e-ISSN:2687-2145

BANDIRMA ONYEDİ EYLÜL ÜNİVERSİTESİ SAĞLIK BİLİMLERİ VE ARAŞTIRMALARI DERGİSİ
BANU Journal of Health Science and Research

DOI: 10.46413/boneyusbad.1763692 ***Özgün Araştırma / Original Research***

Mapping the Scientific Evolution of Peyronie's Disease: A Bibliometric and Machine Learning Analysis

Peyronie Hastalığının Bilimsel Evriminin Haritalandırılması: Bibliyometrik ve Makine Öğrenimi Analizi

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Geliş tarihi / Date of receipt: *12.08.2025*

Kabul tarihi / Date of acceptance: *12.11.2025*

Atıf / Citation: Şimsek, A., Kırdar, M., Görgü, N., Başer, A., Bingöl, G., Kesgin, K. (2025). Mapping the scientific evolution of peyronie's disease: a bibliometric and machine learning analysis. *BANÜ Sağlık Bilimleri ve Araştırmaları Dergisi, 7*(3), 945-952. doi: 10.46413/ boneyusbad. 1763692

* This study was presented as an oral presentation at the 3rd Andology Congress of the Urological Surgery Association (10-13 April 2025 Antalya).

ABSTRACT

Aim: *Peyronie's disease is an acquired penile connective tissue disorder characterized by fibrous plaque formation, leading to curvature, pain, and sexual dysfunction. Research on peyronie's disease has increased markedly in the past two decades, but variability in study quality complicates the identification of impactful work. This study aimed to perform a bibliometric analysis of peyronie's disease-related publications to highlight research trends and guide future studies.*

Material and Method: *A literature search was conducted on February 16, 2025, in Web of Science, Scopus, and TR Dizin using the terms "Peyronie's disease," "treatment of Peyronie's disease," "penile fibrosis," and "tunica albuginea plaque." Only English-language original research articles with "Peyronie" in the title were included. Data were analyzed with BibloX, assessing publication year, citations, journal frequency, and keyword trends. Citation forecasts were generated using machine learning models.*

Results: *A total of 4,550 articles were identified, with the earliest in 1948. Publications rose sharply after 2000, particularly from the United States. The most cited study was Gelbard MK's Natural History of Peyronie's Disease (397 citations). Keyword analysis highlighted "Peyronie's disease" and "erectile dysfunction." Predictive models forecast varying 2026 citation counts.*

Conclusion: *This analysis integrates machine learning algorithms into the bibliometric evaluation of Peyronie's disease research, offering data-driven predictions and insights into future research directions.*

Keywords*: Peyronie disease, Penis, Fibrosis, Bibliometrics, Machine learning*

ÖZET

Amaç: *Peyronie hastalığı, penis eğriliği, ağrılı ereksiyonlar ve cinsel işlev bozukluğu ile sonuçlanabilen fibroz plak oluşumu ile karakterize edinilmiş bir bağ dokusu bozukluğudur. Son yirmi yılda bu hastalıkla ilgili yayınlarda belirgin bir artış olmuştur; ancak bilimsel kalitedeki değişkenlik, yüksek etkili çalışmaları belirlemeyi güçleştirmektedir. Bu çalışma, peyronie hastalığı hakkındaki makalelerin bibliyometrik analizini yaparak güncel araştırma eğilimlerini ortaya koymayı ve gelecekteki çalışmalara rehberlik etmeyi amaçlamaktadır.*

Gereç ve Yöntem*: 16 Şubat 2025'te Web of Science, Scopus ve TR Dizin veri tabanlarında "Peyronie hastalığı", "Peyronie hastalığının tedavisi", "penil fibrozis" ve "tunika albuginea plak" anahtar kelimeleri kullanılarak literatür taraması yapıldı. Yalnızca İngilizce yayınlanan ve başlığında "Peyronie" geçen orijinal araştırma makaleleri dahil edildi. Veriler BibloX yazılımı ile analiz edildi.*

Bulgular: *Toplam 4.550 makale saptandı. Yayınların 2000 yılından sonra, özellikle Amerika Birleşik Devletleri'nde belirgin şekilde arttığı görüldü. En çok atıf alan makale Gelbard MK'nin "Peyronie Hastalığının Doğal Tarihi" çalışmasıydı (397 atıf). Anahtar kelimeler arasında "Peyronie hastalığı" ve "erektil disfonksiyon" ön plandaydı. Makine öğrenimi modelleri 2026 yılı için farklı atıf tahminleri ortaya koydu.*

Sonuç: *Bu çalışma, makine öğrenimi algoritmalarını Peyronie hastalığı araştırmalarının bibliyometrik değerlendirmesine entegre ederek, veri odaklı tahminler ve gelecekteki araştırma yönlerine dair içgörüler sunmaktadır.*

Anahtar kelimeler: *Peyroni hastalığı, Penis, Fibrozis, Bibliometrik analiz, Makine öğrenmesi*

INTRODUCTION

Peyronie's Disease (PD) is an acquired connective tissue disorder characterized by the formation of fibrous plaques in the tunica albuginea of the penis, typically resulting in painful erections, penile curvature, and sexual dysfunction (Nehra et al., 2015). PD significantly affects men's sexual, physical, and psychological health. Its prevalence is estimated to range between 0.7% and 13.1% (Alzubaidi et al., 2025). The pathophysiology of PD is not fully understood; however, it is thought to arise from repetitive microvascular trauma to the penile shaft, leading to abnormal wound healing and plaque formation (Chung, Young, & Brock, 2011).

Surgical procedures such as tunical lengthening, incision or excision with grafting, and tunical shortening are used in its treatment (Başer et al., 2020). For patients who decline surgery or prefer minimally invasive interventions, intralesional injection therapies such as interferon alfa-2b and collagenase clostridium histolyticum (CCH) are commonly preferred (Şahin et al., 2024).

Over the past few decades, the number of publications focusing on the treatment and pathogenesis of Peyronie's Disease has increased substantially. However, the quality of these publications varies, making it challenging for young clinician-scientists to identify high-quality research. Therefore, a systematic evaluation of the literature is necessary to identify the most impactful contributions in this field.

Bibliometrics is an important tool in scientific research. It enables the screening and quantitative analysis of relevant literature, the identification of key points and trends in a given research area, and offers a unique perspective for researchers and clinicians (Garfield, 1987; Cooper, 2015). Among bibliometric methods, citation analysis is the most commonly used. Analyzing highly cited literature allows for an evaluation of the current research landscape, the identification of critical focus areas, and the generation of new ideas for future studies (Kim et al., 2016).

To our knowledge, only two studies have conducted a systematic and comprehensive bibliometric analysis of the PD literature (Gao et al., 2024; Şahin et al., 2024). However, these studies were limited to descriptive analyses and did not integrate predictive modeling or machine learning-based approaches. The present study not only updates and expands the bibliometric evaluation of PD research but also introduces predictive citation modeling using machine learning algorithms, thereby filling an important methodological gap in the existing literature.

MATERIALS AND METHODS

Study Aim and Type

This study was designed as a descriptive and cross-sectional bibliometric analysis aiming to evaluate the scientific publications on Peyronie's disease.

Study Population and Sample

The study population consisted of all scientific publications on Peyronie's disease indexed in the Web of Science (Clarivate Analytics, Philadelphia, USA), Scopus (Elsevier, Amsterdam, Netherlands), and TR Dizin databases. The sample included only original research articles published in English and containing the word "Peyronie" in the title. Review articles, case reports, editorials, and conference abstracts were excluded.

Data Collection Tools

Data were obtained through the search modules of the relevant databases using the keywords "Peyronie's disease," "treatment of Peyronie's disease," "penile fibrosis," and "tunica albuginea plaque."

Data Collection

The literature search was conducted on February 16, 2025. All records retrieved were screened according to the inclusion and exclusion criteria, and eligible articles were included in the study. No pilot application was performed, and data were obtained directly from electronic databases.

Ethical Consideration

As this study was based solely on the analysis of previously published literature, ethical committee approval was not required. Since no patient data were used, institutional permission and informed consent were not applicable.

Data Analysis

The data were analyzed using the BibloX software (Kesgin & Ozer, 2025). Bibliometric parameters evaluated included the number of publications by year, citation trends, most cited articles, journals with the highest number of publications, and keyword distributions. In addition, predictive citation analyses were

performed using machine learning models.

RESULTS

A total of 4,550 publications related to Peyronie's disease were identified, with the earliest publication dated to 1948. A dramatic increase in studies related to Peyronie's disease has been observed since the year 2000 (Figure 1).

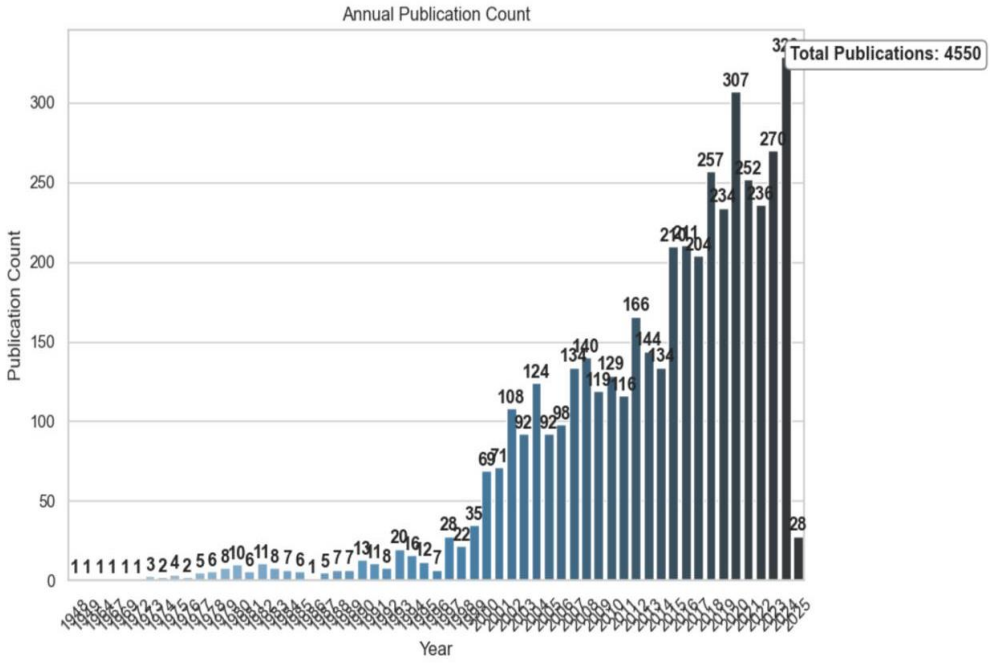

Figure 1. Annual Number of Publications on Peyronie's Disease from Included Databases

Among the countries where the studies were conducted, the United States ranked first with 1,344 publications, followed by China with 87 publications. The United Kingdom is in 3rd place with 45 publications, Italy is in 4th place with 37 publications, and Germany is in 5th place with 36 publications. Turkey ranked eighth with 23 publications.

The most frequently used keyword was "Peyronie's disease" (1,238 occurrences), followed by "erectile dysfunction" (495 occurrences) (Figure 2).

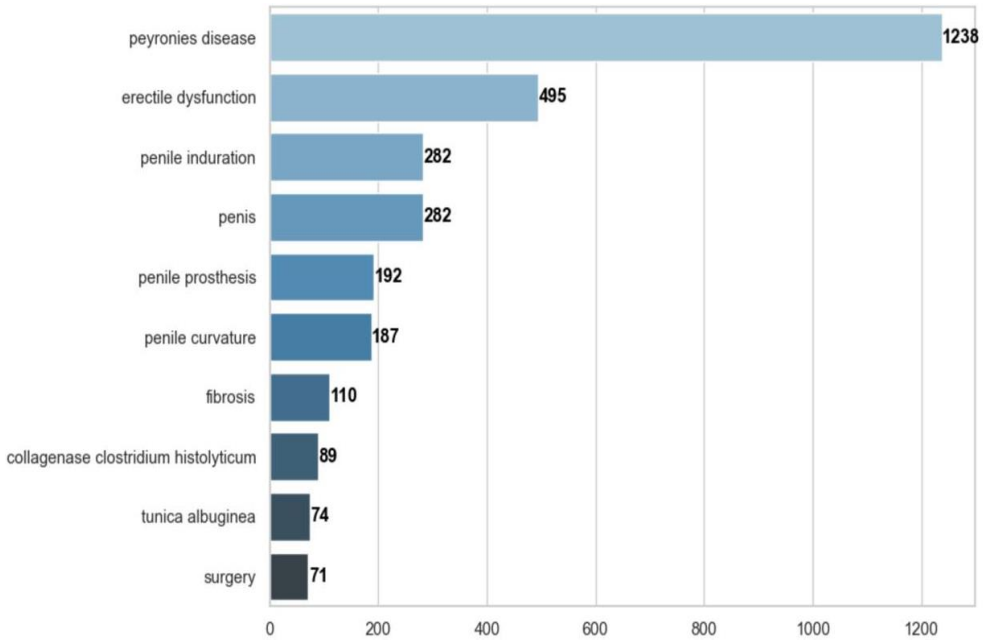

Figure 2. Most Frequently Used Keywords in the Analyzed Articles

Analysis of the annual citation trends showed a marked concentration of citations between 2000 and 2020. The highest number of citations was recorded in 2013, with a total of 4,045 citations. This analysis also indicated that more recent publications tend to receive more citations than older ones (Figure 3).

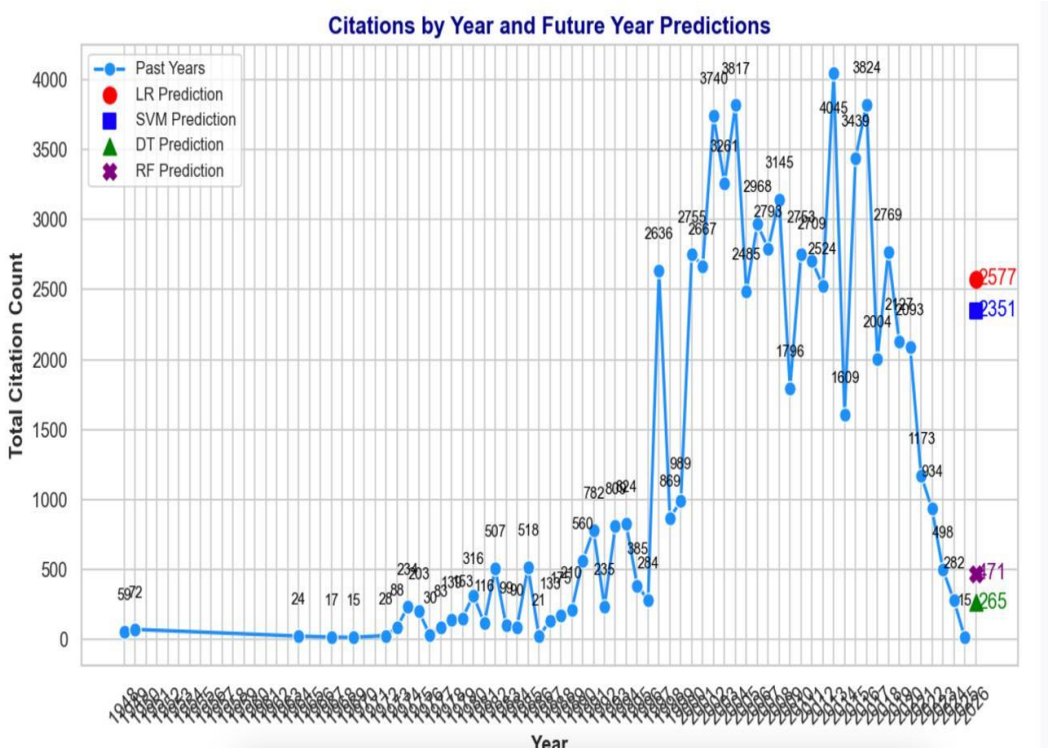

Figure 3. Citation Counts by Year and Predicted Future Citation Trends Using Machine Learning

The Journal of Sexual Medicine led with 1,100 publications, followed by the Journal of Urology with 752 publications. The top 10 journals with the highest number of articles are shown in Figure 4.

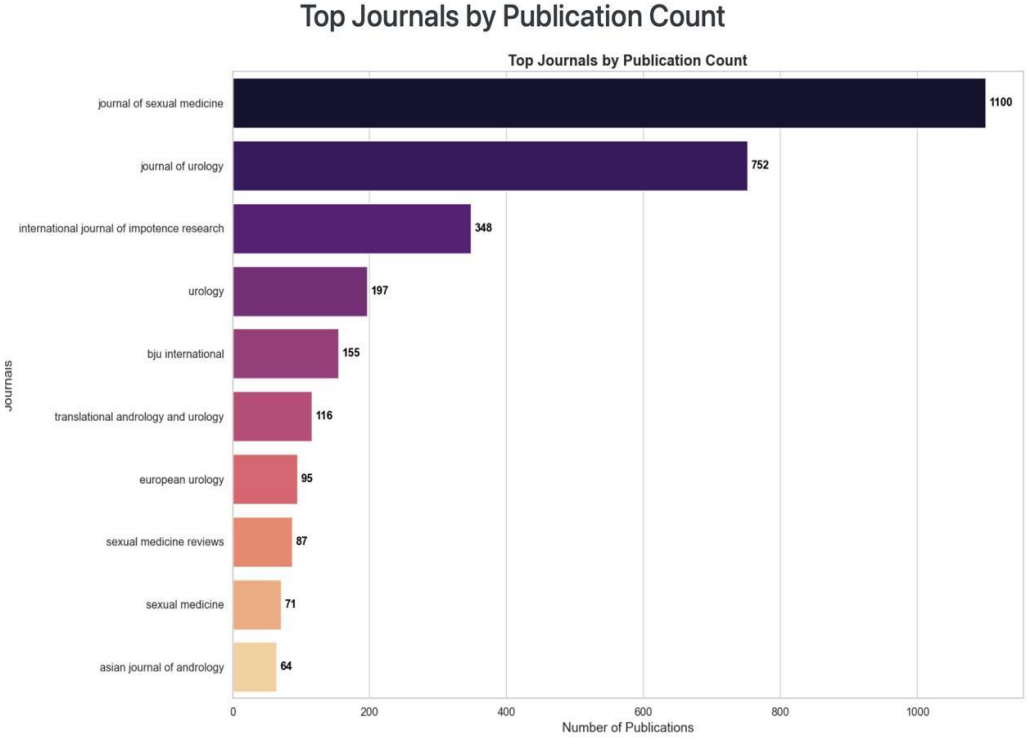

Figure 4. Top Journals Ranked by the Number of Publications Related to Peyronie's Disease

The most highly cited article was "The Natural History of Peyronie's Disease" by Gelbard M.K., with 397 citations. Details of the five most cited articles on Peyronie's disease are presented in Table 1.

Table 1. Top 5 Most-Cited Articles on PD

Title	First Author	Year	Citations	Journal	Topic Summary
The natural history of Peyronie's disease	Gelbard MK	1990	397	Journal of Urology	The progression of Peyronie's disease showed that 13% of cases improved, 47% remained unchanged, and 40% worsened, with no notable link between disease duration and spontaneous curvature improvement (Gelbard, Dorey, & James, 1990)
Clinical efficacy, safety and tolerability of collagenase clostridium histolyticum for the treatment of Peyronie disease in 2 large double-blind, randomized, placebo controlled phase 3 studies	Gelbard MK	2013	350	Journal of Urology	A meta-analysis of two Phase III studies validated the effectiveness and safety of CCH treatment, demonstrating benefits in both physical symptoms and psychological well-being (Gelbard et al., 2013).
An analysis of the natural history of Peyronie's disease	Mulhall JP	2006	326	Journal of Urology	During follow-up, penile pain decreased in all participants, penile curvature improved in 12% of patients, remained stable in 40%, and disease progression was seen in 48% (Mulhall, Schiff, & Guhring, 2006).
Peyronie's disease: AUA Guideline	Nehra A	2015	325	Journal of Urology	This detailed clinical guideline highlights the importance of incorporating patient history, personal values, and treatment objectives to achieve the best therapeutic outcomes (Nehra et al., 2015).
Subjective and objective analysis of the prevalence of Peyronie's disease in a population of men presenting for prostate cancer screening	Mulhall JP	2004	318	Journal of Urology	Peyronie's disease was found in 8.9% of the population and showed a strong association with factors such as advanced age, diabetes, high blood pressure, and erectile dysfunction (Mulhall et al., 2004).

Citation predictions for studies to be conducted on Peyronie's disease in 2026 were estimated as follows: 2,577 for Linear Regression (LR), 2,351 for Support Vector Machines (SVM), 265 for Decision Tree (DT), and 71 for Random Forest (RF) models (Figure 3).

DISCUSSION

This study represents the third comprehensive bibliometric analysis of Peyronie's disease in the international literatüre, incorporating data from the Web of Science, Scopus and TR Dizin databases. A total of 4,550 publications related to PD were identified, with a marked increase in publication volume particularly after the year 2000. This growth is not limited to the number of publications but also reflects an increase in scientific impact, as our analysis revealed that more recent publications have received a higher number of citations compared to older ones. This finding indicates a growing clinical significance

and academic interest in PD over time. Given the limited number of studies that systematically assess this trend in the literature, our analysis contributes valuable insights into the evolution of research focus and scientific priorities in this field.

The United States was by far the leading country in terms of publication volume on PD. In a 2020 study, Christiansen et al. reported that 15.1% of PD-related publications acknowledged funding sources and that most were self-funded (Christiansen, Smelser, Broghammer, & Deibert, 2021). It is not surprising that the USA leads in publication output, as many of the funded studies also originate there (Christiansen et al., 2021). This suggests that conducting research is generally more feasible in countries with stronger socioeconomic infrastructure, such as the United States and several European nations, compared to developing countries.

Our bibliometric analysis revealed that the Journal of Sexual Medicine (n = 1,100) and the Journal of Urology (n = 752) published the highest number of PD-related articles. Both journals are high-impact and widely respected platforms in the fields of urology and sexual medicine. This suggests that the scientific output on PD is not only quantitatively robust but also concentrated in journals with high academic prestige. Similarly, previous bibliometric studies have demonstrated that PD-related literature, particularly in the realms of clinical and translational research, tends to be published in high-impact journals, further increasing the academic visibility of this topic. These findings confirm that Peyronie's disease is emerging as a multidisciplinary research field with growing attention at both the clinical and scientific levels (Gao et al., 2024; Şahin et al., 2024).

In the keyword analysis, the most frequently used term was "Peyronie's disease" (n = 1,238), which is expected and confirms that the literature is directly shaped around this core topic. Notably, the second most frequent keyword was "erectile dysfunction" (n = 495). This suggests that PD is being approached not only as a structural penile deformity but also as a clinical condition closely associated with sexual dysfunction and psychosexual disorders (Nelson et al., 2008; Smith, Walsh, Conti, Turek, & Lue 2008). Indeed, previous studies have shown that erectile dysfunction is a critical factor in the pathophysiology, disease burden, and treatment planning of PD (Deveci, Palese, Parker, Guhring, & Mulhall, 2006). The prominent appearance of erectile dysfunction even at the keyword level reflects a tendency among researchers to evaluate PD in terms of its functional, as well as morphological, implications.

The most highly cited article in the PD literature is "The Natural History of Peyronie's Disease," authored by Gelbard MK (Gelbard et al., 1990). In this study, 13% of patients reported spontaneous improvement over time, 47% noted no significant change, and 40% experienced disease progression. However, no statistically significant relationship was found between disease duration and spontaneous improvement in penile curvature (Gelbard et al., 1990). Findings from longitudinal follow-up of PD patients may not only guide clinical management but also serve as a benchmark for evaluating surgical outcomes. Notably, this publication was also the first to highlight the psychological impact of PD, reporting that 77% of affected individuals experienced psychological distress (Gelbard et al., 1990). These findings prompted clinicians to pay greater attention to the psychological aspects of the disease and emphasized the importance of offering appropriate psychosocial assessments and counseling to PD patients (Nelson et al., 2008; Smith et al., 2008). As a result, many subsequent publications on PD reference this article to provide essential information on the natural history and psychological consequences of the disease.

One of the most important metrics used in the literature to assess the quality of a scientific publication is the number of citations it receives. With the increasing volume of published articles, it has become essential for researchers to identify impactful studies in advance in order to guide their research directions. Moreover, by predicting the number of citations a paper will receive, we can estimate the potential future impact of its authors—an insight that may have practical implications for hiring researchers or faculty members, and for awarding grants and academic recognition.

Several efforts have been made in the literature to gain such insights into the future impact of researchers (Abrishami & Aliakbary, 2019; Kesgin & Ozer, 2025). In the present study, we also addressed the problem of predicting the citation count of a scientific article. Machine learning has increasingly become a powerful tool in scientific research for forecasting future citation and publication counts (Acuna, Allesina, & Kording 2012; Mazloumian, 2012).

Studies in this area have shown that machine learning methods such as Linear Regression (LR), Support Vector Regression (SVR), and Decision Trees (DT) are commonly used for citation prediction. LR models estimate future citation potential using variables such as publication year, number of authors, and journal impact factor, while SVR provides effective results in modeling non-linear relationships. DT models can generate meaningful predictions based on factors such as publication year, keywords, and author collaborations.

Whereas traditional bibliometric tools are often limited to retrospective data analysis, BiBLoX stands out as an innovative, web-based predictive analytics system that integrates LR, SVR, and DT algorithms with bibliometric data to provide forward-looking insights (Kesgin & Ozer, 2025).

In our study, citation counts for PD-related publications expected to be published in 2026 were predicted as follows: 2,577 with the Linear Regression model, 2,351 with Support Vector Machines, 265 with the Decision Tree model, and 71 with the Random Forest (RF) method. These findings contribute to the relatively limited number of applied studies on machine learning–based bibliometric prediction in the literature, while also offering projections about the future trajectory of scientific productivity in the field of Peyronie's disease.

Although this study provides a comprehensive data analysis, it has some limitations. First, the literature search included only those publications with the term "Peyronie" in the title. Therefore, relevant studies that do not explicitly mention "Peyronie" in their titles may have been excluded. Additionally, only original research articles published in English were included, which may have led to the omission of valuable contributions published in other languages. Although Web of Science, Scopus, and TR Dizin were used as data sources, some publications available in other platforms such as PubMed or Google Scholar may not have been accessed.

Furthermore, a common limitation in bibliometric analyses—namely, the dynamic nature of citation counts over time—also applies to this study. Articles published more recently may have received fewer citations simply due to insufficient time having passed since their publication.

In citation prediction using machine learning models, the performance of the algorithms depends on the quality of the selected variables and the size of the dataset. Consequently, predictions made using different algorithms or additional variables may yield varying results.

Lastly, the forecasts generated by the BiBLoX system are based solely on statistical probabilities and may be influenced by unforeseen external factors such as shifts in scientific interest, health policies, or technological advancements.

CONCLUSION

These findings not only map the current state of the PD literature but also provide meaningful projections regarding the future trajectory of scientific productivity in this field. The data obtained through this study serve as a valuable resource for guiding future research and developing scientific strategies.

Ethics Committe Approval

Since this study is based on the analysis of previously published literature, ethical approval was not required.

Author Contributions

Idea/Concept: G.B., K.K.; Design: M.K., A.B.; Supervision/Consulting: A.B., A.S.; Analysis and/or Interpretation: K.K., N.G.; Literature Search: G.B., M.K.; Writing the Article: A.S., K.K.; Critical Review: N.G., G.B.

Peer-review

Externally peer-reviewed.

Conflict of Interest

The authors have no conflict of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

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