

## Ophthalmic Education and Ophthalmologists Growth Trends in Iran (1979–2016)

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### Abstract

**Purpose:** To analyze the growth trends in ophthalmic education in Iran since 1979, and to discuss their implications on the profession.

**Methods:** This comprehensive national study was performed by the Academy of Medical Sciences of I.R. Iran. The data were gathered from the Specialty Training Council of the Ministry of Health and from the Medical Council of Iran.

**Results:** Our analysis revealed ten important current growth trends and seven future trends and implications. Between 1979-80 and 2015-16, the number of residents annually admitted to ophthalmology increased from 21 to 84 and related fellowships and from 0 to 34. The number of ophthalmologists graduating in the country increased from 21 (45%) in 1979 to 69 (98%) in 2015. The ratio of ophthalmologists per 100,000 people averaged 1.91 in 1979 and 3.00 in 2016. Considering migrant and retired ophthalmologists, there are approximately 2400 active ophthalmologists in Iran. In 1979, there was one active ophthalmologist per 52,112 people; in 2014, there was one per 33,333 people. This represents a per capita increase of 57%. Since 1979, the number of active ophthalmologists has increased by 234%. The number of active women ophthalmologists has increased by more than 600%, from 65 (9%) in 1979 to 470 (20%) in 2016.

**Conclusion:** Equitable geographic distribution and balanced combination of ophthalmologists (women/men and specialists/fellowships) are necessary to optimize community eye health. We propose further studies on the effects of fellowship training growth and work patterns of female and male ophthalmologists.

**Keywords:** Ophthalmic Education; Physician Trends; Residency; Fellowship; Women; Future Challenges

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### INTRODUCTION

In the 1970s, the shortage of ophthalmologists was a very serious issue in most provinces of Iran, especially in distant and rural areas. Following the 1979 Revolution, major reforms were implemented in the Iranian

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medical education system and great progress was made in specialty/sub-specialty training in Iran.<sup>[1-3]</sup> The training of sufficient numbers of ophthalmologists based on community needs and the training of competent ophthalmologists to deliver effective care and improve eye health outcomes, were critical priorities in a strategic plan provided by the Ophthalmology Curriculum Committee of the Medical Education and Specialty Council of the Ministry of Health and Medical Education (MOHME).<sup>[4,5]</sup>

Ophthalmology is a desirable specialty discipline among general doctors who plan to continue specialty training in Iran,<sup>[1,4]</sup> because ophthalmologists are medically trained to manage the complete range of vision care and eye medical treatment, and to perform highly technical surgeries.<sup>[6,7]</sup>

A wide range of people of different ages with various problems come to ophthalmologists. Patients who have deteriorating vision due to chronic diseases, such as diabetes, require follow-up with an ophthalmologist to monitor for retinal revascularization every year, while young children with severe bacterial conjunctivitis might only be seen once.<sup>[7]</sup>

Monitoring the ophthalmologists to population ratio to determine whether it is increasing and whether the supply is adequate to meet future demand is an important task of medical educators.

Analysis of ophthalmic education growth trends is important in a country such as Iran with diverse demographic characteristics and health care needs. Despite worldwide recognition of its importance, there is a lack of data on the global state. In Iran, there is lack of information on the available human resources in eye care,<sup>[8]</sup> and there has been little investment in the collection of accurate and timely data that could provide an overview of trends in ophthalmology and inform policy.

To better understand the current and potential future trends, we conducted a comprehensive national study. The aim of this study was to provide accurate data on the quantitative development of ophthalmic education and the growth trends of ophthalmologists by gender from 1979 to 2016, to discuss the consequences of current trends in ophthalmic education. This research work was approved by the Academy of Medical Sciences of I.R. Iran.

## METHODS

This comprehensive national study was performed with the support of the Academy of Medical Science of Iran.

### Data Collection

First hand data of admitted and graduated residents were collected from the Council in Specialty and

Sub-specialty Training and the Department of Exam Evaluation of the MOHME. The data included information about the number of registered residents and the total number of ophthalmologists from 1979-1980 until 2015-2016 by gender and trained fellowships available in ophthalmic sub-specialty fields. The overall ophthalmologist information since 1979 was gathered from the Department of Information and Statistics of the Medical Council of the Islamic Republic of Iran. Data collection was further complemented by information gathered directly from ophthalmic fellowship training centers. We designed structured electronic databases of the quantitative information of ophthalmic residents and specialists to analyze growth trends.

### Data Accuracy

First hand data were collected from multiple sources of information. The consistency and accuracy of the data were confirmed.

## RESULTS

Our results show that ophthalmologic education has experienced increased growth in Iran since 1979. Our analysis also revealed some important growth trends in ophthalmology education and ophthalmologist manpower in Iran.

### Ophthalmology Growth Trends in Iran Since 1979

#### *Increase in the number of ophthalmology residents*

Ophthalmic training has experienced steady, quantitative growth since 1979. Ophthalmology continues to be attractive due to the need for trained ophthalmologists. Ophthalmologic residency training programs are held in 14 medical sciences universities of the country. One important expansion in ophthalmic education in the last 35 years was an increase in the number of residents from 21 in academic year 1979-1980, to 87 in 2011-2012, and to 83 in 2014-2015 [Figure 1]. Figure 1 shows the increase in ophthalmic resident admissions between 1980 and 2015. The first increase occurred in 1985 after the establishment of the MOHME. The second increase occurred in 2005 and the trend has continued in recent years.

#### *Increase in the number of women ophthalmic residents*

During the 1980s, 95% percent of residents in ophthalmic education in Iran were men. The number and percentage of Iranian women physicians graduating from general medicine has increased significantly in recent decades, suggesting an increasing interest in specialty training by women doctors.

The number of Iranian women entering residency programs, especially in ophthalmology, increased in a relatively linear fashion. Women constituted 35% of admitted residents in ophthalmology in Iran in 2014. Today, 33% of ophthalmic residents are women.

*Growth trends of ophthalmologists graduating in Iran*

The proportion of Iranian ophthalmologists trained in the country has risen sharply since the mid-1990s [Figure 2].

The number and percentage of Iranian ophthalmologists who graduated in the country increased from 21 in academic year 1979-1980 to 69 in 2015 [Figure 2]. In 1980, 45% of Iranian ophthalmologists graduated in the country. In 2014-2015, that number had increased to 98%; they were trained at national universities.

After training, Iranian ophthalmologists take pre-board exams and doctors who successfully pass this exam are certified to practice. In the 2014 pre-board exam, 65 ophthalmologists were successfully certified.

Another national examination has been administered by the Iranian board of medical specialties since 1975. After board certification, specialists can enter academic positions in universities and take a sub-specialty/

fellowship entrance exam. A total of 37 ophthalmologists successfully passed certified specialty board exams in the academic year 2013-2014. The number of female ophthalmologists who took and passed certified ophthalmology board exams has also significantly increased in recent years.

*Trends of Iranian physicians' graduating in an ophthalmic specialty since 1979*

There has been a significant increase in the number of Iranian physicians graduating in ophthalmology. The number increased from 843 in 1979 to 1,440 in 1990, 2,128 in 2000, and 2,760 in 2014 [Figure 3].

*Growth of Women Ophthalmologists*

The information presented in Figure 3 shows the trends of Iranian physicians graduating in ophthalmology by gender. The number and percentage of Iranian women graduating in ophthalmology has increased significantly since 1979 [Tables 1 and 2]. Between academic years 1979-1980 and 2013-2014, the number of Iranian women graduating in ophthalmology increased linearly, from 110 in 1980 to 523 in 2013 [Figure 3].

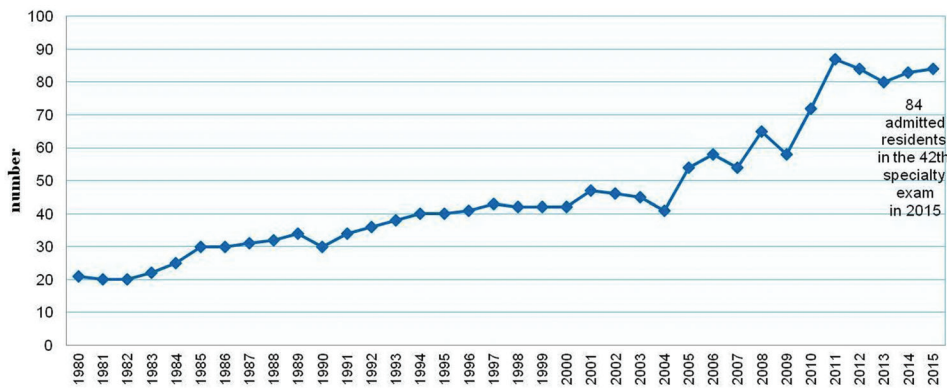


Figure 1. Ophthalmology admission growth trends in Iran since 1979.

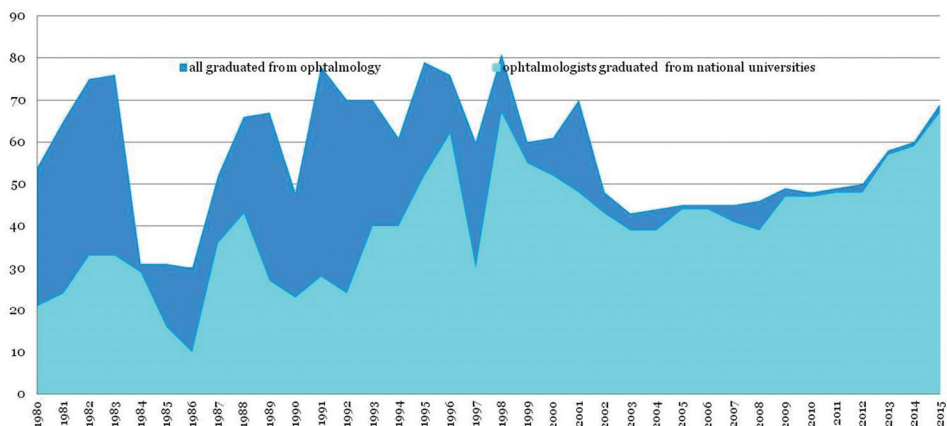
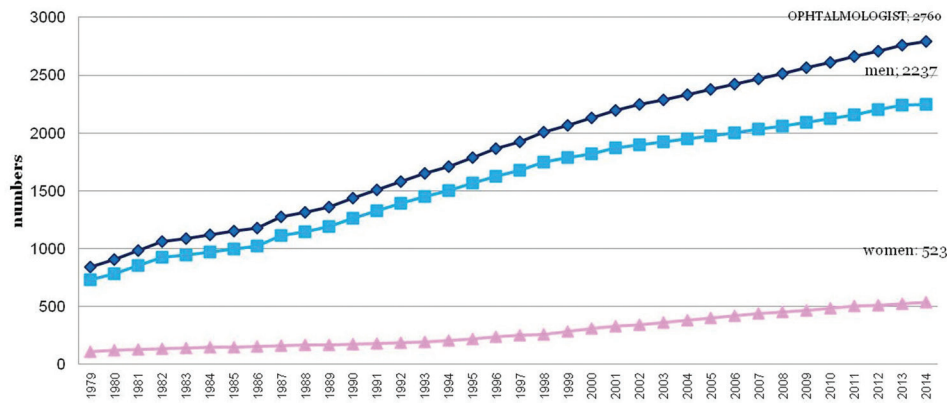


Figure 2. Comparing the growth trends of Iranian ophthalmologists graduated in the country vs abroad.



**Figure 3.** Comparing growth trends of Iranian women and men specialists graduated in ophthalmology disciplines.

**Table 1. Number of active ophthalmologists by sex in Iran vs. the USA**

Country (year)	Ophthalmologists in practice	Men		Women	
		Number	Percent	Number	Percent
Iran (1980)	710	645	91%	65	9%
Iran (2013-2014)	2250	1860	83%	390	17%
Iran (2015-2016)	2370	1900	80%	470	20%
USA (2012)	17,943	14,340	80%	3603	20%
USA (2016)	18,670	14,148	76%	4436	23.9%

*Growth trends of active ophthalmologists*

Considering migrants, retired ophthalmologists, newly graduated physicians, and ophthalmologic residents, there were approximately 2,250 active ophthalmologists in a population of 75 million Iranians in 2014, and approximately 2,370 active ophthalmologists in 2016 for 80 million Iranians [Table 1].

*Growth trends of active women ophthalmologists*

The number and percentage of Iranian women ophthalmologists has increased significantly since 1979. In 1979, approximately 91% of active Iranian ophthalmologists were men. The percentage of active women ophthalmologists grew from 9% in academic year 1979-1980 to 17% in academic year 2013-2014 and to 20% in academic year 2015-2016. This trend will continue because the percentage of Iranian women doctors attending ophthalmic education is increasing.

Compared to the USA,<sup>[9]</sup> with the highest percentage of women ophthalmologists in the world, (approximately 20% in 2012 and 24% in 2015), the percentage of women ophthalmologists in Iran increased significantly [Tables 3 and 4].

*Ophthalmologist to population growth trends*

In 1979, there were approximately 700 active ophthalmologists for 37 million Iranians, and many provinces experienced shortages in ophthalmology services at that time. We considered population growth and

**Table 2. Number and increase in Iranian specialists graduating in ophthalmology by sex**

Year	Total number of specialists graduating in ophthalmology	Number	
		Men	Women
1979-1980	843	733	110
2013-2014	2790	2250	540
Change	+231.96%	+207%	+430%

the number of ophthalmologists in practice, and calculated the ratio of ophthalmologists per 100,000 people and the changes between 1979-2014 and 1979-2016. Between 1979 and 2016, the number of Iranian ophthalmologists per 100,000 people significantly increased [Table 3].

In 2016, the ratio of ophthalmologists per 100,000 people in Iran was 3.0. Table 3 shows the increase in the number of ophthalmologists in Iran compared to the USA.

*The percentage change of Iranian ophthalmologists*

Our analysis revealed that the ratio of active Iranian ophthalmologists per 100,000 people increased by approximately 57% between 1979 and 2016 [Table 3]. In 35 years, the number of Iranian physicians graduating from an ophthalmology specialty increased by 231.96% and the number of Iranian women graduating from an ophthalmology specialty increased by approximately 430% [Table 2].

Between 1979 and 2014, the number of active Iranian ophthalmologists increased by 217% and the number

of active women ophthalmologists increased by 500% [Table 4]. Between 1979 and 2016, the number of active ophthalmologists increased by 234%, while the number of active women ophthalmologists increased by more than 600% [Table 4].

**Ophthalmic fellowships growth trends**

Many ophthalmologists desire extra training in a single aspect of the field. This training requires a post-residency fellowship. Most fellowships are one- to two-year programs that integrate both clinical and research experience.<sup>[7]</sup> Fellowships emphasize research and scholarly work. Unlike many fields of medicine, the completion of fellowship training often does not limit the specialist to that sub-specialty area of practice. Many ophthalmologists who have completed fellowships choose to integrate that area of expertise into their practice of general ophthalmology.<sup>[7]</sup>

Fellowships related to ophthalmology are currently offered by eight medical sciences universities in six fields of study in Iran, including corneal and external

eye diseases, vitreous and retinal diseases, strabismus/ pediatric ophthalmology, oculoplastics, glaucoma, and ophthalmologic pathology. Table 5 shows the year each fellowship program was approved and the duration of each fellowship.

These fellowships programs are rapidly increasing in quantity and quality due to the large number of patients referred. A total of 454 ophthalmologic surgeons had graduated from fellowship programs by academic year 2014-2015. Table 5 shows the total trained fellowship numbers. A number of women ophthalmologists also graduated in each sub-specialty field.

Remarkable quantitative growth and expansion of fellowship training has occurred in the various sub-specialty areas in the last decade [Figure 4]. Two areas of ophthalmology that are sought after by ophthalmologists are corneal and external eye diseases, and vitreous and retinal diseases [Figure 4].

**DISCUSSION**

**Adequacy of the Current Ophthalmic Workforce**

There are many indicators of the adequacy of a surgical workforce. No single measure can provide a definitive assessment of the ophthalmology surgical supply. However, we can use the most recommended benchmark to study whether the ophthalmology workforce adequately meets the current demands of the population, or if there is a significant shortfall or oversupply. One indicator is the surgeon to population ratio (SPR).<sup>[10]</sup>

**Ophthalmic surgeon to population ratio**

Attempts to define the optimal ophthalmologist-to-population ratio are difficult. The ideal ratio for a given population varies depending on regional needs, the services and technology available, and the work patterns, such as efficiency and work hours, used to deliver those services. An evaluation of the workforce patterns of health maintenance from the United States in 1994 suggested three ophthalmologists per 100,000 people.<sup>[11]</sup> Another attempt to estimate the eye care workforce supply in the United States suggested a

**Table 3. Increase in the number of ophthalmologists in Iran vs. the USA**

Country	Year	Ophthalmologists in practice per 100,000 people	Percent change in ophthalmologists per 100,000 people
Iran	1979	1.91	
	2013	3.00	1979-2013: +57%
	2016	3.00	1979-2016: +57%
USA	1980*	5.41*	
	2009	5.86	1980-2012:+49.72%
	2012*	8.1	1980-2016: +6.8%
	2016†	5.78	

\*Workforce Trends. Bulletin of the American College of Surgeons, 2012. †AAMC Workforce Data, 2016

**Table 4. Change in the percentage of practicing ophthalmologists in Iran by sex**

Interval	Percentage	Percentage	
		Men	Women
1979-2014	+217%	+188.3%	+500%
1979-2016	+234%	+194%	+623%

**Table 5. Approval year and duration of each ophthalmic fellowships and graduated numbers**

Fellowship Discipline	Year of Program Approval	Duration (months)	Total trained fellowships to 2014
Cornea and External Eye Diseases	1985	18	180
Vitreous and Retinal Diseases	1985	18	161
Pediatric Ophthalmology and Strabismus	1991	12	60
Oculoplastics	1999	18	26
Glaucoma	2006	15	17
Ophthalmologic Pathology	2006	15	10
			Sum: 454

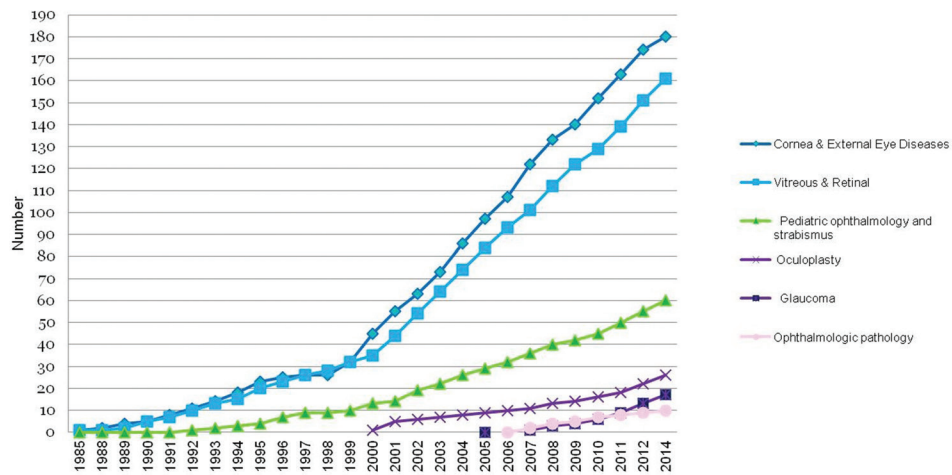


Figure 4. Growth trends in the number of trained specialists in each fellowship discipline.

Table 6. Ratio of ophthalmologists per one million people in different countries in 2012 (based on available data)

Country	Total FTE* Ophthalmologists	Ophthalmologic SPR†	Ophthalmologists per 1 million people
Japan‡	13,911	-	110
Russian Federation‡	14,600	1:9794	102
USA	17945	1:17,287	81
Germany‡	6,638	1:12,398	81
Brazil‡	11,350	-	58
United Kingdom‡	3200	1:19,688	51
Australia‡	895	1:24,916	40
Canada§	1,164	1:29,859	33
Azerbaijan‡	300	1:30,627	33
Iran	2250	1: 33,333	30
Singapore‡	131		26
China‡	28,338	1:47,333	21
Saudi Arabia‡	582	1:47,161	21
Tajikistan	77		11
India‡	11,000		9

\*Full-time equivalent, †Surgeon-to-population ratio, ‡[16], §[13]

ratio of 3.12 ophthalmologists per 100,000 people.<sup>[12]</sup> In 1988, the RCPSC suggested 3.37 ophthalmologists per 100,000 Canadians was necessary, while some references suggested that the ideal ratio for Canada was 3:100,000.<sup>[13]</sup>

The World Health Organization (WHO) recommended target ratios of two per 100,000 people for Asia and one per 250,000 for sub-Saharan Africa, but did not recommend any goals for developed nations.<sup>[14]</sup>

The Australian Medical Workforce Advisory Committee (AMWAC) suggested that a reasonable SPR benchmark for Australia was between 1:22,700 and 1:26,000. The Working Party concluded that, overall, the current ophthalmology workforce was probably adequate to the meet current demand.<sup>[10]</sup> There have been increasingly intense discussions on the adequacy of physicians, which has led to the development of a policy to increase the number of new physicians in the above countries.

Worldwide, the number of ophthalmologists has grown quickly in the past ten years. According to a survey, the highest total numbers of ophthalmologists in the world are in six countries: China, the USA, Russia, Japan, Brazil, and India. However, these countries had different average numbers of ophthalmologists per million people (from 110 for Japan to 9 for India [Table 6]). The lowest average number of ophthalmologists per million people, 2.7, was in Sub-Saharan Africa.<sup>[15,16]</sup>

The USA had an ophthalmologist to population ratio of 1:17,287 in 2012. The UK had 3,200 ophthalmologists and 63 million people in 2012; the SPR was 1:19,688. In 2012, Iran had 2,250 active ophthalmologists for 75.2 million people; the SPR was 1:33,333 [Table 6]. Considering the constant ratio of ophthalmologists per population in Iran and other countries from 2012 to 2016, on average, the number of ophthalmologists

in practice increased at the same rate as the general population [Table 7].

The achievements of the Iranian ophthalmologic education and the current ophthalmology workforce have been considerable. In 1979, there was one ophthalmologist for every 52,112 people. In 2014 and in 2016, there was one active ophthalmologist for every 33,333 Iranian people. This ratio is a significant improvement to that of 1979 [Table 7].

There are currently 3.0 ophthalmologists per 100,000 people. Iran has met the WHO and AMWAC benchmarks of ophthalmologists per 100,000 people and is very close to the target ratios suggested for the USA and Canada. This indicates that by approximately 2013, there was near equilibrium between national demand and the supply of ophthalmological services. However, national averages can be misleading, as found by a closer inspection of the geographic distribution of ophthalmologists and the population.

## Future Trends and Implications for Ophthalmic Education

### *Ophthalmologist distribution pattern in Iran*

Increasing the number of ophthalmologists is a prerequisite for the achievement of cost-effective ophthalmic care, but it is not the only requirement. Substantial geographic variation exists in ophthalmologist distribution in the country. The number of ophthalmologists necessary to meet future demand should not be projected based only on the total number of physicians.<sup>[17,18]</sup>

There is clearly a significantly unequal distribution of ophthalmologists between provinces, particularly in remote areas, and it may be necessary to make adjustments to the workforce. These adjustments could be achieved through localized incentives to encourage local ophthalmologists to serve in their own geographical regions (urban or rural) or through the recruitment and relocation of qualified and skilled ophthalmologists from other provinces or cities.

### *Women ophthalmologists and patterns in the profession*

The number and percentage of applications from Iranian women physicians to specialty programs have increased significantly since 1979. The MOHME emphasizes the integral role of women doctors to satisfy patients' demands for same-gender physicians. Since 2000, the

percentage of Iranian women entering the ophthalmic specialty education has increased linearly.

In the US, between the academic years 2000-2001 and 2005-2006, general surgery and ophthalmology become the surgical specialties with the second highest percentage of women among US medical graduates entering training, behind only obstetrics and gynecology.<sup>[19]</sup> In the USA since 1981, the number of women ophthalmologists has increased to more than 36,000 and constitutes 20% of all US ophthalmologists. The number of Iranian women graduating from the ophthalmology specialty has increased steadily, from 110 in 1980 to 540 in 2015. The number of active female ophthalmologists increased from 65 in 1980 to 470 in 2016 and constitutes 20% of Iranian ophthalmologists.

Women doctors now account for more than 30% of ophthalmic residents.

Women ophthalmologists prefer part-time or other forms of flexible employment. Several studies also indicate that women ophthalmologists have a different practice style than that of men.<sup>[19-22]</sup> Women ophthalmologists have a more empathic, patient-centered style; therefore, they devote more time to each patient, which results in better patient outcomes.<sup>[21]</sup> Other studies indicate that male doctors practice more efficiently and take more risks in practice.<sup>[22]</sup>

However, several academic centers have reported that female productivity increases dramatically and, in many cases, exceeds that of men later in their careers. If this is also true for achievements in ophthalmology, the influence of women "in the pipeline" now will increase in the future.<sup>[23]</sup>

### *Increased high-tech fellowship training*

The effect of new technology and expertise extends within ophthalmology and across specialties. As ophthalmology continues to evolve, ophthalmologists must prepare for the future.<sup>[24,25]</sup>

Ophthalmology is a high-tech field. In recent decades, important technological innovations in the visual sciences have resulted in the development of various new diagnostic techniques and eye surgical procedures. Virtual reality, simulators, and robotic surgeries have considerably changed ophthalmic practice. Continued advances in eye surgery, such as laser photocoagulation, micromanipulation, fluorescent angiography, and microsurgery, have made these procedures safer and their performance more rapid.<sup>[26,27]</sup>

Specialists require extra training to take full advantage of this technology. In addition to the core of basic knowledge central to ophthalmology, there are sub-specialty areas that expand the focus of different areas of ophthalmology and enhance the quality of highly technical eye surgery training.<sup>[27]</sup> Fellowship programs are the most important contributors to

**Table 7. Ophthalmologists per population in 2016**

Country	Ophthalmologists in practice	Ophthalmologists per population
Iran (2015-2016)	2370	1:33,333
Canada (2015)	1223	1:29,512
USA (2015)	18,670	1:17,287

progress in ophthalmology training, and also help faculty recruitment and development. Ophthalmology, with various fellowship opportunities, is highly specialized. Fellowship programs are very attractive to general ophthalmologists. Some studies reported that approximately nine in ten ophthalmologists expect to participate in an ophthalmic fellowship. In comparison, approximately two-thirds of American ophthalmic residents plan to complete a fellowship program, especially in the top two choices in the USA: retinal and corneal diseases.<sup>[27]</sup>

Kent surveys indicate that those who plan to attend a fellowship program believe it is essential for achieving their desired academic and financial position. Survey data have confirmed that sub-specialists work an average of seven to eight hours more per week than general ophthalmologists and spend more time in surgery.<sup>[27,28]</sup>

### *Ophthalmic specialization and sub-specialization challenges*

In previous decades, specialization and sub-specialization were promoted by medical practice as strategies to achieve best practices and to improve the health system as a whole. A survey of residency program directors suggested that, although there was a strong consensus that further ophthalmology training was important, 85% of program directors responded that “a major component” of ophthalmology training should occur in the medical school.<sup>[28]</sup>

In an era of increased recognition of the importance of primary care medicine, it is clear that an understanding of basic ophthalmic disease concepts and examination techniques is fundamental to the training of medical students. In addition to the obvious patient-centric benefits of improved undergraduate ophthalmic medical education, it seems the specialty itself would benefit from curricular improvement.<sup>[29]</sup>

Specialization and sub-specialization have resulted in a greater number of patient-provider visits, the possibility of unnecessary testing, and increasing health care costs as a consequence of induced demand.<sup>[30,31]</sup> Sub-specialists may only serve a certain portion of the population with specific health care needs because of the resources they require. A commonly expressed concern of sub-specialization in medical practice, including ophthalmic care, is that specialized services are not accessible to some patients, especially those in remote communities and underserved regions. This can lead to a degree of inequity in the health care system, in which some patients receive better treatment than others.<sup>[31,32]</sup>

### *Population aging and eye care demand*

Ophthalmology, like almost every other medical specialty, will face substantial manpower challenges by 2020 or 2030 due to demographic trends during the next 20 years.<sup>[12]</sup> The number of physicians is increasing worldwide. However,

on average, the population aged >60 is growing at more than twice the rate of the number of ophthalmologists.<sup>[33]</sup> The Census Bureau anticipates that between 2000 and 2030, the number of Americans over the age of 65 will double. Therefore, the aging of the population will result in an increased demand for eye care services for older patients, yet, in the current care system, there will be a shortage of practicing ophthalmologists to provide care.<sup>[34]</sup>

Educational planners must consider ophthalmologic growth trends, the evolution of ophthalmologic care, and population needs. To meet this increasing gap between patient demands for eye care and ophthalmologist supply, it is necessary to enhance ophthalmic education and improve access to the highest quality eye care to improve the quality of patients' lives. It is critical to train enough competent eye care teams to reduce the current deficit and to prepare for future challenges of ophthalmologist shortages.<sup>[33,34]</sup>

### *Future ophthalmologist supply and training positions*

In addition, ophthalmology is facing a relatively flat supply of future ophthalmologists for at least a decade.<sup>[33]</sup> It will be extremely challenging to train enough ophthalmologists to provide needed care in the future. The decision to expand ophthalmology residency programs and increase the number of training programs would have a nominal and substantially delayed effect on the ophthalmologic capacity to deliver eye care. There is a six-year interval between the decision to increase the number of ophthalmology training positions and the graduation of these residents. Therefore, an increase of 20% would take more than two decades to effect a 10% change in the number of ophthalmologists in practice per 100,000 people.<sup>[12]</sup>

### *Enhancement of ophthalmic education*

Change has occurred rapidly in ophthalmic care, and there is a parallel revolution in medical education. E-learning platforms are increasingly utilized in ophthalmic education. Visual pattern recognition is integral to ophthalmology practice; therefore, learning platforms in ophthalmic education use high quality images, videos, and animations. Also, the e-learning platforms provides virtual patient case studies.<sup>[34-36]</sup> Modernization of ophthalmic education with a well-designed, validated, interactive e-learning system is a cost-effective investment.<sup>[37]</sup>

In conclusion, over the last 37 years, Iran has made remarkable progress in ophthalmic specialty education, fellowship training, and the growth of ophthalmologist manpower. Growth trends suggest that the overall number of ophthalmologists in Iran is at the highest per capita since 1979.

There is room for ophthalmic education to improve with respect to the assessment of future needs and cost-effectiveness.



Obviously, ophthalmologic education expansion models of the last decade will not match for another decade.<sup>[37]</sup> The number of ophthalmologists *vs.* Iranian citizens, the demographics of ophthalmologists, combination of ophthalmic specialists and sub-specialists, and equity in distribution of the ophthalmologists, are important considerations of the ophthalmic education system in Iran.

Our study has at least three policy implications. First, the national supply of ophthalmologists can be misleading, as observed when considering the geographic distribution of ophthalmologists. Second, the growth trends of ophthalmologists entering fellowship training require a more rigorous analysis. In fact, sub-specialized ophthalmologists are attracted to specialized health care centers in large cities, leaving patients in small cities and remote regions. This can lead to a degree of inequity in our health care system. The development of effective strategies to improve the geographic distribution of ophthalmologists, particularly early-career physicians, is also necessary for enhancing the availability of ophthalmic specialty care in remote areas. Third, the rapid increase in the number and percentage of women ophthalmologists who prefer more part-time jobs and lower work time may further increase the gap between supply and demand for eye care services. This indicates that projections of the adequacy of ophthalmologist supply for future demand must focus more on the work pattern and preferences of women ophthalmologists.

The implications are that it will be extremely challenging to train enough ophthalmologists to provide necessary care. Monitoring the growth trends in ophthalmic education and graduated ophthalmologists, would facilitate future ophthalmic workforce planning.

Ophthalmologists can have a huge impact on a patient's quality of life. Community-based ophthalmology education lies where specific care needs and priorities truly begin to be addressed.

Planning to meet the future eye care needs of a growing and aging population requires an understanding of the future possible trends in ophthalmic care and to project future ophthalmic education directions.

Further studies should consider the long-term effects of increasing sub-specialization in ophthalmology and the work patterns of women and men ophthalmologists.

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## Conflicts of Interest

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