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ORIGINAL RESEARCH

Trends and Future Projections of Vitreoretinal Surgery in a Tertiary Hospital in China (2005–2022)

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Purpose: To analyze past trends and project future trajectories of vitreoretinal surgery in China.

Methods: A single-institution, retrospective analysis of vitreoretinal surgeries conducted at Zhongshan ophthalmic center (ZOC), Sun Yat-sen University, from 2005 to 2022, utilizing ZOC's inpatient database. Patients hospitalized in the retinal surgery department were included. The number of surgeries was stratified by final diagnosis, and a time series forecasting model was employed to predict the number of patients undergoing vitreoretinal surgery up to and including the year 2032.

Results: The number of patients undergoing vitreoretinal surgery increased nearly fourfold from 2005 to 2022, reaching a total of 5600 vitreoretinal surgeries in 2022. The majority of indication was given for the treatment was rhegmatogenous retinal detachment (RRD). Among the diagnosis categories, macular diseases (MD) increased by 15.61%, and diabetic retinopathy (DR) by 11.99% during the study period. Vitreoretinal surgeries are projected to increased annually, with an estimated 9231 vitreoretinal surgeries by 2032.

Conclusion: The demand for vitreoretinal surgery in China has grown substantially over the last decade and is anticipated to rise further. Healthcare systems must adapt to accommodate the high demand.

Keywords: vitreoretinal surgery, trend, projection

Introduction

Since Schepens introduced scleral buckle surgery for retinal detachment in 1951,[1] and Machemer developed vitrectomy in 1971,[2] the vitreoretinal subspecialty has undergone significant advancements over the past few decades. The introduction of sutureless small-gauge transconjunctival microincision vitrectomy surgery (MIVS) in 2002 revolutionized vitreoretinal procedures by improving surgical precision, minimizing intraoperative complications, and substantially reducing postoperative recovery times.[3] Concurrently, advanced vitreous-retinal interface imaging systems, such as optical coherence tomography (OCT) introduced in 2004,[4] transformed the diagnostic and therapeutic landscape by enabling unparalleled visualization of retinal structures and facilitating more precise surgical interventions. These innovations have influenced clinical practice by improving success rates of vitreoretinal surgery and contributing to the expansion of vitreoretinal surgeries while more and more vitreoretinal disease can be detectable and treatable.

Previous studies have reported increasing trends in vitreoretinal surgeries across developed countries, including the United States (2010~2012),[5] the United Kingdom (1968~2004),[6] Australia (2001~2019),[7] Korea (2002~0213)[8] and Japan (2010~2017).[9] These findings reflect real-world clinical practices, enabling health planners to allocate medical resources more efficiently and improve the quality of healthcare. However, the data from these studies may be considered relatively

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outdated, and might not accurately represent current clinical practices or disease prevalence. Moreover, there is a notable lack of comprehensive data on vitreoretinal surgery trends in developing countries, particularly China. This lack of up-to date, region-specific data highlights the urgent need for research to better understand and address the evolving demands of vitreoretinal services in China.

This study aims to analyze trends in vitreoretinal surgeries at a tertiary ophthalmic center in China and project surgical volumes for the next decade. Accurate surgical trend predictions are essential for justifying increased funding for retinal surgery departments and guiding workforce planning, including surgeon recruitment and training. Additionally, this study aims to offer critical insights into the future structure of vitreoretinal services in China, supporting the development of more efficient healthcare policies for patients.

Materials and Methods

We conducted a single-institution, retrospective database analysis of patients hospitalized in the retinal surgery department, utilizing the inpatient database of Zhongshan Ophthalmic Center (ZOC), Sun Yat-sen University, a leading tertiary specialized hospital in China. The analysis utilized inpatient database records spanning January, 2005 to December, 2022, specifically focusing on patients undergoing vitreoretinal surgical surgeries. In China, vitreoretinal surgeries, including PPV and scleral buckle surgeries, are predominantly performed as inpatient procedures due to clinical management practices and healthcare policies. Minor procedures, such as intravitreal injections, are typically conducted on an outpatient basis and were therefore excluded from this study.

This study obtained ethical approval from the Research Ethics Committee of ZOC (Number: 2023KYPJ021) before conducting the study. Informed consent was waived by the Research Ethics Committee of ZOC because of the retrospective nature of our study. Patient data were anonymized and handled in accordance with institutional guidelines on confidentiality and data protection. Patients who received intravitreal injections were excluded, as these procedures are outpatient rather than inpatient surgeries.

Patients were classified based on their final diagnoses into the following groups: rhegmatogenous retinal detachment (RRD), other retinal detachment (other RD), diabetic retinopathy (DR), macular diseases (MD), vitreous hemorrhage (VH), lens problems and other retinal diseases. The macular diseases group was further stratified into 7 subgroups, including macular hole (MH), epiretinal membrane (ERM), macular degeneration, macular hemorrhage, vitreous-macular traction (VMT), macular schisis and other macular diseases.

Diagnoses were recorded using both ICD-10 codes and Mandarin text to ensure accurate identification of the main diagnosis. Data management and statistical analyses were conducted using Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA), and figures were created using GraphPad Prism version 9.0.0 (GraphPad Software, Boston, Massachusetts USA), with bar or line graphs illustrating the findings. Descriptive statistics (mean ± standard deviation) were used to summarize the age for each diagnosis.

A predictive analysis was conducted to estimate the monthly number of vitreoretinal surgeries through the end of 2032. This analysis utilized the open-source Prophet package, an additive regression model that leverages historical surgical data to predict future trends.[10] For this model, historical monthly data from 2005 to 2022 were input into the model, which provided a forecast of monthly vitreoretinal surgeries from January 2023 to December 2032, with 95% confidence intervals (CI). The model automatically identified and adjusted for outliers, assigning substantial negative weights to data points corresponding to the COVID-19 lockdown periods in China (February, 2020 to April, 2020 and November, 2022 to January, 2023), given that such anomalies are unlikely to recur in the future.

Results

From 2005 to 2022, a total of 68,212 vitreoretinal surgeries were performed and included in this study. Table 1 provides an overview of the basic demographic and clinical characteristics of patients who underwent vitreoretinal interventions. The average age of patients undergoing surgery was 49.30 (16.44) years, with MD having the highest average age at 59.02 (11.62) years. Males exhibited higher incidence rates for RRD, other RD, DR, VH, lens problems and other retinal diseases. In contrast, macular diseases were more prevalent among female patients. Seventy-one percent of patients are originated from Guangdong province.

Table 1 Demographic Information of Patient Hospitalized in Retinal Surgery Department in the Guangzhou, 2005~2022

Characteristic	RRD	DR	MD	VH	Other RD	Lens Problems	Other Retinal Diseases
Mean Age, yrs (SD)	45.86 (16.40)	52.57 (10.74)	59.02 (11.62)	55.08 (15.38)	43.19 (19.67)	53.80 (14.89)	42.00 (20.55)
Sex							
No. of male	21211	5339	3810	2744	2126	1370	2863
No. of female	11493	4282	6885	1844	1494	1008	1734
Origin							
Guangdong Province	23189	7507	7877	3179	2180	1765	2776
Other Province	9515	2114	2818	1418	1440	613	1821
Ethnicity							
Han	31896	9408	10,450	4490	3514	2326	4018
Other Ethnicity	808	213	245	107	106	52	129

Abbreviations: RRD, rhegmatogenous retinal detachment; DR, diabetic retinopathy; MD, macular diseases; VH, vitreous hemorrhage; RD, retinal detachment.

The inpatient numbers and rate for each disease category from 2005 to 2022 are illustrated in Table 2, Figure 1A and B. The total number of surgeries increased sharply, rising from 1,456 cases in 2005 to 5,600 cases in 2022. RRD was the most common indication for vitreoretinal intervention. Although the consistent growth in the number of RRD patients over the years, the proportion declined steadily. Notably, the MD category experienced a significant rise after 2010, increasing form 273 cases (10.45%) in 2010 to 1,197 cases (21.38%) in 2022. Similarly, DR cases doubled in the first decade, rising from 7.21% in 2005 to 13.64% in 2014, and then continued to increase steadily. Additionally, the rate of lens problems increased steadily over the years, although the number of cases remained relatively low compared to other categories.

Figure 2A and B show the inpatient numbers and rates of each macular disease subgroup. The data indicate that MH was initially the predominant subgroup; however, ERM surpassed MH in 2021. Additionally, the numbers and rates of VMT and macular schisis increased steadily over the years.

Table 2 2005–2022 Actual Number of Vitreoretinal Surgeries

Year	Total Vitreoretinal Surgeries	RRD	DR	MD	VH	Other RD	Lens Problems	Other Retinal Diseases
2005	1456	947	105	84	103	30	5	182
2006	1414	907	97	100	102	41	9	158
2007	1482	926	96	90	104	75	15	176
2008	2597	1523	222	194	164	173	25	296
2009	2677	1550	267	257	163	159	28	281
2010	2612	1463	217	273	154	163	29	313
2011	2741	1502	279	302	168	166	26	298
2012	3074	1502	312	416	226	230	51	337
2013	3984	1934	501	573	315	254	102	305
2014	4692	2103	640	633	388	458	149	321
2015	4767	2213	594	716	421	387	192	244
2016	4763	2404	615	765	263	145	204	367
2017	5108	2524	723	847	288	243	190	293
2018	4434	1927	768	882	275	221	179	182
2019	5482	2262	1002	1054	326	290	305	243
2020	4960	2120	922	920	289	291	211	207
2021	6369	2562	1186	1392	482	202	325	220
2022	5600	2335	1075	1197	360	92	333	208

Abbreviations: RRD, rhegmatogenous retinal detachment; DR, diabetic retinopathy; MD, macular diseases; VH, vitreous hemorrhage; RD, retinal detachment.

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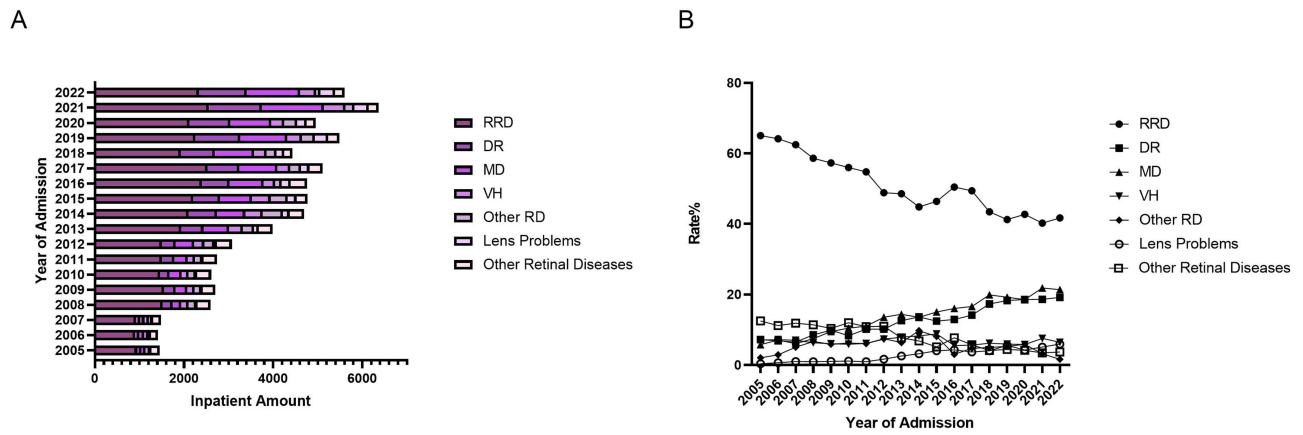

Figure 1 Number and rates of each vitreoretinal disease underwent vitreoretinal surgeries. (**A**) The total amount of vitreoretinal surgeries each year is increasing over the years. (**B**) RRD is the most common cause of patients underwent vitreoretinal surgery, followed by DR and MD, which has an increasing trend over the past few years.
Abbreviations: RRD, rhegmatogenous retinal detachment; DR, diabetic retinopathy; MD, macular diseases; VH, vitreous hemorrhage; RD, retinal detachment; MH, macular hole; ERM, epiretinal membrane; VMT, vitreal macular traction.

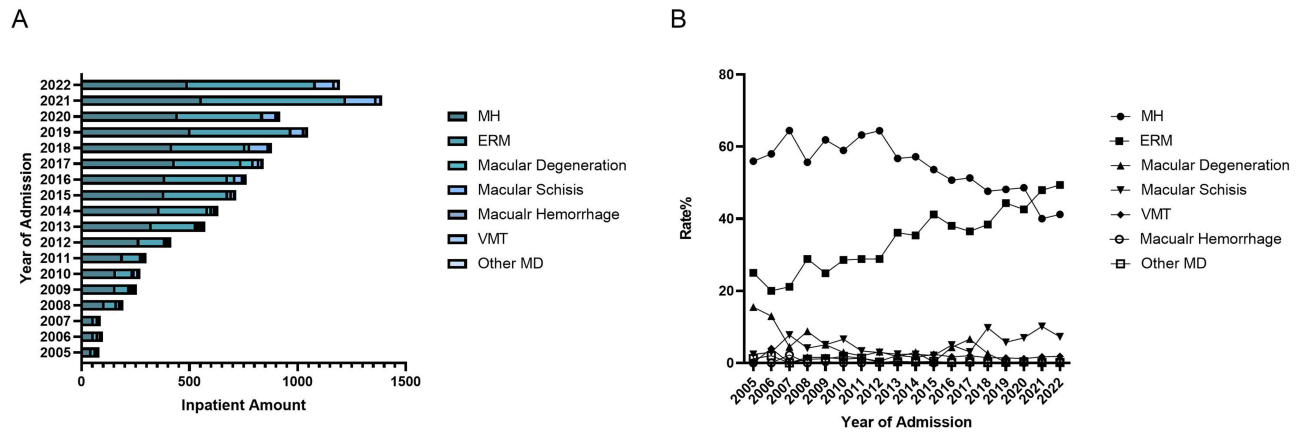

Figure 2 Number and rates of each macular disease subgroup. (**A**) The total amount of MD each year is increasing over the years. MH and ERM are the main two subgroups in MD. (**B**) MH and ERM are the main two subgroups in MD over the years.
Abbreviations: RRD, rhegmatogenous retinal detachment; DR, diabetic retinopathy; MD, macular diseases; VH, vitreous hemorrhage; RD, retinal detachment; MH, macular hole; ERM, epiretinal membrane; VMT, vitreal macular traction.

Figure 3 illustrates the projected number of vitreoretinal surgeries. The predictive analysis estimated that, based on current trends, the total number of vitreoretinal surgeries (Figure 3A and Table 3), DR (Figure 3B and Table 4), MD (Figure 3C and Table 5) and lens problems (Figure 3D and Table 6) will incrementally increase annually, but with a declining growth factor. At the current trajectory, the total number of vitreoretinal surgeries projected for 2032 is approximately 9,231 (95% CI: 8746–9717), with DR, MD and lens problems are estimated to account for 1,730 (95% CI: 1635–1828), 1,959 (95% CI: 1860–2065), 489 (95% CI: 447–532) surgeries respectively.

Discussion

This study retrospectively analyzed over 60,000 patients from the ZOC inpatient database spanning 2005 to 2022, focusing on those hospitalized in the retinal surgery department. The analysis revealed a significant upward trend in vitreoretinal surgeries, with the total number of procedures increasing nearly fourfold. Predictive analysis indicating increasing trends in total vitreoretinal surgeries, as well as DR, MD, and lens problems. These finding offer workforce

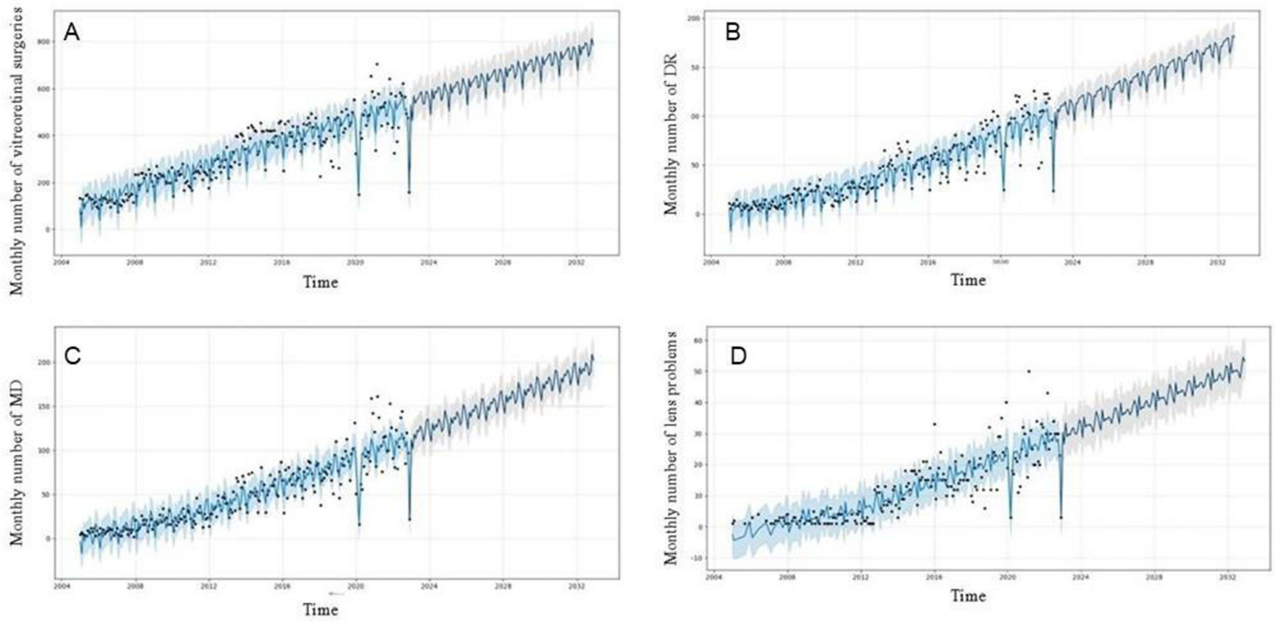

Figure 3 Predictive future trend. (**A**) vitreoretinal surgery. (**B**) DR. (**C**) MD. (**D**) lens problems. Actual numbers of surgeries from 2005 to the end of 2022 (light blue). Forecasted numbers of monthly surgeries for a 10-year period from 2023 to the end of 2032 (navy blue) with 95% confidence intervals (grey shaded area).
Abbreviations: DR, diabetic retinopathy; MD, macular diseases.

planners and healthcare policymakers valuable insights into future landscape of the vitreoretinal field in China, influencing clinical practice.

The total number of vitreoretinal surgeries experienced a steep rise from 1,456 cases in 2005 to 5,600 cases in 2022, particularly within the macular diseases category. However, a notable decline was observed in 2020 and 2022 due to the outbreak of the COVID-19 pandemic and subsequent lockdowns. Several factors contribute to the observed overall increase in vitreoretinal surgeries. Retinal diseases such as RRD, MH, and ERM typically peak in prevalence among individuals in their 50s,[11–13] reflecting their higher incidence in an aging population. An aging population and a rising number of cataract surgeries have contributed to an increase in complications, such as ectopic lens and ectopic IOL, requiring further vitreoretinal interventions. As China transitions into an aging society,[14] the demand for vitreoretinal surgeries has increased.

Table 3 Predicted Number of Vitreoretinal Surgeries from 2023~2032

Year	Forecasted Number of Surgeries	95% Confidence Intervals		Year-Over-Year Growth Factor
		Lower Bound	Upper Bound	
2023	6544	6065	7005	NA
2024	6896	6422	7422	1.05
2025	7221	6746	7749	1.05
2026	7493	6993	7983	1.04
2027	7711	7239	8222	1.03
2028	8064	7542	8550	1.05
2029	8389	7899	8923	1.04
2030	8660	8150	9147	1.03
2031	8879	8372	9382	1.03
2032	9231	8746	9717	1.04

Notes: Predicted number of vitreoretinal surgeries from 2023 to 2032. Growth factor is calculated by the number of surgeries in the year divided by the number of surgeries in the previous year.

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Table 4 Predicted Number of DR from 2023~2032

Year	Forecasted Number of Surgeries	95% Confidence Intervals		Year-Over-Year Growth Factor
		Lower Bound	Upper Bound	
2023	1155	1062	1253	NA
2024	1206	1106	1300	1.04
2025	1292	1191	1394	1.07
2026	1362	1261	1461	1.05
2027	1417	1314	1517	1.04
2028	1468	1372	1568	1.04
2029	1554	1455	1652	1.06
2030	1624	1521	1721	1.05
2031	1679	1579	1778	1.03
2032	1730	1635	1828	1.03

Notes: Predicted number of DR from 2023 to 2032. Growth factor is calculated by the number of surgeries in the year divided by the number of surgeries in the previous year.

Table 5 Predicted Number of MD from 2023~2032

Year	Forecasted Number of Surgeries	95% Confidence Intervals		Year-Over-Year Growth Factor
		Lower Bound	Upper Bound	
2023	1295	1199	1394	NA
2024	1363	1258	1465	1.05
2025	1464	1365	1558	1.07
2026	1541	1440	1643	1.05
2027	1594	1492	1692	1.03
2028	1661	1558	1758	1.04
2029	1762	1670	1867	1.06
2030	1839	1738	1947	1.04
2031	1892	1785	1987	1.03
2032	1959	1860	2065	1.04

Notes: Predicted number of MD from 2023 to 2032. Growth factor is calculated by the number of surgeries in the year divided by the number of surgeries in the previous year.

Table 6 Predicted Number of Lens Problems from 2023~2032

Year	Forecasted Number of Surgeries	95% Confidence Intervals		Year-Over-Year Growth Factor
		Lower Bound	Upper Bound	
2023	331	285	372	NA
2024	329	288	373	0.99
2025	357	313	402	1.09
2026	384	339	429	1.08
2027	411	364	458	1.07
2028	409	367	455	1.00
2029	436	390	478	1.07
2030	464	418	509	1.06
2031	491	446	532	1.06
2032	489	447	532	1.00

Notes: Predicted number of lens problems from 2023 to 2032. Growth factor is calculated by the number of surgeries in the year divided by the number of surgeries in the previous year.

Another significant factor driving the increase in vitreoretinal surgeries, particularly vitreomacular interface disorders such as ERM and VMT, is the widespread adoption of OCT. OCT uses infrared light to capture in vivo retinal images, offering non-invasive, high-resolution cross-sectional views. This technology has revolutionized the way how ophthalmologist assess and manage vitreoretinal interface diseases by enabling detailed visualization of retinal structures, especially factors critical to surgical outcomes. The advanced imaging capabilities of OCT have facilitated ophthalmologist in early detection, precise diagnosis, and effective monitoring of disease progression, thereby significantly improving clinical outcomes in vitreoretinal surgery.

The advent of vitrectomy, particularly the development of 25G and 27G pars plana vitrectomy (PPV), has also played a pivotal role in making a greater range of retinal diseases become treatable The improvement of surgical technologies has allowed for smaller incisions and shorter operative time, substantially reduces surgical trauma and accelerating postoperative recovery. These advancements have made vitreoretinal surgery less invasive and more efficient, resulting in shorter postoperative recovery times and fewer complications.[3,15,16] These benefits have improved success rates and patient satisfaction, encouraging more patients to opt for vitreoretinal surgery.

The prevalence of DR in this study rose significantly, which can be attributed to several factors. China has the largest diabetic population globally, and this population is estimated to increase in the future.[17] The anticipated increase in China's diabetic population is expected to significantly elevate DR prevalence. Although there are several approaches, such as intravitreal anti-VEGF and laser photocoagulation, to prevent non-proliferative diabetic retinopathy (NPDR) from progressing into proliferative diabetic retinopathy (PDR) effectively nowadays,[18,19] there has been nearly a threefold increase in the rate of PPV for PDR, from 7.21% in 2005 to 19.2% in 2022. However, previous studies conducted worldwide, including in the UK, the US, Australia, and Japan, have shown differing results, likely due to the widespread use of anti-VEGF therapy and well-developed medical management of the disease in resource rich countries.[5,7,9,20] This disparity highlights the critical need for annual diabetic screenings to enable early detection and timely treatment of DR. Collaborative efforts between ophthalmologists and endocrinologists are essential to improve diabetes management. Additionally, these findings should encourage government authorities to prioritize DR management and strengthen public health strategies to address this growing concern.

The number of RRD patients continues to increase annually, and continues to play a dominant role in the retinal surgery department. The growing prevalence of myopia and pseudophakia in China, both known risk factors for RRD, is expected to drive a future increase in RRD incidence. Recent studies indicate that timely retinal reattachment within 72 hours leads to better visual outcomes, whether for macular-on or macular-off RD.[21] This underscores the importance of training ophthalmologists in vitreoretinal departments to gain experience in diagnosing and managing RRD, as early diagnosis and intervention of RRD are critical for optimal visual outcomes. The increasing volume of non-RRD vitreoretinal surgeries has led to a relative decline in the proportion of surgeries specifically for RRD. This shift reflects advancements in diagnostic technologies and surgical techniques, along with the rising prevalence of other retinal conditions, highlighting the importance of adaptive healthcare planning and efficient resource allocation.

Our predictive analysis, based on comprehensive historical data, provides valuable insights into future trends. With China's aging population, the prevalence of retinal diseases is anticipated to increase. According to our predictive analysis, the total number of vitreoretinal surgeries, DR, MD and lens problems will incrementally increase annually, but with a declining growth factor, likely reflecting stabilization due to saturation of service capacity, enhanced preventive care, and potential improvements in outpatient surgical management reducing inpatient necessity. Notably, our forecast model effectively identifies and adjusts for anomalies, such as the temporary reduction in vitreoretinal surgeries at ZOC during the outbreak of COVID-19 pandemic and lockdown periods (February to April 2020 and November 2022 to January 2023). This robust model minimizes the influence of these outliers, enhancing the accuracy of our long-term predictions. The future trajectory of retinal disease prevalence and treatment will be shaped by various factors, including advancements in therapies, treatment protocols, and disease prevalence. Increased public awareness of vitreoretinal diseases and the integration of OCT into primary eye care are expected to improve the detection rates for conditions requiring referral and subsequent treatment in specialized centers.

This study provides an overview of vitreoretinal surgery trend in China's tertiary specialized hospitals, emphasizing implications for workforce planning and surgical training. Additionally, the findings offer healthcare planners insights for

optimizing the structure of vitreoretinal services, ensuring efficient resource allocation, securing funding, and improving healthcare quality. However, this study had several limitations. First, the data are limited to tertiary specialized hospitals, which may not reflect trends in other healthcare settings. Second, the geographic focus is limited, potentially overlooking regional differences in the supply and demand for vitreoretinal surgery. Finally, the retrospective design may not capture the most recent trends or emerging changes in the field. Future research should extend to various hospitals across different regions to achieve a more representative and accurate assessment of the supply and demand for vitreoretinal surgery throughout China. The broader perspective study will elucidate regional differences and support more refined healthcare planning and policy decisions, ultimately to implement more cost-effective, efficient, and effective healthcare management for vitreoretinal diseases nationwide.

Conclusion

In conclusion, this retrospective study revealed a significant increase in vitreoretinal surgeries in China over the past decade, particularly for DR and MD. These trends reflect not only advancements in surgical instrumentation and imaging technologies, but also evolving demographic and healthcare dynamics, including an aging population and rising prevalence of diabetes and myopia. Furthermore, the findings emphasize the continued need for effective diabetic complication prevention and early detection initiatives. Our study provides critical insights for future workforce planning and predicting healthcare expenditures to address the increasing demand for vitreoretinal surgery.

Data Sharing Statement

The datasets and models used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval

The study adhered to the tenets of the Declaration of Helsinki and was approved by the Research Ethics Committee of ZOC (the reference number: 2023KYPJ021).

Informed Consent

Informed consent was waived by the Research Ethics Committee of ZOC because of the retrospective nature of our study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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