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Admission due to Malignant Neoplasm of Eye and Adnexa in Australia: A Time-Trend Analysis

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Abstract **Background:** Malignant neoplasms are common and are associated with multiple complications that require hospital admissions. Therefore, this study aimed to investigate trends in hospital admissions for eye cancer in Australia. **Methods:** This is a time trend analysis study used data from the National Hospital Disease Database for the durations between 1998 and 2023. Admissions related to malignant neoplasm of eye and adnexa were identified using relevant ICD codes (C69). **Results:** Over the 25 years from 1998/1999 to 2022/2023, Australia recorded 18,679 hospitals admissions due to "malignant neoplasm of eye and adnexa". Besides, 51.2% (9,556) of these admissions were overnight and 48.8% (9,123) were same-day. From 1998/1999 to 2022/2023, there was a 53.0% increase in the overall number of admissions from 624 to 955, a 62.2% increase in same-day admissions from 275 to 446 and a 45.8% increase in overnight admissions from 349 to 509. Age group 0-14 years accounted for 41.3% or 7,720 of total admissions and males accounting for 54.3% or 10,137 of total admissions. A total of 74.1% of these admissions were due to "malignant neoplasm of retina". **Conclusion:** Our study found several significant findings related to trends in hospital admissions due to "malignant neoplasm of eye and adnexa" in Australia. Younger people (less than 15 years old) represented the largest age group of patients admitted to the hospital during the study period; therefore, admissions due to "malignant neoplasm of retina" were the most common diagnoses. Thus, there is a need to implement interventions aimed at reducing hospital admissions due to "malignant neoplasm of eye and adnexa," particularly for young people and males.

Key Words Admission, Adnexa, Australia, Cancer, Eye, Neoplasm

INTRODUCTION

Many malignant tumors affect the eye and its adnexa [1], with Burkitt's lymphoma, retinoblastoma and conjunctival carcinoma being the most common [2]. Unlike other disorders that affect the eye [3], the diversity and rarity of malignant eye tumors pose significant challenges in their diagnosis and management [3]. Besides, eye cancers are associated with threats to the lives and vision of affected persons and with a substantial economic burden on society [3-5]. The primary cause of cancer-related economic burden is healthcare utilization [6]. In recent decades, cancer treatments have advanced significantly, increasing the demand for healthcare and improving cancer survival rates [7,8]. With these advances in treatment and diagnosis, the number of reported eye and adnexal cancer cases has increased [1]. All these factors have increased costs and economic burdens on healthcare systems more and more [9].

Eye cancer development is influenced by genetic and environmental factors [10]. Additionally, the nature and incidence of eye cancer vary across population groups, with incidence rates being higher in Western countries than in Asia [11]. A previous study by Naser *et al.* showed that during the past two decades over 464,000 hospital admissions were recorded due to malignant neoplasms of eye, brain and other parts of central nervous system in the United Kingdom [12]. According to the latest available statistics, there are over 13 million Australian who have one or more chronic eye conditions [13]. Eye disorders are common and are associated with multiple complications that require hospital admissions [13]. However, studies on epidemiological trends of eye cancer are limited due to the rarity of eye cancer cases [14,15]. Therefore, this study aimed to investigate trends in hospital admissions for eye cancer in Australia. Examining hospital admission profile for eye cancer can by used as a proxy for disease burden as it reflects healthcare utilization pattern

(capturing severe cases that required medical intervention and hospitalization); which enable population level comparison over time. This study provided a longitudinal analysis of the epidemiology of hospital admissions for eye cancer stratified by cancer type, age and gender. Different types of eye cancer (retina vs choroid vs orbit) differ in their associated risk factors including age, genetics. This study hypothesized that patients' age and gender will affect admission rate due to eye cancer.

METHODS

Study Design and Data Sources

This is a time trend analysis study used data from Australian electronic health databases, including information from the Australian Statistical Agency (the Australian Bureau of Statistics (ABS)), which was utilized to collect population data, as this data is reliable and independent [16,17]. Hospital admission data were gathered from the National Hospital Disease Database (NHMD), which includes data from Australian private and public hospitals managed by the Australian Institute of Health and Welfare (AIHW) for the duration between 1998 and 2023 [18,19]. Admissions related to malignant neoplasm of eye and adnexa were identified using relevant ICD codes (C69). The codes were checked and confirmed by expert ophthalmologist. The validity and reliability concerning the quality of data entry in this medical databased were previously mentioned in previous literature. Diagnostic codes were harmonized to ensure consistency. Admission rates were estimated by dividing the number of admissions in a specific year by the number of populations in the same year. The AIHW perform regular validations for patients' data. Data are checked for valid values, consistency and historical consistency.

Statistical Analysis

Data were analysed using the Statistical Package for Social Science Software, version 29. Categorical variables were presented as frequencies and percentage. The significance on the difference in the admission rate between 1998 and 2023 was examined using Chi-Square test. The statistical significance level was assigned as p-value less than 0.05.

RESULTS

Hospital Admissions Numbers

Over the 25 years from 1998/1999 to 2022/2023, Australia recorded 18,679 hospital admissions due to "malignant neoplasm of eye and adnexa". Besides, 51.2% (9,556) of these admissions were overnight and 48.8% (9,123) were same-day. From 1998/1999 to 2022/2023, there was a 53.0% increase in the overall number of admissions from 624 to 955, a 62.2% increase in same- day admissions from 275 to 446 and a 45.8% increase in overnight admissions from 349 to 509 (Figure 1).

Moreover, there are notable age and gender differences in hospital admissions due to "malignant neoplasm of eye and adnexa," with ages 0-14 years accounting for 41.3% or 7,720 of total admissions and males accounting for 54.3% or 10,137 of total admissions. However, across all age groups, hospital admission was higher among males except for younger patients (age 0-14 years), as admission was higher among females. In general, the ascending distribution of hospital admissions due to "malignant neoplasm of eye and adnexa" according to the age group was as follows: age 75 years and over, age 15-59 years, age 60-74 years and age 0-14 years (Figure 2).

There are also considerable variations in the distribution of "malignant neoplasm of eye and adnexa" admissions based on diagnostic categories, with 74.1% of these admissions due to "malignant neoplasm of retina," "malignant neoplasm of choroid," and "malignant neoplasm of orbit," specifically it accounted for 37.9%, 24.5% and 11.7% of total admissions, respectively (Table 1).

Over 25 years, the average length of stay for total admissions cases related to "malignant tumour of the eye and adnexa" was 2.6 days, with variations according to diagnostic categories, ranging from 1.3 to 5.3 days (Figure 3).

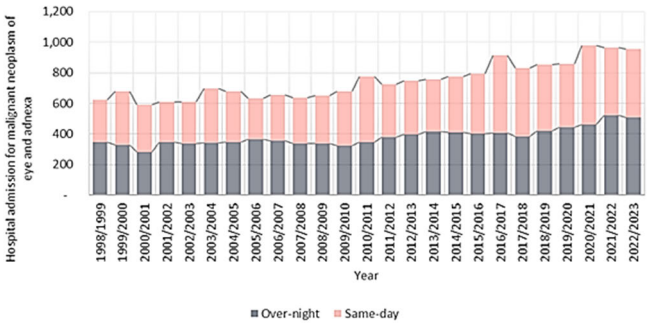

Figure 1: Hospital admission for "malignant neoplasm of eye and adnexa" by admissions type

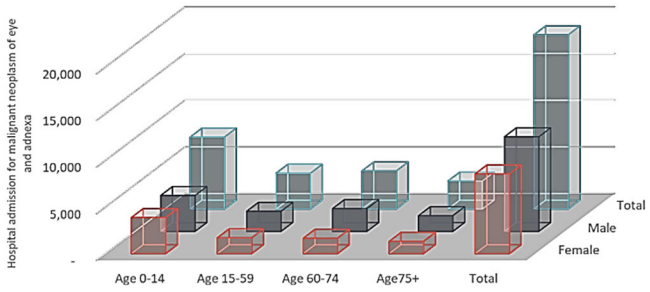

Figure 2: Hospital admission for "malignant neoplasm of eye and adnexa" by age and gender

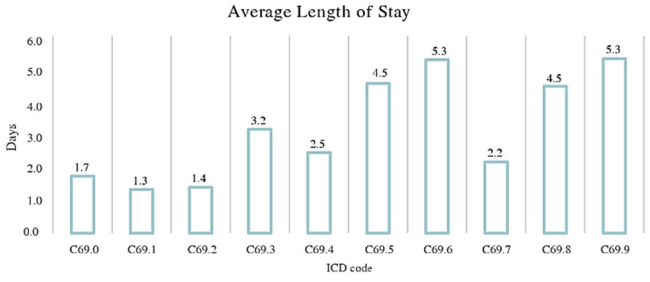

Figure 3: The average length of admission stays for "malignant neoplasm of eye and adnexa" by diagnostic category

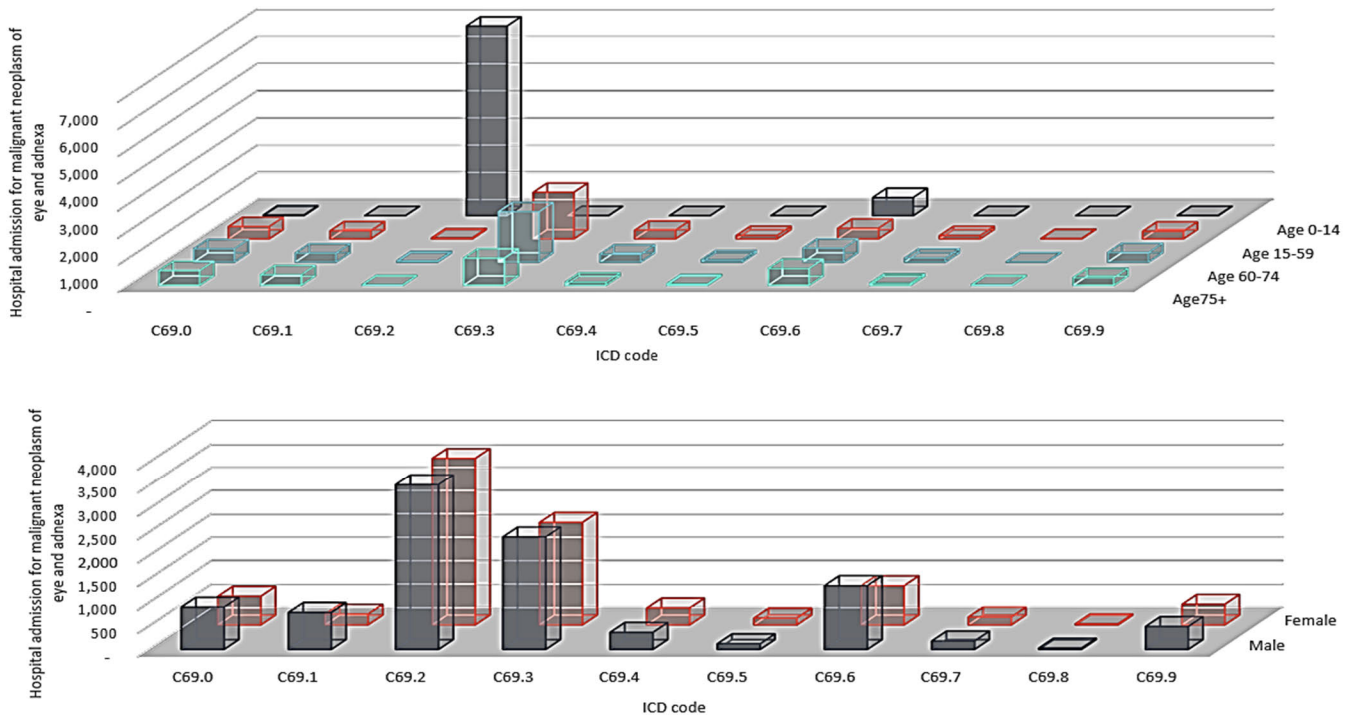

Figure 4: Hospital admissions related to diagnostic categories of "malignant neoplasm of eye and adnexa" by age and gender

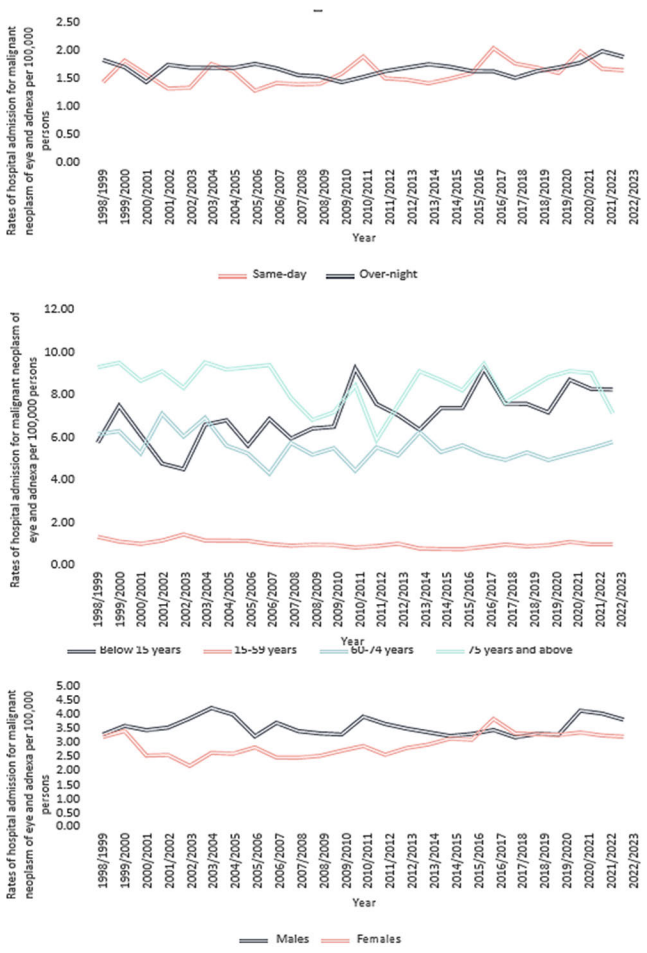

Figure 5: Hospital admission rate for "malignant neoplasm of eye and adnexa" by admissions type, age, and gender

Furthermore, there are substantial variations in the distribution of hospital admissions related to diagnostic categories of "malignant neoplasm of eye and adnexa" based on age and gender. Regarding age differences, the highest admissions were seen in patients with "malignant neoplasm of retina" at age 0-14 years, responding in 37.3% (6,974) of total admissions. Also, concerning gender differences, the highest admissions (3,561 or 19.1%) were seen in female patients with "malignant neoplasm of retina." However, admissions of 80% of these diagnostic categories were higher among patients aged 15 years. Likewise, admissions of 80% of these diagnostic categories were higher in male patients (Figure 4).

Hospital Admissions Rates

Table 2 and Figure 5 describe the change in total admission rate for "malignant neoplasm of eye and adnexa" from 1998/1999 to 2022/2023; the overall admission rate increased by 8.0% from 3.32 to 3.58 per 100,000 persons. Based on admissions type, the total rate for same-day admissions increased by 14.5%, while the total overnight stay admissions increased by 2.9%. As for age groups, the total admissions rate decreased among all age groups except for those aged 0-14 years, as it increased by 42.6%. Finally, regarding gender, the total admissions rate rose by 15.5% among male patients, while it rose only by 0.4% among females.

Table 3 and Figure 6 describe the change in the "malignant neoplasm of eye and adnexa" admission rate stratified by diagnostic categories. From 1998/1999 to 2022/2023, the highest increase in "malignant neoplasm of eye and adnexa" admission rate was for "malignant neoplasm of lacrimal gland and duct," which increased by 97.6%.

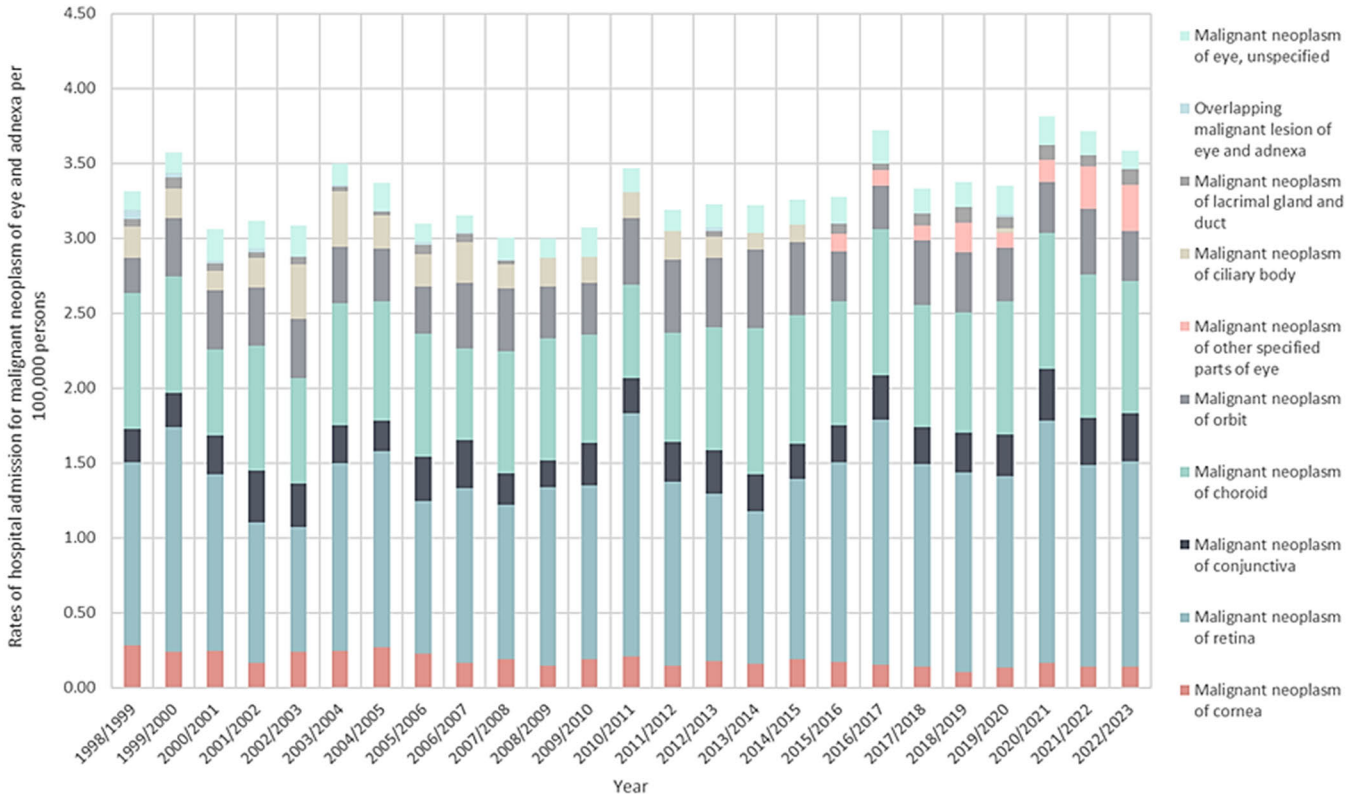

Figure 6: Hospital admission rates for diagnostic categories of "malignant neoplasm of eye and adnexa

Table 1: Hospital admission episodes for “malignant neoplasm of eye and adnexa” per ICD code.

Diagnostic categories	ICD code	Episodes (n)	Percentage from total
“Malignant neoplasm of conjunctiva”	C69.0	1,509	8.1
“Malignant neoplasm of cornea”	C69.1	1,016	5.4
“Malignant neoplasm of retina”	C69.2	7,076	37.9
“Malignant neoplasm of choroid”	C69.3	4,576	24.5
“Malignant neoplasm of ciliary body”	C69.4	722	3.9
“Malignant neoplasm of lacrimal gland and duct”	C69.5	266	1.4
“Malignant neoplasm of orbit”	C69.6	2,193	11.7
“Malignant neoplasm of other specified parts of eye”	C69.7	347	1.9
“Overlapping malignant lesion of eye and adnexa”	C69.8	47	0.3
“Malignant neoplasm of eye, unspecified”	C69.9	927	5.0

Table 2: Percentage change in hospital admission rate for “malignant neoplasm of eye and adnexa” from 1998 to 2023 in Australia

Categories		Admission rate in 1998 per 100,000 persons (95% CI)	Admission rate in 2023 per 100,000 persons (95% CI)	Percentage change from 1998 to 2023
Total admissions		3.32 (3.06 – 3.58)	3.58 (3.36 – 3.81)	8.0
Admissions type	Same day	1.46 (1.29 – 1.63)	1.67 (1.52 – 1.83)	14.5
	Overnight stay	1.86 (1.66 – 2.05)	1.91 (1.74 – 2.08)	2.9
Age groups	0-14 years	5.85 (5.10 – 6.61)	8.35 (7.53 – 9.17)	42.6
	15-59 years	1.43 (1.22 – 1.65)	1.08 (0.91 – 1.24)	-24.9
	60-74 years	6.25 (5.17 – 7.33)	5.89 (5.14 – 6.65)	-5.7
	75 years and over	9.40 (7.52 – 11.28)	7.23 (6.07 – 8.39)	-23.0
Gender	Males	3.36 (2.99 – 3.73)	3.88 (3.55 – 4.22)	15.5
	Females	3.27 (2.91 – 3.64)	3.29 (2.98 – 3.59)	0.4

In addition, the admission rates for “malignant neoplasm of conjunctiva,” “malignant neoplasm of orbit,” and “malignant neoplasm of retina” were raised by 42.8%, 41.2% and 12.0%, respectively. On the other hand, the admission rates for “malignant neoplasm of ciliary body” and “overlapping malignant lesion of eye and adnexa” were decreased by 100.0%. Admission rates for “malignant neoplasm of cornea,” “malignant neoplasm of eye, unspecified,” and “malignant neoplasm of choroid” were decreased by 49.4%, 2.9% and 2.6%, respectively.

DISCUSSION

The results of this study show that most admissions due to “malignant neoplasm of eye and adnexa” (41.3% or 7,720 of

Table 3: Percentage change in hospital admission rates for diagnostic categories of "malignant neoplasm of eye and adnexa" from 1998 to 2023 in Australia

ICD code	Admission rate in 1998 per 100,000 persons (95% CI)	Admission rate in 2023 per 100,000 persons (95% CI)	Percentage change from 1998 to 2023
C69.0	0.22 (0.16 – 0.29)	0.32 (0.25 – 0.39)	42.8
C69.1	0.28 (0.21 – 0.36)	0.14 (0.10 – 0.19)	-49.4
C69.2	1.22 (1.06 – 1.38)	1.37 (1.23 – 1.51)	12.0
C69.3	0.91 (0.77 – 1.05)	0.89 (0.77 – 1.00)	-2.6
C69.4	0.21 (0.14 – 0.27)	0.00 (0.00 – 0.00)	-100.0
C69.5	0.05 (0.02 – 0.09)	0.11 (0.07 – 0.14)	97.6
C69.6	0.23 (0.16 – 0.30)	0.33 (0.26 – 0.40)	41.2
C69.7	0.00 (0.00 – 0.00)	0.31 (0.24 – 0.37)	N/A
C69.8	0.06 (0.02 – 0.09)	0.00 (0.00 – 0.00)	-100.0
C69.9	0.13 (0.08 – 0.18)	0.12 (0.08 – 0.17)	-2.9

total admissions) were among patients aged 0-14 years. From 1998/1999 to 2022/2023, the total admissions rate among those patients increased by 42.6%. In addition, "malignant neoplasm of retina" accounts for most admissions among patients aged 0- 14. Although many previous studies have indicated an increased incidence of eye cancer among older people [20-22], this depends on the type of eye cancer; risk factors vary from one type to another [14,22-25]. For instance, genetic factors, exposure to ultraviolet radiation, light eyes, fair skin, atypical moles and advanced age are all risk factors associated with the development of intraocular melanoma [26,27]. On the other hand, retinoblastoma, a malignant neoplasm of the retina, primarily influences children and is linked to genetic factors [14,28]. These may explain the preponderance of hospital admissions episodes among the younger age group, as "malignant neoplasm of retina" was the primary category for "malignant neoplasm of eye and adnexa" hospital admissions.

In line with our findings, the highest incidence of eye cancer was among younger people (aged 0 to 4 years) in Saudi Arabia [29]. In Uganda, 30.8% of "malignant neoplasm of eye and adnexa" were among younger individuals (aged 0 to 15 years) [30]. Retinoblastoma was the most "malignant neoplasm of eye and adnexa" in the Philippines [31]. However, several studies found a delay in the diagnosis of retinoblastoma [32-38]. Besides, prior research indicated that delayed diagnosis is associated with poor outcomes, including death from cancer [39,40] or delayed hospitalization and then treatment failure [2]. Thus, hospital admissions for retinoblastoma in the current study may be partly attributed to delays in retinoblastoma diagnosis.

The delayed diagnosis of retinoblastoma could result from multiple patient factors, including seeking non-medical or alternative therapies for tumour resection due to fear, difficulty of transportation, knowledge of the severity of the condition, social strain, economic constraints and living in a remote location [41]. All these patient factors must be considered when developing any intervention to reduce the late detection of retinoblastoma. Efforts such as educating healthcare providers and raising community awareness about retinoblastoma may help promote early detection [42]. Early detection and prompt treatment of retinoblastoma are significant in increasing survival and decreasing morbidity rates [42,43]. Consequently, these may also contribute to reducing associated hospital admissions.

Numerous initiatives and efforts in Australia are aimed primarily at the early detection and timely treatment of retinoblastoma [44,45]. Such initiatives have contributed to reducing disability, mortality and retinoblastoma incidence [46]. However, given that hospital admission rates continue to rise, further efforts are needed to reduce hospital admissions, thus reducing the burden on society and the healthcare sector.

Another important finding is that based on diagnostic categories, our study determined considerable variations in the distribution of "malignant neoplasm of eye and adnexa" admissions, with 74.1% of these admissions due to "malignant neoplasm of retina," "malignant neoplasm of choroid," and "malignant neoplasm of orbit." The admissions distributions for "malignant neoplasm of retina" and "malignant neoplasm of choroid" are aligned with the general prevalence of these cancers among different people. As mentioned previously, retinoblastoma is the most common malignant neoplasm among children. In addition, among adults, studies have indicated that the most common intraocular malignant tumours are choroidal metastases [47]. Regarding the distribution of admission due to "malignant neoplasm of orbit," this could be because the orbit is the most common site where ocular lymphoma occurs [48]. At the same time, our study found that the admission rates for "malignant neoplasm of retina" and "malignant neoplasm of orbit" increased by 12.0% and 41.2%, respectively. However, the admission rate for "malignant neoplasm of choroid" decreased by 2.6%. Hence, developing effective strategies are mandated to reduce hospital admissions for "malignant neoplasm of retina" and "malignant neoplasm of orbit." Finally, more research about the reasons for these trends is required.

This study found that males accounted for 54.3% of total admissions of "malignant neoplasm of eye and adnexa." Additionally, the total admissions rate increased by 15.5% among male patients, while it increased only by 0.4% among females. Our findings are consistent with multiple earlier studies. A previous global analysis found that males have higher rates of eye cancer than females [14]. The prevalence of squamous cell carcinoma of the conjunctiva was twice as high in males as in females in Iran [49]. The incidence of choroidal melanoma was higher in Australian men than in Australian women [50]. Besides, hospital admissions for eye and adnexal diseases were higher in males than in females in

the United Kingdom [51]. Several factors could explain these observations. Firstly, the incidence of eye cancer in high-income countries is increasing, particularly among men [14]. Secondly, delayed diagnosis because of delays in seeking medical care [52]; men seek medical care less frequently than women in Australia [53,54]. Thirdly, these may be due to men being more exposed to sunlight than women and spending more time outdoors [49]. Hence, educational programs may help increase male knowledge about eye cancers, their associated risk factors and the importance of early detection, which can aid in reducing the incidence and hospital admissions of eye cancers.

This study has multiple strengths. Uses national hospital database over a long period, which gives a broad view of hospital workload. Furthermore, this research includes both same-day and overnight admissions. Moreover, this study provided detailed admission rate stratified by age, sex and diagnosis, which is useful for planning. This study has limitations. This study examined admission rates on the population-level rather than on the individual patient-level. This limited the ability to identify confounding variables and geographic coverage/variation that might have affected the estimated admission rates. Besides, the estimated admission rates might include readmission cases which might lead to overestimation. Furthermore, the small number of eye cancer cases decrease the statistical stability of the estimated admission rates. Therefore, the study findings should be interpreted carefully.

CONCLUSIONS

Our study found several significant findings related to trends in hospital admissions due to "malignant neoplasm of eye and adnexa" in Australia. Overall, admission rates increase during the study period. Younger people (less than 15 years old) represented the largest age group of patients admitted to the hospital during the study period; therefore, admissions due to "malignant neoplasm of retina" were the most common diagnosis. Furthermore, compared to females, the hospital admission episodes and the increased hospitalization rates were higher among males. Thus, there is a need to implement interventions aimed at reducing hospital admissions due to "malignant neoplasm of eye and adnexa," particularly for young people and males.

Ethical Statement

This study was approved by the Scientific Research Ethics Committee at Isra University, Amman, Jordan (SREC/25/05/144).

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