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Relationships between income levels, lifestyles, occupational factors, and male fertility in peninsular Malaysia

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ABSTRACT

Objective: To explore the associations between income levels, employment risk, lifestyles, occupational stress, and male fertility.**Methods:** This cross-sectional study analyzed 294 men seeking fertility treatment at fertility clinics in Terengganu, Pahang, and Kuala Lumpur from November 2021 to June 2023. Data were collected through structured questionnaires covering income levels, lifestyles, employment risks, occupational stress, and semen quality. Multinomial logistic regression was employed to assess predictors of semen quality, with crude and adjusted odds ratios (OR) reported.**Results:** The lower-income group exhibited higher odds of having abnormal semen quality compared to normal semen quality. Specifically, these participants were more likely to experience azoospermia [crude OR 6.68, 95% confidence interval (CI) 1.84–52.63; adjusted OR 6.26, 95% CI 1.76–51.38], indicating a link between low income and infertility issues. Lifestyle factors did not show significant associations with semen abnormalities after adjustment. High employment risks had significant associations with oligozoospermia after adjustment (crude OR 5.50, 95% CI 2.14–14.11; adjusted OR 5.15, 95% CI 1.93–13.71), while high occupational stress was linked to asthenozoospermia (crude OR 2.26, 95% CI 1.09–4.68; adjusted OR 2.25, 95% CI 1.07–4.69).**Conclusions:** The findings underscore the influence of socioeconomic and occupational factors on male fertility, showing associations between lower income levels, high-risk occupations, and semen abnormalities. In contrast, lifestyle factors did not show significant associations with semen abnormalities after adjustment. Nevertheless, the current findings should be further confirmed through more extensive studies focusing on abnormal semen and lifestyle factors.**KEYWORDS:** Male infertility; Income levels; Employment risks; Occupational stress; Lifestyles

1. Introduction

As reported by the World Health Organization (WHO), infertility is a growing global concern, impacting one in six individuals[1]. A significant contributor is male factor infertility, accounting for about 37% of infertility cases in Asia[2]. However, male fertility issues in Malaysia are not extensively documented due to limited large-scale studies on the subject. While no comprehensive data on Malaysian male fertility exists, the declining fertility rates in Malaysia may hint at underlying infertility challenges, including male infertility. For

Key Points

Question: What are the relationship between income levels, occupational risk factors, and semen quality among male patients attending fertility clinics in Malaysia?**Findings:** This cross-sectional study of 294 male patients revealed that lower income levels and high-risk occupations were associated with abnormal semen quality, including oligozoospermia, asthenozoospermia, and azoospermia.**Meaning:** The study highlights the necessity of implementing interventions to enhance workplace safety and alleviate occupational stress, which may positively influence semen quality.✉To whom correspondence may be addressed. E-mail: suriyani_md@umt.edu.my

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example, Malaysia's total fertility rate (TFR) dropped from 4.9 in 1970 to 1.6 in 2022, compared to the global TFR of 2.3 children per woman[3]. Common issues such as low sperm production, abnormal sperm function, and absence of sperm are often overlooked, highlighting the need for more research on male fertility in Malaysia.

From 1998 to 2017, related research has focused on conditions such as testicular cancer, obesity, and metabolic syndrome, as well as hypogonadism, and the effects of lifestyle and occupational exposures on male fertility[4]. Among the lifestyle factors, smoking, alcohol consumption, obesity, and psychological stress have been linked to reduced fertility[5]. On the other hand, caffeine consumption, while widely debated, has shown mixed results regarding its impact on sperm quality, with studies finding weak or no significant effects on fertility outcomes[6,7]. Caffeine is commonly found in coffee, tea, and energy drinks, with some epidemiological evidence remaining inconclusive.

Vigorous exercise, though beneficial in some ways, has been linked to increased deoxyribonucleic acid (DNA) fragmentation in sperm among highly active men[8]. Work-related stress and occupational environments are also crucial factors affecting male fertility. High stress levels have been linked to poorer quality of semen and increased sperm DNA damage[9]. However, the findings have been mixed, as some studies suggested no significant relationship between work stress and semen parameters, though stress from life events can still negatively affect fertility[10]. Occupational hazards like heat, toxins, and prolonged sitting in low-skilled jobs have been associated with declining sperm health, thus raising concerns about the effects of these unrecognized factors on fertility in industrialized nations[11].

Another critical factor in male fertility is socioeconomic status, particularly income. Higher income has often been associated with healthier lifestyle choices and better living conditions[12]. In contrast, lower-income men have experienced more stress, which correlates with reduced sperm motility[10]. Research carried out in developed countries has generally shown a positive relationship between men's income and fertility[13]. Interestingly, a study conducted in Malaysia found no direct link between household income and sperm abnormalities[14].

Despite extensive studies on male infertility, several important factors, including income levels, employment risk, and occupational stress remain underexplored, particularly in the Malaysian context. Thus, this study aimed to fill that gap by examining how income levels, employment risks, lifestyle choices, and occupational stress collectively influence male fertility. Using a cross-sectional design and logistic regression analysis, the research provides insights into specific occupational and lifestyle factors affecting reproductive health among Malaysian men. This research is particularly relevant given Malaysia's rapid industrialization and shifting socioeconomic conditions, which may uniquely impact male fertility. The findings may contribute to the formulation of public health strategies addressing infertility.

2. Methods

2.1. Study design and participants

The cross-sectional study explored the associations of income levels, employment risks, lifestyles, and occupational stress with male fertility. Data were collected from male patients ($n=1\,068$) who sought fertility treatment at four private clinics in Terengganu, Pahang, and Kuala Lumpur from November 2021 to June 2023. These fertility clinics were selected based on their willingness to collaborate and grant access to data collection. The required sample size was determined using the Krejcie and Morgan formula, which indicated a minimum sample size of 283[15]. To meet the study's objectives, purposive sampling was employed to recruit patients who exhibited specific semen quality characteristics and met the inclusion criteria.

The study included male patients aged 20 to 60 who attended fertility clinics, were part of couples seeking fertility treatment, and had completed seminal fluid analysis. Men with incomplete medical records or missing seminal fluid analysis data were excluded, as these details were essential for assessing semen quality. Ultimately, 294 eligible participants who gave consent were included in this study.

2.2. Data collection method

Data were collected through face-to-face and online interviews using a structured questionnaire comprising five sections: demographic information, lifestyle factors, employment risks, occupational stress, and semen quality. The inclusion of lifestyle factors, employment risks, and occupational stress in the questionnaire was guided by the evidence demonstrating their impact on male fertility outcomes[4,14,16]. Three experts in male reproductive health, health economics, and nutrition reviewed the questionnaire. Their feedback and recommendations were used to revise and improve the questionnaire items. Cronbach's alpha was utilized to measure the reliability of the instrument based on a pilot study conducted in fertility clinics with 30 eligible male patients. The Cronbach's alpha values for the lifestyle, employment risks, and occupational stress sections were 0.69, 0.74, and 0.77, respectively.

2.3. Measurement of variables

2.3.1. Household income

Income levels in this study were categorized based on the classification framework from the Household Income and Basic Amenities Survey Report 2019 by the Department of Statistics Malaysia (DOSM)[17]. The framework divides household income into three categories, namely the bottom 40% ($\leq$ RM 4850), middle 40% (RM 4851–10970), and top 20% ($\geq$ RM 10971) income groups, to represent the economic status of male patients attending fertility clinics.

2.3.2. Lifestyles

Lifestyle factors, including caffeine intake and physical activities, were assessed to account for their influence on fertility. Caffeine consumption was measured based on daily intake, adapted from the National Health Morbidity Survey (NHMS)2014[18]. Physical activities such as jogging, walking, badminton, cycling and stretching, were assessed according to frequency, duration, and intensity, following the National Health Survey 2004[19]. The reliability analysis was satisfactory, with a Cronbach's alpha of $\alpha=0.69$. The scoring method for lifestyle factors was calculated using the mean score, with a minimum possible score of 3 and a maximum of 24. The mean score of 15 was used as a cut-off point to categorize participants. Individuals scoring above 15 were classified as having an unhealthy lifestyle, while those scoring below 15 were classified as having a healthy lifestyle.

2.3.3. Employment risks

Employment risks were assessed using an 8-item questionnaire based on 5-point Likert scale, evaluating factors such as ionizing radiation, electromagnetic radiation, heat exposure, noise, vibration, and chemical exposure. The assessment was developed based on guidelines provided by the Ministry of Human Resources and the Department of Occupational Safety and Health[20,21]. Cronbach's alpha measured the reliability of the questions at $\alpha=0.74$. To facilitate analysis, the scores were computed to obtain the mean scores. The mean scores were divided into percentiles to categorize participants into three groups: below 25th as low-risk, between 25th and 50th as moderate-risk, and above 75th as high-risk.

2.3.4. Occupational stress

Occupational stress was measured using a combined instrument incorporating the Management Standards Indicator and the Work-Family Conflict Scale[22,23]. Responses were recorded on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The measurement demonstrated acceptable reliability ($\alpha=0.77$). The same scoring method used for employment risks was applied to classify participants based on their levels of occupational stress into three categories: low, moderate, and high.

2.3.5. Semen analysis

Male fertility was assessed through semen quality analysis, which is a standardized methods for evaluating key aspects of male fertility, including sperm count, concentration, morphology, and motility. Semen quality was evaluated using seminal fluid analysis (SFA), following WHO 2010 criteria[24]. Semen samples from 294 men were analyzed, after which 135 samples were classified as fertile and 159 samples as sub-fertile. Sub-fertile semen contributes to infertility due to various semen abnormalities. Sub-fertile semen was identified based on parameters including oligozoospermia (sperm

concentration under 15 million per mL or total sperm count under 39 million per ejaculate), asthenozoospermia (progressive motility less than 32%), combined abnormal parameters (combination of low sperm count, abnormal sperm shape, and reduced sperm motility), and azoospermia (absence of sperm in the ejaculate). Fertile semen had parameters exceeding these thresholds.

2.4. Statistical analysis

The current study analyzed demographic data by presenting frequencies and percentages stratified by semen quality. Potential covariates were identified by comparing variable distributions using the *Chi-square* test.

Multinomial logistic regression was employed to determine the effects of income levels, employment risks, lifestyles, and occupational stress on semen quality. This model is suitable for dependent variables with more than two categories. The multinomial logistic regression model estimates the relative risk ratios for each semen quality category compared to a reference category, facilitating comparisons across different semen quality outcomes based on income levels, lifestyles, and occupational factors.

The regression model used is expressed as:

$$\log \left(\frac{P(Y_i=k)}{P(Y_i=\text{base})} \right) = \beta_0 + \beta_1 \text{income}_i + \beta_2 \text{lifestyle}_i + \beta_3 \text{employment risk}_i + \beta_4 \text{occupational stress}_i + \epsilon_i$$

Here, $P(Y_i=k)$ is the probability of the dependent variable Y_i being in category k , and $P(Y_i=\text{base})$ is the probability of Y_i being in the reference category.

This study employed two models—unadjusted and adjusted. The unadjusted model analyzed each predictor individually to determine its crude association with semen quality. All variables identified as having a potential association in the crude model, based on odd ratio (*OR*) and 95% confidence interval (*CI*), were selected for inclusion in the logistic regression[25]. The adjusted model includes all predictors to account for potential confounding effects and determine the independent effect of each variable. Using both models enhanced the reliability of the findings as they ensured robust and consistent results while minimizing bias. Normal semen quality was used as the reference category and is not displayed in multinomial logistic regression analysis to prevent redundancy. Additionally, reporting crude and adjusted *OR* with 95% *CI* and significance levels at $P<0.01$, $P<0.05$ ensures transparency as it captures a range of potential relationships that could be meaningful for this study. The multinomial logistic regression was analyzed using the main effects technique implemented in Statistical Package for Social Sciences (SPSS) 29 to evaluate the significance of independent variables to dependent variables.

2.5. Ethics statement

This study adhered to the Declaration of Helsinki's ethical principles, with approval from the Universiti Malaysia Terengganu Research Ethics Committee (Ref No. UMT/JKEPM/2021/82) on November 1, 2021. Informed consent was obtained from all participants.

3. Results

3.1. Participant characteristics

The demographic characteristics categorized by semen quality (normal, oligozoospermia, asthenozoospermia, combined parameters, and azoospermia) are as shown in Table 1. The study included a total of 294 participants. Age showed a significant relationship with semen quality ($P=0.016$), with men under 40 years of age more likely to exhibit normal semen quality (35.4%) compared to those over 40 years (10.5%). Household income showed a marginal association ($P=0.082$), where lower income ($\leq$ RM 4 850) had higher rates of abnormal semen quality compared to higher-income groups. The type of work was significantly associated with semen quality ($P<0.001$). Skilled workers exhibited the highest proportion of normal semen quality (26.5%), compared to semiskilled workers (12.9%) and armed forces (6.5%). Conversely, abnormal semen quality was more common among armed forces personnel, with 23 participants having oligozoospermia.

3.2. Logistic regression analysis of income, lifestyle, occupational factors and semen quality

The findings as shown in Table 2 revealed that lower household income ($\leq$ RM 4 850) had higher odds of azoospermia (adjusted OR 6.26, 95% CI 1.76–51.38, $P<0.05$) compared to those in the highest household income ($\geq$ RM 10 971). This suggests that lower income

may be associated with an increased risk of azoospermia 6.26 times compared to normal semen quality.

On the other hand, unhealthy lifestyle was associated with slightly increased odds of semen abnormalities, such as oligozoospermia (adjusted OR 1.72, 95% CI 0.84–3.52) and asthenozoospermia (adjusted OR 1.18, 95% CI 0.58–2.39), compared to a healthy lifestyle. However, none of these associations were statistically significant. This finding indicates that lifestyle may have minimal influence when other variables are taken into account. Regarding employment risks, the analysis demonstrated a significant relationship between high employment risk and oligozoospermia (adjusted OR 5.15, 95% CI 1.93–13.71, $P<0.01$). This finding underscored that individuals in high-risk jobs are more prone to lower sperm counts. However, no significant relationships were found between employment risks and other semen abnormalities after adjustment. High occupational stress was significantly associated with an increased likelihood of asthenozoospermia (adjusted OR 2.25, 95% CI 1.07–4.69, $P<0.05$). This suggests that higher occupational stress may increase the risk of asthenozoospermia 2.25 times compared to normal semen quality.

4. Discussion

The study's findings underscore the significant impact of income levels and employment-related factors on male reproductive health, with lower income levels, high employment risks, and high occupational stress being strongly associated with semen abnormalities. For instance, the logistic regression analysis revealed that household income is significantly related to azoospermia in both the crude and adjusted models, suggesting that lower income levels may increase the likelihood of this semen abnormality compared to normal semen quality. However, no significant relationships were observed between household income and other semen abnormalities, such as oligozoospermia, in either the crude or adjusted models. This finding may indicate that azoospermia, which is a more severe form

Table 1. Demographic characteristics by semen quality.

Characteristics	Semen quality, n(%)					P value
	Normal	Oligozoospermia	Asthenozoospermia	Combined parameters	Azoospermia	
Age, years						
<40	104 (35.4)	47 (16.0)	30 (10.2)	24 (8.2)	23 (7.8)	0.016
$\geq$ 40	31 (10.5)	4 (1.4)	18 (6.1)	6 (2.0)	7 (2.4)	
Household income, RM						
$\leq$ RM 4 850	70 (23.8)	33 (11.2)	27 (9.2)	18 (6.1)	18 (6.1)	0.082
RM 4 851–RM 10 970	39 (13.3)	14 (4.8)	16 (5.4)	7 (2.4)	11 (3.7)	
$\geq$ RM 10 971	26 (8.8)	4 (1.4)	5 (1.7)	5 (1.7)	1 (0.3)	
Types of work						
Skilled workers	78 (26.5)	17 (5.8)	23 (7.8)	14 (4.8)	14 (4.8)	<0.001
Semi-skilled workers	38 (12.9)	11 (3.7)	19 (6.5)	10 (3.4)	10 (3.4)	
Unskilled workers	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.7)	
Armed forces	19 (6.5)	23 (7.8)	6 (2.0)	6 (2.0)	4 (1.4)	

Values are presented as frequencies (percentage). *Chi-square* test is used.

Table 2. Multinomial logistic regression analysis of the relationship between income levels, lifestyles, employment risks, occupational stress, and semen quality.

Variables	Semen quality							
	Oligozoospermia		Asthenozoospermia		Combined parameters		Azoospermia	
	Crude OR (95% CI)	Adjusted OR [‡] (95% CI)	Crude OR (95% CI)	Adjusted OR [‡] (95% CI)	Crude OR (95% CI)	Adjusted OR [‡] (95% CI)	Crude OR (95% CI)	Adjusted OR [‡] (95% CI)
Household income, RM								
≤RM 4 850	3.06 (0.98-9.49)	2.18 (0.65-7.26)	2.00 (0.69-5.76)	1.61 (0.52-4.94)	1.33 (0.45-3.97)	1.37 (0.43-4.41)	6.68 (1.84-22.63) [*]	6.26 (1.76-51.38) [*]
RM 4 851–RM 10 970	2.33 (0.69-7.87)	2.11 (0.59-7.49)	2.13 (0.69-6.53)	1.89 (0.59-5.98)	0.93 (0.26-3.25)	0.94 (0.26-3.37)	7.33 (0.89-60.27)	7.25 (0.86-60.70)
≥RM 10 971 (Ref)	-	-	-	-	-	-	-	-
Lifestyle								
Unhealthy lifestyle	1.43 (0.75-2.73)	1.72 (0.84-3.52)	1.28 (0.66-2.47)	1.18 (0.58-2.39)	1.18 (0.58-2.39)	0.94 (0.41-2.18)	1.34 (0.61-2.97)	1.16 (0.50-2.68)
Healthy lifestyle (Ref)	-	-	-	-	-	-	-	-
Employment risk								
High risk	5.50 (2.14-14.11) ^{**}	5.15 (1.93-13.71) ^{**}	1.83 (0.66-5.02)	1.74 (0.61-4.96)	1.46 (0.51-4.21)	1.29 (0.43-3.88)	1.83 (0.57-5.84)	1.62 (0.48-5.41)
Moderate risk	1.58 (0.63-3.93)	1.27 (0.49-3.28)	1.86 (0.82-4.22)	1.66 (0.70-3.94)	0.80 (0.31-2.01)	0.70 (0.26-1.87)	1.52 (0.58-4.01)	1.28 (0.46-3.54)
Low risk (Ref)	-	-	-	-	-	-	-	-
Occupational stress								
High stress	1.05 (0.53-2.09)	1.00 (0.49-2.05)	2.26 (1.09-4.68) [*]	2.25 (1.07-4.69) [*]	1.46 (0.62-3.43)	1.48 (0.62-3.49)	1.78 (0.78-4.05)	1.80 (0.78-4.17)
Moderate stress	1.04 (0.33-3.23)	1.01 (0.31-3.29)	2.09 (0.68-6.39)	1.82 (0.58-5.68)	1.74 (0.48-6.25)	1.80 (0.48-6.69)	0.43 (0.05-3.64)	0.37 (0.04-3.14)
Low stress (Ref)	-	-	-	-	-	-	-	-

[‡]Adjusted by income, lifestyle, employment risk, and occupational stress. Statistically significant differences are highlighted in asterisk with ^{*} $P < 0.05$, ^{**} $P < 0.01$. Ref: reference, OR: odds ratio, CI: confidence interval.

of semen abnormality, is more strongly linked to socioeconomic disparities. However, while lower income has been a known risk factor, a study in Malaysia have reported no correlation between income and male fertility[14]. The findings corroborate the research premise indicating that socioeconomic status significantly impacts reproductive health.

Meanwhile, high employment risks remained consistently related to oligozoospermia, suggesting that high-risk occupations—potentially involving exposure to harmful substances—negatively impact sperm count. Research supports this link, as men working in agriculture and related trades had significantly lower sperm concentrations compared to those in less hazardous occupations[26]. Additionally, exposure to heat has also been known to negatively affect spermatogenesis. Durairajanayagam *et al* found that men who had an exposure to high temperatures had lower sperm counts compared to those in cooler working environments[11].

Occupational stress emerged as a significant determinant, particularly in relation to asthenozoospermia, with an adjusted OR of 2.25. This suggests that workplace stress may adversely affect sperm motility. This finding aligns with research linking work stress to poorer sperm parameters[27]. High stress hormones like cortisol can disrupt the hormonal balance needed for sperm production, thus affecting sperm motility[28]. However, some studies, like those by Hjollund *et al* and Fenster *et al*, did not find any significant impact, potentially due to insufficient stress levels in those populations[29,30]. Occupational stress caused by factors such as job control, workplace relationships, role ambiguity, and lack of support consequently affected semen quality[31].

Overall, lower income and high-risk occupations were consistently associated with higher risk of semen abnormalities, especially azoospermia and oligozoospermia compared to normal semen quality. Types of work associated with lower income and high-risk occupations in Malaysia typically include semiskilled workers such as agricultural workers, manufacturing laborers, construction workers, and plant and machine operators, which commonly involve heavy physical labor, heat, and chemical exposure. Besides, this study also highlighted the occupational risks prevalent in armed forces which are associated with oligozoospermia. Military personnel often face high exposure to heat, noise, electromagnetic radiation, and toxins[32,33]. Conversely, high-stress professions, which typically include skilled workers such as those in managerial and professional roles and are prevalent among higher-income individuals in Malaysia, may elevate oxidative stress and inflammation, negatively impacting sperm motility. This is supported by a review study that found teachers and doctors in Malaysia commonly had higher occupational stress due to heavy workload[31]. Generally, these results align with the existing literature indicating that lower income, higher stress, and greater environmental exposure negatively affect semen quality[16].

Unexpectedly, lifestyle factors, including caffeine intake and physical activities, did not demonstrate a statistically significant relationship with any type of semen abnormality. While the crude analysis suggested a potential association with combined parameters, this was not sustained after controlling for other variables. This finding could indicate that lifestyle factors, while important, may exert a relatively smaller influence compared to socioeconomic and occupational variables in this population. This is contrary to a study by Sobreiro *et al* which reported associations between high caffeine consumption and reduced sperm concentration and count[34]. However, the findings have remained inconsistent. For instance, a systematic review on the effect of caffeine intake and male infertility concluded that most studies found no relationship between semen parameters and caffeine intake, at least caffeine from coffee, tea, and cocoa drinks[6].

Furthermore, physical activities generally promoted reproductive health, with moderate exercise linked to improved semen quality due to better circulation, reduced oxidative stress, and hormonal balance[35]. However, a study among healthy men in Spain demonstrated no differences in semen parameters between moderate to heavy-intensity physical activity[36]. Similarly, a meta-analysis study did not find an association between moderate-intensity physical activity and fertility[37].

Combining caffeine intake and physical activity into a composite lifestyle variable complicated their relationship with semen quality. A lower lifestyle score, indicative of high caffeine consumption and low physical activity, was associated with higher odds of semen abnormalities, suggesting that poor lifestyle choices may cumulatively impact semen quality. However, in this study, these associations did not reach statistical significance.

This study faced several limitations. First, access to clinics with comprehensive male fertility data was limited, and many clinics had few male fertility cases. Obtaining approval to use patient data was also challenging due to confidentiality concerns, resulting in data collection being permitted by only four fertility clinics. As a result, the study's findings may not be generalizable to a broader Malaysian population but are instead specific to the patients from these clinics. Additionally, male fertility is a sensitive issue, and this was proven by difficulty in securing consent and convincing male patients to participate in the survey. Despite these limitations, the study provides valuable insights into male fertility, an area that remains under-researched.

In conclusion, the present study investigated the associations between income levels, employment risks, lifestyles, and occupational stress with male fertility. Lower-income groups face substantial barriers to fertility health, while higher-income groups were not exempt from risks linked to occupational stress. Moreover, men with high-risk occupation were linked to reduced sperm count, while occupational stress was associated with decreased sperm

motility. The practical implications suggest that interventions aimed at improving job safety and mitigating occupational stress could enhance semen quality. Additionally, although lifestyle factors like caffeine intake and physical activity initially appeared influential, their effects diminished when adjusting for other variables. Future research should investigate the interplay between socioeconomic factors and lifestyle with larger samples and refined methods to develop effective strategies for enhancing semen quality across various income groups.

Conflict of interest statement

The authors confirm that they have no conflict of interests that could have influenced the work presented in this paper.

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Authors' contributions

Nur Fatma Hasni Majid conducted the data analysis and drafted the manuscript. Suriyani Muhamad was responsible for developing the concepts and study design. Suhail Kusairi contributed to the conceptual framework and manuscript drafting. Mohd Nasir Nawawi managed data acquisition and performed the statistical analysis. Noor Salihah Zakaria conducted the literature search and edited the manuscript. Roszaman Ramli provided critical manuscript editing and comprehensive review.

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References

- [1] World Health Organisation. *Infertility* (2024). [Online] Available from: <https://www.who.int/news-room/fact-sheets/detail/infertility> [Accessed 5 July 2024].
- [2] Agarwal A, Mulgund A, Hamada A, Chyatte MR. A unique view on male

- infertility around the globe. *Reprod Biol Endocrinol* 2015; **13**: 37. doi: 10.1186/s12958-015-0032-1.
- [3] Department of Statistics Malaysia. *The population of Malaysia (2024)*. [Online] Available from: <https://open.dosm.gov.my/dashboard/population> [Accessed 28 December 2024].
- [4] Baskaran S, Agarwal A, Leisegang K, Peter NP, Selvam MKP, Henkel R. An in-depth bibliometric analysis and current perspective on male infertility research. *World J Mens Health* 2019; **39**(2): 302-314. doi: 10.5534/wjmh.180114.
- [5] Agarwal A, Baskaran S, Parekh N, Cho CL, Henkel R, Vij S, et al. Male infertility. *Lancet* 2021; **397**(10271): 391-393. doi: 10.1016/S0140-6736(20)32667-2.
- [6] Ricci E, Vigano P, Cipriani S, Somigliana E, Chiaffarino F, Bulfoni A, et al. Coffee and caffeine intake and male infertility: A systematic review. *Nutr J* 2017; **16**(1): 37. doi: 10.1186/s12937-017-0257-2.
- [7] Karmon AE, Toth TL, Chiu YH, Gaskins AJ, Tanrikut C, Wright DL, et al. Male caffeine and alcohol intake in relation to semen parameters and *in vitro* fertilization outcomes among fertility patients. *Andrology* 2017; **5**(2): 354-361. doi: 10.1111/andr.12310.
- [8] Krzastek SC, Farhi J, Gray M, Smith RP. Impact of environmental toxin exposure on male fertility potential. *Transl Androl Urol* 2020; **9**(6): 2797-2813. doi: 10.21037/tau-20-685.
- [9] Jurewicz J, Radwan M, Sobala W, Radwan P, Bochenek M, Hanke W. Effects of occupational exposure—is there a link between exposure based on an occupational questionnaire and semen quality? *Syst Biol Reprod Med* 2014; **60**(4): 227-233. doi: 10.3109/19396368.2014.907837.
- [10] Janevic T, Kahn LG, Landsbergis P, Cirillo PM, Cohn BA, Liu X, et al. Effects of work and life stress on semen quality. *Fertil Steril* 2014; **102**(2): 530-538. doi: 10.1016/j.fertnstert.2014.04.021.
- [11] Durairajanayagam D, Sharma RK, du Plessis SS, Agarwal A. Testicular heat stress and sperm quality. In: du Plessis S, Agarwal A, Sabanegh Jr. E. (eds.) *Male infertility*. New York: Springer; 2014, p. 105-125.
- [12] Alfawaz HA, Khan N, Yakout SM, Khattak MN, Alsaikhan AA, Almousa AA, et al. Prevalence, predictors, and awareness of coffee consumption and its trend among Saudi female students. *Int J Environ Res Public Health* 2020; **17**(9): 7020. doi: 10.3390/ijerph17197020.
- [13] Chudnovskaya M. Trends in childlessness among highly educated men in Sweden. *Eur J Popul* 2019; **35**(5): 939-958. doi: 10.1007/s10680-018-9511-3.
- [14] Muhamad S, Sengupta P, Ramli R, Nasir A. Sociodemographic factors associated with semen quality among Malaysian men attending fertility clinic. *Andrologia* 2019; **51**(10): e13383. doi: 10.1111/and.13383.
- [15] Krejcie RV, Morgan DW. Determining sample size for research activities. *Educ Psychol Meas* 1970; **30**: 607-610. doi: 10.1177/001316447003000308.
- [16] Pokhrel G, Yihao S, Wangcheng W, Khatiwada SU, Zhongyang S, Jianqiao Y, et al. The impacts of sociodemographic characteristics, lifestyle, work exposure and medical history on semen parameters in young Chinese men: A cross-sectional study. *Andrologia* 2019; e13324. doi: 10.1111/and.13324.
- [17] Department of Statistics Malaysia. *Household income & basic amenities survey report 2019; 2020*. [Online] Available from: https://www.dosm.gov.my/v1/uploads/files/1_Articles_By_Themes/Prices/HIES/HIS-Report/HIS-Malaysia-.pdf [Accessed 10 June 2021].
- [18] Institute for Public Health. *National Health Morbidity Survey 2014: Malaysian Adult Nutrition Survey*. [Online] Available from: <https://iku.gov.my/nhms-2014> [Accessed 17 May 2021].
- [19] Ministry of Health Singapore. *National Health Survey 2004*. [Online] Available from: <https://www.moh.gov.sg/resources-statistics/reports/national-health-survey-2004> [Accessed 17 May 2021].
- [20] Ministry of Human Resources. *Malaysia standard classification of occupations (MASCO)*. Putrajaya: Ministry of Human Resources; 2020. [Online] Available from: https://jtksm.mohr.gov.my/sites/default/files/2022-12/MASCO_2020_BI_Edaran.pdf [Accessed 13 June 2021].
- [21] Department of Occupational Safety and Health. *Guidelines on reproductive health policy & programmes at the workplace*. Putrajaya: Ministry of Human Resources; 2002. [Online] Available from: <https://www.dosh.gov.my/index.php/competent-person-form/occupational-health/regulation-2-1/guidelines/occupational-health-1/657-04-guidelines-on-reproductive-health-policy-programmes-at-the-workplace-2002> [Accessed 28 May 2021].
- [22] Health and Safety Executive. *Management standards indicator tool user manual*. Ireland: Health and Safety Executive; (n.d.). [Online] Available from: <https://www.hse.gov.uk/stress/standards/index.htm> [Accessed 28 May 2021].
- [23] Pejtersen JH, Kristensen TS, Borg V, Bjorner JB. The second version of the Copenhagen psychosocial questionnaire. *Scand J Public Health* 2010; **38**(Suppl 3): 8-24. doi: 10.1177/1403494809349858.
- [24] World Health Organization. *WHO laboratory manual for the examination and processing of human semen*, 5th ed. Geneva: World Health Organization; 2010. [Online] Available from: <https://iris.who.int/handle/10665/44261> [Accessed 5 July 2024].
- [25] Swartz MD, Yu RK, Shete S. Finding factors influencing risk: Comparing variable selection methods applied to logistic regression models of cases and controls. *Stat Med* 2008; **27**(29): 6158-6174. doi: 10.1002/sim.3434.
- [26] Manikandan I, Bora S, Adole PS, Thyagaraju C, Ganesh RN. Assessment of organophosphate pesticides exposure in men with idiopathic abnormal semen analysis: A cross-sectional pilot study. *Int J Fertil Steril* 2021; **15**(3): 219-225. doi: 10.22074/IJFS.2020.134650.
- [27] Kumar M, Zilate S, Gupta C. Effect of stress and caffeine on male infertility. *Cureus* 2022; **14**(8): e28487. doi: 10.7759/cureus.28487.
- [28] Prasad S, Tiwari M, Pandey AN, Shrivastav TG, Chaube SK. Impact of stress on oocyte quality and reproductive outcome. *J Biomed Sci* 2016; **23**: 26. doi: 10.1186/s12929-016-0253-4.
- [29] Hjollund NH, Bonde JPE, Henriksen TB, Giwercman A, Olsen J. Reproductive effects of male psychologic stress. *Epidemiology* 2004; **15**(1): 21-27. doi: 10.1097/01.ede.0000100289.82156.8b.
- [30] Fenster L, Katz DF, Wyrupak A, Pieper C, Rempel DM, Oman D, et al.

- Effects of psychological stress on human semen quality. *J Androl* 1997; **18**(2): 194-202. doi: 10.1002/j.1939-4640.1997.tb01900.x.
- [31]Awaluddin SM, Mahjom M, Lim KK, Shawaluddin NS, Lah TMAT. Occupational disease and injury in Malaysia: A thematic review of literature from 2016 to 2021. *J Environ Public Health* 2023; **2023**: 1798434. doi: 10.1155/2023/1798434.
- [32]Geretto M, Ferrari M, De Angelis R, Crociata F, Sebastiani N, Pulliero A, et al. Occupational exposures and environmental health hazards of military personnel. *Int J Environ Res Public Health* 2021; **18**(10): 5395. doi: 10.3390/ijerph18105395.
- [33]Mohamed WMMW, Adam SH, Zarkasi KA, Zulkepli SZ. Prevalence of occupational noise-induced hearing loss and its associated factors among marine technicians working on the Royal Malaysian Navy vessels. *Med J Malaysia* 2024; **79**(6): 669-676.
- [34]Sobreiro BP, Lucon AM, Pasqualotto FF, Hallak J, Athayde KS, Arap S. Semen analysis in fertile patients undergoing vasectomy: Reference values and variations according to age, length of sexual abstinence, seasonality, smoking habits and caffeine intake. *Sao Paulo Med J* 2005; **123**(4): 161-166. doi: 10.1590/s1516-31802005000400002.
- [35]Gaskins AJ. Physical activity and television watching in relation to semen quality in young men. *Br J Sports Med* 2015; **47**(3): 185-190. doi: 10.1136/bjsports-2012-091644.
- [36]Minguez-Alarcon L, Chavarro JE, Mendiola J, Gaskins AJ, Torres-Cantero AM. Physical activity is not related to semen quality in young healthy men. *Fertil Steril* 2014; **102**(4): 1103-1109. doi: 10.1016/j.dertnstert.2014.06.032.
- [37]Zhao F, Hong X, Wang W, Wu J, Wang B. Effects of physical activity and sleep duration on fertility: A systematic review and meta-analysis based on prospective cohort studies. *Front Public Health* 2022; **10**: 1029469. doi: 10.3389/fpubh.2022.1029469.

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