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ORIGINAL ARTICLE

Male Infertility

A 10-year longitudinal analysis of the impact of demographic, lifestyle, and medical factors on semen qualities in men in a city in the midwestern region of the United States of America

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This study was to survey the relationship between semen values and demographics, comorbidities, and recreational substance use in a large cohort of adult men at the University of Chicago Medical Center Department of Urology (Chicago, IL, USA). We performed an analysis from January 2013 to December 2023 of semen samples obtained from adult patients at our institution and collected their demographics, comorbid medical conditions, and recreational substance use information. Patients were divided into categories of normozoospermia, oligozoospermia, and azoospermia on the basis of the 5th version of the World Health Organization (WHO) guidelines. Data were analyzed by univariate linear and logistic regression models, after which statistically significant variables were placed into multivariable models. Azoospermia and oligozoospermia were both associated with Caucasian or Black, Indigenous, and People of Color (BIPOC) race (both $P < 0.001$), increasing age ($P = 0.005$ and $P < 0.001$, respectively), anemia ($P < 0.001$ and $P = 0.02$, respectively), lifetime tobacco use (both $P < 0.001$), lifetime alcohol use ($P = 0.02$ and $P < 0.001$, respectively), and lifetime use of at least two recreational substances ($P < 0.001$ and $P = 0.003$, respectively) in multivariable models. Oligospermia was additionally associated with benign prostatic hyperplasia (BPH; $P = 0.003$) in multivariable models. This study suggests that at-risk populations may benefit from additional early screening and workup for infertility.

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Keywords: infertility; men's health; metabolic diseases; race factors; recreational drug use

INTRODUCTION

Several high-profile studies have recently reported a progressive decline in semen values worldwide, necessitating further studies into the potential mechanism, especially considering that 30% of male infertility remains idiopathic.[1–3] Semen values are also a critical indicator of underlying men's health, so a concerted effort of understanding the potential risk factors and others that influence them is considered an integral part in the evaluation and holistic treatment of male patients.[4]

Tobacco use, marijuana use, and alcohol use have all been shown to negatively affect sperm quantity, motility, nuclear maturity, DNA integrity, and morphology, but recent meta-analyses have also shown some evidence that alcohol may not affect these values.[5–10] Several comorbidities, such as hypertension,[11,12] anemias,[13,14] chronic kidney disease (CKD),[15] end-stage renal disease (ESRD),[16,17] benign prostatic hyperplasia (BPH),[18] heart failure,[19] and genitourinary cancers,[19] are also associated with poorer semen quality. These conditions often share common pathological mechanisms, such as impaired oxygen delivery to the testes[13] and hormonal imbalances.[15,17] Finally, demographic factors may also affect sperm quality and quantity. When controlling for body mass index (BMI), ethnicity, age, abstinence, and smoking status, Black, Indigenous, and People of Color (BIPOC) men and older men of all demographics are more likely to have lower sperm concentration, oligozoospermia, asthenozoospermia, and low sperm count compared to Caucasian men.[20,21] Genetic, sociodemographic, dietary, and cultural factors are likely at play, with underlying racial disparities being a likely causative agent.[21]

Investigating the relationship between semen quality and lifestyle and comorbid factors is critical for addressing reproductive health concerns and can be informative for clinicians when advising patients on factors that may affect their fertility. Therefore, this study describes the relationships between sperm values and multiple comorbidities, substance use, and demographic factors through a longitudinal analysis.

PATIENTS AND METHODS

Recruitment and data collection

This retrospective chart analysis conducted at a single institution was approved by the Institutional Review Board (IRB) at the University of Chicago (Chicago, IL, USA; Approval No. IRB23-1616). As the study was retrospective, used de-identified patient information, and hence was declared as posing minimal risk to participants, the IRB waived the informed consent requirement. The inclusion criteria were male

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patients older than 18 years of age who visited University of Chicago Medical Center Department of Urology for any reason from January 2013 to December 2023 and had at least one semen sample analyzed. For patients who had multiple sperm analyses, we used the semen sample that was collected at their initial presentation. The data collected included demographic factors, sperm function, lifestyle factors, and medical conditions, and data from all appointments during the study period were included.

Demographic and lifestyle factors

Demographic factors collected from the patient charts were age, race, gender, and BMI. Lifestyle factors in this study focused on substance use. Therefore, patient-reported variables of whether patients had past, current, or no use of marijuana, tobacco, alcohol, recreational substances, or any combination of at least two of these substances were assessed.

Sperm analyses

Spermatozoa were analyzed by trained technicians at University of Chicago Medical Center Department of Urology laboratory with a Makler sperm counting chamber (Sefi Medical Instruments, Haifa, Israel) that met the standards for consistency. The Makler counting chamber allowed for rapid collection of sperm counts and any errors introduced are unbiased. Semen values included sperm concentration (normal: 15×10^6–200×10^6 spermatozoa per ml), total sperm count (normal: $>39 \times 10^6$ spermatozoa per ejaculate), and total motile sperm (normal: $>20 \times 10^6$ spermatozoa per ejaculate). Patient diagnoses of oligozoospermia ($<15 \times 10^6$ spermatozoa per ml) and azoospermia (0 spermatozoa per ml) according to the 5th edition of the World Health Organization (WHO) laboratory manual guidelines were also included.[22]

Medical conditions

The conditions included in the study were based on the 10th edition of the International Classification of Diseases (ICD) codes: adrenocortical insufficiency, any form of anemia, hypertension (HTN), heart failure, type 1 diabetes mellitus (T1DM; ICD-10-E10), type 2 diabetes mellitus (T2DM; ICD-10-E11), BPH (ICD-10-N40), CKD (ICD-10-N18), ESRD (ICD-10-N18.6), scrotal varices (ICD-10-I86.1), or testicular cancer (ICD-10-C62). These patients did not have to be actively experiencing the conditions, but only had to have experienced them at some point in their lifetime. The patients' low-density lipoprotein (LDL) cholesterol (normal: <110 mg dl^{-1}), high-density lipoprotein (HDL) cholesterol (normal: >40 mg dl^{-1}), triglyceride (normal: <150 mg dl^{-1}), and hemoglobin A1C (HbA1C; normal: <5.7%) blood levels throughout their treatment were collected.

Statistical analyses

To reduce the chances of statistical bias, the denominators for each variable were the number of patients that were asked each variable or had a value for that variable upon chart review. The statistical software R version 4.3.2, developed by the R Development Core Team at the University of Auckland (Auckland; New Zealand), was used, and $P < 0.05$ was considered statistically significant. The aforementioned demographic, lifestyle, and medical variables were first analyzed by univariate linear regression to determine which variables were associated with positive or negative trends in the log values of total sperm count, sperm concentration, or total motile spermatozoa. The variables were also analyzed by logistic regression to determine associations with oligozoospermia or azoospermia. Multivariate linear and logistic regressions were then completed to build models predicting changes in sperm measures and oligozoospermia and azoospermia diagnosis.

RESULTS

Total sample distributions

A total of 2323 patients had at least one semen sample analyzed and were included in this study. The median age of patients in the study was 35 (interquartile range [IQR]: 31–40) years. Of the patients, 9.5% (220) were Asian, 30.9% (718) were BIPOC, 48.1% (1118) were Caucasian, and 11.5% (267) were of unknown or mixed race (**Table 1**).

The median sperm concentration was 51.0×10^6 (IQR: 7.5×10^6–96.5×10^6) ml^{-1}, the median total sperm count was 117.7×10^6 (IQR: 21.6×10^6–255.3×10^6) per ejaculate, and the median total motile sperm count was 60.4×10^6 (IQR: 6.3×10^6–152.3×10^6) per ejaculate. Of the total patients, 28.8% (668) were diagnosed with oligozoospermia, while 13.0% (303) were diagnosed with azoospermia (**Table 1**).

Oligozoospermia and azoospermia

According to univariate linear and logistic regressions and comparison with normozoospermic men, oligozoospermic patients were older ($P = 0.03$), were more likely to be of BIPOC or Caucasian than Asian race ($P < 0.001$), and more likely had been diagnosed with anemia ($P < 0.001$), BPH ($P < 0.001$), CKD ($P = 0.005$), and heart failure ($P = 0.001$). There was an association between oligozoospermia and lifetime tobacco use ($P < 0.001$), previous ($P < 0.001$) or current ($P < 0.001$) alcohol use, lifetime recreational substance use ($P < 0.001$), and at least two different substances used ($P < 0.001$), as shown in **Table 2** and **Figure 1**. Multivariable analyses revealed older age ($P = 0.005$), BIPOC or Caucasian race ($P < 0.001$), anemia ($P < 0.001$), BPH ($P = 0.003$), tobacco use ($P < 0.001$), lifetime alcohol use ($P = 0.02$), lifetime recreational substance use ($P < 0.001$), and at least two substances used ($P < 0.001$) to be associated with oligozoospermia (**Table 3**).

According to univariate linear and logistic regressions, azoospermia was associated with all of the variables as was oligozoospermia with the addition of HTN ($P = 0.02$). Multivariate regressions also revealed that older age ($P < 0.001$), BIPOC or Caucasian race ($P < 0.001$), anemia ($P = 0.02$), heart failure ($P = 0.04$), lifetime tobacco use ($P < 0.001$), lifetime alcohol use ($P < 0.001$), lifetime recreational substance use ($P < 0.001$), and at least two substances used ($P = 0.003$) were associated with azoospermia (**Table 3**).

Sperm concentration

According to univariate linear regressions, older age ($P = 0.001$), BIPOC or Caucasian race ($P < 0.001$), HTN ($P = 0.04$), anemia ($P < 0.001$), BPH ($P < 0.001$), CKD ($P < 0.001$), heart failure ($P < 0.001$), lifetime tobacco use ($P < 0.001$), alcohol use in the past ($P < 0.001$) or currently ($P < 0.001$), marijuana use ($P = 0.04$), the lifetime use of any recreational substances ($P < 0.001$), and the use of at least two recreational substances ($P < 0.001$) were associated with lower sperm concentrations. BIPOC or Caucasian race ($P = 0.009$), BPH ($P = 0.001$), anemia ($P = 0.007$), heart failure ($P = 0.02$), lifetime tobacco use ($P < 0.001$), lifetime alcohol use ($P = 0.002$), lifetime recreational substance use ($P < 0.001$), and lifetime use of at least two recreational substances ($P < 0.001$) were associated with lower sperm concentration in multivariate regressions (**Figure 1**).

Motile sperm count

Older age ($P < 0.001$), BIPOC or Caucasian race ($P < 0.001$), adrenocortical insufficiency ($P = 0.002$), T2DM ($P = 0.04$),

Table 1: Distribution of variables among the total sample of patients

Variable	*Value*
Age (year), median (IQR)	35 (31–40)
Sperm values	
Sperm concentration ($\times 10^6$ per ml of ejaculate), median (IQR)	51.0 (7.5–96.5)
Total sperm count ($\times 10^6$ per ejaculate)[a], median (IQR)	117.7 (21.6–255.3)
Total motile sperm count ($\times 10^6$ per ejaculate)[a], median (IQR)	60.4 (6.3–152.3)
Oligozoospermia, *n*/total (%)	668/2323 (28.8)
Azoospermia, *n*/total (%)	303/2323 (13.0)
Diabetes and cholesterol values, median (IQR)	
Hemoglobin A1C (%)[b]	5.4 (5.1–5.7)
HDL cholesterol (mg dl^{-1})[c]	47.0 (40.0–58.0)
LDL cholesterol (mg dl^{-1})[c]	109.0 (90.0–133.0)
Triglycerides (mg dl^{-1})[d]	101.0 (70.0–159.0)
Substance use, *n*/total (%)	
Any tobacco use ever	368/1213 (30.3)
Any alcohol use ever	847/1075 (78.8)
Current alcohol use	757/1075 (70.4)
Any marijuana use ever	84/1017 (8.3)
Any illegal drug use ever	168/1015 (16.6)
Any substance use ever	987/1357 (72.7)
At least two substances used ever	372/1357 (27.4)
Medical comorbidities, *n*/total (%)	
Adrenocortical insufficiency	11/1473 (0.7)
T1DM	6/1473 (0.4)
T2DM	69/1473 (4.7)
HTN	232/1473 (15.8)
Anemia	123/1473 (8.3)
Enlarged prostate	43/1473 (2.9)
CKD	56/1473 (3.8)
Heart failure	18/1473 (1.2)
Prostate cancer	12/1473 (0.8)
Testicular cancer	78/1473 (5.3)
Scrotal varices	102/1473 (6.9)
Race, *n*/total (%)	
Asian	220/2323 (9.5)
BIPOC	718/2323 (30.9)
Caucasian	1118/2323 (48.1)
Unknown	267/2323 (11.5)
BMI category, *n*/total (%)	
BMI ≥10 kg m^{-2} and <18.5 kg m^{-2}	11/1377 (0.8)
BMI ≥18.5 kg m^{-2} and <25 kg m^{-2}	413/1377 (30.0)
BMI ≥25 kg m^{-2} and <30 kg m^{-2}	523/1377 (38.0)
BMI ≥30 kg m^{-2} and BMI <40 kg m^{-2}	360/1377 (26.1)
BMI ≥40 kg m^{-2} and <70 kg m^{-2}	70/1377 (5.1)

[a]*n*=2249; [b]*n*=673; [c]*n*=769; [d]*n*=774. Not all patients were asked or assessed for each demographic, comorbidity, or substance use statistic, so the statistics in this table are based on those who answered each question/or were assessed for each comorbidity. IQR: interquartile range; HDL: high-density lipoprotein; LDL: low-density lipoprotein; BIPOC: Black, Indigenous, and People of Color; BMI: body mass index; CKD: chronic kidney disease; HTN: hypertension; T1DM: type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus

hypertension ($P = 0.02$), anemia ($P < 0.001$), BPH ($P < 0.001$), CKD ($P = 0.002$), heart failure ($P < 0.001$), higher HbA1c ($P = 0.04$), lifetime tobacco use ($P < 0.001$), lifetime ($P = 0.001$) or current alcohol use ($P = 0.002$), lifetime marijuana use ($P = 0.02$), lifetime recreational drug use ($P < 0.001$), and the use of at least two substances ($P < 0.001$) were associated with lower motile sperm counts in univariate linear regressions (**Figure 1**). Multivariable linear regressions revealed that a lower motile sperm count was associated with older age ($P < 0.001$), BIPOC or Caucasian race ($P = 0.02$), BPH ($P = 0.003$), heart failure ($P = 0.01$), lifetime tobacco use ($P = 0.04$), lifetime recreational substance use ($P < 0.001$), and lifetime use of at least two substances ($P < 0.001$).

Total sperm count

Older age ($P = 0.002$), BIPOC or Caucasian race ($P = 0.009$), higher HbA1C ($P = 0.03$), higher LDL cholesterol ($P = 0.004$), anemia ($P = 0.003$), BPH ($P < 0.001$), testicular cancer ($P = 0.006$), scrotal varices ($P < 0.001$), lifetime tobacco use ($P = 0.001$), lifetime marijuana use ($P = 0.05$), and the lifetime use of at least two substances ($P = 0.02$) were associated with lower total sperm counts in univariate linear regressions (**Figure 1**). In multivariate linear regression, older age ($P < 0.001$), BIPOC or Caucasian race ($P < 0.001$), anemia ($P < 0.001$), BPH ($P = 0.02$), heart failure ($P = 0.04$), lifetime tobacco use ($P < 0.001$), lifetime alcohol use ($P = 0.01$), lifetime recreational substance use ($P < 0.001$), and lifetime use of at least two substances ($P < 0.001$) were associated with lower total sperm counts.

DISCUSSION

Racial factors and associations

In the present study, we show that many socioeconomic and medical factors are associated with lower sperm counts and concentrations, and presumably, male infertility. Consistent with other studies, older individuals were more likely to have lower semen quality, as were BIPOC and Caucasian individuals compared with Asians.[20,21,23] Reasons for the Asian men having higher sperm quality and quantity may include Asian men being less likely to experience azoospermia, as stated in a previous study,[23] or socioeconomic status (SES) serving as a confounder, as SES affects access to preventive health methods and post-diagnosis healthcare.[24] These data also do not account for attitudes toward engagement with the medical system, which may affect the findings in patients of different racial demographics.[25]

Comorbidity factors and associations

Markers of metabolic conditions such as adrenocortical insufficiency, high HbA1C, and high cholesterols, all of which are associated with diabetes and atherosclerosis, were also associated with poor semen values on univariate analysis. Poor glycemic control,[26,27] high BMI,[28,29] and dyslipidemias,[30,31] particularly in individuals with diabetes mellitus, are also associated with these conditions and have been associated with lower levels of normal sperm morphology. Our results, therefore, provide evidence that sexual medicine practitioners should consider screening for metabolic abnormalities. Our data also align with the literature in that urological and blood disorders, such as testicular and prostate cancers, CKD, and anemias, are associated with lowered sperm counts, motility, and concentration, although these results may be confounded by these patients being more likely to have their semen analyzed.[13,15–17]

Recreational drug use factors and associations

Our findings provide a more solidified basis for counseling patients who are worried about their fertility being affected by the recreational use of substances. Our analysis found tobacco and marijuana, substances commonly used for recreational smoking, as well as alcohol, to be associated with decreased sperm quantities and motility, which are both consistent with previous literature.[5–9] Despite our study providing evidence of increased rates of oligozoospermia and azoospermia in patients who use these substances, there is no conclusive evidence of

Table 2: Univariate linear and logistic regressions for oligozoospermia and azoospermia

Variable	*Oligozoospermia*			*Azoospermia*		
	OR	*95% CI*	*P*	*OR*	*95% CI*	*P*
Age	1.15	1.01–1.30	0.03	1.02	1.01–1.04	0.005
BIPOC race	2.70	1.82–4.11	<0.001	3.78	1.98–8.17	<0.001
Caucasian race	2.55	1.74–3.84	<0.001	3.95	2.10–8.45	<0.001
Adrenocortical insufficiency	3.27	0.98–12.5	0.05	3.61	1.03–12.1	0.04
Anemia	2.15	1.48–3.12	<0.001	1.86	1.21–2.82	0.006
BPH	4.00	2.13–7.86	<0.001	2.00	0.93–4.04	0.07
CKD	2.77	1.37–5.78	0.005	2.09	1.13–3.72	0.005
Heart failure	4.91	1.84–15.4	0.001	4.38	1.60–12.0	0.005
HTN	1.32	0.99–1.75	0.06	1.53	1.08–2.15	0.02
HDL cholesterol	1.01	1.00–1.02	0.2	1.01	0.99–1.02	0.4
LDL cholesterol	0.96	0.62–1.49	0.9	1.00	0.99–100	0.3
Hemoglobin A1C	1.00	0.85–1.16	>0.9	1.00	0.82–1.18	>0.9
T1DM	0.37	0.02–2.29	0.3	0.85	0.04–5.33	0.9
T2DM	1.28	0.77–2.08	0.3	1.76	0.98–3.04	0.06
BMI category			0.7			0.9
BMI ≥10 kg m^{-2} and <18.5 kg m^{-2}	–	–		–	–	
BMI ≥18.5 kg m^{-2} and <25 kg m^{-2}	0.5	0.14–1.67		1.09	0.27–7.21	
BMI ≥25 kg m^{-2} and <30 kg m^{-2}	0.48	0.14–1.63		1.14	0.29–7.57	
BMI ≥30 kg m^{-2} and BMI <40 kg m^{-2}	0.51	0.14–1.71		1.24	0.31–8.22	
BMI ≥40 kg m^{-2} and <70 kg m^{-2}	0.63	0.17–2.26		1.38	0.31–9.70	
Any tobacco use ever	1.92	1.53–2.40	<0.001	2.08	1.56–2.75	<0.001
Any alcohol use ever	1.44	1.20–1.74	<0.001	1.99	1.56–2.54	<0.001
Current alcohol use	1.52	1.26–1.83	<0.001	2.07	1.62–2.65	<0.001
Any marijuana use ever	1.42	0.89–2.20	0.1	1.54	0.85–2.62	0.2
Any recreational substance use ever	1.80	1.50–2.16	<0.001	2.49	1.95–3.20	<0.001
At least 2 recreational substances used ever	1.49	1.18–1.89	<0.001	1.60	1.18–2.14	0.003

OR: odds ratio; HTN: hypertension; T1DM: type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus; CKD: chronic kidney disease; BPH: benign prostatic hyperplasia; CI: confidence interval; HDL: high-density lipoprotein; LDL: low-density lipoprotein; BIPOC: Black, Indigenous, and People of Color; BMI: body mass index; –: hundreds of milligrams per deciliter

Table 3: Multivariate logistic regressions for oligozoospermia and azoospermia

Variable	*Oligozoospermia*			*Azoospermia*		
	OR	*95% CI*	*P*	*OR*	*95% CI*	*P*
Age	1.03	1.01–1.05	0.005	1.03	1.01–1.05	0.002
BIPOC race	3.01	1.88–4.98	<0.001	3.35	1.48–9.02	<0.001
Caucasian race	2.76	1.75–4.50	<0.001	2.97	1.34–7.86	<0.001
Anemia	1.98	1.29–3.04	<0.001	1.69	0.84–3.24	0.06
Benign prostatic hyperplasia	3.44	1.65–7.51	0.2	1.60	0.60–3.88	0.8
Heart failure	3.14	0.99–11.9	0.1	3.80	1.12–13.4	0.04
CKD	0.85	0.33–2.13	0.7	–	–	–
Any tobacco use ever	1.76	1.39–2.23	<0.001	1.70	1.26–2.28	<0.001
Any alcohol use ever	1.27	1.05–1.54	0.02	1.76	1.36–2.27	<0.001
Any recreational substance use ever	1.80	1.50–2.16	<0.001	2.49	1.95–3.20	<0.001
At least two recreational substances used ever	1.49	1.18–1.89	<0.001	1.60	1.18–2.14	0.003

CKD: chronic kidney disease; OR: odds ratio; BIPOC: Black, Indigenous, and People of Color; CI: confidence interval; –: hundreds of milligrams per deciliter

the mechanism by which these substances may affect sperm quality and quantity.[9,10] Therefore, future studies should focus on finding the specific causes of drug effects on fertility and use future findings to create educational campaigns for both patients and practitioners.

Strengths and limitations

Strengths of this study include the large sample size and multivariate analysis across multiple categories of patient attributes that allow for a comprehensive evaluation of effects on fertility. Limitations of the study include the potential sampling bias that come with the retrospective nature of the study, such as patients who receive semen analysis being likely to have already been experiencing fertility issues that caused them to seek urological care. Also, patients with the urological and blood disorders that we found to be associated with lower sperm quantity and quality may have been scheduled semen analysis because of the conditions, presenting bias between the variables. We were unable to make causal claims connecting the comorbidities to the sperm values because we did not have a record of the time of diagnosis of the comorbidities nor their quantifiable severity compared to the time of the sperm value recordings. Additionally, our substance use variables were from

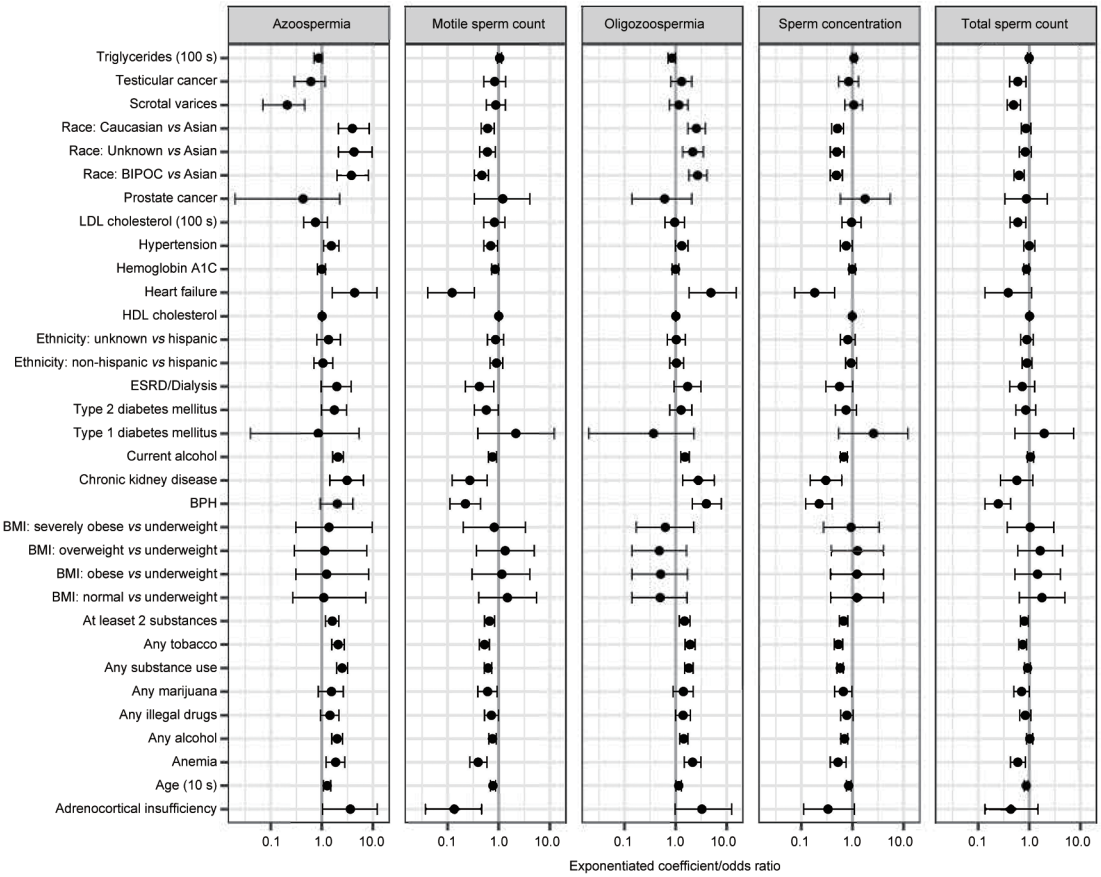

Figure 1: Multiple demographic, lifestyle, and medical factors are associated with sperm quality and quantity in univariate analyses. BIPOC: Black, Indigenous, and People of Color; LDL: low-density lipoprotein; HDL: high-density lipoprotein; ESRD: end-stage renal disease; BPH: benign prostatic hyperplasia; BMI: body mass index.

a question stating "any use ever", which does not account for the quantity of usage, the quality of the drug, or the mode of intake. Future studies can improve upon this research by including more medical conditions in the analyses and evaluating the effects of drug use using prospective analyses that collect data on the frequency, quantity, and quality of usage.

CONCLUSIONS

In this study, high HbA1C or T2DM, anemia, hypercholesterolemia, CKD, heart failure, testicular cancer, BPH, Caucasian or BIPOC race, tobacco use, alcohol use, and marijuana use were associated with reduced semen quantities or qualities. Many couples experiencing infertility undergo emotional distress owing to problems conceiving, and these additional factors can allow sexual and reproductive medicine practitioners to screen men who may be at risk of infertility as a result. Following screening, these men could be treated for their underlying conditions or scheduled for sperm-storing operations such as cryopreservation to store spermatozoa that could be used for *in vitro* fertilization. Future studies are warranted to explore more infertility associations and provide holistic counseling and treatment to patients and practitioners.

AUTHOR CONTRIBUTIONS

MS developed the methodology, helped organize the team, collected the data, interpreted the statistical analysis, and wrote and revised the manuscript. AR and OM developed the methodology, interpreted the statistical analysis, and wrote and revised the manuscript. RN completed the statistical analysis and wrote and revised the manuscript. SDL and OR developed the methodology and wrote and revised the manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declare no competing interests.

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REFERENCES

1 Boeri L, Kandil H, Ramsay J. Idiopathic male infertility – what are we missing? *Arab J Urol* 2008; 22: 1–15.
2 Corsini C, Boeri L, Candela L, Pozzi E, Belladelli F, *et al*. Is there a relevant clinical impact in differentiating idiopathic versus unexplained male infertility? *World J Mens Health* 2023; 41: 354–62.
3 Pfeifer S, Butts S, Dumesic D, Fossum G, Garcia C, *et al*. Diagnostic evaluation of the infertile male: a committee opinion. *Fertil Steril* 2015; 103: e18–25.
4 Schlegel P, Sigman M, Collura B, Treadwell JR, Oristaglio JT, *et al*. Diagnosis and treatment of infertility in men: AUA/ASRM guideline part I. *Fertil Steril* 2020; 115: 54–61.

5 Omolaoye TS, El Shahawy O, Skosana BT, Boillat T, Loney T, *et al*. The mutagenic effect of tobacco smoke on male fertility. *Environ Sci Pollut Res* 2022; 29: 62055–66.
6 Ilnitsky S, Van Uum S. Marijuana and fertility. *CMAJ Can Med Assoc J* 2019; 191: E638.
7 Fonseca BM, Rebelo I. Cannabis and cannabinoids in reproduction and fertility: where we stand. *Reprod Sci Thousand Oaks Calif* 2022; 29: 2429–39.
8 Carroll K, Pottinger AM, Wynter S, DaCosta V. Marijuana use and its influence on sperm morphology and motility: identified risk for fertility among Jamaican men. *Andrology* 2020; 8: 136–42.
9 Amor H, Hammadeh ME, Mohd I, Jankowski PM. Impact of heavy alcohol consumption and cigarette smoking on sperm DNA integrity. *Andrologia* 2022; 54: 1–11.
10 Trautman A, Gurumoorthy A, Hansen KA. Effects of alcohol use on sperm chromatin structure, a retrospective analysis. *Basic Clin Androl* 2023; 33: 14.
11 Guo D, Li S, Behr B, Eisenberg ML. Hypertension and male fertility. *World J Mens Health* 2017; 35: 59–64.
12 Li YD, Ren ZJ, Gao L, Ma JH, Gou YQ, *et al*. Association between male infertility and the risk of hypertension: a meta-analysis and literature review. *Andrologia* 2022; 54: e14535.
13 Naelitz BD, Khooblall PS, Parekh NV, Vij SC, Rotz SJ, *et al*. The effect of red blood cell disorders on male fertility and reproductive health. *Nat Rev Urol* 2024; 21: 303–16.
14 Akhter MS, Hamali HA, Iqbal J, Mobarki AA, Rashid H, *et al*. Iron deficiency anemia as a factor in male infertility: awareness in health college students in the Jazan region of Saudi Arabia. *Int J Environ Res Public Health* 2021; 18: 12866.
15 Holley JL. The hypothalamic-pituitary axis in men and women with chronic kidney disease. *Adv Chronic Kidney Dis* 2004; 11: 337–41.
16 Lehtihet M, Hylander B. Semen quality in men with chronic kidney disease and its correlation with chronic kidney disease stages. *Andrologia* 2015; 47: 1103–8.
17 Lundy SD, Vij SC. Male infertility in renal failure and transplantation. *Transl Androl Urol* 2019; 8: 173–81.
18 Verze P, Cai T, Lorenzetti S. The role of the prostate in male fertility, health and disease. *Nat Rev Urol* 2016; 13: 379–86.
19 Capogrosso P, Ventimiglia E, Boeri L, Cazzaniga W, Chierigo F, *et al*. Male infertility as a proxy of the overall male health status. *Minerva Urol Nephrol* 2018; 70: 286–99.
20 McCray NL, Young HA, Irwig MS, Frankfurter D, Schwartz AM, *et al*. The association between race, obesity, and sperm quality among men attending a university physician practice in Washington, DC. *Am J Mens Health* 2020; 14: 1557988320925985.
21 Gunes S, Hekim GN, Arslan MA, Asci R. Effects of aging on the male reproductive system. *J Assist Reprod Genet* 2016; 33: 441–54.
22 Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HW, *et al*. World Health Organization reference values for human semen characteristics. *Hum Reprod Update* 2010; 16: 231–45.
23 Khandwala YS, Zhang CA, Li S, Behr B, Guo D, *et al*. Racial variation in semen quality at fertility evaluation. *Urology* 2017; 106: 96–102.
24 Glazer CH, Li S, Zhang CA, Giwercman A, Bonde JP, *et al*. Racial and sociodemographic differences of semen parameters among US men undergoing a semen analysis. *Urology* 2019; 123: 126–32.
25 Yan C, Zhang X, Yang Y, Kang K, Were MC, *et al*. Differences in health professionals' engagement with electronic health records based on inpatient race and ethnicity. *JAMA Netw Open* 2023; 6: e2336383.
26 Lotti F, Maggi M. Effects of diabetes mellitus on sperm quality and fertility outcomes: clinical evidence. *Andrology* 2023; 11: 399–416.
27 Facondo P, Di Lodovico E, Delbarba A, Anelli V, Pezzaioli LC, *et al*. The impact of diabetes mellitus type 1 on male fertility: systematic review and meta on inpatie*Andrology* 2022; 10: 426–40.
28 Sermondade N, Faure C, Fezeu L, Shayeb AG, Bonde JP, *et al*. BMI in relation to sperm count: an updated systematic review and collaborative meta-analysis. *Hum Reprod Update* 2013; 19: 221–31.
29 Guo D, Wu W, Tang Q, Qiao S, Chen Y, *et al*. The impact of BMI on sperm parameters and the metabolite changes of seminal plasma concomitantly. *Oncotarget* 2017; 8: 48619–34.
30 Ouvrier A, Alves G, Damon-Soubeyrand C, Marceau G, Cadet R, *et al*. Dietary cholesterol-induced post-testicular infertility. *PLoS One* 2011; 6: e26966.
31 Saez F, Drevet JR. Dietary cholesterol and lipid overload: impact on male fertility. *Oxid Med Cell Longev* 2019; 2019: 4521786.

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