World Journal of Urology (2026) 44:305
https://doi.org/10.1007/s00345-026-06391-4

REVIEW

Vardenafil in the multidisciplinary management of erectile dysfunction: a narrative review on multidimensional outcomes and clinical integration

Jiedong Zhou[1] · Shian Hu[1] · Yong Ouyang[1] · Yucheng Kong[1] · Min Liu[1,2]

Received: 16 November 2025 / Accepted: 30 March 2026
© The Author(s) 2026

Abstract

Background Erectile dysfunction (ED) is a multifactorial condition that often indicates underlying systemic disorders. Among phosphodiesterase type 5 inhibitors (PDE5is), vardenafil has pharmacological properties that may provide advantages in certain clinical situations.

Objective This narrative review aims to synthesize current evidence on the pharmacological mechanisms, clinical efficacy, and future research directions of vardenafil in the multidisciplinary treatment of ED.

Methods A comprehensive literature search was conducted in PubMed, Web of Science, and Embase for studies published between January 2019 and March 2025, focusing on vardenafil's pharmacology, clinical efficacy, and its integration with other therapeutic modalities (endocrine, psychological, lifestyle, cardiovascular). Relevant randomized controlled trials, cohort studies, and key mechanistic studies were reviewed. Due to the heterogeneity of the available evidence, a narrative synthesis was performed to summarize findings across different intervention domains.

Results Evidence indicates that vardenafil demonstrates favorable short-term efficacy across various etiologies of ED. Quantitative data from included studies (summarized in Table 1) support its efficacy as monotherapy and suggest synergistic benefits when combined with testosterone replacement therapy, psychological interventions, lifestyle modifications, and cardiovascular risk management. However, heterogeneity in sample sizes, follow-up durations, and outcome measures limits the robustness of the current evidence.

Conclusions Vardenafil represents a valuable treatment option within multidisciplinary management strategies for ED, particularly when its pharmacokinetic profile aligns with patient needs and preferences. High-quality, long-term randomized trials are necessary to determine optimal combination protocols, treatment duration, and long-term safety, with particular emphasis on precision dosing and biomarker-guided interventions.

Keywords Erectile dysfunction · Vardenafil · Multidisciplinary treatment · PDE5 inhibitors · Precision medicine

Introduction

Erectile dysfunction (ED) is highly prevalent among men worldwide, with its incidence increasing significantly with age. The estimated prevalence is 30–40% in men over 40 years old and exceeds 50% in those over 70; some studies report rates as high as 71.2% among men aged 71–80 [39, 46]. ED is not merely a sexual disorder but also an early manifestation and independent risk marker of systemic conditions such as cardiovascular disease, diabetes, metabolic syndrome, and depression, reflecting broader changes in general health [17, 70]. Moreover, men with ED have a significantly increased risk of major adverse cardiovascular

✉ Min Liu
13879787985@163.com

[1] The First Affiliated Hospital of Gannan Medical University, Ganzhou, China

[2] Department of Urology, the First Affiliated Hospital of Gannan Medical University, Zhanggong District, Ganzhou 341000, Jiangxi Province, China

Published online: 13 April 2026

events, including coronary artery disease, stroke, and all-cause mortality. ED frequently precedes the clinical onset of cardiovascular disease [3].

PDE5 inhibitors are widely recommended in international guidelines as first-line pharmacotherapy for ED due to their efficacy and tolerability. As a member of this drug class, vardenafil exhibits pharmacological characteristics—including a relatively rapid onset of action and minimal interaction with food—that may offer advantages in specific clinical scenarios, making it among other PDE5 inhibitors, a viable first-line therapeutic option for specific patient profiles [5]. However, the complex and heterogeneous mechanisms underlying ED often necessitate more than a single therapeutic approach. Consequently, increasing emphasis has been placed on multidisciplinary treatment, involving collaboration among specialists in urology, endocrinology, cardiology, psychiatry, psychology, and rehabilitation specialists [18, 23]. This holistic strategy addresses the physiological, psychological, and social dimensions of ED, thereby improving treatment outcomes and quality of life.

While numerous reviews discuss PDE5 inhibitors, most treat these agents as a homogeneous category and do not differentiate the distinctive pharmacokinetic and pharmacodynamic properties of vardenafil—such as its rapid onset, minimal food interactions, and superior selectivity for PDE5 [5]. Additionally, evidence supporting its integration within a multidisciplinary framework remains fragmented and inconsistent, and no review has comprehensively synthesized data across pharmacology, endocrinology, psychology, lifestyle medicine, andular disciplines [12].

The present review aims to address this gap by systematically summarizing current data on the pharmacological properties, clinical efficacy, and multidisciplinary applications of vardenafil. Additionally, we propose a conceptual framework for evidence-based, individualized therapy that more accurately reflects the complexity of real-world erectile dysfunction populations.

Research questions:

1. Within a multidisciplinary treatment model, does combination therapy involving vardenafil (e.g., combined with testosterone replacement or psychological interventions) improve erectile function scores and quality of life compared to monotherapy?
2. Compared to other PDE5 inhibitors (e.g., sildenafil, tadalafil), does vardenafil offer unique advantages for specific erectile dysfunction subgroups, such as patients with diabetes mellitus or those with post-prostatectomy ED?

Methods

This narrative review is based on a comprehensive literature search conducted in PubMed, Web of Science, and Embase for articles published between January 1, 2019, and March 31, 2025. The search strategy combined terms related to "erectile dysfunction," "vardenafil," "PDE5 inhibitors," and relevant therapeutic modalities, including endocrine (e.g., testosterone), psychological, lifestyle, and cardiovascular interventions.

Studies were considered eligible if they: (1) involved adult men diagnosed with erectile dysfunction; (2) evaluated vardenafil alone or in combination with any of the above interventions; (3) reported outcomes related to erectile function, treatment satisfaction, quality of life, or adverse events; and (4) were randomized controlled trials, cohort studies, or key mechanistic studies. Case reports, conference abstracts, commentaries, and non-English articles were excluded.

After removing duplicates, titles and abstracts were screened, and full texts of potentially relevant articles were assessed. A total of 71 studies met the inclusion criteria. Due to substantial heterogeneity in study designs, populations, interventions, and outcome measures, a narrative synthesis was performed. Evidence was grouped by intervention type (endocrine, psychological, lifestyle, cardiovascular) and summarized in evidence tables to highlight the role of vardenafil within multidisciplinary management frameworks.

The key evidence supporting the multidisciplinary use of vardenafil is summarized in Table 1. This table presents representative studies that illustrate the synergistic effects of combining vardenafil with endocrine, psychological, lifestyle, and other therapeutic modalities. Across these studies, combination therapies consistently demonstrated greater improvements in erectile function compared to monotherapy, particularly in patients with hypogonadism or significant psychological comorbidities.

Pharmacological characteristics and clinical benefits of vardenafil

Mechanism of action

Vardenafil, a phosphodiesterase type 5 (PDE5) inhibitor, primarily exerts its effects by selectively inhibiting PDE5 enzymatic activity. This inhibition delays the degradation of cyclic guanosine monophosphate (cGMP), resulting in sustained activation of the nitric oxide (NO)–cGMP signaling pathway [38]. The subsequent cascade promotes relaxation of cavernosal smooth muscle and vasodilation, thereby increasing arterial blood flow necessary to facilitate

Table 1 Representative studies supporting the multidisciplinary use of vardenafil for ED

Study (author, year)	Design	Key population/focus	Intervention (vardenafil-based)	Main finding relevant to multidisciplinary care
Zhu et al. [71]	Meta-analysis	Hypogonadal men with ED	PDE5i (incl. vardenafil) + Testosterone	Combined therapy superior to PDE5i alone in improving erectile function.
Mykoniatis et al. [43]	Network Meta-analysis	Broad ED populations	Combination therapies (drug + lifestyle/psychology)	Combination therapies more effective than monotherapy.
Atallah et al. [4]	Systematic Review	ED with psychological factors	PDE5i (incl. vardenafil) + Psychological therapy	Combined approach better than either treatment alone.
Wang et al. [65]	Meta-analysis	General & organic ED	Vardenafil monotherapy	Vardenafil is effective and well-tolerated across etiologies.
Madeira et al. [37]	Network Meta-analysis	General ED populations	Vardenafil vs. other PDE5 inhibitors	Vardenafil offers a favorable efficacy-tolerability profile.
Pyrgidis et al. [48]	Overview of Reviews	Broad evidence synthesis	PDE5 inhibitors (class effect)	PDE5i are foundational; integration into multimodal strategies is key.

This table summarizes key evidence. The full list of 71 studies is available upon request

penile erection (Vardenafil Hydrochloride Trihydrate [61]. Compared to other PDE5 inhibitors such as sildenafil, vardenafil demonstrates higher affinity and a lower half-maximal inhibitory concentration (IC50) for PDE5, indicating a more potent and sustained inhibitory effect. Regarding PDE6 selectivity, vardenafil falls between sildenafil and tadalafil. It exhibits lower affinity for PDE6 than sildenafil, which may correspond to a theoretically lower risk of visual disturbances; however, tadalafil has the highest selectivity for PDE5 over PDE6, suggesting the lowest risk of such adverse events [26].

Pharmacokinetic properties

Clinical pharmacokinetic studies indicate that following oral administration, the time to peak plasma concentration (Tmax) of vardenafil is generally between 0.5 and 1 h [1].Certain formulations, including orally disintegrating tablets or rapid-release preparations, may achieve an onset of action within 15 to 30 min [11].The elimination half-life of vardenafil is approximately 4 to 6 h, providing a balanced therapeutic duration that supports on-demand use while minimizing the potential for drug accumulation [22]. Compared with tadalafil, vardenafil exhibits a more rapid onset of action; in contrast to sildenafil, its bioavailability is less affected by high-fat meals, a characteristic that may improve patient adherence and the predictability of therapeutic response [29].

Clinical advantages

Vardenafil has demonstrated high efficacy in numerous clinical trials. It has shown particular effectiveness in managing ED of complex etiology, such as in patients with spinal cord injury, diabetes, or those recovering from radical prostatectomy, resulting in significant improvements in erectile function and sexual satisfaction scores [42, 59]. This broad spectrum of robust therapeutic efficacy across diverse patient populations underscores its value as a key treatment option, providing a strong rationale for its integration into multidisciplinary ED management strategies [57] (Table 2).

Vardenafil's rapid onset of action may make it a suitable PDE5 inhibitor option for some individuals who prioritize these characteristics [19]. Its pharmacokinetic and safety characteristics allow for effective integration into multidisciplinary treatment paradigms, synergistically improving therapeutic outcomes and quality of life in patients with ED [48]. This underscores its important role within comprehensive management strategies.

Rationale for multidisciplinary combination therapy

Multifactorial etiology of ED

A single-specialty approach is often insufficient to fully assess the diverse etiologies and progression of ED. Urologists typically focus on anatomical factors and pharmacological interventions, while endocrinologists address hormonal imbalances and metabolic disturbances [62]. Cardiologists contribute by identifying underlying atherosclerosis and vascular dysfunction, and psychologists or sexual medicine specialists play a crucial role in recognizing the negative impact of psychological factors—such as anxiety and depression—on sexual function [18, 54]. Collaboration within a multidisciplinary team enables comprehensive screening of underlying causes and supports personalized diagnostic pathways, helping to identify dominant risk contributors in each patient and guiding the development of more rational and holistic treatment strategies.

Limitations of monotherapy

Substantial evidence demonstrates that monotherapy for ED is often associated with declining treatment efficacy and poor adherence over time, particularly in patients with complex comorbid conditions [13]. A robust body of research supports combining pharmacotherapy with multimodal strategies—including lifestyle modification and psychological support—as a scientifically grounded approach to enhancing therapeutic outcomes, adherence, and patient satisfaction, especially in individuals with multiple risk factors [43]. For example, in patients with testosterone deficiency, combining testosterone replacement therapy with a PDE5 inhibitor can improve treatment response [9].Conversely, for individuals experiencing significant psychological distress, structured psychological interventions may increase medication adherence and reduce relapse rates [63].These findings highlight the limitations of monotherapy and underscore the clinical value of an integrated, multidisciplinary approach.

The need for long-term management

ED management should be regarded as a long-term, dynamic healthcare process rather than a one-time pharmacological intervention. A multidisciplinary team is essential for the continuous monitoring of cardiometabolic parameters, endocrine status, and psychological well-being during follow-up. This narrative and proactive approach significantly improves the timeliness of care, facilitates early risk detection, and allows for the dynamic adjustment of therapeutic plans. Importantly, such a long-term framework not only enhances sexual function but also reduces the risk of cardiovascular events and improves overall quality of life [33, 52].Therefore, multidisciplinary intervention serves a dual purpose: it is both a key strategy for addressing the core symptoms of ED and a foundation for promoting general health and longevity.

Figure 1: This schematic outlines the core components of an integrated ED management strategy, where pharmacological treatment with agents like vardenafil is combined with endocrine, psychological, lifestyle, and cardiovascular interventions to address the multifactorial etiology of ED

Combined use of vardenafil and endocrine interventions

Testosterone deficiency and erectile dysfunction

Androgens play a crucial role in maintaining normal libido and erectile function. Testosterone deficiency (hypogonadism) can reduce nitric oxide synthesis, impairing the relaxation of cavernosal smooth muscle and diminishing the therapeutic efficacy of PDE5 inhibitors [66]. Evidence suggests that the response rate to PDE5 inhibitor monotherapy in hypogonadal men is approximately 50%, which is significantly lower than in eugonadal individuals [71]. This indicates that low testosterone is a major contributor to suboptimal responses in a substantial proportion of ED patients. Hypogonadism-related ED is often associated with metabolic disturbances such as obesity, insulin resistance, and type 2 diabetes, which synergistically accelerate the onset and progression of ED [14].

Combined therapeutic strategies

To address inadequate responses to PDE5 inhibitors in hypogonadal men, combining vardenafil with testosterone replacement therapy (TRT) has emerged as a clinically relevant strategy to improve erectile function and overall sexual health [25]. Increasing preclinical and clinical evidence demonstrates that TRT enhances vascular function and erectile physiology in hypogonadal states through multiple mechanisms [68]. Several narrative reviews and clinical trials indicate that combining TRT with PDE5 inhibitors such as vardenafil results in greater improvements in International Index of Erectile Function (IIEF) scores compared to either treatment alone [48]. Among men with metabolic syndrome or type 2 diabetes, this combined approach may not only improve erectile function but also enhance insulin sensitivity and body composition, suggesting broader clinical benefits beyond sexual health.

Table 2 Comparison of pharmacological and clinical features among vardenafil, sildenafil, and tadalafil

Feature	Vardenafil	Sildenafil	Tadalafil
Onset of action	Rapid: typically 0.5–1 h; certain formulations(e.g., orally disintegrating tablets) may take effect within 15–30 min.	Relatively fast: usually 0.5–1 h, but a high-fat meal may delay onset.	Slower: generally 1–2 h.
Duration of action / half-life	Moderate: approximately 4–6 h.	Shorter: approximately 3–5 h.	Long: half-life ~ 17.5 h, with a therapeutic window lasting up to 36 h.
Food effect	Minimal: high-fat meals have limited impact on bioavailability.	Significant: high-fat meals may delay absorption and lower plasma concentrations.	Negligible: food intake has minimal impact on absorption.
Selectivity for PDE6	Higher: lower affinity for PDE6 than sildenafil, associated with reduced risk of visual disturbances (e.g., blurred vision, cyanopsia).	Lower selectivity: certain affinity for PDE6, with visual adverse effects more commonly reported.	Highest: extremely low affinity for PDE6, with the lowest risk of visual side effects.
Common adverse effects	Headache, flushing, dyspepsia, nasal congestion; generally mild and transient.	Similar to vardenafil, but visual disturbances occur more frequently.	Similar to vardenafil, but due to longer half-life, myalgia and back pain are more common.
Clinical use profile	Suitable for patients seeking a rapid onset, minimal dietary restrictions, or lower susceptibility to visual side effects.	A classical PDE5 inhibitor; attention to timing relative to meals is recommended.	Preferred for patients who favor long duration, spontaneous sexual activity, and minimal timing constraints.

The optimal sequence of interventions remains a clinical consideration. Some experts recommend initiating TRT first in cases of confirmed hypogonadism. In men who exhibit inadequate responses to PDE5 inhibitors or when hypogonadism is identified later, adding TRT to an existing PDE5 inhibitor regimen may be appropriate. This complementary approach provides clinicians with a flexible therapeutic algorithm [55, 64].

Special caution is required for men with a history of prostate cancer, particularly those undergoing androgen deprivation therapy [56]. The traditional absolute contraindication to testosterone therapy in men with a history of prostate cancer is being re-evaluated, with contemporary guidelines advocating for more nuanced, risk-adapted approaches [21]. Current guidelines suggest that in low-risk patients with stable prostate-specific antigen levels following definitive therapy, TRT may be considered with informed consent and close monitoring [44]. However, high-quality evidence regarding the safety and efficacy of combining TRT with PDE5 inhibitors such as vardenafil, in this population remains insufficient, highlighting the need for further research.

Combined use of vardenafil and psychological interventions

The role of psychological factors in ED

ED is not solely caused by cardiovascular, neurological, and hormonal abnormalities; it is also significantly influenced by psychological factors [67]. Psychogenic ED accounts for 40% or more of cases in men under 40 years of age, making psychological factors a primary contributor in this population [49]. Anxiety and depression are highly prevalent among men with ED, with some studies reporting rates as high as 80% [53]. The severity of ED has been shown to positively correlate with the burden of psychological symptoms. Psychological distress not only reduces the immediate therapeutic response to PDE5 inhibitors but may also contribute to premature discontinuation or psychological dependence. Communication barriers and relationship tensions can further exacerbate anxiety and self-doubt, creating a vicious cycle that diminishes treatment efficacy.

Efficacy of combined therapy

To break this cycle, psychological interventions are incorporated into the management as complementary therapies. Cognitive-behavioral therapy helps patients identify unrealistic beliefs about sexual performance and cognitive distortions, thereby reducing performance anxiety and enhancing

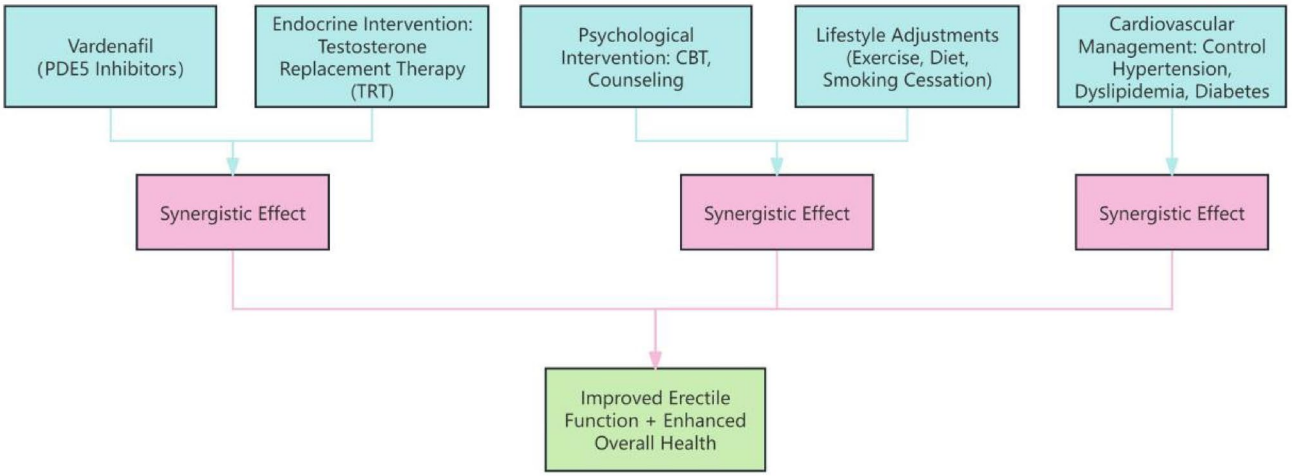

Fig. 1 The multidisciplinary management model for ED

sexual confidence [4]. Sexual counseling improves patients' understanding of physiological mechanisms and medication effects, alleviating fears and misconceptions [7]. Couples therapy strengthens communication and emotional support between partners [27].

Clinical evidence demonstrates that combining vardenafil with psychological interventions produces synergistic benefits. A randomized controlled trial showed that this combined therapy not only improved erectile function but also significantly enhanced sexual quality of life and relationship satisfaction for both patients and their partners [4]. Long-term follow-up studies and international literature further indicate that patients relying solely on medication exhibit higher rates of declining adherence over time [36]. In contrast, integrating psychological treatment promotes sustainable recovery of sexual function and improves overall quality of life.

Combined use of vardenafil with lifestyle modifications and exercise interventions

The essential role of lifestyle factors

A substantial body of evidence indicates that smoking, excessive alcohol consumption, obesity, and physical inactivity are major risk factors for ED [32]. These behaviors impair erectile function through distinct mechanisms: smoking accelerates atherosclerosis, restricting penile arterial blood flow [30]; excessive alcohol consumption disrupts hepatic metabolism, hormonal regulation, and neural conduction, thereby increasing oxidative stress [35]; obesity is strongly associated with insulin resistance, chronic inflammation, and elevated inflammatory biomarkers (e.g., C-reactive protein [CRP], tumor necrosis factor-alpha [TNF-α]), leading to endothelial dysfunction and reduced NO production [31]; sedentary behavior decreases vascular elasticity and penile blood perfusion while exacerbating metabolic dysregulation [47]. Collectively, these factors contribute to declines in testosterone levels and increased oxidative stress, promoting the development of ED. Moreover, these lifestyle risk factors are closely linked to systemic diseases such as cardiovascular disease and diabetes; therefore, lifestyle modification should be considered a fundamental component of ED management.

Combined interventions in practice

Studies indicate that combining lifestyle modifications with vardenafil produces synergistic benefits. Regular exercise and balanced nutrition improve weight control, reduce inflammation, restore endothelial function, and enhance nitric oxide bioavailability, thereby improving penile hemodynamics [20]. Vardenafil increases cGMP levels through PDE5 inhibition, which enhances smooth muscle relaxation and vasodilation [65]. Clinical research shows that lifestyle intervention alone improves IIEF-5 scores by approximately 3 points, whereas combining it with vardenafil results in an improvement of nearly 8 points, demonstrating superior efficacy compared to either intervention alone [69]. This comprehensive approach not only improves erectile function but also promotes overall health, offering a more effective therapeutic strategy for ED patients.

Vardenafil in the management of cardiovascular disease

The comorbidity of ED and cardiovascular disease

Growing epidemiological and clinical evidence indicates that ED is an early clinical marker of systemic vascular dysfunction, driven by endothelial and microvascular abnormalities [16]. Systematic reviews and meta-analyses demonstrate that the onset of ED precedes coronary artery disease and major cardiovascular events by 2 to 5 years, serving as an early sentinel or warning sign of cardiovascular risk [58]. This reinforces the consensus that "ED is a cardiovascular risk marker" and underscores the need for cardiovascular evaluation during ED management [8, 10].

Integrated management strategy

Vardenafil enhances the NO-cGMP signaling pathway, improves endothelial function, reduces oxidative stress, and protects myocardial tissue [12]. Its benefits have been reported in conditions such as hypertension, myocardial infarction, diabetic heart disease, and pulmonary hypertension [6]. Statins improve endothelial function and complement the vascular benefits of vardenafil [2]. ACE inhibitors and ARBs have been shown to improve or reverse ED, synergizing with PDE5 inhibitors [15]. In men requiring β-blockers, agents with minimal sexual side effects can be combined with vardenafil to achieve the dual goals of blood pressure control and improved erectile function [60].

A critical contraindication must be emphasized: vardenafil (or any PDE5 inhibitor) must not be co-administered with nitrate medications due to the risk of severe, potentially life-threatening hypotension [34, 40]. Therefore, a comprehensive medication review is essential for safe cardiovascular and sexual health management.

Safety and precautions

Table 3: Vardenafil is generally safe and well tolerated. Common adverse effects, such as headache, flushing, dyspepsia, and nasal congestion, are typically mild and transient [37]. Compared to other PDE5 inhibitors, vardenafil is associated with lower rates of visual disturbances and demonstrates good tolerability. Meta-analysis data indicate a monthly discontinuation rate of approximately 4% among PDE5 inhibitors, reflecting high satisfaction and adherence [48]

Caution is necessary in patients with recent myocardial infarction, stroke, or severe hypotension [50]. Current guidelines emphasize strict adherence to indications and contraindications in high-risk populations to prevent cardiovascular complications [24]. A thorough risk–benefit assessment is essential to optimize safety and treatment outcomes.

Future perspectives

Precision medicine

Advances in pharmacogenomics have revealed significant inter-individual variability in responses to PDE5 inhibitors, primarily due to genetic polymorphisms [28]. Variants that affect drug metabolism and transport can alter the pharmacokinetics of vardenafil, influencing its absorption, distribution, metabolism, and excretion [41]. Prospective genetic screening may enable personalized therapy for erectile dysfunction, optimizing efficacy while minimizing adverse effects.

Integration with digital health technologies

Wearable health devices and mobile applications enable real-time monitoring of cardiovascular and behavioral metrics, supporting individualized management and improving treatment adherence [45, 51]. Future AI-driven analytics have the potential to further enhance dynamic treatment optimization.

Integrated care model

ED management is increasingly shifting toward a multidisciplinary approach involving urology, endocrinology, cardiology, and psychology. This collaborative model provides comprehensive evaluation, risk management,

Table 3 Comparison of common adverse events among PDE5 inhibitors

Adverse event	Vardenafil	Sildenafil	Tadalafil	Notes
Headache	10–15%	12–18%	11–15%	Most common; usually mild.
Flushing	8–12%	10–15%	3–5%	Less common with tadalafil.
Dyspepsia	4–8%	5–10%	10–15%	More frequent with tadalafil.
Nasal congestion	5–10%	5–10%	3–5%	--
Visual disturbances	1–3%	3–7%	< 1%	Vardenafil lower risk than sildenafil.
Myalgia/back pain	< 2%	< 2%	5–10%	Characteristic of tadalafil.
Discontinuation (due to AEs)	~ 4%	~ 5%	~ 4–6%	Similar across drugs.

pharmacotherapy, and psychosocial support, thereby enhancing treatment outcomes and promoting long-term health.

Evidence-based clinical recommendations

Although direct head-to-head evidence remains limited, pharmacologic properties and clinical data support a practical decision algorithm that integrates individualized patient preferences and clinical characteristics. Vardenafil may be preferred when rapid onset and minimal food interaction are desired; however, treatment selection should be guided by clinical judgment rather than assumptions of superiority.

Figure 2: This algorithm integrates patient preferences, clinical characteristics, and multidisciplinary evaluation to guide the personalized selection of PDE5 inhibitors. Vardenafil is positioned as a preferred option when rapid onset of action and minimal food interactions are prioritized, highlighting its role as one of several evidence-based choices rather than a universally superior agent

Limitations

This review has several important limitations that must be acknowledged. First, and most critically, the included studies exhibited substantial clinical and methodological heterogeneity (e.g., in participant populations, intervention protocols, and outcome measures). This heterogeneity precluded a formal quantitative meta-analysis, necessitating a narrative synthesis and limiting the strength of our conclusions. Second, as this is a narrative review, a formal quality assessment of individual studies was not performed, which may introduce potential bias in the interpretation of findings. Third, some comparative claims regarding vardenafil's advantages (e.g., faster onset vs. tadalafil, fewer visual disturbances vs. sildenafil) are supported more strongly by pharmacokinetic data and indirect comparisons than by direct evidence from large-scale, head-to-head randomized controlled trials. Therefore, these specific advantages should be interpreted as pharmacologically plausible rather than definitively proven by clinical trial data. Fourth, the exclusion of non-English publications may have introduced language bias. Finally, while the multidisciplinary framework is conceptually robust, prospective studies specifically designed to test integrated vardenafil-based combination therapies are still limited.

Clinical positioning of vardenafil

Based on its pharmacodynamic and pharmacokinetic profile, vardenafil may be particularly suited for patients who prioritize a rapid onset of action and minimal interference from food intake. It presents a valuable option for individuals who may have experienced visual side effects with sildenafil or who do not require the extended duration of action provided by tadalafil. Its role in multidisciplinary care is supported by its tolerability and ease of integration with other interventions, although it should be chosen based on individual patient characteristics and preferences rather than assumed superiority.

Conclusion

Current evidence indicates that vardenafil exhibits favorable short-term efficacy across various etiologies of ED. When integrated with testosterone supplementation, psychological therapy, lifestyle modifications, and cardiovascular risk management, vardenafil demonstrates synergistic benefits that enhance overall treatment outcomes. Within a multidisciplinary therapeutic approach, vardenafil represents a valuable and flexible treatment option, particularly when its pharmacokinetic profile—rapid onset and minimal food interactions—aligns with individual patient needs and preferences.

Future research should prioritize large-scale, head-to-head randomized controlled trials evaluating vardenafil-based combination strategies, particularly those incorporating testosterone replacement therapy or structured psychological interventions in men with diabetes, metabolic syndrome, or post-prostatectomy ED. Key study endpoints should extend beyond short-term improvements in erectile function to include metabolic outcomes, cardiovascular risk reduction, and patient-reported quality of life measures. Additionally, integrating digital health technologies and pharmacogenomic profiling may enable personalized dosing and real-time treatment optimization. Establishing such a multidisciplinary, evidence-based framework will be crucial for advancing vardenafil therapy from symptomatic relief toward comprehensive health restoration.

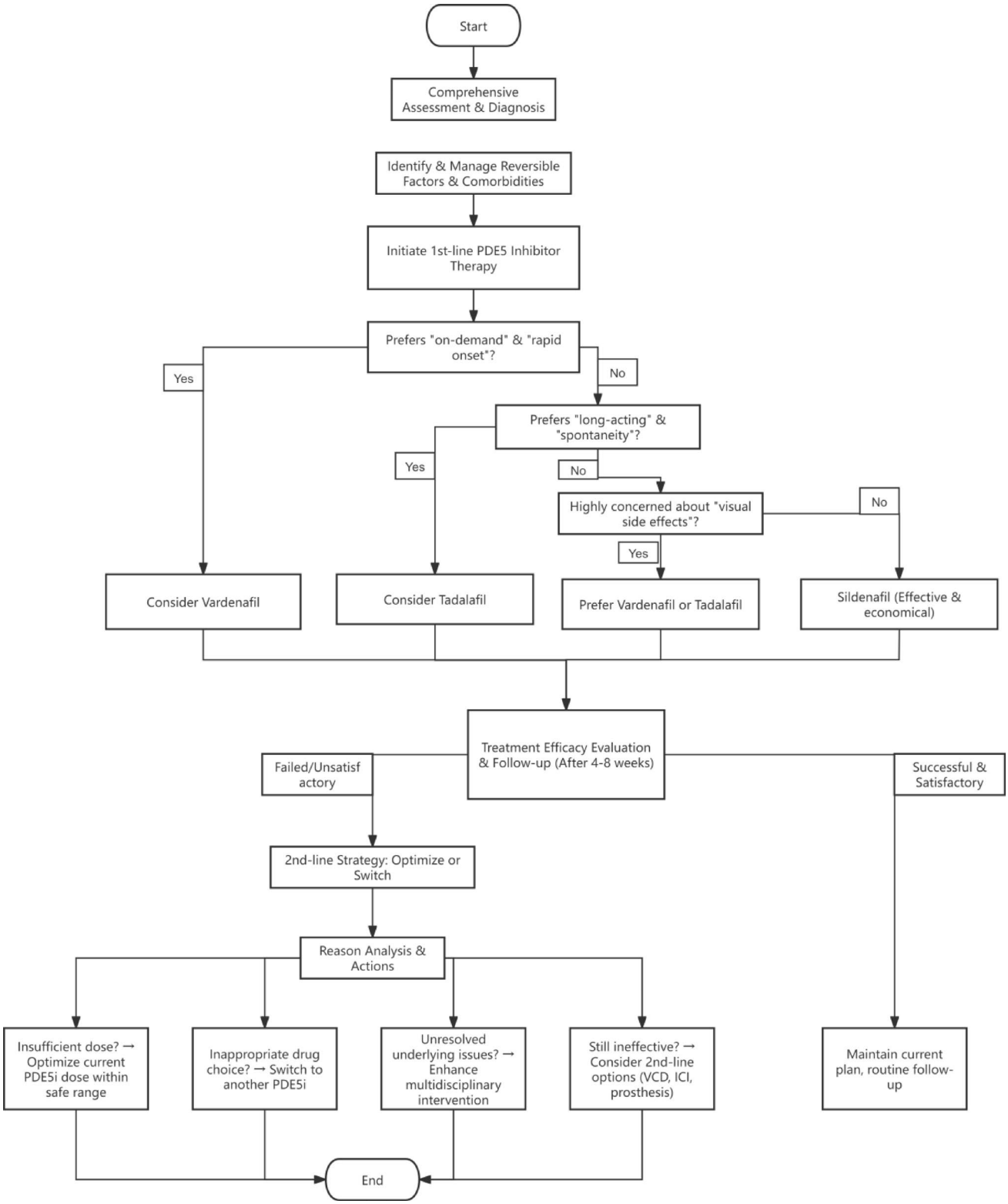

Fig. 2 Algorithm for PDE5 inhibitor selection based on patient preferences and clinical characteristics

Author contributions J.Z. and S.H. wrote the main manuscript text. Y.O. and Y.K. conducted the literature search and data extraction. M.L. designed the study, prepared figures and tables, and critically revised the manuscript. All authors reviewed and approved the final manuscript.

Funding None.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval, consent to participate, and consent for publication Not applicable.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

References

1. Abou-Taleb H, Mustafa W, Makram T, Abdelaty L, Salem H, Abdelkader H (2022) Vardenafil oral dispersible films (ODFs) with advanced dissolution, palatability, and bioavailability. Pharmaceutics 14. https://doi.org/10.3390/pharmaceutics14030517
2. Al-Kuraishy H, Al-Gareeb A, Al-Maiahy T (2020) Erectile dysfunction and statins: the assorted view of preponderance. Asian Pac J Reprod 9:55–63. https://doi.org/10.4103/2305-0500.281074
3. An J, Xiang B, Peng J, Li D (2025) Understanding the erectile dysfunction-cardiovascular disease connection: clinical and pathophysiological insights. Sex Med reviews. https://doi.org/10.1093/sxmrev/qeaf014
4. Atallah S, Haydar A, Jabbour T, Kfoury P, Sader G (2021) The effectiveness of psychological interventions alone, or in combination with phosphodiesterase-5 inhibitors, for the treatment of erectile dysfunction:A systematic review. Arab J Urol 19:310–322. https://doi.org/10.1080/2090598x.2021.1926763
5. Babu BM, Uppal G, Soundarajan S, Chauhan R, Ali AMZ (2025) Comparative efficacy and safety of sildenafil, tadalafil, vardenafil, mirodenafil, coenzyme Q, and testosterone in the treatment of male sexual dysfunction: a systematic review and meta-analysis. BJPsych Open 11. https://doi.org/10.1192/bjo.2025.10789
6. Barbagallo F, Campolo F, Franceschini E, Crecca E, Pofi R, Isidori A, Venneri M (2020) PDE5 inhibitors in type 2 diabetes cardiovascular complications. Endocrines. https://doi.org/10.3390/endocrines1020009
7. Bonarska M, Adasik D, Szymczyk S, Łocik G, Bumbul-Mazurek E, Marianowski P, Ludwin A (2025) A narrative review of independent treatment methods for ED: assessment of the effectiveness of diet, supplements, pharmacotherapy, and physiotherapy. J Clin Med 14. https://doi.org/10.3390/jcm14072386
8. Borges J (2024) Erectile dysfunction and cardiovascular disease risk: an updated 2024 systematic review meta-analysis of prospective studies. https://doi.org/10.1101/2024.07.06.24310031
9. Cayetano-Alcaraz A, Tharakan T, Chen R, Sofikitis N, Minhas S (2022) The management of erectile dysfunction in men with diabetes mellitus unresponsive to phosphodiesterase type 5 inhibitors. Andrology 11:257–269. https://doi.org/10.1111/andr.13257
10. Chowdhury S, Karim M, Ullah S, Bakar M (2020) Association between erectile dysfunction and cardiovascular disease: a systematic review. Chattagram Maa-O-Shishu Hosp Med Coll J. https://doi.org/10.3329/cmoshmcj.v18i2.47779
11. Chung E, Argent C, Strange G (2025) Pharmacokinetics of an oral versus intranasal delivered formulation of the phosphodiesterase type 5 inhibitor vardenafil in healthy men - A Phase 1, Randomized, Open-label, Single-dose, Two-period, Two-treatment, Cross-over Study. Eur J Pharm sciences: official J Eur Federation Pharm Sci 107226. https://doi.org/10.1016/j.ejps.2025.107226
12. Corbic M, Sretenovic J, Živković V, Jakovljevic V, Turnic TN (2023) Phosphodiesterase-5 inhibitors as therapeutics for cardiovascular diseases: a brief review. Iran J Public Health 52:870–879. https://doi.org/10.18502/ijph.v52i5.12704
13. Corona G, Cucinotta D, Di Lorenzo G, Ferlin A, Giagulli V, Gnessi L, Isidori A, Maiorino M, Miserendino P, Murrone A, Pivonello R, Rochira V, Sangiorgi G, Stagno G, Foresta C, Lenzi A, Maggi M, Jannini E (2023) The Italian Society of Andrology and Sexual Medicine (SIAMS), along with ten other Italian Scientific Societies, guidelines on the diagnosis and management of erectile dysfunction. J Endocrinol Investig 46:1241–1274. https://doi.org/10.1007/s40618-023-02015-5
14. Corona G, Maggi M (2022) The role of testosterone in male sexual function. Reviews Endocr Metabolic Disorders 23:1159–1172. https://doi.org/10.1007/s11154-022-09748-3
15. Corona G, Vena W, Pizzocaro A, Salvio G, Sparano C, Sforza A, Maggi M (2024) Anti-hypertensive medications and erectile dysfunction: focus on β-blockers. Endocrine 87:11–26. https://doi.org/10.1007/s12020-024-04020-x
16. De Leonardis F, Colalillo G, Agrò F, Miano R, Fuschi A, Asimakopoulos A (2022) Endothelial dysfunction, erectile deficit and cardiovascular disease: an overview of the pathogenetic links. Biomedicines 10. https://doi.org/10.3390/biomedicines10081848
17. Defeudis G, Mazzilli R, Tenuta M, Rossini G, Zamponi V, Olana S, Faggiano A, Pozzilli P, Isidori A, Gianfrilli D (2021) Erectile dysfunction and diabetes: a melting pot of circumstances and treatments. Diab/Metab Res Rev 38. https://doi.org/10.1002/dmrr.3494
18. Dewitte M, Bettocchi C, Carvalho J, Corona G, Flink I, Limoncin E, Pascoal P, Reisman Y, Van Lankveld J (2021) A psychosocial approach to erectile dysfunction: position statements from the European Society of Sexual Medicine (ESSM). Sex Med 9. https://doi.org/10.1016/j.esxm.2021.100434
19. Dróżdż O, Dołęga M, Gacka P, Musialska D, Grzelka M (2024) Comprehensive management of erectile dysfunction in diabetes mellitus: pathogenesis, treatment modalities, and future perspectives. Qual Sport. https://doi.org/10.12775/qs.2024.17.53372
20. Duca Y, Calogero A, Cannarella R, Giacone F, Mongioì L, Condorelli R, Vignera L, S (2019) Erectile dysfunction, physical activity and physical exercise: Recommendations for clinical practice. Andrologia 51. https://doi.org/10.1111/and.13264
21. Edison MA, Kirby M, Hackett G (2025) Testosterone replacement therapy in hypogonadal men with a prostate cancer diagnosis: a

British Society for sexual medicine consensus statement. World J Men's Health. https://doi.org/10.5534/wjmh.250086
22. Eldon M, Parsley E, Maurer M, Tarara T, Okikawa J, Weers J (2020) Safety, tolerability, and pharmacokinetics of RT234 (vardenafil inhalation powder): a first-in-human, ascending single- and multiple-dose study in healthy subjects. J Aerosol Med Pulmonary Drug Delivery 34:251–261. https://doi.org/10.1089/jamp.2020.1651
23. Fu X, Sheikholeslami A, Zhanbyrbekuly U, Asl F D., Mussin N, Fazaeli H, Daniyalov K, Tanideh N, Mahdipour M, Kurmanalina M, Tamadon A (2025) Advances in stem cell therapy for erectile dysfunction: preclinical evidence and emerging therapeutic approaches. Front Med 12. https://doi.org/10.3389/fmed.2025.1519095
24. Ghantous I, Tlais M, Khatib AE, Ghantous G, Maroun G, Challita A, Ayek M, Barmo G, Sahyoun M, Kary G (2025) The impact of PDE5 inhibitors on cardiovascular outcomes. Global Cardiol Sci Pract. https://doi.org/10.21542/gcsp.2025.31
25. Gourma D, Kalampokas E, Triantafyllidou O, Kalampokas T, Vlachos N (2023) Various interventions for infertility in men with type II diabetes and hypogonadism. Hellenic J Obstet Gynecol. https://doi.org/10.33574/hjog.0519
26. Hainsworth A, Arancio O, Elahi F, Isaacs J, Cheng F (2023) PDE5 inhibitor drugs for use in dementia. Alzheimer's Dementia: Translational Res Clin Interventions 9. https://doi.org/10.1002/trc2.12412
27. He J, Liu W, Huang W, Luo X, Zou G, Du P, Yang R (2025) Treatment model for young patients with psychogenic erectile dysfunction and resultant infertility. J visualized experiments: JoVE 219. https://doi.org/10.3791/67132
28. He M, Shi Y, Han F, Cai Y (2025) Prediction of adverse drug reactions based on pharmacogenomics combination features: a preliminary study. Front Pharmacol 16. https://doi.org/10.3389/fphar.2025.1448106
29. He S, Wu X, Zhang W, Wang K, Chen Y, Zheng Z, Zhang T, Chen L, Duan Q, He D, Wu B (2024) Pharmacokinetics and bioequivalence of vardenafil hydrochloride in healthy chinese volunteers. Clin Pharmacol Drug Dev 13. https://doi.org/10.1002/cpdd.1432
30. Ioakeimidis N, Terentes-Printzios D, Angelis A, Rokkas K, Dima I, Gourgouli I, Chatzistamatiou E, Kalfountzos D, Tsioufis C, Vlachopoulos C (2022) Erectile dysfunction, generalized vascular disease and the long term effects of smoking exposure on arterial properties: time is of the essence. Eur Heart J. https://doi.org/10.1093/eurheartj/ehac544.2556
31. Jalali S, Zareshahi N, Behnoush A, Azarboo A, Shirinezhad A, Y Hosseini S, Javidan A, Ghaseminejad-Raeini A (2024) Association of insulin resistance surrogate indices and erectile dysfunction: a systematic review and meta-analysis. Reproductive Biology Endocrinology: RB&E 22. https://doi.org/10.1186/s12958-024-01317-4
32. Kaltsas A, Zikopoulos A, Dimitriadis F, Sheshi D, Politis M, Moustakli E, Symeonidis E, Chrisofos M, Sofikitis N, Zachariou A (2024) Oxidative stress and erectile dysfunction: pathophysiology, impacts, and potential treatments. Curr Issues Mol Biol 46:8807–8834. https://doi.org/10.3390/cimb46080521
33. Kliesch S, Cremers J-F, Krallmann C, Epplen R, Scheffer B, Schubert T, Schubert M, Dreger N, Raschke R, Khaljani E, Maxeiner A, Miller K, Wiemer L, Zitzmann M (2024) App-based therapy of erectile dysfunction using a digital health application (EDDIG Study): a randomized, single-blind, controlled trial. Eur Urol focus. https://doi.org/10.1016/j.euf.2024.05.020
34. Kloner R, Burnett A, Miner M, Blaha M, Ganz P, Goldstein I, Kim N, Kohler T, Lue T, McVary K, Mulhall J, Parish S, Sadeghi-Nejad H, Sadovsky R, Sharlip I, Rosen R (2023) Princeton IV consensus guidelines: PDE5 inhibitors and cardiac health. J Sex Med. https://doi.org/10.1093/jsxmed/qdad163
35. Li S, Song J, Zhang K, Zhang C (2021) A meta-analysis of erectile dysfunction and alcohol consumption. Urol Int 105:969–985. https://doi.org/10.1159/000508171
36. Liu W-R, Li N (2025) [Psychological intervention based on the extension and expansion of positive psychology model improves psychosexual resilience and erectile function in patients with psychogenic ED]. *Zhonghua nan ke xue = National journal of andrology*, *31 2*, 144–149. https://consensus.app/papers/psychological-intervention-based-on-the-extension-and-liu-li/1948f26920d5ddb82bb97972248a4c2/
37. Madeira C, Tonin F, Fachi M, Borba H, Ferreira V, Leonart L, Bonetti A, Moritz R, Trindade A, Gonçalves A, Fernandez-Llimos F, Pontarolo R (2020) Efficacy and safety of oral phosphodiesterase 5 inhibitors for erectile dysfunction: a network meta-analysis and multicriteria decision analysis. World J Urol 39:953–962. https://doi.org/10.1007/s00345-020-03233-9
38. Malykhina A, Efimova S, Ostroumova O (2025) Membrane-mediated action of phosphodiesterase 5 inhibitors. Pharmaceutics 17. https://doi.org/10.3390/pharmaceutics17050563
39. Mark K, Arenella K, Girard A, Herbenick D, Fu J, Coleman E (2024) Erectile dysfunction prevalence in the United States: report from the 2021 National Survey of Sexual Wellbeing. J Sex Med. https://doi.org/10.1093/jsxmed/qdae008
40. Morrisette M, Dunn S (2023) Phosphodiesterase type 5 inhibitors and oral nitrates in male patients with ischemic heart disease. Curr Cardiol Rep 25:553–560. https://doi.org/10.1007/s11886-023-01873-y
41. Mostafa T, Hassan A, Alghobary M, Abdelrahman S (2020) Effect of genetic polymorphism on the response to PDE5 inhibitors in patients with erectile dysfunction: a systematic review and a critical appraisal. Sex Med reviews. https://doi.org/10.1016/j.sxmr.2020.05.005
42. Mwende W (2024) Pharmacological treatments for erectile dysfunction in diabetic patients: efficacy, safety, and emerging therapies. INOSR EXPERIMENTAL Sci. https://doi.org/10.59298/inosres/2024/1322932.000
43. Mykoniatis I, Pyrgidis N, Sokolakis I, Ouranidis A, Sountoulides P, Haidich A, Van Renterghem K, Hatzichristodoulou G, Hatzichristou D (2021) Assessment of combination therapies vs monotherapy for erectile dysfunction. JAMA Netw Open 4. https://doi.org/10.1001/jamanetworkopen.2020.36337
44. Natale C, Carlos C, Hong J, Khera M, Baum N, Raheem O (2021) Testosterone therapy after prostate cancer treatment: a review of literature. Sex Med reviews. https://doi.org/10.1016/j.sxmr.2020.12.003
45. Neudakh O (2024) (082) Erectile dysfunction: tool to break men's sexual stigma. J Sex Med. https://doi.org/10.1093/jsxmed/qdae002.074
46. Pellegrino F, Sjoberg D, Tin A, Benfante N, Briganti A, Montorsi F, Eastham J, Mulhall J, Vickers A (2022) Relationship between age, comorbidity, and the prevalence of erectile dysfunction. Eur Urol focus. https://doi.org/10.1016/j.euf.2022.08.006
47. Pitta R, Kaufmann O, Louzada A, Astolfi R, De Lima Queiroga L, Dias RR, Wolosker N (2022) The association between physical activity and erectile dysfunction: a cross-sectional study in 20,789 Brazilian men. PLoS ONE 17. https://doi.org/10.1371/journal.pone.0276963
48. Pyrgidis N, Mykoniatis I, Haidich A, Tirta M, Talimtzi P, Kalyvianakis D, Ouranidis A, Hatzichristou D (2021) The effect of phosphodiesterase-type 5 inhibitors on erectile function: an overview of systematic reviews. Front Pharmacol 12. https://doi.org/10.3389/fphar.2021.735708
49. Quang N, Van Truong L, Chung E, Van Quang B, Long LQ, Ngoc NT, Minh NT, Anh DM, Thanh ND, Nam NT (2024) Predicting anxiety and depression among erectile dysfunction patients: a

cross-sectional Study. *American Journal of Men's Health*, *18*. https://doi.org/10.1177/15579883231223502
50. Rosen R, Miner M, Burnett A, Blaha M, Ganz P, Goldstein I, Kim N, Kohler T, Lue T, McVary K, Mulhall J, Parish S, Sadeghi-Nejad H, Sadovsky R, Sharlip I, Kloner R (2024) Proceedings of PRINCETON IV: PDE5 inhibitors and cardiac health symposium. Sex Med reviews. https://doi.org/10.1093/sxmrev/qeae043
51. Saffati G, Rendon DO, Daily R, Khera M, Mulhall J (2025) Wearable penile devices: the TechRing. Translational Androl Urol 14:152–157. https://doi.org/10.21037/tau-24-548
52. Saffati G, Seyan Z, Rendon DO, Almuhaideb M, Hinojosa-González D, Kronstedt S, Khera M (2024) Erectile dysfunction as a holistic indicator of well-being: a narrative review. Sex Med reviews. https://doi.org/10.1093/sxmrev/qeae066
53. Saito J, Kumano H, Ghazizadeh M, Shimokawa C, Tanemura H (2024) Differences in psychological inflexibility among men with erectile dysfunction younger and older than 40 years: web-based cross-sectional study. JMIR Formative Res 8. https://doi.org/10.2196/45998
54. Salonia A, Bettocchi C, Boeri L, Capogrosso P, Carvalho J, Çilesiz N, Cocci A, Corona G, Dimitropolous K, Gül M, Hatzichristodoulou G, Jones T, Kadıoğlu A, Salamanca JM, Milenkovic U, Modgil V, Russo G, Şerefoğlu E, Tharakan T, Minhas S (2021) European Association of Urology guidelines on sexual and reproductive health-2021 update: male sexual dysfunction. Eur Urol. https://doi.org/10.1016/j.eururo.2021.06.007
55. Salonia A, Capogrosso P, Boeri L, Cocci A, Corona G, Dinkelman-Smit M, Falcone M, Jensen CF, Gül M, Kalkanlı A, Kadioglu A, Martínez-Salamanca J, Morgado A, Russo G, Şerefoğlu E, Verze P, Minhas S (2025) European Association of Urology guidelines on male sexual and reproductive health: 2025 update on male hypogonadism, erectile dysfunction, premature ejaculation, and Peyronie's disease. Eur Urol. https://doi.org/10.1016/j.eururo.2025.04.010
56. Santucci J, Stapleton P, Perera M, Ischia J, Murphy D, Bolton D, Lawrentschuk N, Frydenberg M, Sathianathen N (2025) Oncological safety of testosterone replacement therapy in men with localised prostate cancer: a systematic review of observational studies. BJU Int. https://doi.org/10.1111/bju.16870
57. Tar M, Draganski A, Davies K (2025) Synergy between oral PDE5 inhibitors and topically applied nitric oxide microparticles on the erectile response in a rat model of cavernous nerve injury. Int J Impot Res. https://doi.org/10.1038/s41443-025-01147-x
58. Terentes-Printzios D, Ioakeimidis N, Rokkas K, Vlachopoulos C (2021) Interactions between erectile dysfunction, cardiovascular disease and cardiovascular drugs. Nat Reviews Cardiol 19:59–74. https://doi.org/10.1038/s41569-021-00593-6
59. Tienforti D, Castellini C, A. Barbonetti P (2024) (360) Which of pde5 inhibitors is most effective in the treatment of erectile dysfunction in patients with spinal cord injury? A network meta-analysis. J Sex Med. https://doi.org/10.1093/jsxmed/qdae041.018
60. Uschner F, Glückert K, Paternostro R, Gnad T, Schierwagen R, Mandorfer M, Magdaleno F, Ortiz C, Schwarzkopf K, Kamath P, Alessandria C, Boesecke C, Pfeifer A, Reiberger T, Kreisel W, Sauerbruch T, Ferlitsch A, Trebicka J, Klein S (2020) Combination of phosphodiesterase-5-inhibitors and beta blockers improves experimental portal hypertension and erectile dysfunction. Liver Int 40:2228–2241. https://doi.org/10.1111/liv.14586
61. Vardenafil Hydrochloride Trihydrate (2020) *Definitions*. https://doi.org/10.32388/95h6j3
62. Vasan S, Pandey S, Rao S, Gupte D, Gangavaram R, Saxena A, Kovil R, Joshi P, Goel R, Mittal S, Neogi R, Joseph S, Shah D, Khan Z (2025) Association of sexual health and mental health in erectile dysfunction: expert opinion from the indian context. Cureus 17. https://doi.org/10.7759/cureus.77851
63. Wang C, Wu B, Xiang P, Xiao J, Hu X (2023) Management of male erectile dysfunction: From the past to the future. Front Endocrinol 14. https://doi.org/10.3389/fendo.2023.1148834
64. Wang C, Zhang H, Wang F, Guo J, Yuan J, Hou G, Gao M, Li Z, Zhang Y (2023) Efficacy and safety of PDE5 inhibitors in middle-aged and old patients with and without hypogonadism. Aging Male 27. https://doi.org/10.1080/13685538.2023.2288347
65. Wang H, Guo B, Huang Z, Zhao X, Ji Z (2021) Vardenafil in the treatment of male erectile dysfunction: a systematic review and meta-analysis. Adv Therapy 38:1301–1313. https://doi.org/10.1007/s12325-020-01559-9
66. Wang Y, Jiang R (2024) Androgens and erectile dysfunction: from androgen deficiency to treatment. Sex Med reviews. https://doi.org/10.1093/sxmrev/qeae030
67. Xiao Y, Xie T, Peng J, Zhou X, Long J, Yang M, Zhu H, Yang J (2023) Factors associated with anxiety and depression in patients with erectile dysfunction: a cross-sectional study. BMC Psychol 11. https://doi.org/10.1186/s40359-023-01074-w
68. Xu Z, Chen X, Zhou H, Ren C, Wang Q, Pan Y, Liu L, Liu X (2024) An updated systematic review and meta-analysis of the effects of testosterone replacement therapy on erectile function and prostate. Front Endocrinol 15. https://doi.org/10.3389/fendo.2024.1335146
69. Yang B, Wei C, Zhang Y-C, De L, Bai J, Liu Z, Liu X-M, Liu J-H, Yuan X-Y, Yao W-M (2024) Association between improved erectile function and dietary patterns: a systematic review and meta-analysis. Asian J Androl 27:239–244. https://doi.org/10.4103/aja202485
70. Yannas D, Frizza F, Vignozzi L, Corona G, Maggi M, Rastrelli G (2021) Erectile dysfunction is a hallmark of cardiovascular disease: unavoidable matter of fact or opportunity to improve men's health? J Clin Med 10. https://doi.org/10.3390/jcm10102221
71. Zhu J, Zhang W, Ou N, Song Y, Kang J, Liang Z, Hu R, Yang Y, Liu X (2020) Do testosterone supplements enhance response to phosphodiesterase 5 inhibitors in men with erectile dysfunction and hypogonadism: a systematic review and meta-analysis. Translational Androl Urol 9:591–600. https://doi.org/10.21037/tau.2020.01.13

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.