classification of “smoker” and “non-smoker,” similar to the approach used in the present study. The authors suggested that other dominant factors, particularly elevated leukocyte levels in semen, may have exerted a stronger influence on sperm quality through increased oxidative stress and free radical production, thereby masking the effect of smoking exposure.[12]

In the present study, smoking habits were classified only into “smoker” and “non-smoker,” without further stratification based on smoking intensity, duration, or the number of cigarettes consumed per day. Factors used as the basis for smoking classification in studies conducted in Bengkulu, Surabaya, and Purwokerto—such as smoking dose, duration, and exposure intensity—are known to significantly influence sperm quality through oxidative stress-related mechanisms. Therefore, the absence of detailed assessment of these factors, along with the presence of potential uncontrolled confounding variables such as obesity and environmental exposures, may explain the lack of a statistically significant association between smoking habits and sperm quality observed in this study. [1], [2], [4], [16], [18], [19]

Several limitations of this study should be acknowledged when interpreting the findings. First, smoking habits were classified solely based on smoking status (smoker or non-smoker) as recorded in medical records, without detailed assessment of smoking intensity, duration, or cumulative exposure, such as the number of cigarettes smoked per day or smoking history in years, which limited the ability to evaluate dose–response relationships between smoking and sperm quality. Second, other potential determinants of sperm quality, including radiation exposure, sleep quality, and exposure to non-tobacco toxic substances, were not assessed due to constraints in the available secondary data, despite evidence that these factors may impair spermatogenesis through oxidative stress and physiological disruption. Third, inflammatory semen parameters, particularly leukocyte concentration, were not evaluated, although previous studies have demonstrated their influence on sperm motility, morphology, and concentration, which may have affected the interpretation of the association between smoking habits and sperm quality. Fourth, individual clinical and physiological characteristics, such as nutritional status, stress levels, physical activity, heat exposure, and inter-individual variability in biological responses to oxidative stress, were not specifically analyzed because this study relied on medical record data with limited detailed clinical information. Finally, the cross-sectional design of the study precludes causal inference, as smoking habits and sperm quality were assessed simultaneously, and therefore the results reflect statistical associations rather than cause-and-effect relationships.

D. Conclusion

This study found no statistically significant association between smoking habits and sperm quality among men of reproductive age at Permata Bunda Syariah Clinic, Cirebon, in 2024. The majority of participants were non-smokers, while more than half of the study population exhibited abnormal sperm quality, indicating that impaired sperm parameters remain a prevalent issue in this clinical setting. The absence of a significant association suggests that smoking status alone, when classified simply as smoker or non-smoker, may not sufficiently capture the complex relationship between tobacco exposure and sperm quality.

These findings highlight the possibility that other factors, such as the intensity and duration of smoking, individual susceptibility to oxidative stress, inflammatory conditions, lifestyle factors, and environmental exposures, may play a more substantial role in determining sperm quality than smoking status alone. Additionally, the use of secondary medical record data and a cross-sectional design may have limited the ability to detect subtle or cumulative effects of smoking on spermatogenesis.

Therefore, future studies are recommended to incorporate more detailed assessments of smoking exposure, including smoking duration, number of cigarettes consumed per day, and types of tobacco products, as well as to evaluate additional biological and environmental factors that may influence sperm quality. Such approaches may provide a more comprehensive understanding of the impact of smoking on male reproductive health and support the development of targeted preventive and clinical strategies for male infertility.

Acknowledgement

The authors would like to express their gratitude to Permata Bunda Syariah Clinic, Cirebon, for granting permission and providing facilities for data collection. The authors also thank all parties who contributed to the completion of this research and the preparation of this article.

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