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The relationship between physical occupational exposures and health on semen quality: Data from the LIFE Study

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Abstract

Objective—To study the relationship between occupation, health, and semen quality in a cohort of men attempting to conceive.

Design—Observational prospective cohort

Setting—Sixteen Michigan/Texas counties

Patients—A total of 501 couples discontinuing contraception were followed for 1 year while trying to conceive; 473 men (94%) provided one semen sample, and 80% provided a second sample.

Interventions—None.

Main Outcome Measure—Semen data obtained through at home semen collection with next day analysis/quantification.

Results—In all, complete data were available for 456 men with a mean age of 31.8 years. Work related heavy exertion was consistently associated lower semen concentration and total sperm count. 13% of men who reported heavy exertion displayed oligospermia, compared to 6% who did not report workplace exertion. Shift work, night work, vibration, noise, heat, and prolonged sitting were not associated with semen quality. Men with high blood pressure had significantly lower strict morphology scores compared to normotensive men (17% vs. 21%). In contrast, hyperlipidemia, diabetes, and composite of total comorbidities were not associated with semen quality. The number of medications a man was taking as a proxy of health status was associated

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with semen quality. There was a negative association between number of medications and sperm count (pTrend <0.05).

Conclusions—A negative relationship between occupational exertion, hypertension, and the number of medications with semen quality was identified. As these are potentially modifiable factors, further research should determine if treatment or cessation may improve male fecundity.

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Keywords

male infertility; oligospermia; workplace; comorbidity; health

Introduction

Up to 15% of all couples are unable to conceive after a year of trying and are labeled infertile.(1, 2) Among them, up to half have a male factor to explain the etiology.(3) Given the sensitivity of spermatogenesis to extrinsic and intrinsic factors, a man's environment may have a profound impact on semen quality. A potential source of adverse exposure may be a man's occupation and past investigators have examined chemical, physical, and psychological factors.(4–6) Much of the existing literature has examined the role of chemical exposure with limited data on physical exposures such as exertion, heat, shift work, vibration, noise, and sedentary positions in an occupational context. As such, conflicting data exists regarding the harms of work related physical exposures and applicability to the general population is uncertain.

While heat exposure is known to negatively impact spermatogenesis, whether occupational amounts have severe impacts is uncertain. Several studies demonstrate that excess heat can impair fertility, though other studies have not found an association.(7, 8) Studies have suggested impairments to fertility in men with occupations with significant exposure to vibration.(4) Moreover, shift work and heavy exertion have also demonstrated negative impact on fertility.(4, 7) However, it is difficult to isolate a particular occupational exposure given that hazards tend to coexist (e.g. noise and vibration) and are also related to other confounding factors such as smoking, age, and socioeconomic status.(9) Much of the available literature has relied on cross-sectional, case control or retrospective designs that have not prospectively measured the time required for couples to become pregnant.

In addition, health related factors may be related to occupation which may mediate an impact on sperm production. Indeed, exposure to occupational noise is known to increase the risk for cardiovascular disease and mortality.(10) In addition, obesity can impact health, semen quality, and may be directly impacted by occupational activity.(11, 12) Given the complex interplay between occupational environment, health, and fertility, we sought to determine their separate and combined effects on man's fertility.

Methods

Study Population

We used data from the Longitudinal Investigation of Fertility and the Environment (LIFE) Study that has been described previously.⁽¹³⁾ Briefly, the LIFE Study is a prospective cohort of 501 couples attempting to conceive in two geographic areas (Texas and Michigan) in 2005–2009. Couples planning pregnancy were recruited from four counties in Michigan and twelve counties in Texas to ensure a range of environmental exposures and lifestyle characteristics. Minimal eligibility criteria were required: female ages 18–44 years and male ages 18+ years; in a committed relationship; ability to communicate in English or Spanish; menstrual cycles between 21 and 42 days; no hormonal contraception injections during past year; and no sterilization procedures or physician diagnosed infertility. The study cohort comprised 501 (42%) screened eligible couples; a complete description is presented elsewhere.⁽¹³⁾ The most frequent reasons for ineligibility included: age (27%), not interested in pregnancy (19%), not in a committed relationship (19%), and moving outside study area (16%). Full human subjects' approval was granted prior to obtaining informed consent from all couples.

Data collection and operational definitions

All participants completed baseline interviews by trained research assistants, usually at the patient's home, that queried men about their medical and reproductive history, lifestyle and occupational activity. For study purposes, occupational exposures were defined by men's responses to the following question:

Does your current job involve any of the following? (Yes/No)

- Night work, rotating shifts, whole body vibration, noise, extreme heat, heavy exertion or lifting, prolonged sitting (Importantly, separate questions were asked for each occupational exposure)

Medical history was defined by men's responses to the following question:

Have you ever been told by a doctor that you have any of the following health conditions? (Yes/No)

-Hypothyroid (under-active thyroid), Hyperthyroid (over-active thyroid), high blood pressure, high cholesterol, diabetes (Importantly, separate questions were asked for each occupational exposure)

Men were also queried as to whether they were taking medications for any health conditions:

(If yes) Are you currently receiving medical treatment for this condition? (Yes/No)

Research nurses performed the standardized anthropometric assessment using the methodology adapted from the NHANES III survey.⁽¹⁴⁾ Specifically, all men were weighed after removing shoes and excessive clothing using the digital self-calibrating Health-O-Meter scale. The nurse was instructed to take two measurements and record weight to the nearest pound. If the measurements differed by more than one pound, a third measurement

was taken. The scale is reported to be accurate up to 330 pounds. For men with weights in excess, we relied upon self-reported weight.

Height was measured using a standardized cloth tape measure. The male was asked to remove shoes, stand erect with his back to the wall and shoulders relaxed at the sides and looking straight ahead. The nurse took two measurements rounded to the nearest ½ inch and a third if the difference was more than ½ inch. Multiple measurements were averaged and converted to kg and m to calculate BMI.

Biospecimen collection and analysis

Semen samples were collected via masturbation without the use of any lubricant following two days of abstinence using home collection kits that comprised an insulated shipping container (Hamilton Research, Beverly, MA) for maintaining sperm integrity. An aliquot of semen was placed in a 20µm deep chamber slide (Leja, Luzemestraat, Netherlands), and sperm motility was assessed using the HTM-IVOS (Hamilton Thorne Biosciences, Beverly, MA) computer assisted semen analysis system (CASA). Sperm concentration was also measured using the IVOS system and the IDENT™ stain. Microscope slides were prepared for sperm morphometry and morphology assessment and completed by Fertility Solutions® (Cleveland, OH). An aliquot of the whole semen was diluted in TNE buffer with glycerol and frozen for the sperm chromatin stability assay (SCSA®) analysis.(15)

To insure integrity of the next day analysis, steps taken to ensure the quality of the semen parameters. A thermometer was attached to all collection jars to ensure the temperature of the sample was within acceptable limits as was the integrity of the sample as judged by laboratory personnel. All samples were found to be acceptable. Motility endpoints are most sensitive to next day analysis and were excluded from our analysis. Other investigators have successfully utilized similar at home semen collection approaches.(16, 17)

Statistical analysis

We conducted descriptive analyses to assess distributions of semen outcomes, occupational and health factors, with means (standard deviation; SD) or medians (inter-quartile range; IQR) for continuous measures and valid n (percent; %) for categorical measures. For association between semen outcomes and occupational and health factors, we used linear (for continuous) and logistic (for dichotomized) regressions. When two semen samples were available, we used generalized estimating equations (GEE) approach to account for the induced correlation. All regression models were adjusted for a set of *a priori* selected covariates: age (continuous, years), race (white(reference), others), BMI (continuous, kg/m²), smoking status (yes, no(reference)). When dichotomizing semen outcomes, abnormal semen parameters were defined based on the WHO 5th edition of the manual on semen analyses.(18). We assumed that data were missing at random, which enables us to conduct likelihood based estimation and inference without resorting to multiple imputations. Confidence intervals that excluded 1.0 or p-values <0.05 were interpreted as statistically significant. All analyses were implemented using SAS 9.3 (SAS Institute, Cary NC).

Results

A description of the study cohort is provided in Table 1, and reflects that the cohort comprised men who mostly reported being white (77%), college educated (91%) and who had never fathered a pregnancy (52%). In all, complete data were available for 456 (91%) men. Many men described physical exposures at work including noise (27%), heat (21%) and exertion (32%). In addition, night work (23%) or shift work (16%) was also reported. Hyperlipidemia was the most common medical condition in the cohort present in 16% of men. The median sperm concentration for the men in the cohort was 61.8 M/mL with 8% having oligospermia (<15 M/mL).

Semen parameters were analyzed on a continuous scale and after stratifying based on abnormal parameters as defined by the WHO 5th edition.(18) Work related heavy exertion was consistently associated **with** lower semen concentration and total sperm count. 13% of men who reported heavy exertion displayed oligospermia, compared to 6% who did not report workplace exertion.

Moreover, the average sperm counts were 16% lower in men who reported workplace exertion. Such associations persisted after adjusting for age, BMI, race, and smoking. In contrast, no other work place exposure showed consistent detriments or improvements in semen quality (Tables 2 and 3).

When examining men with hypertension, diabetes, and hyperlipidemia, only hypertension was consistently associated with semen quality. High blood pressure led to a lower WHO and strict morphology scores compared to normotensive men (WHO: 27% vs. 31%, strict: 17% vs. 21%). Moreover, a trend of lower total sperm counts was also identified, though it failed to meet statistical significance ($p < 0.1$). In contrast, hyperlipidemia, diabetes, and a composite of total comorbidities did not impact semen quality (Tables 2 and 3).

The number of medications a man reported taking at baseline appeared to influence semen quality (Table 4). The more medications a man took, the higher the risk of low sperm count (p -value for trend < 0.05). For example, 7% of men who were not taking medications had a total sperm count < 39 M compared to 15% of men who reported taking 2 or more medications. In addition, when examining all men with sperm counts < 39 M, the average number of medications per man is 1.2. In contrast, a man with normal sperm counts took on average 0.6 medications.

Discussion

To our knowledge, the LIFE Study is the first prospective cohort study with preconception enrollment of couples to examine the relationship between physical occupational reproductive hazards while accounting for health and socioeconomic factors. We identified a negative relationship between strenuous occupational activity and sperm counts. Interestingly, no other work exposure impacted semen quality. When examining somatic health, hypertension was associated with impaired sperm morphology. While no relationship was identified between total medical comorbidities and semen quality, a positive association was identified between number of medications and sperm count.

Similar to the findings of the current report, El Helaly and colleagues demonstrated a relationship between male infertility and workplace exertion.(7) In contrast, the literature does suggest that exercise and activity may improve semen parameters and hypothalamic-pituitary-gonadal hormone levels.(19–22) Other studies have failed to demonstrate a relationship between physical activity and semen quality.(23) However, similar to those who exercise to exhaustion (e.g. marathon runners or cyclists), it is conceivable that a threshold of exertion can be reached which may negatively impact fertility.(20)

Other studies have examined the relationship between physical work place exposures and semen quality. While heat exposure in certain occupations such as for welders are associated with impaired semen quality, other examinations have not demonstrated a detriment to semen production from excessive workplace heat. In two separate case control studies, investigators failed to identify a higher risk of male infertility due to self reported occupational heat exposure.(4, 7) It is possible that many levels of occupational heat are of insufficient intensity or duration to impact spermatogenesis. As the data are self-reported and not quantified, it is also possible that methods of self reporting are inadequate to capture relevant exposures. Moreover, we did not examine a job exposure matrix to attempt to identify relevant exposures.

Shift work has also been shown to impact fertility in some studies but not others suggesting and unclear relationship.(4, 7) While the HPG axis can be altered by such work conditions, the reproductive impact is uncertain.(24) Similar to our findings, sedentary behavior has not been clearly associated with male reproductive harm in the literature.(4, 25, 26) However, Italian taxi drivers have higher rates of abnormal morphology suggesting it may be vehicle noise, vibration, or exhaust that contributes rather than sitting itself.(27)

Prior reports have identified possible links between somatic health and male fertility.(28) For example, diabetes has been linked to impaired sperm production.(29, 30) In addition, investigators have demonstrated a relationship between hyperlipidemia, lipid levels, and male fertility.(31–33) Salonia et al. suggested higher medical comorbidities in infertile men.(34) Indeed, men with impaired semen quality have a higher rate of overall mortality compared to men with normal sperm production suggesting that semen quality may represent a biomarker of overall health.(35, 36) In the current report, hypertension was associated with impaired sperm morphology. However other comorbidities were not associated with semen quality. Importantly, total number of comorbidities was not associated with semen quality suggesting that medical problems may interact with reproductive health in varied ways. In contrast to Steiner and colleagues, we identified a relationship between the number of medications taken and sperm count.(4) Moreover, when stratifying by semen quality, men with impaired parameters were more likely to take more medications. Given the absence of a complete medication history including clinical indication, we cannot determine if this association is a proxy for health status or indicative of pharmacotoxic effects. While our numbers were inadequate to determine if the comorbidity or treatment may explain this relationship, it merits further research.

Our study findings are strengthened by our population based sampling framework rather than reliance on a convenient or clinically based sample, and our in depth semen analysis.

Still, the findings require cautious interpretation given that our exposures are subject to possible reporting errors, though we are unaware of any potential biases that may have been introduced, as men were unaware of their semen quality at the time of reporting. Similarly, we were unable to verify self reported medical diagnoses so reporting errors may be possible. Another important limitation is the use of home semen collection. As such, our semen analysis may not be directly comparable to clinical analyses. Given the strong relationship between sociodemographic factors and many of our occupational and health exposures, even after adjustment we may be unable to isolate the workplace contribution. Next, while several semen parameters are incorporated into a clinical evaluation, only certain factors were identified as related to occupational or work exposures in the current analysis leading to uncertain clinical significance. Lastly, we cannot rule out residual confounding or chance findings in light of the multiple comparisons made in the analysis.

Nevertheless, the current report demonstrates a relationship between occupational exertion, hypertension, and medications with semen quality. As these are potentially modifiable factors, further research should determine if treatment or cessation may improve male fecundity.

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References

1. Louis JF, Thoma ME, Sorensen DN, McLain AC, King RB, Sundaram R, et al. The prevalence of couple infertility in the United States from a male perspective: evidence from a nationally representative sample. *Andrology*. 2013; 1:741–748. [PubMed: 23843214]
2. Thoma ME, McLain AC, Louis JF, King RB, Trumble AC, Sundaram R, et al. Prevalence of infertility in the United States as estimated by the current duration approach and a traditional constructed approach. *Fertility and sterility*. 2013; 99:1324–1331. e1. [PubMed: 23290741]
3. Thonneau P, Marchand S, Tallec A, Ferial ML, Ducot B, Lansac J, et al. Incidence and main causes of infertility in a resident population (1,850,000) of three French regions (1988–1989). *Human reproduction*. 1991; 6:811–816. [PubMed: 1757519]
4. Sheiner EK, Sheiner E, Carel R, Potashnik G, Shoham-Vardi I. Potential association between male infertility and occupational psychological stress. *J Occup Environ Med*. 2002; 44:1093–1099. [PubMed: 12500450]
5. Buck Louis GM, Sundaram R, Schisterman EF, Sweeney AM, Lynch CD, Gore-Langton RE, et al. Persistent environmental pollutants and couple fecundity: the LIFE study. *Environmental health perspectives*. 2013; 121:231–236. [PubMed: 23151773]
6. Buck Louis GM, Sundaram R, Schisterman EF, Sweeney AM, Lynch CD, Gore-Langton RE, et al. Heavy metals and couple fecundity, the LIFE Study. *Chemosphere*. 2012; 87:1201–1207. [PubMed: 22309709]
7. El-Helaly M, Awadalla N, Mansour M, El-Biomy Y. Workplace exposures and male infertility - a case-control study. *Int J Occup Med Environ Health*. 2010; 23:331–338. [PubMed: 21306978]
8. Oliva A, Spira A, Multigner L. Contribution of environmental factors to the risk of male infertility. *Human reproduction*. 2001; 16:1768–1776. [PubMed: 11473980]
9. Claman P. Men at risk: occupation and male infertility. *Fertility and sterility*. 2004; 81(Suppl 2):19–26. quiz 57–60. [PubMed: 15126094]

10. Gopinath B, Thiagalingam A, Teber E, Mitchell P. Exposure to workplace noise and the risk of cardiovascular disease events and mortality among older adults. *Prev Med.* 2011; 53:390–394. [PubMed: 22004617]
11. Sermondade N, Faure C, Fezeu L, Shayeb AG, Bonde JP, Jensen TK, et al. BMI in relation to sperm count: an updated systematic review and collaborative meta-analysis. *Hum Reprod Update.* 2013; 19:221–231. [PubMed: 23242914]
12. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. workers and associations with occupational factors. *Am J Prev Med.* 2014; 46:237–248. [PubMed: 24512862]
13. Buck Louis GM, Schisterman EF, Sweeney AM, Wilcosky TC, Gore-Langton RE, Lynch CD, et al. Designing prospective cohort studies for assessing reproductive and developmental toxicity during sensitive windows of human reproduction and development--the LIFE Study. *Paediatr Perinat Epidemiol.* 2011; 25:413–424. [PubMed: 21819423]
14. Anthropometric Standardization Reference Manual. Champaign: Human Kinetic Books, 1988; 1988.
15. Evenson DP, Larson KL, Jost LK. Sperm chromatin structure assay: its clinical use for detecting sperm DNA fragmentation in male infertility and comparisons with other techniques. *J Androl.* 2002; 23:25–43. [PubMed: 11780920]
16. Luben TJ, Olshan AF, Herring AH, Jeffay S, Strader L, Buus RM, et al. The healthy men study: an evaluation of exposure to disinfection by-products in tap water and sperm quality. *Environmental health perspectives.* 2007; 115:1169–1176. [PubMed: 17687443]
17. Royster MO, Lobdell DT, Mendola P, Perreault SD, Selevan SG, Rothmann SA, et al. Evaluation of a container for collection and shipment of semen with potential uses in population-based, clinical, and occupational settings. *J Androl.* 2000; 21:478–484. [PubMed: 10819457]
18. Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HW, Behre HM, et al. World Health Organization reference values for human semen characteristics. *Hum Reprod Update.* 2010; 16:231–245. [PubMed: 19934213]
19. Hakonsen LB, Thulstrup AM, Aggerholm AS, Olsen J, Bonde JP, Andersen CY, et al. Does weight loss improve semen quality and reproductive hormones? Results from a cohort of severely obese men. *Reprod Health.* 2011; 8:24. [PubMed: 21849026]
20. Safarinejad MR, Azma K, Kolahi AA. The effects of intensive, long-term treadmill running on reproductive hormones, hypothalamus-pituitary-testis axis, and semen quality: a randomized controlled study. *J Endocrinol.* 2009; 200:259–271. [PubMed: 19066291]
21. Bobbert T, Mai K, Brechtel L, Schulte HM, Weger B, Pfeiffer AF, et al. Leptin and endocrine parameters in marathon runners. *Int J Sports Med.* 2012; 33:244–248. [PubMed: 22261828]
22. Gaskins AJ, Mendiola J, Afeiche M, Jorgensen N, Swan SH, Chavarro JE. Physical activity and television watching in relation to semen quality in young men. *Br J Sports Med.* 2013
23. Eisenberg ML, Kim S, Chen Z, Sundaram R, Schisterman EF, Buck Louis GM. The relationship between male BMI and waist circumference on semen quality: data from the LIFE study. *Human reproduction.* 2014; 29:193–200. [PubMed: 24306102]
24. Axelsson J, Akerstedt T, Kecklund G, Lindqvist A, Attefors R. Hormonal changes in satisfied and dissatisfied shift workers across a shift cycle. *J Appl Physiol.* 2003; 95:2099–2105. [PubMed: 12882998]
25. Hjollund NH, Storgaard L, Ernst E, Bonde JP, Olsen J. Impact of diurnal scrotal temperature on semen quality. *Reprod Toxicol.* 2002; 16:215–221. [PubMed: 12128094]
26. Stoy J, Hjollund NH, Mortensen JT, Burr H, Bonde JP. Semen quality and sedentary work position. *Int J Androl.* 2004; 27:5–11. [PubMed: 14718040]
27. Figa-Talamanca I, Cini C, Varricchio GC, Dondero F, Gandini L, Lenzi A, et al. Effects of prolonged automobile driving on male reproduction function: a study among taxi drivers. *Am J Ind Med.* 1996; 30:750–758. [PubMed: 8914722]
28. Eisenberg ML, Li S, Behr B, Pera RR, Cullen MR. Relationship between semen production and medical comorbidity. *Fertility and sterility.* 2015; 103:66–71. [PubMed: 25497466]
29. Dinulovic D, Radonjic G. Diabetes mellitus/male infertility. *Archives of andrology.* 1990; 25:277–293. [PubMed: 2285351]

30. Garcia-Diez LC, Corrales Hernandez JJ, Hernandez-Diaz J, Pedraz MJ, Miralles JM. Semen characteristics and diabetes mellitus: significance of insulin in male infertility. *Archives of andrology*. 1991; 26:119–128. [PubMed: 1903630]
31. Ramirez-Torres MA, Carrera A, Zambrana M. [High incidence of hyperestrogenemia and dyslipidemia in a group of infertile men]. *Ginecologia y obstetricia de Mexico*. 2000; 68:224–229. [PubMed: 10902292]
32. Schisterman EF, Mumford SL, Browne RW, Barr DB, Chen Z, Louis GM. Lipid concentrations and couple fecundity: the LIFE study. *J Clin Endocrinol Metab*. 2014; 99:2786–2794. [PubMed: 24846535]
33. Schisterman EF, Mumford SL, Chen Z, Browne RW, Boyd Barr D, Kim S, et al. Lipid concentrations and semen quality: the LIFE study. *Andrology*. 2014; 2:408–415. [PubMed: 24596332]
34. Salonia A, Matloob R, Gallina A, Abdollah F, Sacca A, Briganti A, et al. Are Infertile Men Less Healthy than Fertile Men? Results of a Prospective Case-Control Survey. *Eur Urol*. 2009; 56:1025–1031. [PubMed: 19297076]
35. Jensen TK, Jacobsen R, Christensen K, Nielsen NC, Bostofte E. Good semen quality and life expectancy: a cohort study of 43,277 men. *American journal of epidemiology*. 2009; 170:559–565. [PubMed: 19635736]
36. Eisenberg ML, Li S, Behr B, Cullen MR, Galusha D, Lamb DJ, et al. Semen quality, infertility and mortality in the USA. *Human reproduction*. 2014; 29:1567–1574. [PubMed: 24838701]

Table 1

Baseline characteristics of men, LIFE Study (n=456).

Category	Characteristics	Mean(SD)	n(%)
Demographics	Age (Mean, SD)	31.8(4.9)	
	BMI (Mean, SD)	29.8(5.6)	
	White		384(77)
	College educated		454(91)
	Prior Paternity		225(48)
	Smoker		70(15)
Occupational	Night work		106(23)
	Rotating shifts		73(16)
	Vibration		105 (23)
	Noise		124(27)
	Extreme heat		98(21)
	Heavy exertion		145(32)
Health	Prolonged Sitting		224(49)
	High Cholesterol		76(16)
	Diabetes		14(3)
	High blood pressure		49(10)
		Median (IQR)	n (%)
Semen	Volume (mL)	3.25(2.2, 4.25)	
Parameters	Volume <1.5 ml		43(9)
	Concentration (million/mL)	61.75(36.7, 102.5)	
	Concentration <15 million/mL		40(8)
	Total sperm count (million)	195.3(108.05, 309.8)	
	Total sperm count <39 million		41(9)
	Morphology (% WHO normal)	30.5(21.75, 39)	
	WHO normal <30%		208(48)
	Morphology (% strict criteria)	20(13, 27)	
	strict criteria <4%		18(4)
	DNA (% fragmentation index)	12.44(8.5, 19.27)	
	fragmentation index 30%		34(7)

Table 2
Linear regression results for the association between baseline occupational and health factors and semen quality

Occupational/Health Factor	Volume (ml)	Concentration (M/ml)	Total Count (M)	WHO Morphology (%)	Strict Morphology (%)	DFI (%)	
Night work	Yes	3.4 (1.6)	82.4 (66.5)	250.4 (199)	29.9 (13.9)	19.8 (11)	14.5 (9.5)
	No	3.3 (1.5)	72.4 (51)	230.1 (179.3)	30.7 (11.9)	20.3 (9.6)	15.5 (10.7)
Rotating shifts	Yes	3.2 (1.5)	82.3 (67.4)	236.3 (189.8)	29.7 (13.5)	19.3 (10.8)	15.4 (9.8)
	No	3.4 (1.5)	73.2 (52.4)	234.1 (183.1)	30.6 (12.1)	20.3 (9.7)	15.3 (10.6)
Whole body vibration	Yes	3.1 (1.4)	78.6 (63.6)	227.7 (181)	30.8 (12.6)	20.2 (10)	13.5 (10)
	No	3.4 (1.5)	73.5 (52.2)	236.9 (184.8)	30.4 (12.3)	20.1 (9.9)	15.8 (10.5)
Noise	Yes	3.5 (1.6)	69.2 (58.9)	226.9 (193.3)	29.5 (12.2)	19.4 (9.7)	13.9 (9.3)
	No	3.3 (1.5)	76.9 (53.4)	238.3 (180.3)	30.9 (12.4)	20.4 (10)	15.8 (10.8)
Extreme heat	Yes	3.6 (1.6)	78.8 (67)	248.3 (198.1)	31 (13)	20.3 (10)	14.1 (9)
	No	3.3 (1.5)	73.6 (51.3)	231 (179.8)	30.4 (12.2)	20.1 (9.9)	15.6 (10.8)
Heavy exertion or lifting	Yes	3.3 (1.6)	68.1 (59.4)*	207.5 (179.2)*	30.1 (12.1)	19.7 (9.8)	14.9 (11.6)
	No	3.4 (1.5)	77.8 (52.7)*	247.4 (184.8)*	30.7 (12.5)	20.4 (10)	15.5 (9.9)
Prolonged sitting	Yes	3.3 (1.4)	76.4 (51.4)	241.5 (174.2)	31 (12.8)	20.7 (10.4)	15.7 (11.1)
	No	3.4 (1.6)	73 (58.3)	228.3 (192.8)	30.1 (11.9)	19.6 (9.5)	15 (9.8)
High cholesterol	Yes	3.1 (1.3)	79.9 (62.6)	239.1 (210.3)	29.2 (13.1)	19 (10.3)	16.7 (9.7)
	No	3.4 (1.6)	73.2 (52.9)	230.6 (176.4)	30.7 (12.3)	20.3 (9.9)	15 (10.5)
Diabetes	Yes	2.6 (1.4)	72.9 (57.6)	159.2 (116.9)	29.8 (10)	20 (8)	10.1 (5)*
	No	3.4 (1.5)	74.1 (54.3)	233.7 (182.5)	30.4 (12.5)	20.1 (10.1)	15.5 (10.4)*
High blood pressure	Yes	3 (1.5)	69.4 (57.8)	190.4 (193.7)	26.6 (13.1)	17.1 (10.2)	14.1 (7.9)
	No	3.4 (1.5)	75 (54.3)	236.9 (180.3)	30.9 (12.3)	20.5 (9.9)	15.5 (10.6)
Comorbidities (High BP, High Cholesterol, DM)	0	3.4 (1.6)	73.2 (51.7)	234.4 (172.5)	31 (12.4)	20.6 (10)	15.4 (10.8)
	1	3.1 (1.5)	80.2 (66)	237.7 (224.2)	28.8 (12.1)	18.6 (9.6)	15.1 (8.8)
	2+	2.9 (1.1)	69.4 (48.3)	176.1 (128.6)	27.9 (14.6)	18.5 (11.4)	15.4 (9.7)
Medications	0	3.3 (1.4)	78.8 (61.2)	253.1 (213.7)	29.7 (12.2)	19.7 (9.8)	15.9 (9.4)
	1+	3.4 (1.6)	72.2 (51)	222.5 (163.7)	30.9 (12.6)	20.3 (10.1)	15 (10.8)

* (indicates $p < 0.05$ for linear regression model adjusted for age, race, BMI, smoking status)

Table 3

Linear regression results for the association between baseline occupational and health factors and abnormal semen quality parameters.

Occupational/Health Factor	n	Volume <1.5 mL n(%)	Concentration <15M/mL n(%)	Total Count <39M n(%)	WHO Morphology <30% n(%)	Strict Morphology <4% n(%)	DFI (30%) n(%)
Night work							
Yes	106	13(12)	7(7)	8(8)	50(50)	6(6)	8(8)
No	350	28(8)	31(9)	30(9)	150(47)	10(3)	25(7)
Rotating shifts							
Yes	73	10(14)	6(8)	8(11)	34(48)	4(6)	6(8)
No	383	31(8)	32(8)	30(8)	166(48)	12(3)	27(7)
Whole body vibration							
Yes	105	12(11)	12(11)	13(12)	43(44)	3(3)	4(4)
No	352	29(8)	26(7)	25(7)	157(48)	13(4)	29(8)
Noise							
Yes	124	8(6)	13(10)	14(11)	57(51)	5(5)	8(7)
No	332	33(10)	24(7)	23(7)	143(46)	11(4)	25(8)
Extreme heat							
Yes	98	6(6)	6(6)	6(6)	42(45)	4(4)	5(5)
No	359	35(10)	32(9)	32(9)	158(48)	12(4)	28(8)
Heavy exertion or lifting							
Yes	145	14(10)	19(13)*	19(13)	66(51)	4(3)	9(6)
No	312	27(9)	19(6)*	19(6)	134(46)	12(4)	24(8)
Prolonged sitting							
Yes	224	17(8)	13(6)	12(5)	102(49)	7(3)	18(8)
No	233	24(10)	25(11)	26(11)	98(46)	9(4)	15(7)
High cholesterol							
Yes	76	7(9)	8(11)	8(11)	36(51)	3(4)	8(11)
No	396	36(9)	32(8)	33(8)	171(47)	15(4)	26(7)
Diabetes							
Yes	14	2(14)	3(21)	4(29)	6(46)	0(0)	0(0)
No	458	41(9)	37(8)	37(8)	202(48)	18(4)	34(8)
High blood pressure							
Yes	49	9(18)	9(18)*	9(18)	26(58)	5(11)*	3(6)
No	423	34(8)	31(7)*	32(8)	181(46)	13(3)*	31(8)
Comorbidities (High BP, High Cholesterol, DM)							
0	360	30(8)	26(7)	26(7)	153(46)	11(3)	25(7)
1	91	9(10)	9(10)	11(12)	44(52)	6(7)	7(8)
2+	22	4(18)	5(23)	4(18)	11(55)	1(5)	2(10)
Medications							
0	316	30(9)	25(8)	22(7)*	140(47)	13(4)	20(7)
1+	156	13(8)	15(10)	19(12)*	67(48)	5(4)	14(9)

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indicates p<.05 for logistic regression model adjusted for age, race, BMI, smoking status)
*

Table 4

Logistic regression results for the association between number of medications and abnormal semen parameters. (p values represent logistic regression model adjusted for age, race, BMI, smoking status)

Semen Parameter	Cutpoint	N(%)	Medications, mean (SD)	p
Volume	<1.5 mL	43(9)	0.9(1.5)	0.90
	1.5 mL	430(91)	0.6(1.2)	
Concentration	<15 M/mL	40(8)	0.9(1.5)	0.97
	15 M/mL	433(92)	0.6(1.2)	
Total Count	<39 M	41(9)	1.2(1.8)	0.02
	39 M	432(91)	0.6(1.2)	
WHO Morph	<30 %	208(48)	0.7(1.2)	0.94
	30 %	228(52)	0.6(1.2)	
Strict Morph	<4 %	18(4)	0.6(1)	0.72
	4 %	418(96)	0.6(1.2)	
DFI	30 %	34(7)	1.2(1.9)	0.03
	<30 %	425(93)	0.6(1.2)	