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Eye and Adnexa Procedures Profile in the Past Two Decades: A Descriptive Time-Trend Study from Australian Hospitals

Dina M. Abdulmannan[1] and Abdallah Y. Naser[2]
[1]College of Medicine, Umm Alqura University, Makkah, Saudi Arabia
[2]Department of Applied Pharmaceutical Sciences and Clinical Pharmacy, Faculty of Pharmacy, Isra University, Amman, 11622, Jordan

Author Designation: [1,2]Associate Professor

*Corresponding author: Dina M. Abdulmannan (e-mail: dmabdulmannan@uqu.edu.sa).

Abstract **Background:** Adnexa is defined as the accessory structures that are involved in protecting and supporting the function of the eye. Understanding ophthalmic procedure trends aids considerably in developing healthcare plans. This research seeks to study trends in eye and adnexa procedures in Australia from 2000 to 2023. **Method:** This study was a descriptive time-trend study. We collected procedure data from the Australian Institute of Health and Welfare (AIHW), National Hospital Morbidity Database (NHMD) and population data from the Australian Bureau of Statistics (ABS) dataset between 2000 and 2023. Eye and adnexa procedures were identified using the codes (160-256). We analyzed procedure data based on gender, age and same-day status. **Results:** Over the study period, the total number of eye and adnexa procedures of recorded cases in Australia was 10,567,738. Procedure's rate increased from 1,041.39 (95% CI 1036.86-1,045.92) to 3,474.91 (95% CI 3,467.95-3,481.86) per 100,000 population-years. The annual number and rate of eye and adnexa procedures increased by 3.61 times and 2.34 times, respectively. The bulk of cases were between females and the older population. Regarding the same-day status, the same-day procedures accounted for most cases. Besides, procedures on "anterior segment-lens" accounted for most cases (65.6%) of eye and adnexa procedures. **Conclusion:** There has been a significant increase in eye and adnexa procedures in Australia, partly due to an aging population. Anterior segment-lens procedures accounted for the majority of eye and adnexa procedures. Targeted prevention strategies for age-related lens diseases are needed. Implementing age- and gender-specific strategies, based on the type of procedure prevalent in each group, could help reduce the number of procedures required by the population, thereby reducing the burden on the population and healthcare services.

Key Words Adnexa, Australia, Eye, Ocular, Procedures

INTRODUCTION

Over the past decade, there have been significant advances in ophthalmic diagnosis, treatment and procedures [1]. Regarding procedures, the use of minimally invasive surgical techniques, e.g., minimally invasive vitreoretinal surgery, minimally invasive lens procedures such as microincision cataract surgeries, micro-invasive vitrectomy surgery, phacoemulsification surgery and micro-invasive glaucoma surgery [2-4], has increased, which results in improved patient outcomes [4]. Despite the cost-effectiveness of ophthalmic procedures, healthcare systems are under significant pressure due to the increasing number of cases requiring eye procedures [5,6]. This increase in cases is attributed to an aging population, population growth, increased life expectancy and changing lifestyles [6,7]. Besides, factors such as the lack of data for eye care planning pose more challenges to healthcare systems [7].

Research reported that globally, the annual number of conducted cataract surgeries exceeds 26 million [8], making it the most common eye surgery [9]. Similarly, in Australia, cataracts account for more than 5 per 1,000 eye problems among the Aboriginal population and are the most treated eye condition by ophthalmologists among this population group [10]. An earlier study among Aboriginal patients referred for surgery in Australia showed an increase of about 2% to 45% in cataract surgery completion rates because of a new surgical pathway (integrating local primary care and surgery), improving patient outcomes [11]. Likewise, a

previous report showed that cataract surgery rates among First Nations Australians increased by 24% from 2015-16 to 2022-23 [12].

There are limited prior research that has examined all trends in ophthalmic procedures in Australia, including how patients' gender, age and same-day status can influence these rends. Comprehending ophthalmic procedure trends aids considerably in developing healthcare plans [4]. During the past two decades, there was a noticeable shift toward same-day and outpatient care for ophthalmic healthcare [13]. This change in ophthalmic care delivery increases the importance of examining the temporal trends in eye and adnexa procedures for different age groups and both genders. A previous study in Australia showed that there is a systematic variation in cataract surgery based on patients' socioeconomic status and insurance status [14]. Therefore, this research aims to describe the trends in same-day and overnight stay eye and adnexa procedures in Australia. Besides, this study aimed to examine procedures rates stratified by age group and gender.

It worth mentioning that trend studies using long administrative series must handle reclassification issues. Previous literature reported that administrative data cannot be used to compare procedures rate across long time period and recommended the validation of diagnostic codes before study implementation [15]. This study hypothesized that same-day procedures rate for eye and adnexa increased during the past two-decades, while overnight-stay procedures showed lower increase or decrease. Furthermore, this study hypothesized that procedure rates will show gender-differences across different age groups.

METHODS

Study Design and Data Sources

This study was a descriptive time-trend study. Procedure data were collected from the Australian Institute of Health and Welfare (AIHW) National Hospital Morbidity Database (NHMD) [16] and population data were collected from the Australian Bureau of Statistics (ABS) dataset from 2000-2023 [17]. There is no publicly available data before 2000. Eye and adnexa procedures were identified using the codes (160-256). This included "160-165: procedures related to eyeball, 166-203: anterior segment (cornea, sclera, iris, ciliary body and anterior chamber and lens), 204-208: aqueous, vitreous, 209-214: posterior segment-retina, choroid and posterior chamber, 215-250: ocular adnexa (extraocular muscles, orbit, eyelid and lacrimal System) and 251-256: conjunctiva". The tenth and eleventh edition of the diagnostic codes for eye and adnexa procedures were used across the study period in the NHMD database. Diagnostic codes were harmonized to ensure consistency. Procedure rate was estimated by dividing the number of procedures performed for specific procedure block by the total number of populations in the same year.

The AIHW conducts extensive validations for patients' data. Patients' data are checked for consistency, valid values and historical consistency [18]. Data in individual data sets are checked with data from other data sets. Potential errors in reported data are queried with territories and states and resubmissions and corrections are made [18].

Ethical Approval

The Scientific Research Ethics Committee at Isra University, Amman, Jordan, approved this research (SREC/25/05/145). Ethical approval was waived for de-identified national administrative data. There is no privacy risk as all patient's data are available anonymized. This study adhered to STROBE guidelines.

Statistical Analysis

Data were analysed using the Statistical Package for Social Science Software, version 29. Categorical variables were presented as frequencies and percentage. The statistical significance level was assigned as p-value less than 0.05. The significance on the difference in the procedure rate between 2000 and 2023 was examined using Chi-Square test.

RESULTS

Trends for Eye and Adnexa Procedures

From 2000-2023, there were 10,567,738 eye and adnexa procedures in Australia, with an annual increase of 3.61 times from 200,725 to 926,159 procedures with an average number of 459,467 procedure per year. During the same period, the rates of eye and adnexa procedures increased 2.34 times from 1,041.39 (95% CI 1036.86-1,045.92) to 3,474.91 (95% CI 3,467.95-3,481.86) per 100,000 population-years, with an average of increase of 5.6% per year. There were discrepancies in procedure distribution, rate and changes in the rate by gender, age and same-day status. Regarding gender, females accounted for the preponderance of cases, 5,619,042 or 53.6% of cases, while the rate increase was slightly higher among males compared to females (2.49 fold increase versus 2.36 fold increase). Regarding age, procedures were directly related to age, with the older population (75 years and older) accounting for most of the cases (4,577,938 or 43.7%), while the rate increase was highest among those aged 60-74, with a 2.30 fold increase. Finally, regarding the same-day status, the same-day procedures accounted for most cases and their rate increased by 3.14 fold (Table 1, Figure 1).

Trends in Eye and Adnexa Procedures

Over the study period, we observed a difference in the distribution of eye and adnexa procedures, as procedures on "anterior segment-lens" accounted for most cases, 6,931,606 or 65.6% of eye and adnexa procedures. The highest rate of increased eye and adnexa procedures was seen on "posterior

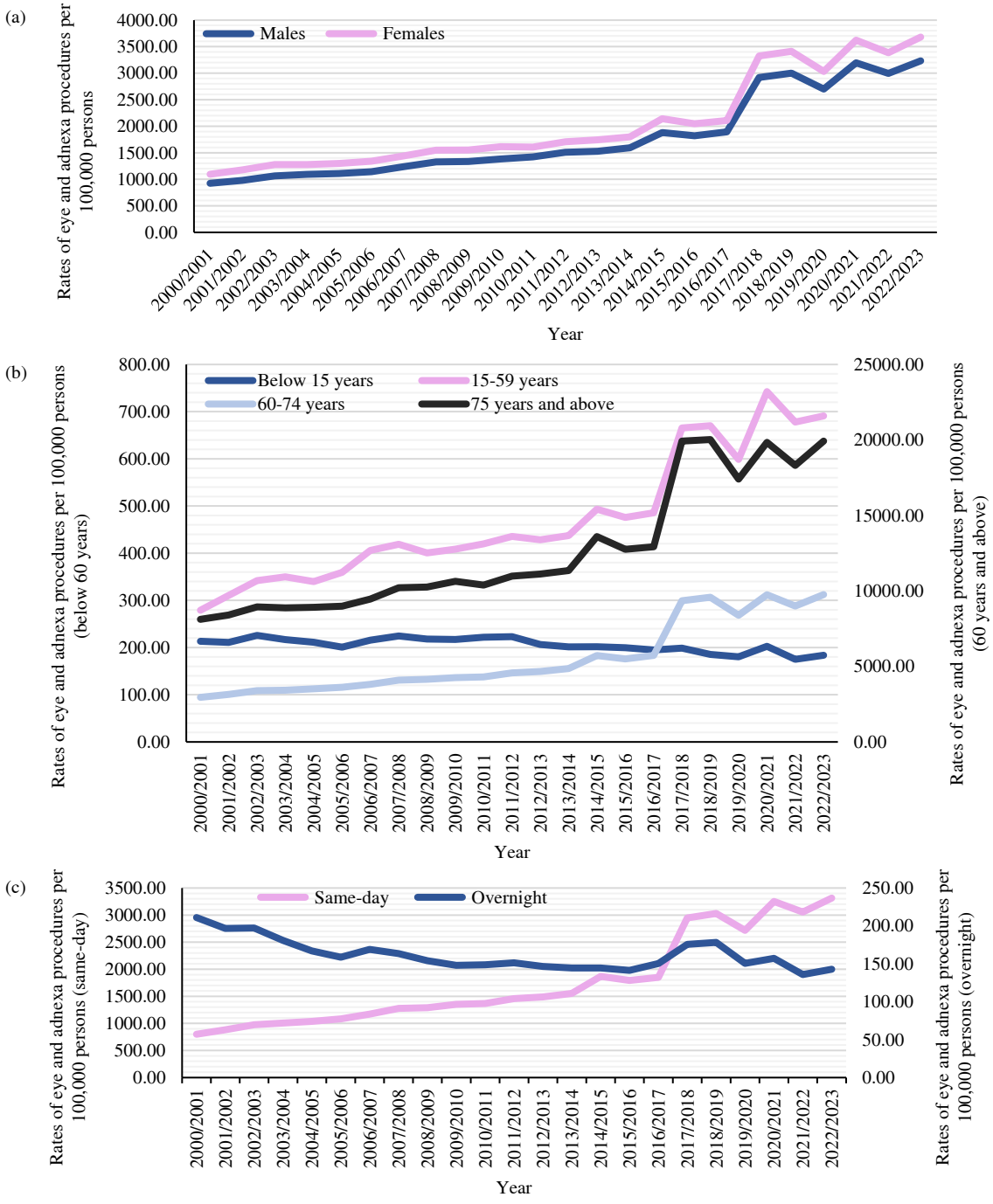

Figure 1(a-c): Total Eye and Adnexa Procedures from 2000-2023 in Australia by Gender, Age and Same-Day Status

Table 1: Eye and Adnexa Procedures Rates Stratified by Age and Gender

Categories	N (Percentage from total)	Procedure rate in 2000 per 100,000 persons (95% CI)	Procedure rate in 2023 per 100,000 persons (95% CI)	Percentage change from 2000-2023	Average annual growth
Gender					
Males	4,855,504 (46.4%)	925.60 (919.53-931.67)	3,234.61 (3,225.08-3,244.14)	249.5%	+5.6%
Females	5,619,042 (53.6%)	1,096.40 (1,089.85-1,102.95)	3,680.08 (3,670.01-3,690.16)	235.7%	+ 5.4%
Age groups					
0-14 years	204,633 (2.0%)	213.30 (208.75-217.84)	183.82 (179.98-187.66)	-13.8%	- 0.6%
15-59 years	1,538,770 (14.7%)	279.14 (276.16-282.11)	690.98 (686.90-695.07)	147.5%	+ 4.0%
60-74 years	4,153,572 (39.7%)	2,953.54 (2,930.79-2,976.29)	9,759.84 (9,730.77-9,788.91)	230.4%	+ 5.3%
75 years and over	4,577,938 (43.7%)	8,126.39 (8,075.49-8,177.29)	19,925.33 (19,870.97-19,979.69)	145.2%	+ 4.0%
Same-day status					
Same-day	9,636,259 (92.0%)	800.54 (796.56-804.51)	3,316.23 (3,309.43-3,323.03)	314.3%	+ 6.4%
Overnight stay	838,660 (8.0%)	211.14 (209.09-213.19)	142.92 (141.48-144.35)	-32.3%	- 1.7%

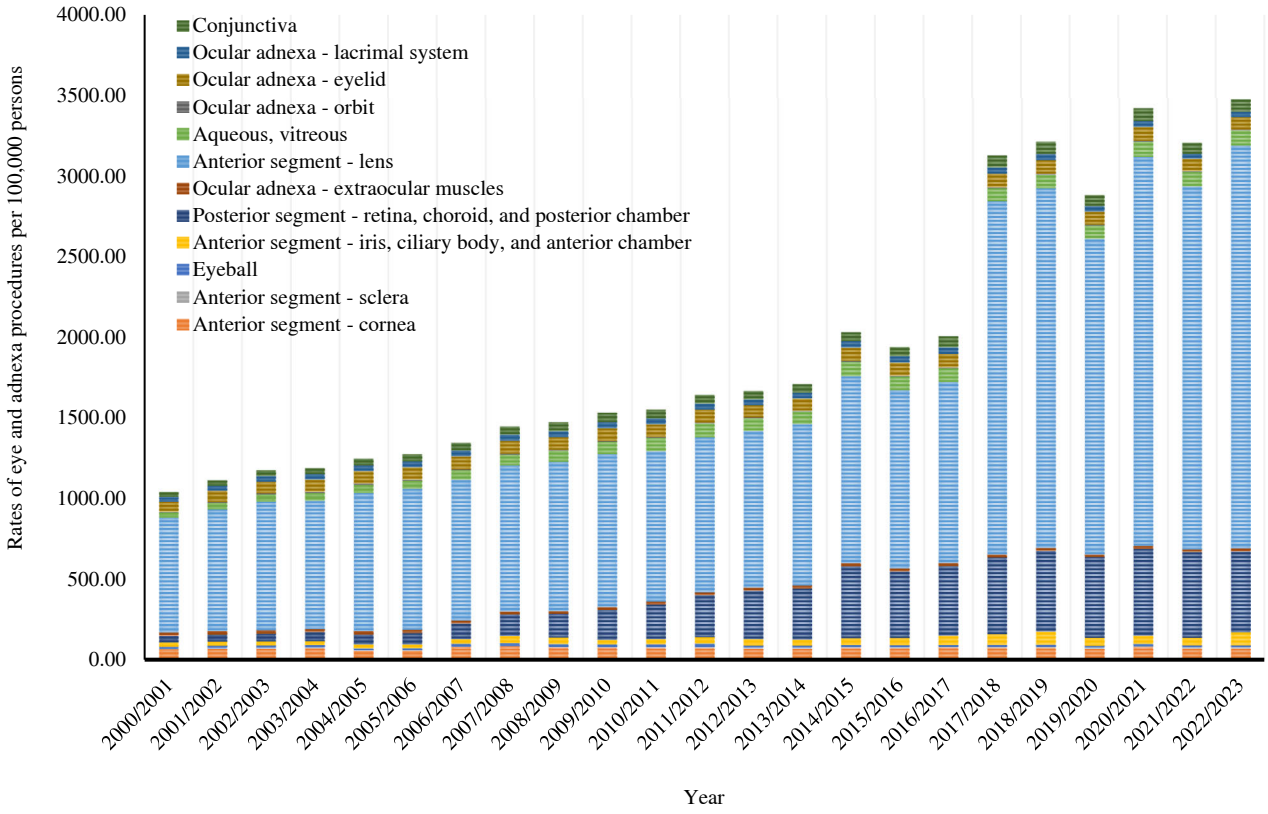

Figure 2: Eye and Adnexa Procedures Trends

Table 2: Eye and adnexa procedures rates from 2000 to 2023 in Australia

Procedures	N (Percentage from total)	Procedure rate in 2000 per 100,000 persons (95% CI)	Procedure rate in 2023 per 100,000 persons (95% CI)	Percentage change from 2000-2023	Average annual growth
"Eyeball"	82,228 (0.8%)	17.98 (17.38-18.58)	12.86 (12.43-13.29)	-28.5%	-1.5%
"Anterior segment-cornea"	395,726 (3.7%)	65.41 (64.27-66.55)	75.02 (73.98-76.06)	14.7%	+0.6%
"Anterior segment-sclera"	19,090 (0.2%)	2.36 (2.14-2.57)	5.26 (4.98-5.53)	123.2%	+3.6%
"Anterior segment-iris, ciliary body and anterior chamber"	219,981 (2.1%)	25.95 (25.23-26.66)	78.24 (77.18-79.30)	201.6%	+4.9%
"Anterior segment-lens"	6,931,606 (65.6%)	713.80 (710.04-717.55)	2,495.72 (2,489.80-2,501.64)	249.6%	+56%
"Aqueous, vitreous"	384,630 (3.6%)	32.96 (32.14-33.77)	95.06 (93.89-96.23)	188.4%	+4.7%
"Posterior segment-retina, choroid and posterior chamber"	1,523,858 (14.4%)	39.84 (38.95-40.73)	501.05 (498.37-503.73)	1,157.7%	+11.6%
"Ocular adnexa-extraocular muscles"	94,457 (0.9%)	18.59 (17.98-19.20)	18.71 (18.20-19.23)	0.7%	0.0%
"Ocular adnexa-orbit"	27,997 (0.3%)	5.41 (5.08-5.74)	5.12 (4.85-5.39)	-5.4%	+0.2%
"Ocular adnexa-eyelid"	410,017 (3.9%)	63.91 (62.78-65.04)	77.33 (76.27-78.38)	21.0%	+0.8%
"Ocular adnexa-lacrimal system"	189,192 (1.8%)	27.27 (26.53-28.01)	32.77 (32.08-33.46)	20.2%	+0.8%
"Conjunctiva"	288,956 (2.7%)	27.94 (27.19-28.68)	77.77 (76.71-78.83)	178.4%	+4.6%

segment-retina, choroid and posterior chamber" with an 11.58 fold increase, while the most decreased was on "eyeball" with a 28.5% decrease (Table 2, Figure 2).

There were also differences in the rates of eye and adnexa procedures by gender and age. All procedure rates were higher in males, except for "anterior segment-lens," "posterior segment-retina, choroid and posterior chamber" and "ocular adnexa-lacrimal system," which were higher in females (Figure 3). Regarding the difference by age, all eye and adnexa procedure rates were higher in populations aged 75 years and above, except for procedures on "eyeball" and "ocular adnexa-extraocular muscles," which were higher in those aged 15 years and below (Figure 4).

DISCUSSION

Between 2000 and 2023, our study found a 3.61 fold and 2.34 fold increase in the number and rate of eye and adnexa procedures in Australia, respectively. This finding is consistent with numerous studies in several countries, as the

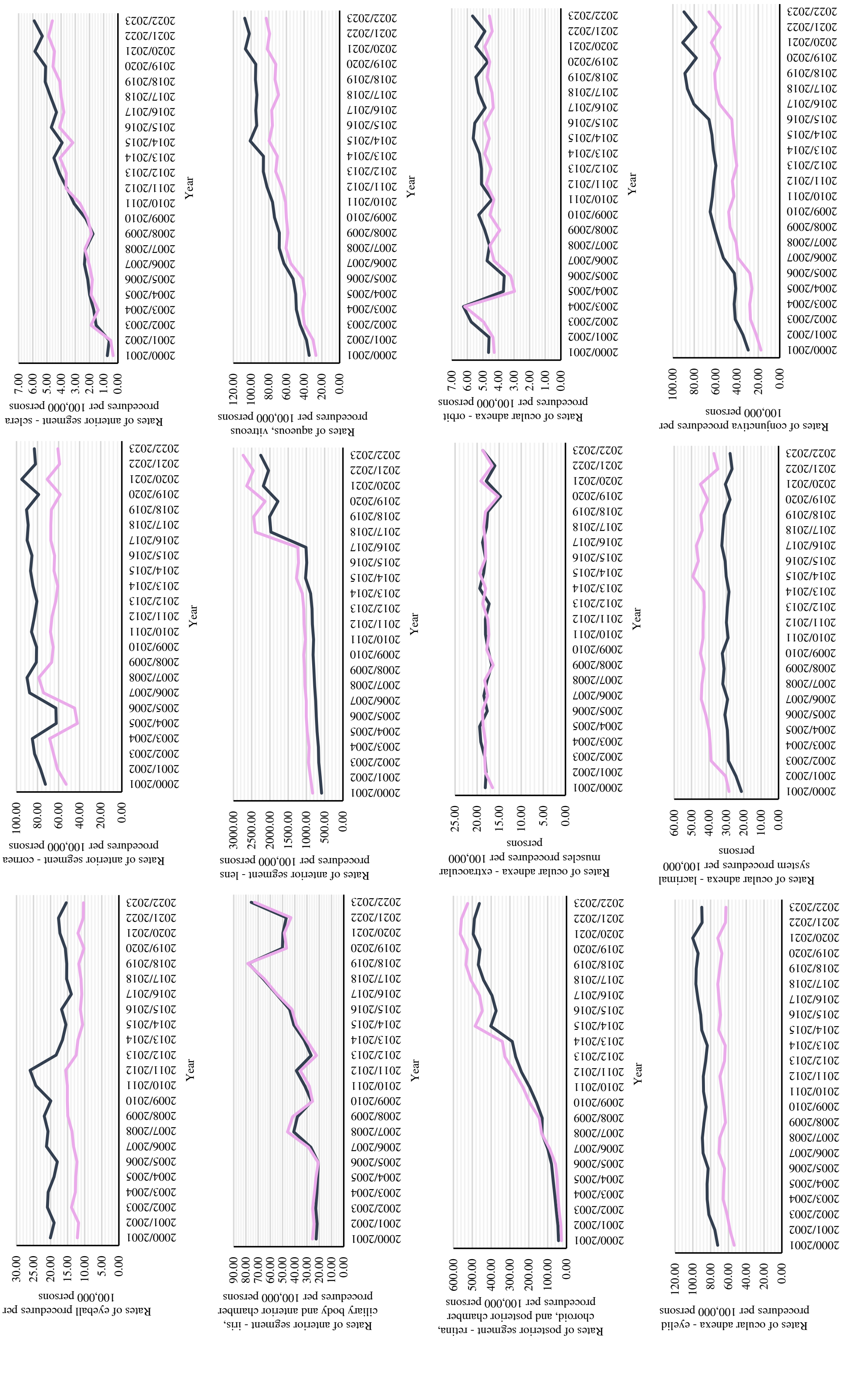

Figure 3: Eye and Adnexa Procedures from 2000-2023 in Australia by Gender

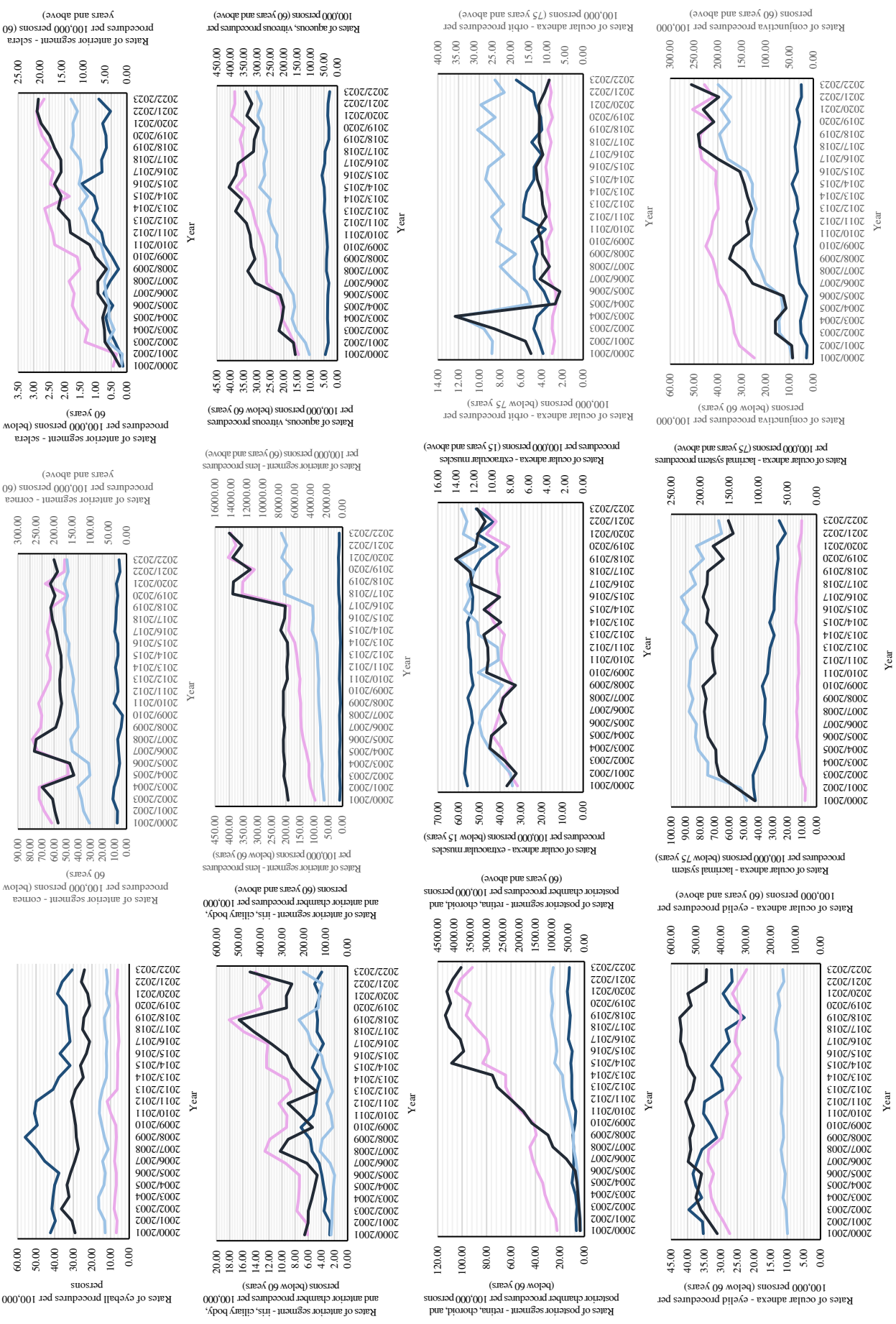

Figure 4: Eye and Adnexa Procedures from 2000-2023 in Australia by Age

number of eye procedures has increased in Germany [19], Norway [20], Ireland [21], New Zealand [22] and Japan [4]. Eye and adnexa disease-related hospital admissions were increased in Australia [23] and the United Kingdom [24]. These trends may be due to advances in ophthalmic diagnostic and surgical techniques [4,25], including increased use of minimally invasive surgical techniques [4]. Moreover, it may also be due to an aged population, as statistics in Australia indicate that people aged 65 and over constitute approximately 16% of the population [26,27] and this percentage is expected to rise [26]. This suggestion is consistent with earlier studies in Germany [19], Norway [20], New Zealand [22] and Japan [4], where an upsurge in eye procedures has accompanied the aging population. Likewise, cataract procedures have increased globally, partially due to an aged population. Yet, in recent years, the COVID-19 pandemic has also impacted eye surgery trends [4,23]. Hence, there is a need to ensure that the number of eye surgeons is commensurate with the increasing requirement for eye and adnexa procedures. Furthermore, managing modifiable risk factors for eye procedures (such as diabetes) may aid in reducing the need for these procedures.

Another important finding from the current study is that same-day procedures account for most cases (92.0%). In addition, the rate of same-day procedures increased by 3.14 fold while the rate of overnight procedures decreased by 32.3%. These findings are in line with those of previous studies. Most ophthalmic procedures in the United States were same-day procedures [28]. In Australia, most hospital admissions for the disease of eye and adnexa were same-day and the rate for same-day admissions increased while it decreased for overnight admissions [23]. Over recent years, it has been reported that there has been a shift toward same-day admissions in Australia, predominantly because of the rise in same-day stays for non- and sub-acute care [29]. A possible explanation for our findings might be an advancement in surgical techniques; for instance, using minimally invasive techniques is associated with several advantages, including decreasing recovery times [4]. It may also result from measures implemented by countries during the COVID-19 pandemic to limit infection, which included reducing hospitalization time [30,31]. Furthermore, the increased rate of same-day eye and adnexa procedure could be due to the availability of ophthalmic workforce, scheduling theatre operation, follow-up services.

The literature has found numerous positive outcomes for day surgery compared to inpatient surgery, such as reduced risk of infection, lower costs, fewer complications and shorter hospital stays [32]. A previous review indicated that cataract surgery costs in inpatients were approximately 20% higher than in same-day patients [33]. Although same-day procedures are associated with many positive outcomes, the significant global increase in these procedures highlights the importance of ensuring proper follow-up of patients after procedures to prevent related re-admission.

In this study, females accounted for the preponderance of eye and adnexa procedures. Nevertheless, the rate increase was slightly higher among males than females (2.49 fold versus 2.36 fold). These results match those observed in earlier studies. In the United States [28,34] and Canada [35], ophthalmic procedures were more elevated in females than males. Hospitalizations for eye and adnexa disease in Australia and the United Kingdom were higher in females than males, with a higher increase in the admissions rate among males than among females [23,24]. The preponderance of eye and adnexa procedures among females could be attributed to the higher burden of lens disorders, cataracts and refractive errors among Australian females than males [36]. Another possible explanation for this is that the life expectancy for Australian females is higher than that of males [26]. In terms of the higher rate increase among males versus females, this could be due to men often delaying seeking medical help and their condition becomes more severe [37], potentially increasing their need for procedures. Furthermore, it could be because eye injuries are more common among men than among women as a result of working outdoors and in high-risk occupations [38]. Regardless, the significantly increased rate of procedures between males and females indicates the requirement for targeted interventions to improve awareness of modifiable risk factors for eye and adnexa procedures for both genders, considering gender-specific factors.

Our study demonstrated that eye and adnexa procedures were directly related to age, with the older population (75 years and older) accounting for most cases (43.7%). Additionally, the rate of increase in procedures was highest among those aged 60 to 74, with a 2.30 fold increase. These results can be explained partly by an aging population; as mentioned earlier, the number of older adults is increasing in Australia and several other countries. Previous studies have shown that the prevalence of most eye diseases [39-41] and the use of eye care services have increased with age [42]. Consistent with our findings, in a prior investigation in Ghana, most participants who underwent eye examinations (over 88%) were 75 and older [42]. In Australia and the United Kingdom, hospital admissions are directly proportional to age, with older individuals comprising the bulk of cases and the highest increase in rates was in those aged 60-74 [23,24]. In Japan, there has been a significant upward trend in eye surgery among individuals aged 70 and older [4]. In the United States, individuals over 65 years of age constitute the most considerable proportion of patients undergoing glaucoma, cataract and corneal procedures [28]. Therefore, eye health strategies are mandated for older individuals, including preventive strategies, early diagnosis and ensuring their access to timely medical services.

Over our study period, procedures on “anterior segment - lens” accounted for most (65.6%) eye and adnexa procedures. Moreover, the highest rate of increased eye and adnexa procedures was seen on “posterior segment-retina, choroid and posterior chamber,” with an 11.58 fold increase. In line with these, hospital admission for lens disorders accounted for most hospital admissions related to eye and adnexa in Australia (65.7%) and the United Kingdom

(62.3%) and the highest rate of eye and adnexa admissions was reported on choroid and retina disorders by 13.19 fold increase in Australia and 3.6 fold increase in the United Kingdom [23,24]. Likewise, cataract procedures accounted for the majority of ophthalmic procedures [43]. In the United States, cataract and lens procedures accounted for 66.5% of ophthalmic procedures [28]. Ultimately, implementing specific approaches may help reduce the incidence of these procedures. For example, our study documented that lens procedures, which include cataract procedures, are more common among females. Ultimately, further research is needed to determine the effectiveness and outcomes of such strategies.

This study has several strengths. Using national AIHW and ABS sources, captures a very large dataset across 23 years. Reporting procedure rates per 100,000 (not just counts), which improves interpretability. Stratifying by age, gender and same-day status, which are meaningful service variables. The highlighted increase in procedure rates is relevant for healthcare planning. This study has limitations. This study presented eye and adnexa procedures rate, which might lead to overestimation as multiple procedures might be accounted for the same patient. Due to the type of publicly available data which was accumulative on the population level rather than individual level-data we were not able to apply other stronger statistical approach and adjust for confounding variables (such as age) or apply forecasting for procedure trends. The publicly available data cannot be stratified by sector (private versus public) or emergency vs elective cases. Furthermore, available data does not provide information on indigenous status or State/territory. This might affect the generalizability of the findings as services funding and planning decisions differ across the two systems. Using national hospital morbidity data gives strong coverage for admitted/same-day hospital activity, however, it does not cover procedures conducted in non-hospital settings. Moreover, publicly available data does not include data related to costs, waiting times or procedure complexity, which are the real "resource" variables policymakers need. Future research should examine the differences across different sectors and examine costs, waiting times or procedure complexity. Furthermore, future studies applying regression-based and joinpoint methods are recommended to identify time-trends. Furthermore, it should account for code changes across 2000-2023 and consider state/territory and remoteness.

CONCLUSIONS

There has been a significant increase in eye and adnexa procedures in Australia, partly due to an aging population. Females and older adults constituted the highest proportion of individuals undergoing eye and adnexa procedures, with the preponderance of these procedures being for the lens. Targeted prevention strategies for age-related lens diseases are needed. Expansion for age-focused lens and retina care pathways is recommended. Implementing age- and gender-specific strategies, based on the type of procedure prevalent in each group, could help reduce the number of procedures required by the population, thereby reducing the burden on the population and healthcare services. Planning initiatives should focus on day surgery capacity and follow-up. Rapid growth in posterior segment procedures suggests increasing demand in retina services and related clinics.

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