Original Article

Geographical distribution of semen quality parameters in men visiting tertiary care infertility centers across india: A retrospective study

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Abstract

Context: Male factor infertility is a growing concern globally, with recent trends suggesting a decline in sperm quality. This retrospective study aimed to investigate regional variations in sperm quality among infertile Indian men over a period of 4 years (2018–2021) to shed light on the prevalence and potential causes of male infertility in the country. **Aims:** The main objective of this study was to examine regional variations in sperm concentration, total sperm motility, sperm morphology, and the incidence of azoospermia among infertile Indian men seeking infertility evaluation. **Settings and Design:** This study was a retrospective analysis conducted at Indira IVF Private Limited. tertiary care facilities located throughout India. A total of 64,452 infertile male participants were included in the study. **Materials and Methods:** The participants seeking infertility treatment at the designated facilities provided semen samples, which were collected in a sterile wide-mouthed plastic container by masturbation. The samples were processed and examined as per the World Health Organization (WHO) guidelines for semen analysis. The geographical locations of the participants were used to categorize them into four zones: east, west, north, and south. **Statistical Analysis Used:** Basic descriptive statistics (means standard error) were computed for the study groups. Analysis of variance (ANOVA) was used for statistically comparing means across several study periods. Regression analysis was conducted using the Statistical Package for the Social Sciences (SPSS). **Results:** The study revealed statistically significant variations in sperm density, motility, and normal sperm morphology among the participants tested over the 4-year period. The mean sperm count was found to be 44.67 million/mL, sperm motility was 36.87%, and normal sperm morphology was 2.21%. Overall, 72.1% of the participants had abnormal semen quality parameters, indicating male factor infertility is attributable up to three fourth of causes in couple seeking treatment. The incidence of azoospermia varied significantly among the zones, with the East zone having the highest incidence (14.2%) and the South zone having the lowest (5.8%). **Conclusions:** This 4-year retrospective study provides evidence of declining sperm quality among infertile Indian men. The findings suggest regional variations in sperm parameters, indicating the importance of considering geographical differences when addressing male factor infertility. Further research is needed to identify the underlying causes and develop effective strategies to manage and treat male infertility.

Keywords: Male infertility, Sperm quality, Semen analysis, Regional variations, Male factor infertility, Azoospermia

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Submission: 3–08–2023, **Revised:** 6–09–2023, **Accepted:** 9–09–2023, **Published:** 30–September–2023

Access this article online	
Quick Response Code:	Website: www.fertilityscienceresearch.org
	DOI: 10.4103/fsr.fsr_31_23

How to cite this article: Bhoi NR, Chandra V, Murdia N, Murdia K, Aggrawal R, Shah N, Basant S, Salunkhe A, Suwalka I. Geographical distribution of semen quality parameters in men visiting tertiary care infertility centers across india: A retrospective study. Fertil Sci Res 2023;10:158-63.

Key Message

This study highlights the decline in sperm quality among infertile Indian men over 4 years and emphasizes the need to address male factor infertility on a regional basis. Understanding the geographical variations in sperm parameters can guide targeted interventions and further research into the factors affecting male fertility.

INTRODUCTION

Failure to achieve a clinical pregnancy after at least a year of regular, unprotected intercourse is considered infertility.[1] Recent trends suggest that male factor infertility accounts for nearly 35 to 40% of all infertility cases.[2] The public and the scientific community are both concerned about a global drop in sperm quality as numerous research reports have repeatedly been published, either supporting or refuting a compromise in sperm quality.[2–4] The pathogenesis of this decline is multifaceted, as any change to the normal physiology of the male reproductive organs may impair the spermatogenesis process, thereby giving rise to conditions such as oligozoospermia (low sperm count), asthenozoospermia (poor or loss of motility), teratozoospermia (abnormal morphology), and azoospermia (sperms absent from ejaculation).[3,5,6]

Various retrospective studies suggest a decrease in sperm concentration in some regions of the world, mainly due to dietary preferences and lifestyle habits.[7-10] The baseline sperm quality and functional parameters in fertile Indian men have been documented by World Health Organization (WHO),[11-14] but the study examining changes in sperm attributes in Indian men over time found no appreciable drop in sperm count from 1990 to 2000.[4] Given the large population density, diversity of the Indian population, disparities in meteorological conditions, and dietary preferences, it is important to determine whether a comparable trend is present across the many regions or zones of the same country.

AIM AND OBJECTIVE

The objective of this study was to examine the regional variations in sperm concentration, total sperm motility, sperm morphology, and incidence of azoospermia among males in India seeking infertility evaluation over 4 years.

MATERIAL AND METHODS

In addition to receiving signed analysis reports for their personal records, participants were required to give written consent for the inclusion of their analysis results in the study dataset. The study received approval from the Indira IVF Hospital Private Limited (IIHPL) Institutional Ethics Committee, ensuring adherence to ethical guidelines and patient confidentiality (ECR/1614/Inst/RJ/2021). Informed consent was not required in this study.

Subjects

The study was based on a retrospective examination of a total of 64,452 participants who had their semen analyzed at different centers of IIHPL between the years of 2018 and 2021 as part of the infertility evaluation.

We divided our tertiary infertility care centers located across India into four zones, i.e., east, west, north, and south zone, on the basis of geographical variations and demographic similarities. The centers are spread across a total of 21 states and the zone-wise categorization of those states is mentioned in Table 1.

Semen Analysis

The patients were requested to collect their semen samples in the semen collection room at the hospital in a sterile wide-mouthed plastic container by masturbation only and to report any instances of sample spillage during collection. Following liquefaction, semen was processed and examined as per WHO guidelines, 2010.[13,14] A graduated tube was used to calculate the seminal volume. Sefi Medical Instruments, Israel's Makler counting chamber or Shivani Scientific, India's Wonder Sperm counting chamber were used to measure the sperm concentration and expressed it in millions/mL. At least 100 sperm were examined for sperm motility, which was expressed as a percentage of motile sperm (sum of rapid progression plus slow progression sperm).[13] Diff-Quick kits were used to assess the sperm morphology.

Statistical Analysis

The study groups' basic descriptive statistics (means standard error) were computed. Analysis of variance (ANOVA) for normalcy distribution was used to statistically compare the means across several study periods. Statistical Package for the Social Sciences (SPSS) was used to do regression analysis. A Chi-square analysis of the incidence of azoospermia was done. Statistical significance was defined as a *P*-value of 0.05.

RESULTS

The findings revealed statistically significant variations in the seminal traits of the participants tested for 4 years, i.e.,

Table 1: Zone-wise Distribution of Different States across India

Variables	No of States	States
East	6	Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal
West	4	Gujarat, Madhya Pradesh, Maharashtra, Rajasthan
South	4	Andhra Pradesh, Karnataka, Tamil Nadu, Telangana
North	7	Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, Uttarakhand

between 2018 and 2021. These variations were particularly pronounced in sperm density, motility, and normal sperm morphology, as determined by the WHO criteria (2010).

In the 64,452 couples that were examined, we found that 72.1% of the male partners had aberrant semen parameters. The overall and zone-wise semen parameters trend during these 4 years has been elaborated in detail in Table 2.

Infertile men had a mean sperm density of 47.5 ± 26.8 million/mL (n = 11,268) in 2018, which was much higher than the average sperm density seen in 2020 (44.22 ± 27.32 million/mL) and 2021 (43.92 ± 29.92 million/mL).

The mean sperm count (44.67 ± 28.41), sperm motility (36.87 ± 24.16), and sperm morphological defects both showed a similar pattern during these successive years. The results revealed significant variations in seminal traits, with the mean sperm count being 44.67 million/mL, sperm motility at 36.87%, and sperm morphology at 2.21%. As per WHO guidelines, 80.9% had a normal sperm count, 43.4% had normal sperm motility, and 70% of the participants had normal sperm morphology (>4%). Overall, 72.1% of the participants had abnormal semen quality parameters (either of three parameters), contributing to three fourth of male factor infertility. In comparison to WHO guidelines (2010), 9.1% of samples were reported to be having azoospermia [Table 2].

Table 2 shows the highest mean sperm count was observed in the North zone (48.88 ± 26.53), whereas the lowest was in the South zone (37.92 ± 24.78).The East zone had the lowest mean sperm motility (36.37 ± 23.16), while the West zone had the highest (37.31 ± 25.54). The East zone had the lowest mean sperm morphology (1.85 ± 1.74), whereas the North zone had the highest (2.51 ± 1.67) of azoospermia (absence of sperm in ejaculate), the overall prevalence was 9.1%. Significant variations were observed among the zones ($P < 0.001$). The East zone had the highest incidence of azoospermia (14.2%), while the South zone had the lowest (5.8%).

Table 2: Distribution of Different Abnormal Sperm Parameters as per World Health Organization Guideline 2010

Variables	Total (N =64,452)
Age (mean ± SD)	36.06 ± 5.89
Sperm count (M/mL) (mean ± SD)	44.67 ± 28.41
Sperm motility (%) (mean ± SD)	36.87 ± 24.16
Sperm morphology (%) (mean ± SD)	2.21 ± 1.67
Azoospermia	5896 (9.1%)
Oligozoospermia	40 (0.1%)
Asthenozoospermia	1281 (2%)
Teratozoospermia	18,044 (28%)
Normozoospermia	17,972 (27.9%)
Others	21,219 (32.9%)
Normal sperm parameters (WHO Guidelines, 2010)	
Normal sperm count (M/mL)	52,165 (80.9%)
Normal motility (%)	27,944 (43.4%)
Normal morphology (%)	45,096 (70%)
Abnormal semen quality parameter (male factor)	46,480 (72.1%)

SD = standard deviation, WHO = World Health Organization.

Table 3 shows the univariate analysis which revealed a significant association between age groups and the odds of the event. The odds of having abnormal sperm parameters were found to be lower in the age group "≤30" compared to the higher age group. The year-wise analysis showed that in 2021, the odds ratio is 2.415, indicating a significant increase in the odds of having abnormal sperm parameter compared to 2018 (statistically significant with P-value <0.001). The odds ratio increases

Table 3: Zone-wise Distribution of Sperm Count, Motility, and Morphology.

Variables	Overall	Zones				P-value
		East	West	North	South	
Number of samples	64,452	13,924	22,199	3969	24,360	
Sperm count (M/mL) (mean ± SD)	44.67 ± 28.41	42.07 ± 30.2	42.9 ± 29.24	37.92 ± 24.78	48.88 ± 26.53	0.003
Sperm motility (%) (mean ± SD)	36.87 ± 24.16	36.37 ± 23.16	37.31 ± 25.54	36.9 ± 21.92	36.74 ± 23.78	<0.001
Sperm morphology (%) (mean ± SD)	2.21 ± 1.67	1.85 ± 1.74	2.1 ± 1.61	2.2 ± 1.37	2.51 ± 1.67	<0.001
Azoospermia	5896 (9.1%)	1983 (14.2%)	1883 (8.5%)	232 (5.8%)	1798 (7.4%)	<0.001

Table 4: Univariate Logistic Regression Analysis to Identify Independent Predictors of Male Factor Infertility.

Covariates	Univariate Analysis	
	Odds Ratio (95% CI)	*P*-value
Age Group	Reference	
≤30	0.937 (0.89–0.986)	0.012
31–35	0.953 (0.904–1.005)	0.073
36–40	1.076 (1.016–1.14)	0.012
>40	1.353 (1.332–1.374)	<0.001
Year		
Yearly trend in each zone separately		
East (year)	1.394 (1.346–1.444)	<0.001
West (year)	1.278 (1.243–1.313)	<0.001
South (year)	1.156 (1.073–1.246)	<0.001
North (year)	1.448 (1.413–1.484)	<0.001
Year		
2018	Reference	-
2019	1.107 (1.052–1.164)	<0.001
2020	1.456 (1.382–1.534)	<0.001
2021	2.415 (2.295–2.541)	<0.001
Zone wise trend		
East		
2018	Reference	-
2019	1.057 (0.946–1.182)	0.327
2020	1.211 (1.076–1.363)	0.002
2021	2.823 (2.514–3.169)	<0.001
West		
2018	Reference	-
2019	1.209 (1.105–1.323)	<0.001
2020	1.489 (1.358–1.634)	<0.001
2021	2.087 (1.91–2.281)	<0.001
South		
2018	Reference	-
2019	0.984 (0.748–1.294)	0.907
2020	0.853 (0.653–1.115)	0.245
2021	1.508 (1.149–1.981)	0.003
North		
2018	Reference	-
2019	1.127 (1.04–1.221)	0.003
2020	1.801 (1.66–1.954)	<0.001
2021	2.808 (2.592–3.042)	<0.001

with each passing year, indicating a rising trend in abnormal sperm parameters over passing year [Table 4].

DISCUSSION

This is the first study to examine the semen quality in a sizable population of Indian men from the length and breadth of the country.[14] Our data explicitly showed that the semen quality is declining over the last 4 years. Our results corroborate earlier reports that human semen quality appears to be diminishing globally.[1,2,15,16] To rule out bias, the protocol for semen analysis remained unchanged during the research period. Though we followed WHO 2010 guidelines for evaluating semen parameters (as the study duration was from 2018 to 2021), but we do have the opportunity to compare as per the new WHO 2021 criteria [Table 5].

Table 5: WHO Criteria.[31,32]

	WHO 2010	WHO 2021
Semen volume (mL)	1.5 (1.4–1.7)	1.4 (1.3–1.5)
Total sperm number (10^6 per ejaculate)	39 (33–46)	39 (35–40)
Total motility (%)	40 (38–42)	42 (40–43)
Progressive motility (%)	32 (31–34)	30 (29–31)

It may also be noted that the reason behind the decline in semen quality may be caused by unknown environmental, dietary, socioeconomic, or other factors.[1,2,9,11,20] Exogenous estrogenic chemicals can disrupt neonatal testicular development and lower adult men's sperm production when they are exposed to them *in utero*.[17-22] Crucially, our findings are in tandem with studies that cases of oligoasthenoteratozoospermia point to a qualitative impairment of spermatogenesis with a probable impairment of the sertoli cells.[23]

It is important to investigate population-based trends in semen quality over time as significant geographic and ethnic variance in semen quality has been observed by various researchers.[9,12,24-27] Earlier research has suggested a decline in the quality of semen in various regions of the world.[9-11,27-30] The baseline sperm concentration and motility for Indian men were reported to be 68.22 ± 15.14 million/mL and $40.95 \pm 9.15\%$, respectively.[12] A prior study that looked at infertile men in the northern region of India for 11 years failed to show any change in the quality of their semen.[4] The mean sperm count recorded in our study was 44.67 ± 28.41 millions/mL.[12] The motility, however, did not significantly change between the two trials, indicating a clear reduction in sperm concentration in India. The current study contains few drawbacks. Since the study's participants were infertile patients, they may not accurately represent the general population. Additionally, there is a lack of information on factors that may affect the quality of semen, such as occupation, smoking, eating habits, and stress levels. However, a lengthier study period may be affected by a variety of circumstances, such as changes in the laboratory staff, tools, and methodology over time. India has a highly diverse human population, making up about 25% of the world's population. It is crucial to evaluate the semen quality in various regions of the nation for additional confirmation of the claim due to the variety of environmental, nutritional, socioeconomic, and climatic aspects. Further studies using a large cohort of normal subjects with additional information on their occupation, socioeconomic condition, and lifestyle-related factors are warranted to confirm the findings of the current report. The significant time-related decline in semen quality

observed in this study has important implications for fertility.

A similar study from our neighboring countries like Pakistan and Nepal, found oligozoospermia to be the most common cause of infertility in males.[27] In a study done on the African population, literature reported that cases of asthenozoospermia were the most common. In our study, we reported that sperm motility was impacted in 36.87 ± 24.16% of the cases. According to some other literature,[28] the prevalence rate of azoospermic men was 10 to 20% which is in tandem with our observation, that is, 9.2%. However, this is now documented that even though sperm concentration or motility is good, a morphological defect may be the dominant factor reflecting the actual sperm fertilization capacity.[30] Variations seen in the results may be due to local ethnic differences, environmental factors, dietary disparity, socioeconomic factors, and evolving lifestyle factors.

Currently, very few management strategies and therapies are available to manage or treat male infertility. New strategies to determine the underlying cause of idiopathic infertility and treatment to reverse the disorders would be the game changers in addressing male factor infertility.

Strength

To our knowledge, our study represents a huge sample size across each corner of India.

Limitations

This was a hospital-based study including subjects who visited tertiary care hospitals; hence, the results cannot be extrapolated to the general population.

CONCLUSION

Though we could not find any significant regional variation in sperm quality parameters the declining trend was well-marked over time and the prevalence of azoospermia was found alarming.

Acknowledgment

Authors would like thank all the MIS team and other support team of Indira IVF Hospital Private Limited for data retrieval.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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