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ORIGINAL ARTICLE

Will treating progressive myopia overwhelm the eye care workforce? A workforce modelling study

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Abstract

Purpose: Treatments for myopia progression are now available, but implementing these into clinical practice will place a burden on the eye care workforce. This study estimated the full-time equivalent (FTE) workforce required to implement myopia control treatments in the UK and Ireland.

Methods: To estimate the number of 6- to 21-year-olds with myopia, two models utilising separate data sources were developed. The examination-based model used: (1) the number of primary care eye examinations conducted annually and (2) the proportion of these that are for myopic young people. The prevalence-based model used epidemiological data on the age-specific prevalence of myopia. The proportion of myopic young people progressing ≥0.25 dioptres (D)/year or ≥0.50 D/year was obtained from Irish electronic health records and the recommended review schedule from clinical management guidelines.

Results: Using the examination and prevalence models, respectively, the estimated number of young people with myopia was 2,469,943 and 2,235,713. The extra workforce required to provide comprehensive myopia management for this target population was estimated at 226–317 FTE at the 0.50 D/year threshold and 433–630 FTE at the 0.25 D/year threshold. Extra visits required for myopia control treatment represented approximately 2.6% of current primary eye care examinations versus 13.6% of hospital examinations.

Conclusions: Implementing new myopia control treatments in primary care settings over the medium-term is unlikely to overwhelm the eye care workforce completely. Further increases to workforce, upskilling of current workforce and tools to reduce chair time will help to ensure sustainability of the eye care workforce into the future.

KEYWORDS
Ireland, myopia, treatment, UK, workforce

INTRODUCTION

Myopia typically develops during childhood and is regularly encountered within eye care clinics. The prevalence of myopia varies substantially depending on age, geography and ethnicity and has been estimated to affect between approximately 7% to 35% of 10-year-old and 13% to 70% of 15-year-old children.[1] The prevalence of myopia is also increasing in many parts of the world making it a major public health issue.[2]

Myopia, particularly high myopia, is associated with greater risk of irreversible vision loss[3] due to associated eye conditions such as retinal detachment, glaucoma and myopic macular degeneration.[4] A recent Global Burden of Disease Study estimated that in China (data were sparse elsewhere), myopic macular degeneration causes more moderate to severe visual impairment than diabetic retinopathy, age-related macular degeneration (AMD) and glaucoma, and causes more blindness than diabetic retinopathy, but is similar to AMD.[5] Myopia is, therefore, already becoming a leading cause of vision loss in some parts of the world. Other nations are likely to see similar trends of increasing myopia-associated vision loss as more myopic, younger generations age and their risk of myopic macular degeneration and vision impairment increases;[3] the costs of which are likely to be substantial, both in human and in economic terms.[6]

There have been recent advancements in treatments to reduce the progression of myopia in children.[7] These treatments ultimately aim to lower a child's final myopic refractive error (i.e., in adulthood) and, consequently, reduce their risk of irreversible vision loss in later life.[8] Treatments shown to have good efficacy in preventing progression of myopia or axial elongation of the eye (a marker of myopia progression) include low-dose (0.01%–0.10%) atropine eye drops[9–11] and various optical treatments that impose myopic defocus on the peripheral retina, such as orthokeratology contact lenses[12] and certain, specially designed, soft contact lenses[13–15] and spectacles.[16] Results from randomised controlled trials investigating the efficacy of low-dose atropine in European populations are yet to emerge,[17–19] but orthokeratology, contact lenses and spectacles are currently approved for the treatment of myopia in Europe.

Over the coming years, the standard of care for optometrists and ophthalmologists is likely to change such that all children with progressing myopia should be offered myopia control treatment. For instance, in a recent World Council of Optometry resolution, evidence-based interventions to slow the progression of myopia were incorporated into the definition of standard of care myopia management.[20] This will require more and longer clinical visits.[21] The relatively high prevalence of myopia, compared to other conditions, means that even a small increase in required clinic visits to manage myopia could add a large burden to the eye healthcare system. This study aimed to estimate the optometry and ophthalmology workforce required to implement treatments for all young people with progressive myopia in the UK and Ireland and compare it to the estimated current workforce. Importantly, we aimed to assess the need for myopia control treatment, as opposed to uptake, to maximise access to myopia control treatments and minimise future vision loss. The results of our study will inform evidence-based workforce planning and policy development in the optometry and ophthalmology sectors to ensure that service capacity meets the evolving population health needs specific to myopia management.

Key points

- Recent advances in myopia control treatments will ultimately prevent vision loss, but implementing these will place an added burden on the eye care workforce.
- The primary/community eye care sector will be best-placed to expand capacity to address the extra visits required to implement myopia control treatments.
- With appropriate management of existing and emerging eye care workforce supply, the introduction of myopia control services is unlikely to overwhelm eye care services in the UK and Ireland.

METHODS

Estimating population with myopia

Two models for estimating the young myopic population were developed: first, an examination model that was based on: (1) the current number of primary care eye examinations performed annually in the UK and Ireland and (2) the proportion of these examinations that are for young myopic individuals; and second, a prevalence model that was based on the estimated age-specific prevalence of myopia. Models were developed for ages 6–21 years as this group is most likely to have progressive myopia and require myopia control treatment.[22] All population estimates for the Republic of Ireland (ROI),[23] Scotland[24] and the UK[25] overall were obtained from government statistics agencies.

Examination model

Complete data on primary care eye examinations conducted in the UK and Ireland are not available. To estimate the rate of primary care eye examinations per 100,000 population, we used Scotland National Health Service (NHS) data. Most eye examinations in Scotland, with some exceptions, are free-of-charge for all UK citizens.[26] Consequently, data on NHS-funded examinations likely represent close to 100% of primary care eye examinations in Scotland. An added benefit is that the recorded number of eye examinations is likely to be closer to the actual eye care need for that population. In contrast, using data from another nation, where cost is a barrier to accessing eye care, would underestimate eye care need. Data on community-based eye examinations by both optometrists and ophthalmic medical practitioners were extracted for the period 01 April 2018 to 31 March 2019,[27] to avoid any impact of the COVID-19 pandemic. The eye examination rate in Scotland was used to estimate the annual number of primary care eye examinations in the UK and Ireland. To investigate the feasibility of treating myopia within hospitals, the number of eye examinations conducted in Scotland hospital outpatient departments over the same period was extracted separately.[28]

The proportion of primary care eye examinations that are for young myopic people was estimated using electronic health record (EHR) data collected from 30 optometry practices in the ROI (>700,000 patient visits). Applying this proportion to the number of eye examinations estimates the annual number of examinations conducted for myopic young people. The Ireland Eye Study (IES)[29] found that approximately 5%–8% of children with refractive error had uncorrected or under-corrected refractive error. Therefore, we conservatively added 5% to the estimated number of eye examinations to account for unmet need. It was assumed that myopia control treatments were not being prescribed in 2018–2019 and that myopic young people not receiving myopia control treatment are seen once a year.[30]

Prevalence model

The number of young people with myopia in the UK and Ireland was calculated by multiplying, for each year of age, the estimated prevalence of myopia by the population. Data on the prevalence of myopia were derived from the IES[29] and the Northern Ireland Childhood Errors of Refraction (NICER) study.[31] IES data were used in preference to those from NICER because it was more recent (2016–2018 vs. 2006–2008) and reported on a mix of ethnicities.[29] The IES found the prevalence of myopia in 6–7 (mean 6.7 years, rounded to 7) and 12- to 13-year-olds (mean 12.8 years, rounded to 13) was 3.3% and 19.9%, respectively. We assumed the incidence of myopia was constant from 6–13 years (incidence = 2.8%/year). Between ages 13 and 19 years, we used the annual myopia incidence reported in NICER (0.7%/year).[32] There were no myopia prevalence data for 19–21 years of age. We assumed a fourfold reduction in myopia incidence at ages 19–21 years, in line with the change in incidence from age 6–12 years to 13–19 years (incidence = 0.2%/year). Figure 1 shows the estimated age-specific prevalence of myopia.

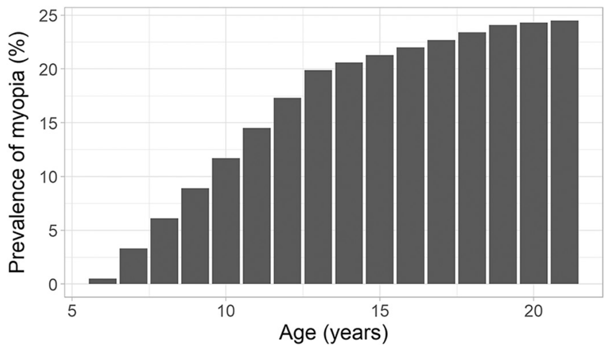

FIGURE 1 The estimated age-specific prevalence of myopia in Ireland and the UK based on the prevalence model. Estimates of the prevalence and incidence of myopia are extrapolated from the Ireland Eye Study and the Northern Ireland Childhood Errors of Refraction Study.

Progression of myopia

Irish EHR data, which contained data on subjective refraction at each visit, were utilised to calculate the prevalence of progressing myopia. Annual change in spherical equivalent (dioptres [D]/year) was calculated for right and left eyes of young people with myopia and the proportion who were progressing either ≥0.25 or ≥0.50 D/year in either eye was determined. This was calculated for each year of age for the prevalence model and using all ages combined for the examination model, as the latter did not use age-specific data. While a 0.25 D change in refraction could fall within measurement error for subjective refraction, we chose this cut-off because optometrists and ophthalmologists are likely to measure a 0.25 D change in refractive error (whether real or not) and make treatment decisions based on this change alongside other clinical information.

Treatments for myopia progression

Having estimated the population who may benefit from myopia treatment, we examined separately the required workforce to provide: (1) low-dose atropine eye drops, (2) orthokeratology, (3) soft contact lenses (SCL) for myopia control and (4) spectacles for myopia control, and compared this to the workforce needed to provide refractive correction alone (no myopia control treatment). The annual review schedule for each intervention type was extracted from clinical management guidelines and summarised in Table 1.[34]

The mean number of visits for each intervention was calculated by weighting the recommended number of visits in the first or subsequent year of treatment by the proportion of myopic patients in that year of treatment. For the examination model, the frequential probability that a person is in their first year of treatment (11.76%) was calculated by dividing 16 by 16-factorial (16 years of age between 6 and 21, inclusive). For the prevalence model, we calculated the proportion of all young people with myopia

TABLE 1 Estimated number of visits per person required in a given year for various treatments of myopia, including no treatment

	Number of visits[a] in 1st year of treatment	Number of visits[a] after 1st year	Mean number of visits[a] (examination model)	Mean number of visits[a] (prevalence model)
No treatment	1	1	1	1
Atropine	5	2	2.35	2.29
Orthokeratology	6	2	2.47	2.39
Soft contact lenses	4	2	2.23	2.19
Spectacles	3	2	2.12	2.10

Note: Data on number of visits derived from International Myopia Institute Clinical Management Guidelines.

[a]All visit numbers are per person per year.

who had incident myopia in the last year (9.63%) and assumed this proportion of patients were in their first year of treatment. We further assumed that patients remain on treatment until 21 years of age or until myopia progression ceases, the latter being based on the estimated proportion of the myopic population that is progressing.

Short-term impacts of initiating myopia treatment

These visit estimates are conservative because they overlook that most progressing myopia is not currently being treated. As more myopia control treatments are prescribed, a greater number of people will be in their first year of treatment. Therefore, we also modelled the impact on the workforce of rolling out myopia treatment in all young people over the following short-term periods: 1 year (assumed 95% are treated first year and 5% are treated the following year); 2 years (50% per year); 3 years (33% per year) and 4 years (25% per year). After the initial short-term spike in workforce required for myopia control treatment initiation, the workforce burden will be expected to decrease and plateau to a constant level, assuming practice guidelines, treatments and resources remain stable, before gradually increasing as population and myopia prevalence increases.

Required workforce and current workforce capacity

Based on a recent optometric workforce survey,[33] we assumed that a full-time equivalent (FTE) eye care clinician (optometrist or ophthalmologist) examines 60 patients per week and takes 5 weeks of annual leave (minimum entitled annual leave is 4 weeks in the UK and Ireland). The numbers of optometrists and ophthalmologists registered in the UK and Ireland between 2015–2020 were obtained from professional registration councils (CORU, Medical Council of Ireland, General Optical Council, General Medical Council) through annual reports or freedom of information requests. We only considered paediatric ophthalmologists as part of the workforce involved in implementing myopia control treatments and estimated their number from self-reported data obtained from the Irish College of Ophthalmologists and Royal College of Ophthalmologists. The 2015 UK Optical Workforce Survey[34] estimated mean FTE per registered optometrist to be 0.883 and this was applied to calculate FTE workforce capacity.

Effect of increasing myopia prevalence

The prevalence of myopia is predicted to increase in Europe at approximately 6%–8% per decade in all ages.[2,35] We estimated the impact of this on workforce by modelling the expected change in myopia prevalence using highly-cited methods.[2] As the estimated prevalence of myopia in the UK and Ireland was less than 28.3%, a constant increase in myopia prevalence of 3.8% per year was applied. The yearly increase in myopia prevalence is expected to be lower among children of younger ages and a weighting of 0.25 and 0.5 was applied to the yearly change for 5- to 9- and 10- to 19-year-olds, respectively.

Role of the funding source

No funding was obtained for this study and, therefore, no funders had input into the study design, analysis or interpretation.

RESULTS

Estimating population with myopia

The outcomes of both the examination and prevalence models for estimating the number of myopic young people in the UK and Ireland are shown in Figure 2. The estimated number of myopic young people was similar between the models at approximately 2.2 to 2.4 million.

Treatments for myopia progression

The estimated mean number of visits for each intervention type is shown in Table 1. Despite the large variation in

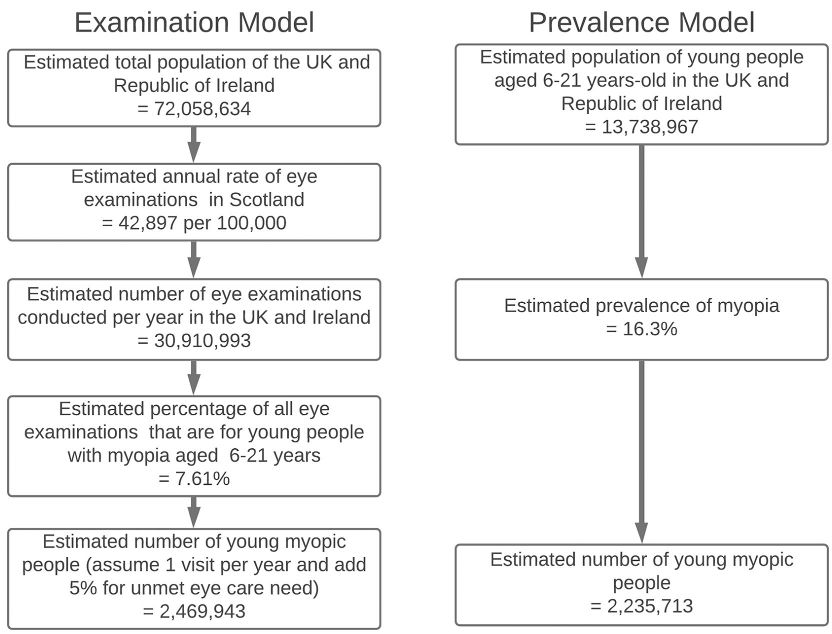

FIGURE 2 Flowchart showing the process for estimating the number of myopic young people aged 6–21 years using either the examination model or the prevalence model. For the examination model, eye examinations refer to primary or community care eye examinations only. For the prevalence model, calculations were done separately for each year of age and data shown is the sum total.

the number of first-year visits between treatment options, there was little overall difference in the mean number of visits, reflecting that relatively few patients (~10%) are in their first year of treatment in a given year. Mean visits were slightly lower for the prevalence model because this model accounts for myopia incidence being higher at younger ages and therefore, relatively few patients are in their first year of treatment.

Progression of myopia

For all myopic 6- to 21-year-olds combined, mean spherical equivalent was −2.02 D (SD: 1.64) and the proportion with myopia progression of at least 0.25 D/year and 0.50 D/year in either eye was 48.9% and 24.6%, respectively. Table 2 shows the estimated number of 6- to 21-year-olds with myopia and, of those, the number progressing and the estimated FTE workforce required to implement each myopia control intervention. Changing treatment type made little impact on the estimated required FTE workforce. However, compared to 0.50 D/year, defining myopia progression requiring treatment as a progression of ≥0.25 D/year approximately doubled the estimated extra required workforce.

Short-term impacts of initiating myopia treatment

The data presented up to now do not consider that most young people are not currently receiving myopia control treatment. Thus, relatively more people will be in their first year of treatment in the coming years. The effect of this on the mean number of visits is shown in Table 3, and the subsequent impact on the required workforce at the ≤−0.50 D/year threshold is shown in Figure 3. In the most extreme scenario, initiating myopia control treatment in 95% of young people in a single year increased the required workforce from around 220–240 FTE to 400–420 FTE for spectacles, and from approximately 280–320 FTE to 990–1030 FTE for orthokeratology.

Required workforce and current workforce capacity

On an ongoing basis, treating all progressing myopia at the 0.50 D/year threshold was estimated to result in approximately an extra 800,000 visits per year (mean of prevalence and examination models: atropine 822,055; orthokeratology 893,538; soft contact lenses 750,572; spectacles 679,089). This equates to a 2.6% (range: 2.2% to 2.9%) increase in the number of total primary care eye examinations. Based on Scotland NHS hospital data,[28] the estimated total number of hospital outpatient visits in the UK and Ireland in 2020 was 5,881,880. Therefore, treating myopia within the hospital system would approximately represent a 13.6% (range: 11.5% to 15.2%) increase in outpatient visits.

In the year 2020, there were 2962 ophthalmologists (2675 [90%] in the UK) and 17,565 optometrists (16,670 [95%] in the UK) registered to practice in the UK and Ireland. Of ophthalmologists registered with the Irish

TABLE 2 Estimated workforce requirements for the treatment of myopia using either the examination or prevalence model and defining progression as either ≤−0.25 D/year or ≤−0.50 D/year

	Progressing ≤−0.25 D	
	Examination model	**Prevalence model**
Estimated number of myopic 6- to 21-year-olds	2,469,943	2,235,713
Estimated number with progressing myopia	1,207,802	1,115,506
Estimated FTE workforce required for no myopia control treatment	876	793
Additional FTE workforce[a] required for:		
Treatment with atropine	+579	+510
Treatment with orthokeratology	+630	+548
Treatment with soft contact lens	+529	+472
Treatment with spectacles	+479	+433
	Progressing ≤−0.50 D	
	Examination model	**Prevalence model**
Estimated number of myopic 6- to 21-year-olds	2,469,943	2,235,713
Estimated number with progressing myopia	607,606	582,821
Estimated FTE workforce required for no myopia control treatment	876	793
Additional FTE workforce[a] required for:		
Treatment with atropine	+291	+266
Treatment with orthokeratology	+317	+286
Treatment with soft contact lens	+266	+246
Treatment with spectacles	+241	+226

[a]Number of extra full-time equivalent (FTE) optometric/ophthalmic workforce required to implement treatment, supplementary to the workforce required without myopia control treatment for myopia progression, that is, annual review for change in spectacle or contact lens prescription.

TABLE 3 Mean visits per intervention type by proportion of young myopic people in their first year of treatment

Percent in first year of treatment	Mean visits—Atropine	Mean visits—Orthokeratology	Mean visits—Soft contact lenses	Mean visits—Spectacles
25%	2.75	3	2.5	2.25
33%	2.99	3.32	2.66	2.33
50%	3.5	4	3	2.5
95%	4.85	5.8	3.9	2.95

Note: Treatment percent is the percentage of all progressing myopic 6- to 21-year-olds requiring treatment who are in their first year of treatment in a given year. For example, 95% indicates that, of all myopic 6- to 21-year-olds being treated for myopia progression, 95% are in their first year of treatment. Mean visits are the same for both the prevalence and examination models.

College of Ophthalmologists and the Royal College of Ophthalmologists, 21% (33/156) and 8% (156/2146) self-reported a paediatric subspecialty interest, resulting in an estimated 60 and 214 paediatric ophthalmologists in the ROI and the UK, respectively. The ROI likely has a higher proportion because some ophthalmologists (approximately 10%) are community-based and regularly see paediatric patients. Assuming an average FTE of 0.883 per registration, this equates to a total FTE workforce of 15,752 in the UK and Ireland, combined. The extra workforce required to implement myopia treatments represents a relative increase to the existing combined optometry and paediatric ophthalmology workforce of approximately 1.4% to 2.0% and 2.8% to 4.0%, depending on the intervention, at the 0.50 and 0.25 D/year thresholds, respectively.

Current workforce trends

Data on the change in the number of FTE optometrists and ophthalmologists per 100,000 population in the UK and Ireland are presented, separately, in Figure 4. Between 2015 and 2020, the overall mean relative increase in FTE optometrists and ophthalmologists was 2.4% and 3.2%, respectively, but was greater in the UK (2.4%–3.5%), compared with the ROI (0.8%–1.4%).

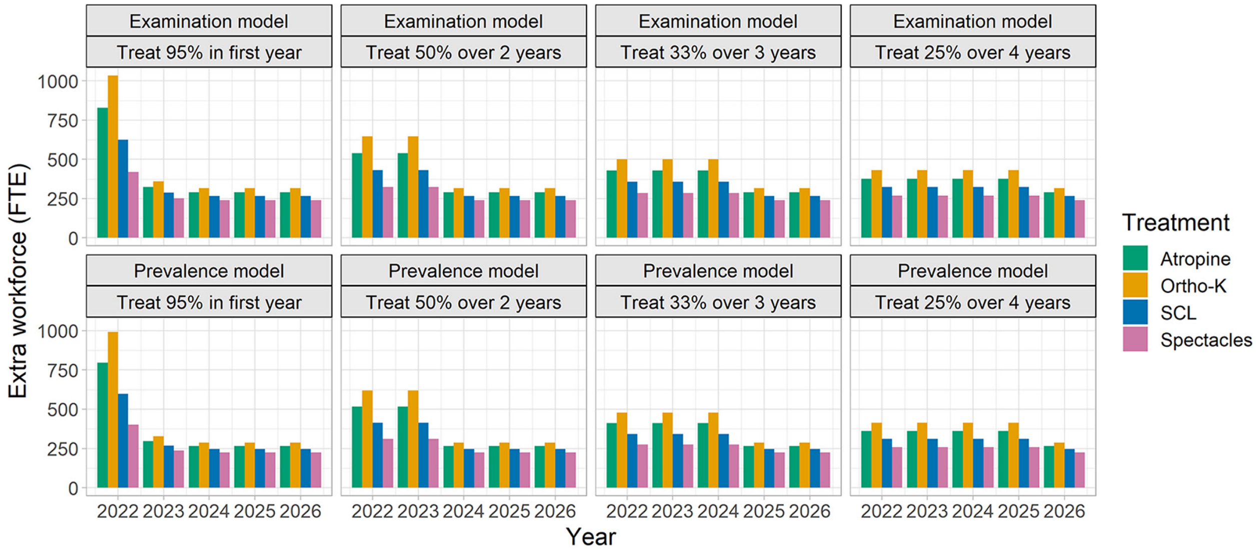

FIGURE 3 Extra full-time equivalent (FTE) workforce (beyond FTE workforce required for no active treatment) required to initiate myopia treatment in 95%, 50%, 33% and 25% of myopic people aged 6–21 years (progressing at ≤−0.50 D/year threshold) over a period of 1, 2, 3 and 4 years, respectively. Data are shown for prevalence and examination models separately. Ortho-K, Orthokeratology; SCL, Soft contact lenses.

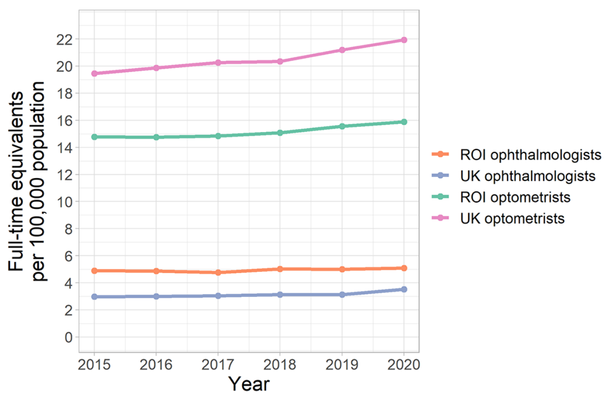

FIGURE 4 Temporal changes in the estimated full-time equivalent (FTE) number of optometrists and ophthalmologists in the UK and Republic of Ireland (ROI), separately. Data are derived from the number of registrations with the relevant national regulatory council multiplied by an assumed average 0.883 FTE per registration. In the ROI, mean annual relative increase in FTE workforce per 100,000 population between 2015 and 2020 was 1.4% for optometrists and 0.8% for ophthalmologists and, in the UK, was 3.5% for optometrists and 2.4% for ophthalmologists.

Effect of increasing myopia prevalence

The prevalence of myopia is expected to increase and additional workforce will be required to manage the higher demand for myopia treatment. The estimated annual mean increase in the number of myopic 6- to 21-year-olds in the UK and Ireland is 1.9%. Figure 5 illustrates this increase and demonstrates that a modest increase in required FTE is seen: approximately an extra 50 (range 41–52) FTE in 10 years' time and an extra 100 (range 97 to 136) FTE in 20 years' time.

DISCUSSION

Treatments for myopia progression will allow clinicians to alter the course of myopia and, ultimately, prevent vision loss.[8] However, implementing such treatments could place a substantial burden on the eye care workforce. This situation is not unprecedented; for example, the emergence of anti-vascular endothelial growth factor therapy for neovascular age-related macular degeneration placed a large burden on tertiary eye care services.[36] We estimated that the extra workforce capacity required to treat progressing myopia is relatively small, approximately 250–550 FTE staff in the UK and Ireland, if the service is rolled out over 3 to 4 years. This represents an increase of around 1%–3% of the entire optometry and ophthalmology workforce. However, initial requirements will be higher as a larger proportion of myopic young people enter their first year of treatment. Implementing treatments over a 3-year period appeared to provide a good balance between managing workforce capacity and enabling timely access to treatment.

Intervention type only had a substantial impact on workforce requirement when initiating myopia treatments over the shorter-term. For example, if 95% of young progressing individuals with myopia were to start treatment next year, the required workforce tripled for treatment with orthokeratology, compared to the longer-term estimates in Table 2, and was more than twice that required to treat children with myopia control spectacles alone. However, the differences between treatments became minimal in the longer term. It is unlikely and unfeasible that myopia control treatments could be rolled out in a 1-year period and there will probably be a natural delay in the uptake of treatments. While we estimated that implementing myopia control treatments with spectacles required the smallest

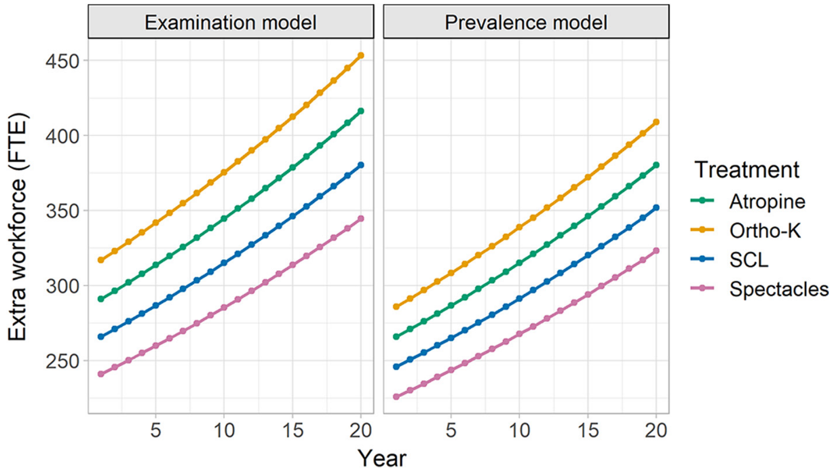

FIGURE 5 Estimated increases in extra full-time equivalent (FTE) workforce (beyond that required for no active treatment) for each treatment type over a 20-year period. Increases in FTE are related to a predicted increase in the prevalence of myopia in this age group of approximately 1.9%. Ortho-K, Orthokeratology; SCL, Soft contact lenses.

workforce increase, training and equipment requirements differ between interventions. We have not factored these expenses into this study as decisions on provision of an intervention are likely to be driven by financial, preference and efficacy considerations at the clinic- and patient-level.

The progression threshold for initiating myopia treatment was an important factor. Compared to a threshold of 0.50 D/year, treating myopia progression at 0.25 D/year approximately doubled the required extra FTE workforce. There is currently no consensus on a threshold at which to initiate myopia treatment,[21] and future recommendations on treatment thresholds may need to consider the impact of workforce capacity. As clinicians adapt to providing myopia control treatments, greater capacity to treat progressing myopia may become available or further evidence may arise to guide clinical decision-making through, for example, updates on clinical management guideline recommendations and review schedules or additional tools to reduce the length of visits.

A full assessment of current workforce capacity in the optometry and ophthalmology sectors was beyond the scope of this study. We estimated the current FTE workforce based on professional registrations, but this does not provide information on whether 'spare' FTE capacity exists within the current eye care workforce, or whether additional optometrists and ophthalmologists need to be recruited or trained. It is also possible that the role or scope of practice of other existing staff and professionals within the eye care sector will expand to take on some of the burden of treating myopia; thus reducing demand on the optometry and ophthalmology sectors.

It is unlikely that myopia control treatments could occur entirely within hospitals (requires 14% increase in capacity), particularly given that visits would almost entirely occur within paediatric clinics, which are a small proportion of all hospital eye care services. Primary care optometrists and community-based ophthalmologists are therefore best placed to provide myopia treatments; however, other barriers, such as lack of appropriate training,[37] will need to be addressed. Differences in prescribing rights for optometrists also exist; for instance, UK optometrists can prescribe atropine eye drops, but ROI optometrists cannot. Hence, uptake of low-dose atropine treatment in the ROI would be limited by community-based ophthalmology capacity. Reassuringly, there has been a 2%–3% annual increase in the number of FTE optometrists and ophthalmologists per 100,000 population in the UK and Ireland over the last 5 years. While this approximately matches the FTE workforce required for myopia treatments, other demands on the eye care workforce that come from ageing populations and provision of other treatments cannot be neglected. Therefore, it is likely that strategies to reduce workforce requirement, such as through more efficient provision of services, will be needed to meet ongoing demand for myopia treatments. The cost of treatment to the patient is another factor that will affect uptake of myopia control treatments and, consequently, workforce demand. Our estimates represent a scenario where cost is not a barrier to uptake, but, if treatments are not subsidised and costs remain steady, uptake and workforce demand is likely to be lower.

The workforce estimates in the present study are likely to be conservative and there are additional factors we did not incorporate. The models assumed that all people whose myopia naturally ceases to progress will stop treatment. However, clinicians are likely to attribute any natural reduction in myopia progression to a treatment effect and thus continue treatment, resulting in more prolonged treatment durations. We limited the population to ages 6–21 years; some adults aged 22 years or older may also require treatment, but myopia progression at this age is generally low.[38] Additional factors may partially balance these conservative assumptions. We assumed myopia control treatments were not being utilised in the years 2019–2020, whereas it is likely that soft contact lenses and orthokeratology lenses were being prescribed, albeit for a minority of children. Thus, the extra FTE workforce required could be lower than that estimated. In practice, clinicians measuring a 0.25 D change in refraction without accompanying visual acuity changes may not view this as evidence of myopia progression (due to measurement error) and hence not initiate myopia control treatment. Relative to the 0.50 D/year threshold, the increase in FTE workforce associated with treating myopia at the 0.25 D/year threshold may therefore actually be lower than estimated in this study, but will be higher than estimated at the 0.50 D/year threshold. Adverse events associated with myopia control treament[10,15,39] are likely to require extra visits beyond that estimated in this study. We additionally did not consider differences in 'chair time' for the different myopia interventions. Currently, the International Myopia Institute (IMI) clinical guidelines recommend that all assessments be repeated at every visit, but, in practice, visit lengths are likely to be quicker for interim than baseline or annual reviews. Without evidence to guide our assessment, we opted to focus on the number of visits for our calculations, rather than visit length. Estimated required workforce will additionally vary depending on national myopia prevalence, and may be much lower or higher in countries with a low or high prevalence of myopia, respectively. Finally, we did not investigate the costs associated with myopia control treatments, both in terms of the treatments themselves, as well as in terms of additional training, resources or equipment. These costs may present an additional barrier to patients accessing, or practitioners providing, myopia control treatments.

There are some limitations to this study. First, we assumed it was valid to combine workforces from the ROI and the UK. Differences in their respective healthcare systems exist, such as relatively more community-based ophthalmologists in the ROI, but these differences are not major. There are substantial cultural and demographic similarities between the UK and ROI as well as similarities in the healthcare system plus cross-over and movement of workforce between the UK and the ROI. A key assumption for both the examination and prevalence models is that data from each of the ROI, Northern Ireland and Scotland are representative of the wider UK and Irish population. For example, we assumed that eye care need in Scotland, as estimated from eye examination data, is consistent with that in the UK and Ireland. Using Scottish data may represent a 'best-case' scenario where cost is not a barrier to accessing eye care; however, alternative barriers to health care, such as lack of access or trust in healthcare systems or ethnic differences in healthcare utilisation could all contribute to underestimation of true eye care need. To conservatively account for under-utilisation, we added 5% to all eye examinations. Population ethnicity differences may also impact estimated myopia prevalence.[1] The most recent census data on population ethnicity in the UK are from 2011, in which 85%, 96%, 96% and 98% identified as being of white ethnicity in England, Wales, Scotland and Northern Ireland, respectively, and 94% of the ROI population reported being of white ethnicity in the same year. The proportion of white children in the IES was slightly lower than the entire 2011 population, likely because it was conducted more recently and in Dublin, and is approximately comparable with the total 2011 UK population (89% vs. 87%).[29,40] White children tend to have less myopia compared to non-white children,[29,41] and thus, the true myopia prevalence may be underestimated in this study. The IES was also conducted in urban areas, where myopia prevalence is generally higher,[42] and this may have led to an overestimation of the prevalence of myopia. Irish EHR data were largely from non-cycloplegic examinations, and the prevalence and progression of myopia in this data set may therefore have been overestimated. Whether Irish EHR data are representative of UK EHR data is unclear. The only approximately comparable UK EHR data set was an abstract[43] that reported mean spherical equivalent in 5- to 15-year-olds in 2002–2004 to be −1.58 D; this is somewhat comparable to the −2.02 D value noted in this study, given the UK data are from nearly two decades earlier. It is generally unclear whether the combined effect of errors in these assumptions would result in an over- or underestimation of myopia prevalence. More comprehensive data are unlikely to become available in the near future and conducting a large study to address gaps in the data used to guide our assumptions is unlikely to be cost-effective. Additionally, the use of EHR data reflects real-world clinician measurements upon which treatment decisions are based. The estimates obtained independently from the examination and prevalence models were relatively similar, differing by only approximately 10%. Given these models used different data sources and assumptions, this is somewhat reassuring that any errors in the assumptions did not have a particularly large impact.

In summary, an increase in the eye care workforce of approximately 250–300 and 450–600 FTE is required for the ongoing provision of myopia treatment at thresholds of 0.50 D and 0.25 D/year, respectively, and this will be higher in the short-term. This represents a relatively small increase in the current FTE workforce. However, to avoid overwhelming eye care service capacity, it will be necessary to maintain or increase growth of the eye care workforce, provide additional training for the current workforce, manage the speed at which myopia control treatments are implemented into practice and generate further evidence and tools to optimise clinical review schedules and reduce visit length. Arresting current upward trends in the prevalence of myopia will also be crucial in easing pressure on service capacity. Appropriate workforce training and planning will ensure young people can access treatments for myopia progression, ultimately preventing vision loss in later life.

AUTHOR CONTRIBUTIONS

Gareth Lingham: Data curation (lead); formal analysis (lead); investigation (lead); methodology (equal); visualization (lead); writing – original draft (lead); writing – review and editing (equal). **James Loughman:** Conceptualization (lead); methodology (equal); supervision (equal); writing

– review and editing (equal). **Stella Kuzmenko:** Data curation (supporting); investigation (supporting); writing – review and editing (equal). **Matilda Biba:** Data curation (supporting); investigation (supporting); writing – review and editing (equal). **Daniel Ian Flitcroft:** Conceptualization (equal); methodology (equal); supervision (equal); writing – review and editing (equal).

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CONFLICT OF INTEREST

JL has received research grant funding support from Health Research Board (Ireland), Nevakar, and CooperVision; has consultancy relationships with Dopavision, Kubota Vision, Ocuco and Ebiga Vision; has received honoraria from Thea Pharmaceuticals and Ocuco for lectures; has received equipment on loan from Topcon and CooperVision; has two patents pending (one in myopia management data analytics and one in biomonitoring for low-dose atropine treatment in myopia); and is Director of Ocumetra, all in the field of myopia management. DIF has received research grant funding support from Health Research Board (Ireland), Nevakar and CooperVision; has consultancy or other relationships with Dopavision, Kubota Vision, Essilor, Johnson & Johnson, Thea Pharmaceuticals and Vivior; has received equipment on loan from Topcon and CooperVision; has two patents pending (one in myopia management data analytics and one in biomonitoring for low-dose atropine treatment in myopia); and is Director of Ocumetra, all in the field of myopia management.

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