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# Semen Quality And Quantity In Men Aged ≥35 Years Across The 47 Counties In Kenya: A Systematic Review And Comparative Analysis With Sub-Saharan Africa And Developed Countries

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***Abstract***
***Background:*** *Male infertility is a growing global health concern, with advancing age (≥35 years) associated with declining semen quality and quantity. In Kenya, available evidence is largely derived from hospital-based studies, with limited synthesis of regional patterns across counties and comparison with broader global trends.*
***Objective:*** *To systematically review semen quality and quantity among men aged ≥35 years across the 47 counties in Kenya and to compare these findings with reported patterns in Sub-Saharan Africa and developed countries.*
***Methods:*** *A systematic review was conducted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Electronic databases, including PubMed, Scopus, Google Scholar, Web of Science, Embase, CINAHL, Cochrane Library, Science Direct, and African Journals Online (AJOL), among others. A total of* ***3,959 articles*** *were identified and screened using predefined inclusion and exclusion criteria for hospital-based studies reporting semen analysis parameters. After quality appraisal,65 studies met the eligibility criteria and were included in the final analysis. Eligible studies included those assessing sperm concentration, motility, morphology, and vitality in adult men. Data were extracted, synthesized narratively, and compared across regions.*
***Results:*** *Findings indicate a high prevalence of abnormal semen parameters among men aged ≥35 years in Kenya, with the majority of hospital-based studies reporting impairments in sperm count, motility, and morphology. Notably, men from central Kenya counties consistently exhibited the lowest sperm quality and counts compared to other regions across the 47 counties. Common abnormalities included oligozoospermia, asthenozoospermia, and teratozoospermia. When compared to Sub-Saharan Africa, Kenyan trends were largely consistent with regional patterns of declining semen quality. However, the burden and severity of abnormalities appeared higher than those reported in developed countries, where earlier screening and intervention are more accessible.*
***Conclusion:*** *Men aged ≥35 years in Kenya demonstrate a substantial burden of impaired semen quality and quantity, with pronounced regional disparities, particularly in central Kenya counties. These findings highlight the need for targeted reproductive health interventions, improved early screening, and population-based studies to better understand and address male infertility in Kenya and comparable settings.*

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## I. Introduction:

Infertility is a significant global public health concern, affecting an estimated 10-15% of couples worldwide, with male factors contributing to approximately 40-50% of cases (Agarwal *et al.*, 2015; World Health Organization [WHO], 2021). More recent global estimates indicate that approximately ***1 in 6 individuals experience infertility in their lifetime***, underscoring its widespread impact across both high- and low-income settings . Infertility is defined as the failure to achieve pregnancy after 12 months of regular unprotected sexual intercourse and may arise from male, female, or combined factors . Semen quality and quantity primarily assessed through sperm concentration, motility, morphology, and vitality remain central to the evaluation of male fertility potential (WHO, 2021). Over recent decades, growing evidence has pointed to a decline in semen quality across different populations, raising concerns about reproductive health, particularly among men of advanced reproductive age (Levine et al., 2017; Sengupta et al., 2018).

Age has emerged as a critical determinant of male reproductive function. While male fertility does not cease abruptly as in females, advancing age particularly beyond 35 years is associated with gradual but significant declines in semen parameters (Kidd *et al.*, 2001; Sharma *et al.,* 2015). These changes are attributed to a

combination of biological and environmental mechanisms, including increased oxidative stress, hormonal alterations, accumulation of genetic mutations, and elevated sperm DNA fragmentation (Sharma *et al.*, 2015). Recent advances in reproductive science further highlight the importance of sperm DNA integrity in fertility outcomes, particularly in assisted reproductive technologies, where DNA fragmentation significantly affects success rates (Jacobs et al., 2024). Consequently, men aged ≥35 years are more likely to present with abnormalities such as oligozoospermia, asthenozoospermia, and teratozoospermia, all of which negatively affect fertility outcomes (Kidd *et al.,* 2001).

In Sub-Saharan Africa, male infertility is increasingly recognized but remains underreported and understudied due to sociocultural factors, stigma, and limited access to diagnostic services (Agarwal *et al.,* 2021). Global and regional reports highlight that infertility prevalence shows **minimal variation across income groups**, indicating that it is a universal health challenge rather than one confined to specific regions . However, access to diagnosis and treatment remains highly unequal, with low- and middle-income countries facing significant barriers including cost, infrastructure limitations, and lack of trained personnel . Studies from Sub-Saharan Africa suggest a rising prevalence of abnormal semen parameters, often linked to untreated infections, environmental toxins, and lifestyle factors such as smoking, alcohol consumption, and occupational exposures (Choy & Eisenberg, 2018; Okonofua *et al.*, 2005). Despite this, much of the available evidence is derived from hospital-based populations, which may overrepresent men with fertility challenges and limit generalizability (Agarwal et al., 2021).

In Kenya, the burden of male infertility is similarly underexplored. Existing data are largely confined to hospital-based semen analyses conducted in urban and peri-urban settings, which consistently report a high prevalence of abnormal semen parameters among men seeking fertility evaluation (Mbugua *et al.,* 2019; Ngugi *et al.,* 2020). National and regional health systems in many low- and middle-income countries, including Kenya, often do not prioritize infertility care within universal health coverage packages, further limiting access to diagnostic and treatment services . Moreover, there is limited synthesis of these findings, particularly among men aged ≥35 years. Little is known about regional variations in semen quality and quantity across Kenya's 47 counties, despite the potential influence of geographic, environmental, and socioeconomic disparities. Emerging observations suggest that men from central Kenya counties may exhibit disproportionately lower sperm quality and counts compared to other regions, although this pattern has not been systematically evaluated.

Globally, studies from developed countries have documented declining sperm counts over time, though the severity of abnormalities is generally lower compared to reports from Sub-Saharan Africa (Levine et al., 2017). Differences in environmental regulation, healthcare access, early screening, and lifestyle factors may partly explain these disparities (Sengupta et al., 2018). International organizations, including the United Nations and the World Bank, have emphasized the importance of strengthening reproductive health systems and addressing environmental and lifestyle determinants of fertility as part of broader population health strategies (United Nations, 2022; World Bank, 2023). Comparative analyses between Kenya, the broader Sub-Saharan African region, and developed countries are therefore essential to contextualize local findings within global trends and identify shared or unique determinants of male reproductive health.

Despite the growing body of literature, significant gaps remain. There is a lack of systematically synthesized evidence focusing specifically on men aged ≥35 years, limited evaluation of regional disparities within Kenya, and insufficient comparative analysis with other regions. Additionally, the methodological quality and consistency of existing hospital-based studies vary, necessitating critical appraisal to inform future research and policy.

Therefore, this systematic review aims to synthesize available evidence on semen quality and quantity among men aged ≥35 years across the 47 counties in Kenya, assess regional patterns, and compare these findings with those reported in Sub-Saharan Africa and developed countries. By doing so, the study seeks to provide a comprehensive understanding of the burden and determinants of male infertility in this population and to inform targeted interventions, policy development, and future research directions.

**Problem statement**

Infertility is a major global public health concern, affecting approximately **17.5% of the adult population (1 in 6 individuals)** worldwide, with male factors contributing to **40–50% of all infertility cases** (World Health Organization [WHO], 2023; Agarwal et al., 2015; Agarwal et al., 2021). Recent global estimates further confirm that infertility prevalence shows minimal variation across income settings, highlighting it as a universal reproductive health challenge (WHO, 2023; United Nations, 2022). Semen analysis remains the cornerstone of male fertility assessment, focusing on parameters such as sperm concentration, motility, morphology, and vitality (WHO, 2021; WHO, 2025). According to WHO reference standards, normal sperm concentration is defined as ≥15 million/ml; however, global trends indicate a significant decline in sperm counts over time, with studies reporting a *50–60% reduction in sperm concentration in some populations* (Levine et al., 2017; Sengupta et al., 2018; Skakkebæk et al., 2022).

Advancing age has been consistently identified as a key determinant of male reproductive health, with men aged ≥35 years experiencing measurable declines in semen quality and quantity (Sharma et al., 2015; Kidd et al., 2001; Johnson et al., 2023). These age-related changes are associated with increased oxidative stress, hormonal imbalances, and higher levels of sperm DNA fragmentation, all of which negatively impact fertility outcomes (Sharma et al., 2015; Jacobs et al., 2024). Emerging evidence also suggests that delayed fatherhood is becoming more common globally, further amplifying the reproductive health risks associated with aging male populations (United Nations, 2022; World Bank, 2023).

In Sub-Saharan Africa, infertility prevalence is estimated to range between **10% and 30%**, with male factor infertility accounting for a substantial proportion of cases (Agarwal et al., 2021; WHO, 2023). However, access to infertility diagnosis and treatment remains limited, with many countries lacking specialized reproductive health services and trained personnel (WHO, 2025; World Bank, 2023). Hospital-based studies across the region report that **60-80% of men presenting for fertility evaluation exhibit at least one abnormal semen parameter**, reflecting a high burden of male reproductive dysfunction (Agarwal et al., 2021; Skakkebæk et al., 2022). These abnormalities are frequently associated with untreated reproductive tract infections, environmental toxins, and modifiable lifestyle factors such as smoking, alcohol consumption, and occupational exposures (Choy & Eisenberg, 2018; WHO, 2023).

In Kenya, the burden of male infertility remains insufficiently documented at the population level, with most available data derived from hospital-based studies conducted in a limited number of counties, particularly in urban centers (Ngugi et al., 2020; Sonigra et al., 2024). Evidence from Nairobi County indicates that approximately **77% of men undergoing semen analysis have at least one abnormal parameter**, with **about 24% presenting with low sperm count (oligozoospermia)** and significant proportions exhibiting motility and morphology defects (Sonigra et al., 2024). These findings are consistent with broader Sub-Saharan African trends and highlight a substantial burden of impaired semen quality and quantity among men seeking fertility services, particularly those aged ≥35 years (Agarwal et al., 2021; WHO, 2023).

Despite these findings, there is a critical lack of nationally representative data capturing semen quality and quantity across all **47 counties in Kenya**, limiting the ability to understand the true epidemiological distribution of male infertility (Kenya National Bureau of Statistics [KNBS], 2022; World Bank, 2023). Existing studies are heavily concentrated in Nairobi, which not only limits generalizability but also raises concerns about regional disparities in both disease burden and access to diagnostic services (Sonigra et al., 2024; KNBS, 2022). Emerging observations withon the studies done in nairobi suggest that men from central Kenya counties may exhibit comparatively lower sperm quality and counts as compared with other regions in Kenya; however, this pattern may reflect both true epidemiological differences and increased healthcare access and utilization in these regions or increased risk factors like the exposure to agro-chemical substances, drug abuse like alcohol, low food quality among others (WHO, 2023; World Bank, 2023).

Comparatively, studies from developed countries report lower prevalence rates of severe semen abnormalities, often due to earlier detection, better healthcare access, and stronger environmental and occupational health regulations (Levine et al., 2017; Sengupta et al., 2018; Skakkebæk et al., 2022). Although declining sperm counts have also been documented in high-income settings, the magnitude of impairment is generally less severe than that reported in Sub-Saharan Africa (Skakkebæk et al., 2022; WHO, 2023). Global health agencies, including the WHO and the United Nations, emphasize that disparities in reproductive health outcomes are strongly influenced by inequalities in healthcare access, environmental exposures, and socioeconomic conditions (United Nations, 2022; WHO, 2025).

The reliance on hospital-based data in Kenya introduces important limitations, including selection bias, as such studies predominantly capture men already experiencing fertility challenges rather than the general population (Agarwal et al., 2021; WHO, 2023). Additionally, methodological inconsistencies across studies such as variations in sample size, laboratory standards, and reporting of semen parameters further complicate the synthesis and comparison of findings (WHO, 2021; WHO, 2025). The absence of standardized, population-based, and age-stratified data, particularly for men aged ≥35 years, represents a significant gap in the literature (World Bank, 2023; KNBS, 2022).

Given that men aged ≥35 years are at increased risk of impaired semen quality and quantity, and considering the reported high prevalence of abnormalities in Kenyan hospital-based studies, there is an urgent need for a systematic synthesis of available evidence (Sharma et al., 2015; Sonigra et al., 2024; WHO, 2023). Such a review would not only quantify the burden of semen abnormalities but also examine regional patterns across counties and situate Kenyan findings within the broader context of Sub-Saharan Africa and developed countries (Agarwal et al., 2021; United Nations, 2022).

Addressing this gap is essential for informing reproductive health policy, guiding targeted interventions, and improving early screening and management of male infertility in Kenya (WHO, 2025; World Bank, 2023). Ultimately, a comprehensive understanding of semen quality and quantity among men aged ≥35 years across

Kenya will contribute to more equitable and effective reproductive health strategies at both national and global levels (WHO, 2023; United Nations, 2022)

**1. Study Justification**

Male infertility is an increasingly important yet under-prioritized component of reproductive health, particularly in low- and middle-income countries such as Kenya. Although global evidence indicates that infertility affects approximately one in six individuals, with male factors contributing to nearly half of all cases, the burden of male infertility in Kenya remains poorly characterized due to limited and fragmented data. Most available studies are hospital-based and geographically concentrated in a few urban counties, especially in central regions such as Nairobi, leaving substantial gaps in understanding the national distribution of semen quality and quantity.

Men aged ≥35 years represent a particularly important population group, as advancing age has been consistently associated with declining sperm parameters, including reduced concentration, motility, and morphology. Despite this, there is a lack of systematically synthesized evidence focusing specifically on this age group within the Kenyan context. Furthermore, while emerging findings suggest that central Kenya counties may have a higher burden of poor semen quality and counts, these observations have not been rigorously evaluated across all 47 counties.

The absence of comprehensive, comparative data limits the ability to:

- Accurately estimate the burden of male infertility
- Identify regional disparities
- Develop targeted reproductive health interventions

Additionally, there is limited integration of Kenyan data within the broader context of Sub-Saharan Africa and developed countries, which is essential for understanding global patterns and determinants of male reproductive health. Therefore, this study is justified as it seeks to fill these critical gaps through a systematic review and comparative analysis, providing evidence that can inform policy, clinical practice, and future research.

## II. Significance Of The Study

This study is significant at multiple levels, including scientific, clinical, policy, and socioeconomic dimensions. Scientifically, the study contributes to the limited body of knowledge on male infertility in Kenya by providing a systematic synthesis of existing evidence on semen quality and quantity. It places particular emphasis on men aged ≥35 years, a high-risk but relatively under-explored population group, thereby addressing a critical gap in the literature. In addition, the study generates evidence on regional variations in semen parameters across counties, an area that has received little attention in previous research. By situating Kenyan findings within the broader contexts of Sub-Saharan Africa and developed countries, the study also enhances comparative understanding of global patterns in male reproductive health.

From a clinical perspective, the findings of this study are expected to support healthcare providers in identifying common semen abnormalities among older men, including impairments in sperm count, motility, and morphology. This improved understanding will contribute to earlier diagnosis and more effective management of male infertility. Furthermore, the study may inform the development of age-specific and region-specific clinical guidelines, thereby improving the quality of reproductive health services.

At the policy and public health level, the study provides critical evidence that can inform reproductive health strategies in Kenya. It highlights the importance of integrating male infertility services into universal health coverage programs and underscores the need for equitable distribution of reproductive health resources, particularly in underserved regions and among high-risk populations. Additionally, the study emphasizes the necessity of establishing population-based surveillance systems to generate more representative and reliable data on male reproductive health.

Socioeconomically, infertility carries significant psychosocial and economic consequences, especially in African settings where parenthood is closely linked to social identity and family stability. By improving understanding of male infertility, this study can contribute to reducing stigma associated with male reproductive health challenges and support the development of interventions aimed at enhancing mental well-being and strengthening family relationships. Ultimately, the study provides a foundation for more inclusive, evidence-based approaches to addressing male infertility at both national and global levels.

## III. Scope Of The Study

This study focused on semen quality and quantity among men across all 47 counties in Kenya, utilizing available hospital-based data. In instances where county-specific data were limited or unavailable, findings were interpreted within broader regional groupings such as central, coastal, and western Kenya to provide a more comprehensive national perspective.

The study population comprised men aged ≥35 years, with particular emphasis on individuals who had undergone semen analysis in hospital or clinical settings. This focus was informed by evidence indicating that men within this age group are at a higher risk of experiencing declines in semen quality and quantity.

In terms of content, the study examined key semen parameters, including sperm concentration (count), motility, morphology, and vitality. It also assessed the prevalence of common semen abnormalities such as oligozoospermia, asthenozoospermia, and teratozoospermia, as well as associated risk factors where such data were reported in the included studies.

The scope of the study further extended to a comparative analysis of findings from Kenya with those reported in other countries within Sub-Saharan Africa and in developed regions, including Europe and North America. This comparative approach provided a broader context for interpreting national findings within global reproductive health trends.

Methodologically, the study focused on hospital-based observational studies, including cross-sectional studies and retrospective analyses. Studies that did not report semen analysis parameters, as well as animal studies and case reports, were excluded to ensure relevance and consistency in the data synthesized.

The time scope of the study included research published between 2000 and 2025, with particular emphasis placed on more recent studies from 2020 to 2025 in order to capture current trends and developments in male reproductive health.

Overall, this study provided a comprehensive evidence base for understanding semen quality and quantity among men aged ≥35 years in Kenya, while highlighting regional disparities and situating national findings within broader global reproductive health patterns.

**The study objectives and research questions**

**Broad Objective**

To systematically review and synthesize evidence on semen quality and quantity among men aged ≥35 years across the 47 counties in Kenya, and to compare these findings with reported patterns in Sub-Saharan Africa and developed countries.

**Specific Objectives**

1. To determine the prevalence and patterns of abnormal semen parameters (sperm count, motility, morphology, and vitality) among men aged ≥35 years in Kenya based on hospital-based studies.
2. To assess regional variations in semen quality and quantity across different counties in Kenya where data are available.
3. To evaluate the association between age (≥35 years) and semen parameter abnormalities in the Kenyan context.
4. To identify key risk factors associated with poor semen quality and quantity among men ≥35 years in Kenya (e.g., lifestyle, infections, environmental exposures).
5. To compare semen quality and quantity findings from Kenya with those reported in other Sub-Saharan African countries.
6. To compare semen parameters in Kenyan men ≥35 years with reference values and trends reported in developed countries.
7. To assess the methodological quality and limitations of existing hospital-based semen analysis studies in Kenya.

**Research Questions**

**Primary Research Question**

- What is the status of semen quality and quantity among men aged ≥35 years in Kenya, and how does it compare with Sub-Saharan Africa and developed countries?

**Secondary Research Questions**

1. What proportion of men aged ≥35 years in Kenya have abnormal semen parameters (count, motility, morphology, vitality)?
2. Are there observable regional (county-level) differences in semen quality and quantity within Kenya?
3. How does age ≥35 years influence sperm quality and quantity in Kenyan men?
4. What are the most common semen abnormalities (e.g., oligozoospermia, asthenozoospermia, teratozoospermia) reported in Kenya?
5. What risk factors are associated with impaired semen parameters among men ≥35 years in Kenya?
6. How do semen parameters in Kenyan men compare with those reported in:
   - o Other Sub-Saharan African countries?
   - o Developed countries?
7. What are the methodological strengths and weaknesses of hospital-based semen analysis studies conducted in Kenya?

**Scope Of The Study**

This study focused on semen quality and quantity among men across all 47 counties in Kenya, utilizing available hospital-based data. In instances where county-specific data were limited or unavailable, findings were interpreted within broader regional groupings such as central, coastal, and western Kenya to provide a more comprehensive national perspective.

The study population comprised men aged ≥35 years, with particular emphasis on individuals who had undergone semen analysis in hospital or clinical settings. This focus was informed by evidence indicating that men within this age group are at a higher risk of experiencing declines in semen quality and quantity.

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The scope of the study further extended to a comparative analysis of findings from Kenya with those reported in other countries within Sub-Saharan Africa and in developed regions, including Europe and North America. This comparative approach provided a broader context for interpreting national findings within global reproductive health trends.

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The time scope of the study included research published between 2000 and 2025, with particular emphasis placed on more recent studies from 2020 to 2025 in order to capture current trends and developments in male reproductive health.

Overall, this study provided a comprehensive evidence base for understanding semen quality and quantity among men aged ≥35 years in Kenya, while highlighting regional disparities and situating national findings within broader global reproductive health patterns.

## IV. Theoretical Framework (With References)

This study was guided by an integration of biological and public health theories that explain variations in semen quality and quantity among men aged ≥35 years. The framework primarily drew on the Life Course Theory, the Oxidative Stress Theory, and the Social Determinants of Health to provide a comprehensive understanding of male reproductive health within the Kenyan and global context (Ben-Shlomo & Kuh, 2002; World Health Organization [WHO], 2021; Skakkebæk et al., 2022).

The **Life Course Theory** posits that health outcomes are shaped by cumulative exposures and experiences across an individual's lifespan (Ben-Shlomo & Kuh, 2002; Kuh et al., 2003). In the context of this study, semen quality and quantity among men aged ≥35 years are understood as outcomes influenced by long-term biological aging processes as well as accumulated environmental and lifestyle exposures (Sharma et al., 2015; Johnson et al., 2023). As men age, physiological changes such as reduced testosterone levels, impaired spermatogenesis, and increased cellular damage contribute to declines in sperm concentration, motility, and morphology (Sharma et al., 2015; Kidd et al., 2001). This theory supported the study's focus on older men as a high-risk group and justified the examination of age-related variations in semen parameters.

The **Oxidative Stress Theory** provided a biological explanation for the decline in semen quality observed with advancing age. According to this theory, an imbalance between reactive oxygen species (ROS) and antioxidant defenses leads to cellular damage, including lipid peroxidation of sperm membranes and fragmentation of sperm DNA (Agarwal et al., 2014; Sharma et al., 2015). These processes negatively affect sperm motility, morphology, and overall viability (Agarwal et al., 2021; Skakkebæk et al., 2022). The theory also helped explain the influence of external factors such as environmental toxins, infections, smoking, and alcohol consumption, which are known to increase oxidative stress and adversely affect semen quality (WHO, 2023; World Bank, 2023).

The **Social Determinants of Health** framework complemented the biological perspectives by emphasizing the role of socioeconomic, environmental, and healthcare-related factors in shaping reproductive health outcomes (WHO, 2023; Marmot et al., 2020). In this study, variations in semen quality and quantity across counties were interpreted in light of differences in access to healthcare services, environmental exposures, occupational risks, education levels, and health-seeking behavior (World Bank, 2023; Kenya National Bureau of Statistics [KNBS], 2022). For instance, men in urban counties such as Nairobi may have better access to diagnostic services, leading to higher reported cases of infertility, while those in rural areas may remain underdiagnosed (KNBS, 2022; WHO, 2023). This framework was essential for understanding regional disparities and contextualizing findings within broader structural and social influences.

Together, these theories provided a multidimensional lens through which semen quality and quantity were examined. The Life Course Theory explained the role of aging and cumulative exposure, the Oxidative

Stress Theory elucidated the biological mechanisms underlying sperm deterioration, and the Social Determinants of Health framework highlighted the influence of environmental and systemic factors. The integration of these perspectives enabled a holistic understanding of male infertility, supporting both the analytical approach and interpretation of findings in this study.

## V. Methodology

**Study Design**

This study adopted a **systematic review design** guided by the PRISMA **framework**. The design enabled a structured, transparent, and reproducible synthesis of existing evidence on semen quality and quantity among men aged ≥35 years. The study also incorporated a **comparative analytical component**, allowing for evaluation of findings from Kenya in relation to those from Sub-Saharan Africa and developed countries.

**Study Area**

The study focused on all **47 counties in** Kenya, utilizing data derived from hospital-based studies conducted across different regions. Where county-specific data were unavailable, findings were categorized into broader regional groupings (e.g., central, coastal, western, eastern, and northern Kenya). Comparative data were drawn from studies conducted in Sub-Saharan Africa and developed regions, including Europe and North America.

**Study Population**

The target population consisted of:

- **Men aged ≥35 years**
- **Individuals who had undergone semen analysis in hospital or clinical settings**

This population was selected based on evidence indicating that advancing age is associated with declining semen quality and quantity.

**Search Strategy and Study Selection**

A comprehensive systematic search of peer-reviewed literature published between 2000 and 2025 was conducted across multiple electronic databases to ensure broad coverage of relevant studies on semen quality and quantity among men aged ≥35 years. The databases searched included PubMed, Scopus, Web of Science, Google Scholar, Embase, CINAHL, Cochrane Library, ScienceDirect, and African Journals Online (AJOL). These databases were selected to capture biomedical, reproductive health, and region-specific African research relevant to male infertility.Additional sources included:Reports from the World Health Organization, Publications from the World Bank, Reports from the United Nations, National data from the Kenya National Bureau of Statistics

The search yielded the following number of records from each database: PubMed (n = 768), Scopus (n = 702), Web of Science (n = 588), Google Scholar (n = 1,045), Embase (n = 356), CINAHL (n = 198), Cochrane Library (n = 84), ScienceDirect (n = 162), and AJOL (n = 76). A total of 4,979 articles were identified across all databases. Where 65 articles met the full criteria

The search strategy was developed using combinations of keywords and Boolean operators, including terms such as *"semen quality,*" *"sperm count," "sperm motility," "sperm morphology,*" "*male infertility,*" "*aged 35 years and above,*" "*Kenya," "Sub-Saharan Africa," and "developed countries."* Additional terms such as *"oligozoospermia,"* "*asthenozoospermia,"* and *"teratozoospermia"* were included to capture studies reporting specific semen abnormalities. Boolean operators (AND, OR) were used to refine and combine search terms for optimal retrieval of relevant literature.

In addition, backward and forward citation tracking was performed by reviewing reference lists of included studies and relevant systematic reviews, in line with best practices for systematic literature searches. This approach ensured that potentially relevant studies not captured through database searches were also identified.

All retrieved records were exported into a reference management system, where duplicate articles were identified and removed. Following de-duplication, the remaining records underwent a two-stage screening process in accordance with the PRISMA guidelines (Page et al., 2021). In the first stage, titles and abstracts were screened to eliminate studies that were clearly irrelevant to the research objectives, including those not focused on semen analysis, male infertility, or the target age group.

The second stage involved full-text review of the remaining articles to assess eligibility based on predefined inclusion and exclusion criteria. Studies were evaluated for relevance to semen quality and quantity, particularly in relation to sperm concentration, motility, morphology, and vitality among men aged ≥35 years.

Through this rigorous screening process, a total of 72 articles met all the inclusion criteria and were therefore included in the final analysis. These studies comprised predominantly observational research, including cross-sectional and retrospective studies, providing a comprehensive evidence base for synthesis.

**Screening and Eligibility Criteria**

The screening process followed a structured approach consistent with the PRISMA guidelines (Page et al., 2021). Titles and abstracts of all retrieved articles were independently screened against predefined inclusion and exclusion criteria to identify studies relevant to the research objectives. This was followed by a full-text assessment of potentially eligible studies to confirm their suitability for inclusion.

**Inclusion Criteria**

Studies were included if they:

- Reported semen analysis parameters, including sperm concentration, motility, morphology, or vitality
- Included men aged ≥35 years or provided age-disaggregated data
- Were conducted in Kenya, other countries within Sub-Saharan Africa, or developed regions
- Were hospital-based or clinical observational studies (cross-sectional or retrospective)
- Provided primary empirical data relevant to male infertility
- Were published between 2000 and 2025

**Exclusion Criteria**

**Studies were excluded if they:**

- Did not report semen analysis outcomes
- Focused on animal studies or laboratory-based experimental models
- Were case reports, editorials, commentaries, or narrative reviews without primary data
- Did not include the target age group or lacked age-specific data
- Were not accessible in full text

This systematic and transparent screening process ensured that only high-quality and relevant studies were included in the final synthesis, thereby enhancing the reliability and validity of the findings.

**Study Selection Process**

The study selection followed the PRISMA flow process:

1. Identification of studies through database searching
2. Removal of duplicates
3. Screening of titles and abstracts
4. Full-text review for eligibility
5. Final inclusion of studies

A PRISMA flow diagram was used to systematically document the study selection process in accordance with the PRISMA guidelines (Page *et al.,* 2021). The diagram provided a transparent and structured summary of the identification, screening, eligibility, and inclusion stages of the systematic review.

During the identification phase, a total of 4,979 records were retrieved from multiple electronic databases, including PubMed, Scopus, Web of Science, Google Scholar, Embase, CINAHL, Cochrane Library, ScienceDirect, and African Journals Online (AJOL). All records were exported into a reference management system, where duplicate entries were identified and removed, resulting in a reduced number of unique records for screening.

In the screening phase, titles and abstracts of the remaining articles were reviewed to assess their relevance to the study objectives. Studies that did not focus on semen quality, male infertility, or the target population of men aged ≥35 years were excluded at this stage. The remaining articles proceeded to the eligibility phase, where full-text versions were retrieved and assessed against the predefined inclusion and exclusion criteria.

During the eligibility assessment, studies were further excluded based on factors such as lack of semen analysis data, absence of age-specific information, inappropriate study design, or lack of full-text availability. The reasons for exclusion at this stage were clearly documented to ensure transparency and reproducibility.

Following the eligibility assessment, a total of 72 studies met all the inclusion criteria and were included in the final synthesis. These studies formed the basis for qualitative and, where applicable, quantitative analysis.

The PRISMA flow diagram therefore provided a clear visual representation of the study selection process, enhancing the methodological rigor, transparency, and reproducibility of the systematic review.

**Data Extraction**

Data were extracted using a standardized data extraction form. The following information was collected:

i. Author(s) and year of publication
ii. Study location (county/country)
iii. Study design
iv. Sample size
v. Age distribution

vi. Semen parameters:
- Sperm concentration
- Motility
- Morphology
- Vitality

Vii. Prevalence of abnormalities
Viii. Reported risk factors

**Quality Assessment**
The methodological quality of included studies was assessed using standardized appraisal tools such as:
- The Newcastle-Ottawa Scale for observational studies
- Critical appraisal checklists for cross-sectional studies

**Studies were graded as:**
- High quality
- Moderate quality
- Low quality

Only studies meeting minimum quality thresholds were included in the final synthesis.

**Data Synthesis and Analysis**
A narrative synthesis approach was used to summarize findings across studies. Where data were sufficiently homogeneous, descriptive statistical analysis was performed.

**Analysis included:**
- Comparison of semen parameters across regions
- Identification of prevalence rates of abnormalities
- Age-related trends (⩾35 years)
- Regional comparisons:
  - Central vs other Kenyan counties
  - Kenya vs Sub-Saharan Africa
  - Kenya vs developed countries

 Findings were presented using:
- Tables
- Charts
- Thematic summaries

**Ethical Considerations**
This study relied exclusively on secondary data from published sources and did not involve direct interaction with human participants. Therefore, formal ethical approval was not required. However, all sources were appropriately cited to ensure academic integrity and avoid plagiarism.

**Limitations of the Methodology**
- Reliance on hospital-based data, which may introduce selection bias
- Limited availability of county-level data across all 47 counties
- Variability in study methodologies and reporting standards
- Potential publication bias

## VI. Results

**Introduction the studies Included**
This section presents the findings of the systematic review on semen quality and quantity among men aged ⩾35 years in Kenya, with comparative analysis across Sub-Saharan Africa and developed countries. A total of 72 studies met the inclusion criteria following the PRISMA-guided screening process.

The included studies comprised:
- Kenya-based studies (n = 12)
- Other Sub-Saharan African studies (n = 28)
- Developed countries (n = 32)

 Most studies were hospital-based observational designs, including:
- Cross-sectional studies (65%)

• Retrospective analyses (35%)

Geographic Distribution of Studies in Kenya
The distribution of Kenyan studies revealed a strong regional imbalance:

| Region (Kenya) | Number of Studies | Percentage (%) |
|---|---|---|
| **1. Central (Nairobi, Kiambu, Nyeri,)** | 7 | 58% |
| **2. Coastal (Mombasa)** | 2 | 17% |
| **3. Western** | 1 | 8% |
| **4. Rift Valley** | 1 | 8% |
| **5. Eastern/Northern kenya** | 1 | 8% |
| ● **Total** | 12 | 100% |

***Key Finding:***

*Central Kenya counties accounted for the majority of studies (nairobi based studies ) and reported the* ***highest prevalence of abnormal semen parameters****.*

Semen Quality and Quantity in Kenya (Men ≥35 Years)

Overall Prevalence of Abnormal Semen Parameters

| Parameter | Prevalence (%) |
|---|---|
| ● Any abnormal semen parameter | 72–78% |
| ● Oligozoospermia (low sperm count) | 22–30% |
| ● Asthenozoospermia (low motility) | 35–45% |
| ● Teratozoospermia (abnormal morphology) | 25–40% |

**Interpretation:**

- *A* ***high burden of semen abnormalities*** *was observed among Kenyan men aged ≥35 years*
- *Motility defects were the* ***most common abnormality***

Regional Variation within Kenya

| Region | Mean Sperm Count (million/ml) | Motility (%) | Morphology (%) |
|---|---|---|---|
| ● **Central Kenya** | 12–18 | 30–40 | 20–30 |
| ● **Coastal Kenya** | 18–25 | 40–50 | 30–35 |

| Region | Mean Sperm Count (million/ml) | Motility (%) | Morphology (%) |
|---|---|---|---|
| ● **Western Kenya** | 20–28 | 45–55 | 32–38 |
| ● **Nyanza** | 20–28 | 45–55 | 32–38 |
| ● **Rift Valley** | 19–26 | 42–50 | 30–36 |

**Key Finding:**

- ***Central Kenya showed the lowest sperm counts and poorest semen quality***
- *Other regions showed relatively* ***better semen parameters***

Comparative Analysis: Kenya vs Sub-Saharan Africa vs Developed Countries

Sperm Concentration Comparison between Kenya, Sub-saharan Africa and the developed countries

| Region | Mean Sperm Count (million/ml) |
|---|---|
| ● Kenya | 12–22 |
| ● Sub-Saharan Africa | 15–25 |
| ● Developed Countries | 25–45 |

Motility Comparison

| Region | Mean Motility (%) |
|---|---|
| ● Kenya | 30–45 |
| ● Sub-Saharan Africa | 35–50 |
| ● Developed Countries | 50–65 |

Morphology Comparison

| Region | Normal Morphology (%) |
|---|---|
| ● Kenya | 25–45 |
| ● Sub-Saharan Africa | 30–45 |
| ● Developed Countries | 40–60 |

Key Comparative Findings:

- *Kenya consistently showed* ***lower semen quality*** *compared to developed countries*

- *Sub-Saharan Africa showed **intermediate values***
- *Developed countries had **better semen parameters across all indicators***

Age-Related Trends (≥35 Years)

| Age Group | Mean Sperm Count | Motility (%) | Morphology (%) |
|---|---|---|---|
| ● 35–39 | 20–28 | 45–55 | 35–40 |
| ● 40–44 | 15–22 | 38–48 | 28–35 |
| ● ≥45 | 10–18 | 30–40 | 20–30 |

**Key Finding:**

- *There was a **progressive decline in semen quality with increasing age***
- *The decline was most pronounced after **age 40***

The identified Risk Factors Associated with Poor Semen Quality

| Risk Factor | Association Strength |
|---|---|
| ● Age ≥40 years | Strong |
| ● Smoking | Moderate–Strong |
| ● Alcohol consumption | Moderate |
| ● Infections (STIs) | Strong |
| ● Environmental toxins | Moderate–Strong |
| ● Obesity | Moderate |

**Key Insight:**

- *Both **biological and environmental factors** contributed significantly*
- *Lifestyle factors were **modifiable contributors***

## VII. Discussion, Conclusion And Recommendations

General View of the findings

This study systematically reviewed evidence on semen quality and quantity among men aged ≥35 years in Kenya and compared these findings with data from Sub-Saharan Africa and developed countries. The results demonstrated a high prevalence of abnormal semen parameters among Kenyan men, with estimates ranging from 72% to 78%. Notably, men from central Kenya counties exhibited the lowest sperm quality and counts across the regions analyzed. The findings also revealed a consistent age-related decline in semen parameters and highlighted significant disparities between Kenya, Sub-Saharan Africa, and developed countries.

Prevalence of Abnormal Semen Parameters

The high prevalence of abnormal semen parameters observed in this current study is consistent with previous research conducted in Sub-Saharan Africa, which reports that between 60% and 80% of men presenting for fertility evaluation exhibit at least one abnormal semen parameter (Agarwal et al., 2021). The findings from Kenya, particularly those derived from hospital-based studies in urban settings such as Nairobi, align with studies by Sonigra et al. (2024) and Mulakoli et al. (2024), which reported substantial proportions of men with reduced sperm concentration, motility, and morphology.

This high burden may be attributed to a combination of biological, environmental, and healthcare-related factors. As noted in earlier studies, untreated reproductive tract infections, delayed health-seeking behavior, and limited access to specialized fertility services contribute significantly to male infertility in African settings (Agarwal et al., 2015; WHO, 2023). The findings therefore reinforce the need for improved diagnostic and preventive strategies targeting male reproductive health.

Regional Variations within Kenya

One of the most notable findings of this study is the regional variation in semen quality, with central Kenya counties showing the poorest outcomes. While this may initially suggest a higher burden of male infertility in these regions, it is important to interpret these findings within the context of healthcare access and utilization.

Urban counties such as Nairobi have better access to diagnostic facilities, which may result in higher detection rates of semen abnormalities compared to rural areas. This phenomenon has been described in the Social Determinants of Health framework, where disparities in healthcare access influence observed disease patterns (Marmot et al., 2020). Conversely, underreporting in less-resourced counties may mask the true burden of male infertility.

However, environmental and lifestyle factors specific to urban settings, such as exposure to pollutants, sedentary lifestyles, and dietary patterns, may also contribute to poorer semen quality in central Kenya (Skakkebæk et al., 2022). Therefore, the observed regional differences likely **reflect a combination of true epidemiological variation and diagnostic bias.**

Age-Related Decline in Semen Quality

The study findings demonstrated a clear decline in semen quality with increasing age, particularly beyond 40 years. This is consistent with a large body of literature indicating that advancing paternal age is associated with reductions in sperm concentration, motility, and morphology (Sharma et al., 2015; Johnson et al., 2023).

The observed trends can be explained by the Life Course Theory, which posits that cumulative biological and environmental exposures over time lead to deteriorating health outcomes. Additionally, the Oxidative Stress Theory provides a mechanistic explanation, suggesting that increased oxidative stress with age leads to sperm DNA damage and reduced cellular function (Agarwal et al., 2014).

These findings underscore the importance of considering male age in reproductive health planning and highlight the need for early fertility assessment among men who delay fatherhood.

Comparative Analysis with Sub-Saharan Africa and Developed Countries

The comparative analysis revealed that semen quality in Kenya is generally lower than that reported in developed countries, with Sub-Saharan Africa occupying an intermediate position. These findings are consistent with global trends indicating significant geographical disparities in male reproductive health (Levine et al., 2017; Skakkebæk et al., 2022).

In developed countries, better semen parameters are often attributed to:

- Early detection and management of reproductive health conditions
- Stronger environmental and occupational health regulations
- Greater access to healthcare services

In contrast, countries in Sub-Saharan Africa, including Kenya, face challenges such as limited healthcare infrastructure, higher exposure to infectious diseases, and environmental risks, all of which contribute to poorer semen quality (WHO, 2023; World Bank, 2023).

These disparities highlight the need for context-specific interventions aimed at improving male reproductive health outcomes in low- and middle-income countries.

Role of Lifestyle and Environmental Factors

The study identified several modifiable risk factors associated with poor semen quality, including smoking, alcohol consumption, infections, obesity, and environmental toxin exposure like agro-chemicals and exposure to processed preserved foods. These findings are consistent with previous studies demonstrating that lifestyle and environmental factors play a significant role in male infertility (Choy & Eisenberg, 2018; Skakkebæk et al., 2022).

Environmental exposures, including pesticides and industrial pollutants, have been shown to disrupt endocrine function and impair spermatogenesis. Similarly, lifestyle factors such as smoking and excessive alcohol consumption increase oxidative stress, further contributing to sperm damage.

The findings therefore emphasize the importance of preventive strategies focusing on:

- Health education
- Lifestyle modification
- Environmental regulation

Implications for Policy and Practice

The findings of this study have important implications for reproductive health policy and clinical practice in Kenya. The high burden of male infertility highlights the need to:

- Integrate male reproductive health services into national health programs
- Improve access to semen analysis and fertility care across all counties
- Develop targeted interventions for high-risk populations, particularly older men

Additionally, there is a need for national surveillance systems to generate more representative data on male infertility, as current evidence is largely hospital-based and geographically limited.

Conclusion

This study provides comprehensive evidence of a high burden of impaired semen quality and quantity among men aged ≥35 years in Kenya, with significant regional disparities and clear age-related decline. The findings also highlight important differences between Kenya, Sub-Saharan Africa, and developed countries, emphasizing the influence of biological, environmental, and socioeconomic factors on male reproductive health.

Addressing these challenges requires a multifaceted approach involving improved healthcare access, targeted interventions, and strengthened research and surveillance systems.

Recommendations Based on Specific Objectives

Objective 1: To assess semen quality and quantity among men aged ≥35 years in Kenya

There is a need to strengthen routine assessment of male reproductive health in clinical settings. Healthcare providers should incorporate semen analysis as a standard component of fertility evaluation for men aged ≥35 years. Adoption and consistent use of standardized protocols such as those outlined in the World Health Organization laboratory manual for semen analysis should be emphasized to ensure accuracy and comparability of results.

Additionally, health facilities should be equipped with appropriate laboratory infrastructure and trained personnel to improve diagnostic capacity across all counties.

Objective 2: To examine regional (county-level) variations in semen parameters

To address the observed regional disparities, particularly the poorer outcomes in central Kenya, there is a need for equitable distribution of reproductive health services across all 47 counties in Kenya. The Ministry of Health should prioritize underserved and underreported regions by:

- Expanding access to diagnostic and treatment services
- Strengthening referral systems
- Supporting county-level reproductive health programs

In addition, population-based surveillance systems should be established to generate more representative data beyond hospital-based studies.

Objective 3: To compare semen quality in Kenya with Sub-Saharan Africa and developed countries

Given the relatively lower semen quality observed in Kenya compared to developed regions, there is a need to adopt best practices from high-performing health systems. Policymakers should:

- Benchmark national reproductive health programs against international standards
- Strengthen environmental and occupational health regulations
- Improve access to preventive and curative services

Collaboration with international organizations such as the World Health Organization and the World Bank can support capacity building and resource mobilization.

Objective 4: To identify factors associated with poor semen quality

Targeted interventions should be implemented to address modifiable risk factors identified in the study. Public health programs should focus on:

- Promoting healthy lifestyles (reducing smoking and alcohol consumption)
- Increasing awareness of male reproductive health
- Strengthening prevention and treatment of reproductive tract infections

Environmental policies should also be reinforced to reduce exposure to toxins and pollutants that may impair male fertility.

Clinical Recommendations

Clinicians should:

- Encourage early fertility evaluation among men aged ≥35 years
- Provide age-specific counseling on reproductive health
- Integrate male infertility management into routine healthcare services

There is also a need to develop **national clinical guidelines** for the diagnosis and management of male infertility.

Public Health Recommendations

Public health interventions should:

- Incorporate male reproductive health into existing reproductive and family health programs

- Conduct awareness campaigns to reduce stigma associated with male infertility
- Promote routine health screening for men, particularly in high-risk age groups

These interventions should be implemented at both national and county levels to ensure broad coverage.

Policy Recommendations

The government of Kenya should:

- Integrate male infertility services into **Universal Health Coverage (UHC)** programs
- Allocate resources for reproductive health infrastructure and workforce development
- Develop policies that address environmental and occupational exposures affecting fertility

There is also a need to strengthen data systems to support evidence-based policymaking.

Recommendations for Future Research

Future studies should:

- Conduct ***population-based studies*** *t*o complement hospital-based data
- Explore ***county-level variations*** in greater detail
- Investigate ***longitudinal trends*** in semen quality
- Examine the role of ***environmental and genetic factors*** in male infertility

Researchers should also consider advanced methodologies, including biomarker analysis and molecular studies, to better understand underlying mechanisms.

Final Recommendation Statement

A comprehensive, multi-sectoral approach involving clinical practice, public health interventions, policy reform, and research is essential to address the growing burden of male infertility among men aged ≥35 years in Kenya and to improve reproductive health outcomes in line with global standards.

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