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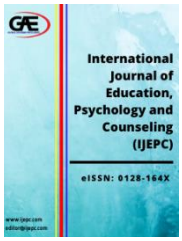

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STRUCTURED MODULE DEVELOPMENT FOR SELF-INSTILLATION EYE DROP TECHNIQUE: ENHANCING PATIENT EDUCATION AND ADHERENCE IN GLAUCOMA CARE

Norsiah Abdullah [1], Salizar Mohamed Ludin [2*]

[1] Institut Latihan Kementerian Kesihatan Malaysia, 47000 Sungai Buloh, Selangor, Malaysia
Email: norsiahabdullah5@gmail.com
[2] Kulliyyah of Nursing, International Islamic University Malaysia, Kuantan, 25200 Malaysia
Email: msalizar@iium.edu.my
[*] Corresponding Author

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Abstract:

The field of glaucoma care has increasingly focused on enhancing patient adherence and self-management, particularly through structured modules for self-instilling eye drops. Effective patient education is crucial for maintaining intraocular pressure and slowing disease progression, yet adherence remains a significant challenge. This study conducts a bibliometric analysis to identify key trends, gaps, and influential studies related to structured educational interventions for glaucoma patients. The problem addressed here centres on the need for comprehensive modules that empower patients to manage their treatment effectively, thereby improving adherence and overall outcomes. Using Scopus analyser and VOSviewer software, a systematic search was conducted, covering publications from 2021 to 2024. A final dataset of 1,663 relevant documents was obtained, reflecting a concentrated research effort on this topic. Methodologically, the Scopus analyser provided descriptive statistics, identifying leading authors, publications, and frequently cited studies, while VOSviewer enabled a network visualisation of keyword co-occurrences, highlighting prominent research themes such as "intraocular pressure," "adherence," and "quality of life." Numerical results indicate a peak in publications in 2021, suggesting heightened academic interest during that period, followed by a gradual decline, likely due to saturation in foundational studies. The keyword analysis also shows high link strengths for terms associated with patient adherence challenges, suggesting a substantial need for structured modules that address these barriers. In conclusion, the analysis underscores the importance of developing targeted educational frameworks to enhance self-care techniques, improve medication adherence, and ultimately support better outcomes in glaucoma management. The findings provide a

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valuable foundation for future research in educational strategies for patient-centred glaucoma care.

Keywords:

Glaucoma, Self-Instillation Eye Drops, Patient Education, Medication Adherence, Structured Module Development

Introduction

Glaucoma is a leading cause of irreversible blindness worldwide, primarily managed through the reduction of Intraocular Pressure (IOP) using topical medications. However, adherence to these medications is notably low, significantly impacting disease management and progression (Tapply & Broadway, 2021). Effective administration of eye drops is crucial for achieving optimal therapeutic outcomes. Yet, many patients struggle with proper instillation techniques, leading to issues such as bottle contamination and missed doses (Davis et al., 2018). This underscores the need for structured educational interventions to enhance patient adherence and technique. Educational interventions have shown promise in improving eye drop instillation techniques and self-efficacy among glaucoma patients. For instance, the Support, Educate, Empower (SEE) program demonstrated significant improvements in the accuracy of eye drop administration and self-efficacy scores among participants (Schneider et al., 2020). Similarly, a randomised controlled trial found that a short educational video significantly enhanced patients' eye drop technique and self-efficacy immediately after viewing and sustained these improvements for at least one month (Davis et al., 2018). These findings highlight the potential of structured educational programs in addressing the challenges associated with eye drop instillation.

Pharmacist-led interventions have also been effective in improving eye drop techniques. A study conducted at Sarawak General Hospital revealed that patients who received counselling from pharmacists showed significant improvements in their eye drop instillation techniques (Kan et al., 2022). This suggests that healthcare providers, including pharmacists, play a critical role in patient education and can significantly impact adherence and technique through targeted interventions. Moreover, the use of visual aids, such as eye drop charts, has been shown to improve adherence and reduce IOP, further supporting the need for comprehensive educational strategies (Choi et al., 2021). Despite the demonstrated benefits of educational interventions, there remains a gap in consistently implementing these strategies in clinical practice. Many patients do not receive adequate instruction on eye drop techniques during their office visits, which can hinder their ability to manage their condition effectively (Carpenter et al., 2016). Therefore, integrating structured module development for self-instillation eye drop techniques into routine patient education could enhance adherence and improve clinical outcomes for glaucoma patients. By leveraging various educational tools and involving multiple healthcare providers, a multifaceted approach can be developed to support patients in their treatment journey.

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Literature Review

Structured modules for self-instillation of eye drops have been increasingly emphasised in glaucoma care, given the critical role of correct instillation techniques in enhancing patient adherence and medication efficacy. Studies by Tripathi et al. (2023) and Rajanala et al. (2022) underscore that inadequate awareness and ineffective self-administration of eye drops contribute significantly to the progression of glaucoma. Specifically, Tripathi et al. (2023) observed that nearly 25% of patients lacked essential knowledge regarding medication, leading to inconsistent adherence. Rajanala et al. (2022) further correlated instillation ineffectiveness with increased glaucoma progression, highlighting the importance of accurate self-administration. Similarly, findings from Cvenkel and Kolko (2023) indicate that barriers to adherence, such as difficulty in self-administration, can be mitigated through structured patient education and personalised interventions. The impact of comprehensive training modules on eye drop instillation accuracy is evidenced by studies exploring various educational methods. Saif et al. (2024) demonstrated that instructional sessions significantly improved patients' handling of eye drop administration, notably enhancing adherence and technique. This aligns with the findings by Taribagil et al. (2022), who found that glaucoma health coaching greatly empowered patients, especially when initiated at the onset of treatment. These results, alongside Lee et al. (2024) study on video feedback for instillation training, suggest that innovative educational methods, including visual aids and personalised coaching, improve patient competence in eye drop administration.

Moreover, the integration of digital tools and AI-based monitoring systems offers a promising enhancement in adherence. Research by Tabuchi et al. (2024) on cloud-based AI support demonstrated a 95.6% accuracy in detecting correct instillation techniques, reinforcing the effectiveness of digital monitoring. Kang et al. (2022) further support this approach by linking higher health literacy levels to improved instillation success, suggesting that digital and AI-assisted tools can potentially bridge literacy gaps among glaucoma patients. Complementing these findings, Cho and Lee (2023) observed that video recordings provided a more accurate assessment of instillation performance, unveiling discrepancies in patients' perceived and actual techniques. While the need for structured modules is clear, the existing research reveals limitations, particularly in sample diversity and long-term outcome studies. Tanito et al. (2023) pointed out that older age and cognitive impairments often lead to instillation failure. Yet, most training modules do not accommodate these patient-specific challenges. Similarly, Kashiwagi et al. (2021) identified physical limitations, such as limited arm mobility and poor visual acuity, as significant barriers to correct self-administration. Future studies should, therefore, focus on developing inclusive modules tailored to elderly patients and those with physical or cognitive constraints.

In conclusion, current research strongly advocates for the development of structured educational modules for eye drop self-instillation in glaucoma care, aiming to enhance patient adherence and improve clinical outcomes. However, there remains a gap in studies addressing patient diversity and long-term adherence efficacy, emphasising the need for further research in developing adaptive, patient-centred modules incorporating digital tools and addressing specific limitations identified across patient demographics.

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Research Question

- What are the research trends in online learning studies according to the year of publication?
- Who writes the most cited articles, and where do they work?
- Who are the top 10 authors based on citation by research?
- What are the popular keywords related to the study?
- What are co-authorship countries' collaboration?

Methodology

Bibliometrics refers to the collection, management, and analysis of bibliographic data derived from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). It encompasses general descriptive statistics, such as publishing journals, publication years, and author classifications (Wu & Wu, 2017), as well as advanced methodologies, including document co-citation analysis. Conducting a successful literature review involves an iterative process of identifying relevant keywords, performing a systematic literature search, and conducting detailed analyses to construct a comprehensive bibliography and generate reliable findings (Fahimnia et al., 2015). In this context, the study concentrated on high-impact publications, as these provide critical insights into the theoretical frameworks shaping the progression of the research field. To ensure data accuracy and comprehensiveness, the Scopus database was employed as the primary source for data collection (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). To maintain the quality of the reviewed literature, the inclusion criteria were restricted to articles published in peer-reviewed academic journals, explicitly excluding books and lecture notes (Gu et al., 2019). Elsevier's Scopus database, renowned for its extensive and multidisciplinary coverage, was utilised to gather publications dated from 2021 to December 2024 for subsequent analysis.

Data Search Strategy

Advanced searching on the Scopus database is a technique that allows users to perform highly specific and targeted searches to locate scholarly articles and other publications relevant to their research topic. Unlike basic keyword searches, advanced searching offers multiple options and operators to refine search results, enabling users to retrieve precise and relevant data from Scopus's extensive academic collection.

Table 1: The Search String.

Scopus	TITLE-ABS-KEY (eye AND drop OR instillation AND glaucoma) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024) OR LIMIT-TO (PUBYEAR , 2025)) AND (LIMIT-TO (LANGUAGE , "English"))

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Table 2: The Selection Criterion Is Searching.

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2021 – 2024	< 2020
Literature type	Journal (Article) and Proceeding	Book, Review

Data Analysis

VOSviewer is a widely-used bibliometric tool created by Nees Jan van Eck and Ludo Waltman at Leiden University, Netherlands (van Eck & Waltman, 2010, 2017). Known for its simplicity and efficiency, VOSviewer allows researchers to visualise and analyse scientific literature, specialising in generating intuitive network visualisations, clustering related items, and producing density maps. This tool supports the analysis of co-authorship, co-citation, and keyword co-occurrence networks, providing a comprehensive overview of research landscapes. Its interactive design, along with regular updates, enables users to explore large datasets effectively. The tool's ability to calculate metrics, create customised visualisations, and integrate with various bibliometric data sources makes it an invaluable asset for scholars seeking to understand complex research fields. A key advantage of VOSviewer is its ability to convert complex bibliometric datasets into clear visual representations, such as maps and charts. The software is highly effective in network visualisation, enabling the clustering of related items, keyword co-occurrence analysis, and the creation of density maps. Its user-friendly interface supports both beginners and experienced researchers in exploring research landscapes with ease. Continuous development keeps VOSviewer at the forefront of bibliometric analysis, offering insightful metrics and customisable visualisations. By supporting various types of bibliometric data, including co-authorship and citation networks, VOSviewer stands out as a flexible and essential tool for gaining deeper insights within research domains.

Datasets containing details such as publication year, title, author, journal, citations, and keywords in PlainText format were obtained from the Scopus database, covering publications from 2021 to December 2024. These datasets were processed using VOSviewer software version 1.6.19. Through VOS clustering and mapping techniques, the software enabled the analysis and generation of visual maps. Unlike the Multidimensional Scaling (MDS) method, VOSviewer places items in low-dimensional spaces, ensuring that the distance between two items accurately represents their similarity and relationship (van Eck & Waltman, 2010). While VOSviewer shares some similarities with the MDS approach (Appio et al., 2014), it uses a more suitable method for normalising co-occurrence frequencies, such as Association Strength (AS_{ij}), calculated as (Van Eck & Waltman, 2007):

$$AS_{ij} = \frac{C_{ij}}{W_i W_j},$$

which is "proportional to the ratio between, on the one hand, the observed number of co-occurrences of *i* and *j* and, on the other hand, the expected number of co-occurrences of i and j under the assumption that co-occurrences of *i* and *j* are statistically independent" (Van Eck

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and Waltman, 2010, p. 531) (van Eck & Waltman, 2017). Hence, with the help of this index, the VOSviewer places items in the form of a map after reducing the weighted sum of the squared distances between all item pairs. According to Appio et al. (2016), the LinLog/modularity normalisation was implemented. Furthermore, by applying visualisation techniques through VOSviewer to the data set, patterns built on mathematical relationships were uncovered, and analyses such as keyword co-occurrence, citation analysis, and co-citation analysis were performed.

Result and Discussion

What Are The Research Trends In Online Learning Studies According To The Year Of Publication?

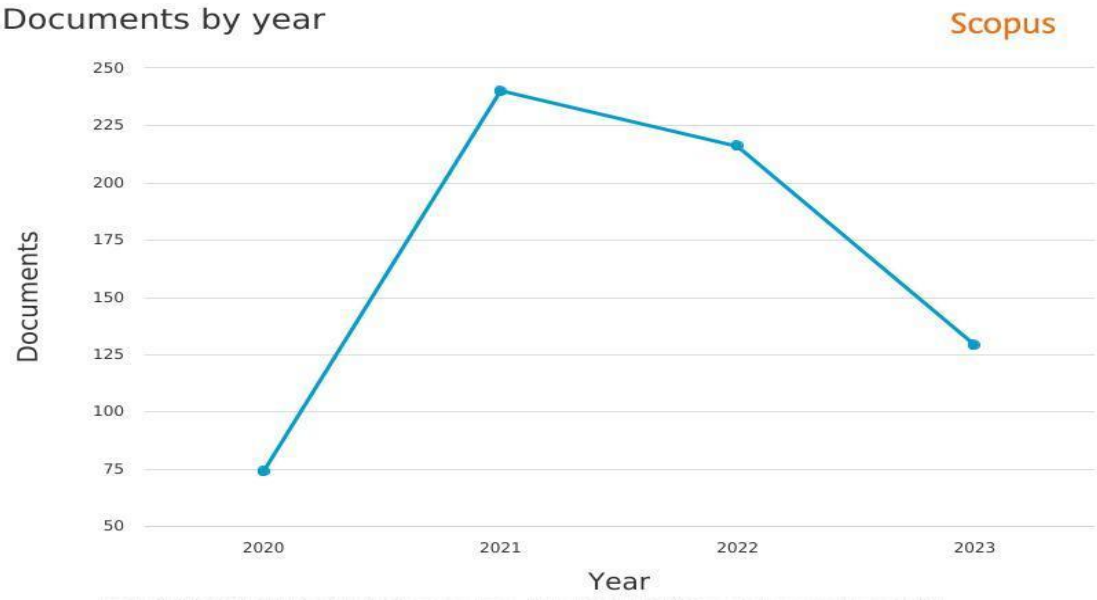

Figure 1: Plotting Document Publication by Years.

The line graph presented highlights a notable trend in publication frequency concerning structured module development for self-instillation eye drop techniques within glaucoma care. The peak in publications was observed in 2021, with around 250 documents, followed by a gradual decline in subsequent years. This peak might reflect an increased interest and urgency in addressing patient adherence challenges and self-management in glaucoma, potentially spurred by heightened awareness of patient-centred care or advancements in self-administration techniques. The years 2020 and 2021 likely represented a period of accelerated research output, possibly influenced by new developments in digital health tools, adherence-focused devices, or innovative educational strategies aimed at empowering patients in their glaucoma care routines.

Following the peak in 2021, the decline in publications from 2022 onwards suggests either a shift in research focus or the natural saturation of foundational studies in this area. This trend could indicate that the initial surge of interest has paved the way for more specialised, lower-volume research or that other emerging fields are competing for scholarly attention. The steady decline might also reflect the completion of preliminary studies, with subsequent work focusing on longitudinal studies, clinical trials, or technology implementations rather than new foundational research. Nevertheless, the cumulative research output over these years provides

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a robust basis for developing structured modules to enhance patient education and adherence, underscoring the ongoing significance of this field in glaucoma management.

Who Writes The Most Cited Articles, And Where Do They Work?

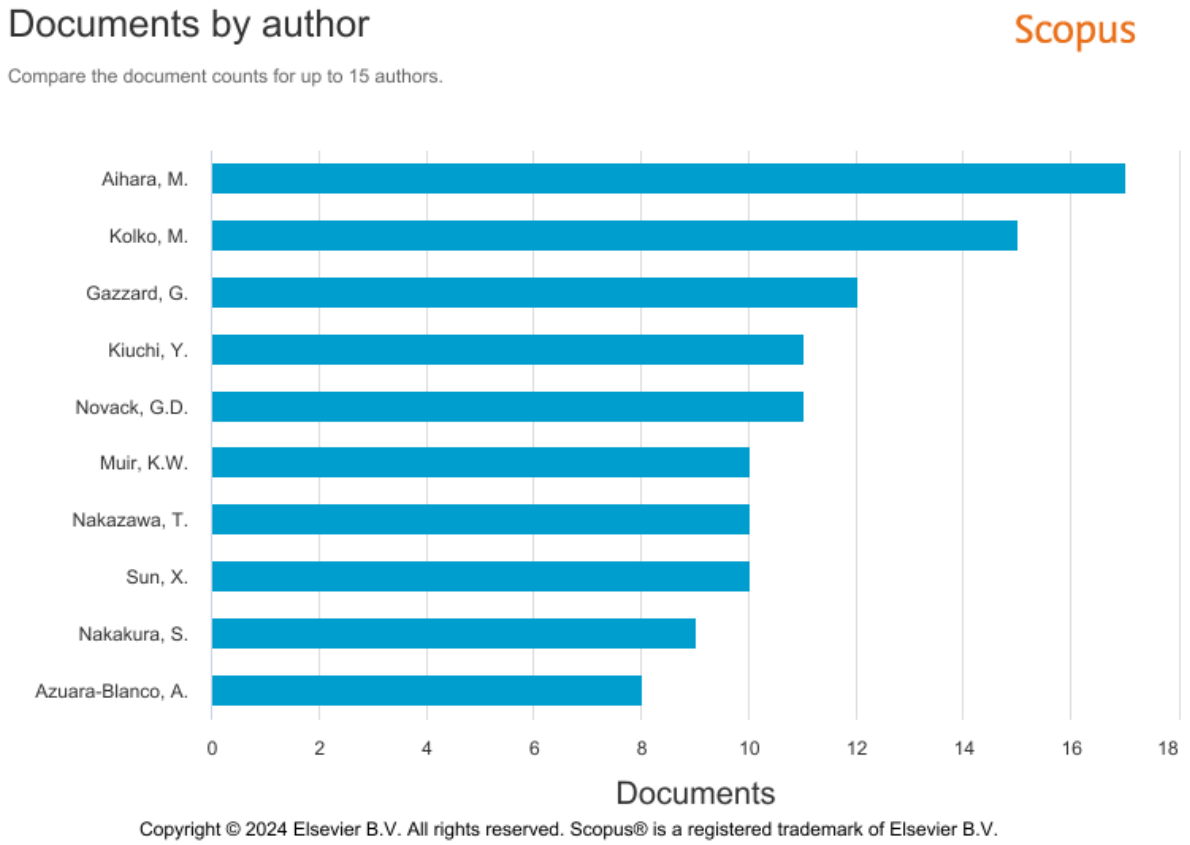

Figure 2: Contributing Authors in the Field: Document Counts from Scopus by Years.

Table 3: Contributing Authors by Document Count and Percentage in the Field by Years.

AUTHOR NAME	Number of Document	Percentages (%)
Aihara, M.	17	1.02
Kolko, M.	15	0.90
Gazzard, G.	12	0.72
Kiuchi, Y.	11	0.66
Novack, G.D.	11	0.66
Muir, K.W.	10	0.60
Nakazawa, T.	10	0.60
Sun, X.	10	0.60
Nakakura, S.	9	0.54
Aihara, M.	17	1.02
Kolko, M.	15	0.90
Gazzard, G.	12	0.72
Kiuchi, Y.	11	0.66

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The data presented in the chart illustrates the publication trends of prominent authors in the field of glaucoma research, particularly in developing and evaluating patient education techniques for self-instillation of eye drops, a critical area for enhancing adherence among glaucoma patients. Between 2021 and 2024, there is a notable concentration of research output from leading authors, with Aihara, M., Kolko, M., and Gazzard, G. contributing the most documents. This trend highlights the growing academic interest in patient self-management and adherence techniques, reflecting an increasing emphasis on structured educational modules for glaucoma care. Aihara, M., leads with the highest number of publications, possibly indicating a focused research agenda on innovations in eye drop instillation education or adherence technology. Other prominent researchers, such as Kolko and Kiuchi, also demonstrate substantial contributions, suggesting a collaborative or parallel effort in advancing patient adherence and management techniques within the field.

The data suggests that these authors are pivotal in advancing glaucoma care practices, potentially addressing critical challenges in patient adherence and self-care capabilities. Notable contributions from Muir, K.W., and Novack, G.D. further support this trend, as their research is likely to address patient-centred interventions or clinical outcomes associated with self-instillation techniques. The involvement of multiple researchers with high document counts indicates a robust interest in developing and refining structured modules, possibly driven by the urgent need for practical, effective solutions to mitigate glaucoma progression through improved medication adherence. The cumulative research by these authors could provide a foundation for structured module development in clinical and educational settings, focusing on enhancing both the effectiveness and accessibility of self-care techniques for glaucoma patients.

Who Are The Top 10 Authors Based On Citation By Research?

Table 4: Articles in Ophthalmology and Related Fields by Years.

Authors	Title	Year	Journal	Cited by
Gedde S.J.; Vinod K.; Wright M.M.; Muir K.W.; Lind J.T.; Chen P.P.; Li T.; Mansberger S.L.	Primary Open-Angle Glaucoma Preferred Practice Pattern®	2021	Ophthalmology	185
Roskoski R., Jr.	Properties of FDA-approved small molecule protein kinase inhibitors: A 2021 update	2021	Pharmacological Research	264
Spaeth G.L.	European Glaucoma Society Terminology and Guidelines for Glaucoma, 5th Edition	2021	British Journal of Ophthalmology	246
Onugwu A.L.; Nwagwu C.S.; Onugwu O.S.; Echezona A.C.; Agbo C.P.; Ihim S.A.; Emeh P.; Nnamani P.O.; Attama A.A.; Khutoryanskiy V.V.	Nanotechnology-based drug delivery systems for the treatment of anterior segment eye diseases	2023	Journal of Controlled Release	96

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Ahmed S.; Amin M.M.; Sayed S.	Ocular Drug Delivery: a Comprehensive Review	2023	AAPS PharmSciTech	78
Jonas J.B.; Ang M.; Cho P.; Guggenheim J.A.; He M.G.; Jong M.; Logan N.S.; Liu M.; Morgan I.; Ohno-Matsui K.; Pärssinen O.; Resnikoff S.; Sankaridurg P.; Saw S.-M.; Smith E.L., III; Tan D.T.H.; Walline J.J.; Wildsoet C.F.; Wu P.-C.; Zhu X.; Wolffsohn J.S.	IMI prevention of myopia and its progression	2021	Investigative Ophthalmology and Visual Science	223
Allyn M.M.; Luo R.H.; Hellwarth E.B.; Swindle-Reilly K.E.	Considerations for Polymers Used in Ocular Drug Delivery	2022	Frontiers in Medicine	73
Goldstein M.H.; Silva F.Q.; Blender N.; Tran T.; Vantipalli S.	Ocular benzalkonium chloride exposure: problems and solutions	2022	Eye (Basingstoke)	108
Kompella U.B.; Hartman R.R.; Patil M.A.	Extraocular, periocular, and intraocular routes for sustained drug delivery for glaucoma	2021	Progress in Retinal and Eye Research	71
Yang C.; Wu Q.; Liu J.; Mo J.; Li X.; Yang C.; Liu Z.; Yang J.; Jiang L.; Chen W.; Chen H.-J.; Wang J.; Xie X.	Intelligent wireless diagnostic contact lens for electrical sensing and regulation of intraocular pressure	2022	Nature Communications	69

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The data suggests that these authors are pivotal in advancing glaucoma care practices, potentially addressing critical challenges in patient adherence and self-care capabilities. Notable contributions from Muir, K.W., and Novack, G.D. further support this trend, as their research is likely to address patient-centred interventions or clinical outcomes associated with self-instillation techniques. The involvement of multiple researchers with high document counts indicates a robust interest in developing and refining structured modules, possibly driven by the urgent need for practical, effective solutions to mitigate glaucoma progression through improved medication adherence. The cumulative research by these authors could

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provide a foundational basis for structured module development in clinical and educational settings, focusing on enhancing both the effectiveness and accessibility of self-care techniques for glaucoma patients.

What Are The Popular Keywords Related To The Study?

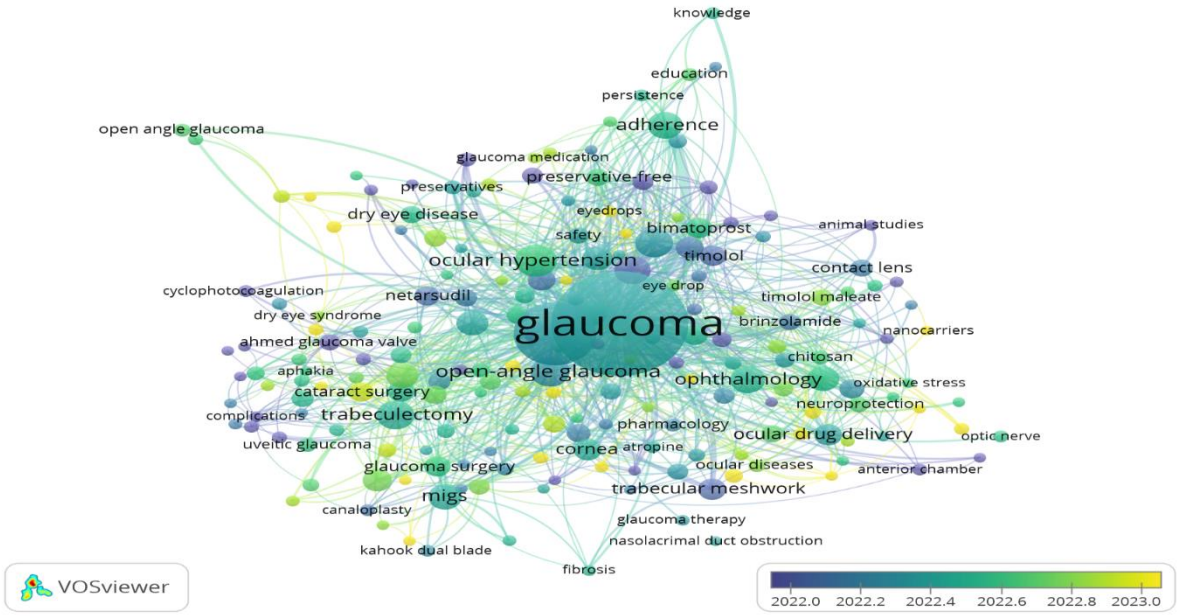

Figure 3: Network Visualisation Map of Keywords' Co-Occurrence.

The figure outlines keywords associated with research publications from 2021 to 2024 on glaucoma care, eye drop instillation, and related pharmacological interventions, with each keyword accompanied by its occurrence and total link strength. These metrics are valuable in bibliometric analysis as they help identify the most prominent themes and trends in the field, particularly those relevant to structured educational modules for eye drop self-instillation. Keywords such as "intraocular pressure" (occurrence: 202, total link strength: 431), "glaucoma" (occurrence: 555, total link strength: 1001), and "adherence" (occurrence: 36, total link strength: 74) are among the most frequently occurring terms with high link strength, underscoring the central focus on patient adherence and the management of IOP in glaucoma research. The prominence of these keywords indicates that maintaining IOP through regular and correct eye drop instillation is a primary concern, aligning with the need for structured educational modules to improve adherence and self-management in glaucoma patients.

The frequent occurrence and high link strength of keywords such as "ocular hypertension" (occurrence: 53, link strength: 148), "dry eye" (occurrence: 29, link strength: 59), and "ocular surface disease" (occurrence: 23, link strength: 59) highlight common challenges patients face that affect adherence. These conditions can complicate eye drop administration, making it difficult for patients to adhere to their treatment regimen consistently. Structured modules can play a critical role in addressing these issues by educating patients on proper techniques, managing side effects, and understanding the importance of adherence to control disease progression. Furthermore, terms like "medication adherence" (occurrence: 16, link strength: 28) and "quality of life" (occurrence: 16, link strength: 27) suggest a growing focus on the

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impact of adherence on patient well-being. Effective educational modules that enhance adherence could lead to better disease management, potentially improving the quality of life for glaucoma patients. The table also includes emerging pharmacological solutions, such as "nanoparticles" (occurrence: 19, link strength: 45) and "minimally invasive glaucoma surgery" (occurrence: 27, link strength: 51), indicating innovative approaches in treatment that could complement educational interventions in enhancing patient adherence and outcomes.

Overall, this data provides a comprehensive understanding of the interconnected themes in glaucoma care, with a clear emphasis on the need for structured patient education to address adherence and self-care challenges. The high link strength of keywords related to medication adherence, IOP management, and patient quality of life further supports the value of developing structured educational modules for self-instillation of eye drops in glaucoma care, ensuring better patient outcomes and a deeper understanding of their treatment needs.

What Are Co-Authorship Countries' Collaboration?

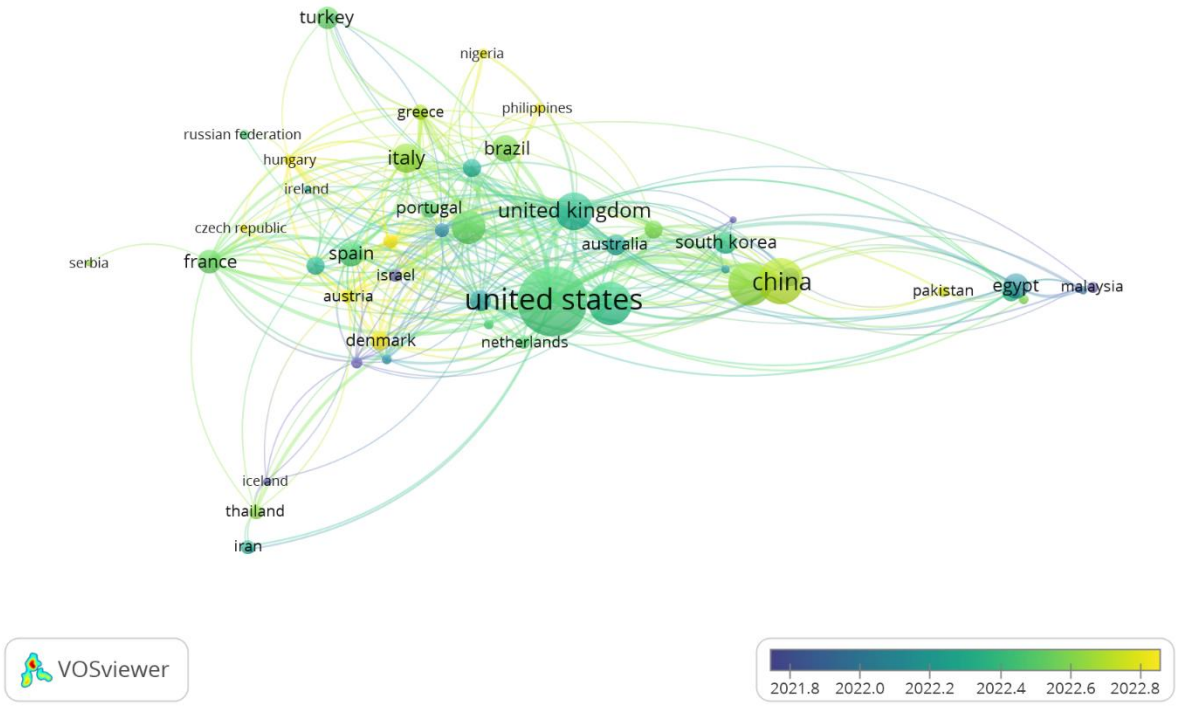

Figure 4: Network Visualisation Map of Co-Authorship

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Conclusion

Recent studies on glaucoma treatment have highlighted the critical role of medication adherence and patient behaviour in effectively managing the disease and mitigating its progression. Kolko et al. (2024) and Barakat et al. (2024) provided substantial evidence that long-term adherence to glaucoma medications is crucial in reducing the risk of visual field loss and disease progression. Their research underscored the necessity of structured interventions, such as patient education and support, to improve medication compliance and enhance clinical outcomes. These findings emphasised the need for continuous patient engagement and the implementation of tailored strategies to foster adherence, which is pivotal in the successful management of glaucoma. The correct technique in administering glaucoma medications, particularly eyedrop instillation, is vital in treatment efficacy. Lee et al. (2024) demonstrated that improving patients' instillation techniques through self-video feedback significantly enhances the effectiveness of glaucoma medications by ensuring proper IOP control. This study, along with the work of Kiyota et al. (2024) on the systemic effects of β-blocker eye drops, highlighted the importance of personalised treatment plans that consider both the efficacy of the medication and the patient's tolerance to side effects. Together, these studies

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suggested that a holistic approach to glaucoma management—integrating patient education, monitoring, and personalised care—is essential for optimising treatment outcomes.

Furthermore, the effectiveness and safety of glaucoma treatments continue to be a focus of research, with significant attention given to managing side effects associated with long-term medication use. Messmer et al. (2024) highlighted the need to balance treatment efficacy with the preservation of ocular surface health, particularly in patients using prostaglandin analogues and beta-blockers. Complementary studies by Xia et al. (2024) and Motta et al. (2024) underscored the importance of proper eyelid positioning and the consideration of patient-specific factors such as financial burden and side effects in ensuring treatment adherence and effectiveness. These findings reinforced the necessity of a comprehensive, patient-centred approach in glaucoma management, which addresses both the therapeutic and side effect profiles of the medications. The interplay between preservatives, drug delivery systems, and adverse effects is a complex but crucial aspect of glaucoma management. Studies by Eraslan and Celikay (2023) and Wang et al. (2023) have highlighted the ocular and systemic risks associated with long-term use of preserved eye drops, particularly in vulnerable populations with comorbid conditions like CKD. The integration of innovative drug delivery systems, such as the smart eye drop bottle sensors evaluated by Tabuchi et al. (2024), offers promising solutions for enhancing adherence while minimising preservative-related side effects. Meanwhile, Montolío-Marzo et al. (2024) further emphasised the need for careful selection of medication formulations to balance the benefits of active drugs with the potential risks posed by preservatives.

In conclusion, managing glaucoma requires a multifaceted approach that integrates patient adherence, proper medication administration techniques, and the careful consideration of both ocular and systemic safety. Furthermore, the studies reviewed demonstrate the importance of continuous innovation in treatment strategies and the need for personalised care that addresses the unique needs of each patient. Nevertheless, as the field of glaucoma treatment evolves, integrating new technologies and a deeper understanding of patient-specific factors will be key to optimising care and improving long-term outcomes.

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