

Laser refractive surgery in the UK Biobank study: Frequency, distribution by socio-demographic factors and general health, happiness and social participation outcomes.

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Funding

This work was funded by the National Eye Research Centre, UK (grant code SCIAD 066).

Phillippa Cumberland is funded by the Ulverscroft Foundation and Jugnoo Rahi receives part funding from the NIHR Biomedical Research Centre at Moorfields Eye Hospital NHS Foundation

Trust and UCL Institute of Ophthalmology. The study was undertaken at UCL Institute of Child Health which receives a proportion of its funding from the Department of Health's NIHR Biomedical Research Centres funding scheme.

Acknowledgement

This research has been conducted using the UK Biobank Resource.

Abstract

Purpose

To investigate the frequency and distribution of laser refractive surgery in the UK, by socio-demographic factors and outcomes of social participation and well-being.

Setting

Six regional recruitment centres in England and Wales

Design

Cross-sectional epidemiological study

Methods

Between 2009 and 2010, 117,281 subjects recruited by UK Biobank undertook an ophthalmic assessment, including autorefractometry. Data were collected on socio-demographic factors and medical history; self-report on eyes/vision included reason for wearing optical correction, eye diseases and treatment received (including refractive laser surgery). Mean spherical equivalent was used to categorise individuals as myopic (<-1.0 diopter) or hypermetropic ($>+1.0$ diopter).

Results

Of those with refractive error within a range eligible for laser refractive surgery ($n=60,352$), 1,892 (3.1%) reported having bilateral refractive surgery and 549 (0.9%) unilateral surgery. Frequency of bilateral surgery decreased with increasing age and was higher in females. Frequency did not vary with educational attainment or accommodation status but increased with income among working age adults. Social participation e.g. regular visits to a pub or social club, was more common among those who underwent surgery. Other eye conditions were reported by 28% of those reporting refractive surgery compared to 11% of those eligible for treatment but not reporting surgery.

Conclusions

This study provides information, not available routinely, on the frequency and distribution of laser refractive surgery in an adult UK population. A high frequency of ocular conditions conventionally considered contra-indications to laser refractive surgery raises the possibility that extant guidance on patient selection may not be being followed.

Introduction

Refractive error is an important public health issue: it affects at least 30% of the adult population in industrialised countries^{1, 2} and is a leading cause of visual impairment and blindness in the world^{3, 4}. There has been significant progress in developing surgical interventions for refractive error since the late 1970s⁵⁻⁸.

In the UK, only 5% of laser refractive surgery services are hosted within the publicly funded, (i.e. free at the point of use) National Health Service⁹. The lowest cost of LASIK treatment for one eye has remained static at £395 since 2001 although the average cost is nearer £1,000 and charges are reported to vary considerably by provider⁹. The cost and the elective nature of refractive surgery may influence which individuals undergo it but, regardless, it is essential to the success of the procedure that it is being offered to appropriate individuals. Guidance on patient selection have been issued by the National Institute for Health and Care Excellence (NICE)⁵ and includes the need for a stable prescription for the preceding 2-3 years, otherwise healthy eyes, having reasonable expectations of the surgery and absence of some specific conditions e.g. diabetes. The Royal College of Ophthalmologists has issued patient guidance¹⁰ and professional standards¹⁰ and has initiated a certificate of competence to practice for surgeons who successfully complete appropriate training. Recent surveys indicate an increase in both the number of clinics offering refractive laser surgery in the UK and the techniques available^{9, 11}. However, there is a paucity of data on the number of procedures performed and outcomes in the UK, as these procedures are not subject to routine and publicly reported NHS mechanisms.

UK Biobank is a large prospective study within which 122,000 adults, aged 40 to 69 years, had an ophthalmic assessment, including autorefractometry and habitual distance visual acuity (<http://www.ukbiobank.ac.uk/>). In addition, diverse and detailed data were collected on socio-demographic factors and medical history, specifically, self-report on eyes/vision included reason for and age of wearing glasses/contact lenses, eye diseases and treatment received (including refractive laser surgery). This provides a unique opportunity to investigate the frequency of

refractive laser surgery in the UK and to compare the socio-demographic profile of those electing and not electing to have this treatment, as well as self-reported outcomes related to their social activities and well-being.

Material and Methods

Study population

Between 2009 and 2010, 117,281 subjects were invited to have autorefraction as part of an ophthalmic assessment at one of 6 recruitment centres, 5 in England and 1 in Wales. Non-cycloplegic autorefraction was carried out using the Tomey RC 5000 auto refkeratometer (Tomey Corp., Nagoya, Japan). The right eye was tested first, up to 10 refractive error measurements for each eye were taken and the most representative result automatically recorded. A reliability score, 0 to 9 (smaller scores indicating more reliable measurements), was recorded for each measurement with a score of 4 or more defining an unreliable measurement. Those who reported having any eye surgery in the preceding 4 weeks or a current eye infection were not eligible for the ophthalmic assessment. Additionally, participants reported on their life-style, environment and medical history via touchscreen and face-to-face interviews ¹².

Classification of refractive error, report of laser refractive surgery and other outcomes

Mean spherical equivalent (SpE) (algebraic sum in diopters (D), sphere+0.5cylinder), was used, as a summary measure, to categorise individuals, both those who had refractive surgery in *both* eyes and those who did not report any laser surgery: emmetropia (SpE -0.99 D to +0.99 D), mild primary myopia (SpE -1.0 D to -2.99 D), moderate primary myopia (SpE -3.0 D to -5.99 D), high primary myopia (SpE -6.0 D or more extreme), mild hypermetropia (SpE +1.0 D to +2.99 D) and moderate/high hypermetropia (SpE + 3.0 D or more extreme). Spherical equivalent in the treated eye is reported for those who had unilateral surgery. Subjects with highly discordant SpE values for the two eyes were excluded from this analysis. Discordance was defined as: one eye hypermetropic and the other eye myopic, or one eye high refractive error and the other eye

emmetropic or one eye highly myopic and the other eye mild myopic with an absolute difference of at least 10 D in SpE between the eyes.

Participants reported on demographic and socio-economic factors as well as history of any eye condition and treatment received, as shown in the Box.

Box 1: Demographic, socio-economic, clinical and other factors

Factors	Description and/or categorisation
Age	Age group: 40 – 49 years, 50 – 59 years, 60 – 69 years
Gender	Male or female
Ethnicity	White, mixed, Asian or Asian British, Black or Black British, Chinese or Other
Highest educational attainment	No qualifications, 'O' levels, 'A' levels or University/other professional qualification
Accommodation tenure	Council rental, private rental, home-ownership with a mortgage or outright ownership
Wearing glasses/contact lenses	Reason for and age at first time of wearing optical correction
Ever had eye surgery? If so, ever had refractive laser surgery?	Yes/No Both eyes, right or left eye

Common eye conditions and age of diagnosis	Has a doctor told you that you have any of the following problems with your eyes? e.g. diabetes-related eye disease, glaucoma, trauma, cataract, macular degeneration or other serious eye condition
Non-cancerous or cancerous illness	Eye and eyelid problems e.g. retinal detachment or eye and/or adnexal cancer including retinoblastoma
General health - rating	Excellent, good, fair, poor
Satisfaction	Extremely/very/moderately satisfied or dissatisfied
Happiness	Extremely/very/moderately happy or unhappy
Frequency of visits to/from family and friends	Almost daily, 2-4 times a week, once a week, once a month, once every few months, never/almost never
Attend weekly social activities	Sports/gym club, pub/social club, religious activity, adult education, other group activity

Statistical methods

Descriptive analysis was undertaken comparing those who had surgery with those who did not have surgery but would have been eligible for treatment, according to national guidelines^{5, 10}, i.e. those with refractive error (either myopia (≤ -1.0 D) or hypermetropia ($\geq +1.0$ D)).

Frequency of laser refractive surgery (unilateral and bilateral) and distribution of demographic and socio-economic factors as well as health, happiness and social participation outcomes, were investigated. The Chi-square test and two sample tests of proportion were used for between group

comparisons and the Kolmogorov-Smirnov test for equality of distribution functions. Logistic regression was used to evaluate the difference in the frequency of laser surgery of each category with respect to the lowest category (reference).

Results

Participation and study sample

Of 115,797 subjects eligible for an ophthalmic examination, 6481 (5.6%) were excluded. 1,864 of these subjects did not meet the protocol requirements e.g. unwilling to remove contact lenses, 731 were tested but no reading was obtained due to equipment failure and 3154 reported an eye condition, other than refractive laser surgery, known to affect refractive error status. In addition, 732 subjects who had highly discordant refraction measures for the two eyes were excluded. Thus data on 109,316 subjects was analysed; 106,875 (98%) without, and 2441 with report of laser refractive surgery.

Representativeness

The UK Biobank population is older and has fewer males than the UK Census 2011 data [<https://www.nomisweb.co.uk/census/2011>], however the distribution of ethnic variation is comparable. The study population, on average, is more affluent in terms of accommodation status and educational attainment than the UK population. Those excluded were more likely to be in the older age group compared to the youngest age group (Odds Ratio 1.5 [95% confidence interval 1.4, 1.6] and, independently, of Asian, Black or other ethnicity (OR 1.5 [1.4, 1.7], OR 1.3 [1.2, 1.5] or OR 1.4 [1.2, 1.7] respectively, compared to those of White ethnicity, as well as to live in council rental accommodation than renting privately or self-owned property.

Frequency and mean spherical equivalent by report of laser eye surgery

Of all subjects, 2,441 (2.2% of 109,316) self-reported having laser refractive surgery, 1,892 (77.5%) had surgery to both eyes and 549 (22.5%) in only one eye.

The distribution of refractive error differed between those reporting laser refractive surgery and those who were eligible but did not report surgery, as shown in Table 1. Figure 1 shows the distribution of mean spherical equivalent in those reporting bilateral refractive surgery to be less skewed (i.e. shifted towards myopic values) and more leptokurtotic ('peaked') than that of those not reporting surgery, the latter being consistent with the distribution of mean SpE found in similar adult populations¹³. In those who had bilateral surgery, the range of mean SpE was -25.04 D to 7.36 D, (mean -0.11 D), with 77.3% [95% CI 75.3-79.2] emmetropic, 13.6% [12.1-15.3] myopic and 9.1% [7.7-10.5] hypermetropic (Table 1). In comparison, in those who did not have surgery, the range of mean SpE was -24.1 D to 13.9 D, (mean 0.17 D) with 45.8% [45.5-46.1] emmetropic, 26.5% [26.2-26.7] myopic and 27.7% [27.5-28.0] hypermetropic. In those who had laser eye surgery in only one eye, manifest spherical equivalent in the operated eye ranged from -19.59 D to 9.19 D, (mean -0.4 D), with 47.9% [43.5-52.3] emmetropic, 34.8% [30.6-39.1] myopic and 17.4% [14.2-20.9] hypermetropic. A lower proportion of those reporting bilateral laser eye surgery reported wearing glasses or contact lenses compared to those reporting unilateral surgery or those who had refractive error with no report of surgery (56.3%, 75.6% and 88.9% respectively).

Frequency of laser surgery, overall and by age, by socio-demographic factors

Overall, of those with refractive error eligible for laser refractive surgery 3.1% [3.0-3.3] reported bilateral and 0.9% [0.8-1.0] unilateral treatment, 4.4% [4.1-4.6] in women and 3.7% [3.4-3.9] in men. There was a decreasing trend in frequency with age, from 8.6% [7.8 -9.5] in the younger age group (40-44 years) to 2.5% [2.3- 2.8] in the oldest age group (65-69 years) (Table 2).

Laser surgery was also more common amongst those in higher categories of accommodation tenure and with higher educational attainment. There was an increasing trend in frequency of surgery with increasing income in those of pre-retirement age (i.e. 40–60 years). Among the employed, frequency decreased with age, 7.7% [7.1-8.3] (40-49 years), 4.2% [3.9-4.5] (50-59 years) and 2.6 [2.3-3.0] (60-69 years).

Distribution of refractive surgery by socio-demographic factors

The distributions of age, gender, ethnicity and socio-economic factors differed between those who had bilateral surgery and those who had refractive error and would have been eligible for refractive surgery but did not report it (Table 3). There were no such differences observed when comparing with the unilateral surgery group.

A higher proportion of participants who had refractive surgery were female (60.4 % vs 55.9%), were younger (49% vs 26%, age 40-54 years), with higher income (34% vs 26% in the range > 52k) and of minority ethnicity (89.2% vs 91.6% White) (Table 3). There was some indication that those having surgery were less likely to be in the lowest or highest category of educational qualification or accommodation tenure.

Frequency of other self-reported ocular conditions

Of note, the frequency of other self-reported eye conditions was higher in the group reporting laser refractive surgery group (27.5%) than those with refractive error but no surgery (11.4%) and those without refractive error (8.1%), (Table 4). Specifically, cataract was reported by 8.9%, ocular trauma by 1.7%, retinal detachment by 2.1%, diabetic eye disease by 3.3% and glaucoma by 2.5% of those who reported having laser refractive surgery. As these were cross-sectional data it was not possible to determine whether these additional ocular disorders occurred before or after refractive surgery.

Distribution and frequency of general health and happiness, and social activity outcomes

There were no consistent differences found in report of general health, happiness or visits from/to friends, between the two groups, in either distribution or frequency of laser eye surgery (Tables 2 & 5). There were significant differences in the distribution of those reporting social and physical activities. Of those who reported attending a sports/gym club in the preceding month 39.1% reported treatment versus 28.9% who did not, of those going to a pub or social club 28.2% reported treatment versus 24.0% who did not, of those attending a religious group 10.7% reported

treatment versus 17.1% who did not and of those attending other group activities 19.3% reported treatment versus 23.2% who did not (Table 5). For all activities the frequency in both groups decreased with age (Table 2).

Discussion

Amongst a contemporary UK adult population aged 40 years and above, 4% of those with refractive error at the conventional threshold that is considered eligible for laser refractive surgery reported having undergone this treatment, 3.1% for bilateral and 0.9% for unilateral surgery. The frequency of bilateral laser eye surgery decreased with increasing age and those having surgery were consistently more likely to be female. There was no trend seen with increasing accommodation tenure or educational attainment, markers of social position, with indeed a lower frequency of surgery in the group with the highest educational attainment.

We found no difference in self-reported general health or happiness between the two groups however there was evidence that laser treatment was more frequent amongst those who participating more frequently in social activities and attending sports/gym clubs. This is consistent with findings in studies examining the reasons for seeking LASIK which generally report improving uncorrected vision, freedom from spectacles/contact lenses and participation in sport and leisure activities to rank highest^{14, 15}. Improved uncorrected vision is the expected clinical outcome of surgery but a proportion of those having surgery will require post-operative refractive correction and it is well recognised that it is important that patients have realistic expectations in relation to this^{5, 7, 10, 16}. We found 56.3% of those who had bilateral surgery were still wearing glasses or contact lenses post-operatively for refractive error, including 7.8% for presbyopia. This could be considered a useful benchmark for similar populations elsewhere.

As anticipated, in a setting where most laser refractive surgery is undertaken in the private sector, the frequency of laser surgery increased with income but no association was seen with the other markers of social position, indicating that the level of disposable income may have influenced the

decision to have surgery. UK Biobank is not a population survey so prevalence cannot be reported but the frequency estimate of those who have had laser eye surgery provides information which is not otherwise available routinely and indicates that laser refractive surgery has become relatively common, reported by 4% of those eligible in this population. In the UK, individuals undergoing laser eye surgery will have made a positive decision to seek and pay for this treatment thus the likelihood of recall bias in reporting surgery will be minimal. However, reliability of the self-report of laser surgery needs to be considered. Whilst we are not able to validate reports of surgery, the distribution of mean manifest spherical equivalent in those who report having bilateral laser surgery shows considerable shift towards the emmetropic range of spherical equivalent, as would be expected after refractive surgery. It may be that laser surgery has been under-reported but, by the same token, the mean spherical equivalent distribution in those who do not report surgery appears appropriate for this age group of population so if there is some under-report of surgery it seems unlikely to have influenced the observed results.

Data on the precise type and date of surgery and prior ophthalmic measures are not available in UK Biobank. This prevents analysis of the data to address clinical (versus epidemiological) questions about the 'success' of procedures in terms of post-operative refraction¹⁷.

We were not able to differentiate between prior and post-operative onset of concurrent ocular conditions. Nevertheless, there was a higher level of self-report of other ocular conditions among those with refractive error who had laser surgery than eligible subjects who did not report surgery. There are a number of potential explanations. For example, misreporting/misclassification of self-reported eye illness, a higher rate of post-operative conditions in those who had laser surgery or inappropriate selection for surgery of those with pre-existing eye illness. Whilst we were unable to explore this further with this dataset, the findings suggest there may be value in further more detailed investigation using clinical population samples, given the trend for increase in uptake of refractive surgery, particularly in the younger population.

Conclusion

This study has provided an estimate of frequency of laser refractive surgery in a contemporary adult UK population and some understanding of the characteristics of those electing to undergo this treatment, which is almost exclusively undertaken outside the National Health Service. The personal financial cost of surgery is reflected in the profile of those undergoing surgery. The social outcomes associated with surgery are consistent with previously reported reasons for seeking treatment. Whilst the cross-sectional nature of the study limits the analysis of the association with reported ocular comorbidity, the frequency of ocular conditions conventionally considered contra-indications to laser refractive surgery does raise the possibility that extant guidance on patient selection may not be being followed.

WHAT WAS KNOWN

- In the UK, there has been an increase in both the number of clinics offering laser refractive surgery and the techniques available. There is a paucity of publicly available data on the frequency of procedures performed and outcomes, as only 5% of these services are hosted within the National Health Service (NHS) and therefore subject to NHS audit.

WHAT THIS PAPER ADDS

- This study provided an estimate of frequency of laser refractive surgery in an adult UK population, information unavailable elsewhere, and some understanding of the characteristics of those electing to undergo this treatment.
- Whilst socio-demographic characteristics and social outcomes of those treated are consistent with other studies, the frequency of other ocular conditions was higher than in those with refractive error who did not report having undergone refractive surgery.

References

1. Rahi JS, Cumberland PM, Peckham CS. Myopia over the lifecourse: prevalence and early life influences in the 1958 British birth cohort. *Ophthalmology* 2011;118(5):797-804.
2. Kempen JH, Mitchell P., Lee K.E. et.al. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. *Arch Ophthalmol* 2004;122:495-505.
3. Bourne RR, Jonas JB, Flaxman SR, et al. Prevalence and causes of vision loss in high-income countries and in Eastern and Central Europe: 1990-2010. *Br J Ophthalmol* 2014;98(5):629-38.
4. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ* 2008;86(1):63-70.
5. National Institute for Health and Clinical Excellence: Photorefractive (laser) surgery for the correction of refractive errors. 2006.
6. Ang EK, Couper T, Dirani M, et al. Outcomes of laser refractive surgery for myopia. *J Cataract Refract Surg* 2009;35(5):921-33.
7. Sakimoto T, Rosenblatt MI, Azar DT. Laser eye surgery for refractive errors. *Lancet* 2006;367(9520):1432-47.
8. Gyldenkerne A, Ivarsen AR, Hjortdal JO. Factors affecting the decision for refractive surgery in patients with high degrees of ametropia. *J Cataract Refract Surg* 2014;40(8):1371-6.
9. Ewbank A. Ten years of trends in UK refractive surgery. *The Optician* 2010;26(11):10.
10. Royal College of Ophthalmologists. Standards for Laser Surgery April 2012.
11. Ewbank A. Trends in refractive surgery in the UK 2008. *The Optician* 2008.
12. Allen N, Sudlow C, Downey P, et al. UK Biobank: Current status and what it means for epidemiology. *Health Policy and Technology* 2012;1(3):123-6.
13. Wolfram C, Hohn R, Kottler U, et al. Prevalence of refractive errors in the European adult population: the Gutenberg Health Study (GHS). *Br J Ophthalmol* 2014;98(7):857-61.

14. McGhee CN, Craig JP, Sachdev N, et al. Functional, psychological, and satisfaction outcomes of laser in situ keratomileusis for high myopia. *J Cataract Refract Surg* 2000;26(4):497-509.
15. Khan-Lim D, Craig JP, McGhee CN. Defining the content of patient questionnaires: reasons for seeking laser in situ keratomileusis for myopia. *J Cataract Refract Surg* 2002;28(5):788-94.
16. Bastawrous A, Silvester A, Batterbury M. Laser refractive eye surgery. *BMJ* 2011;342:d2345.
17. Jaycock PD, O'Brart DP, Rajan MS, Marshall J. 5-year follow-up of LASIK for hyperopia. *Ophthalmology* 2005;112(2):191-9.

Table 1: Distribution of mean spherical equivalent, by report of laser refractive surgery

	Report of bilateral laser surgery					Eligible but no report of laser surgery				
	N ‡	%	95% CI*	median	IQR*	N	%	95% CI	median	IQR
Severe myopia	15	0.83†	[0.5-1.4]	-9.26	(-18.78 to -8.45)	4299	4.02	[3.9-4.1]	-7.53	(-9.03 to -6.63)
Moderate myopia	24	1.32†	[0.8-2.0]	-3.66	(-4.67 to -3.23)	10254	9.59	[9.4-9.8]	-4.14	(-4.91 to -3.53)
Mild myopia	208	11.47	[1.0-13.0]	-1.37	(-1.81 to -1.15)	13726	12.84	[12.6-13.0]	-1.82	(-2.35 to -1.37)
<i>All myopia</i>	247	13.62†	[12.1-15.3]	-1.48	(-2.39 to -1.18)	28279	26.46	[26.2-26.7]	-3.08	(-4.83 to -1.85)
Emmetropia	1402	77.29	[75.3-79.2]	-0.07	(-0.42 to 0.29)	§				
Mild hypermetropia	144	7.94†	[6.7-9.3]	1.39	(1.15 to 1.73)	23300	21.80	[21.6-22.0]	1.64	(1.28 to 2.12)
Moderate/severe hypermetropia	21	1.16†	[0.7-1.8]	4.53	(3.54 to 5.36)	6332	5.92	[5.8-6.1]	4.02	(3.41 to 5.13)
<i>All hypermetropia</i>	165	9.10†	[7.7- 10.5]	1.45	(1.17 to 2.00)	29632	27.73	[27.5-28.0]	1.88	(1.37 to 2.77)
Total	1814			-0.11	(-0.61 to 0.39)	57911			1.03	(-3.01 to 1.91)

‡ n=78 no autorefraction measure (n=52 participants - surgery in the 4 weeks prior to recruitment)

*95 % CI= 95% Confidence Interval; IQR= Interquartile Range;

§ excluding n=48964 emmetropes (ineligible for laser refractive surgery)

† p<0.001 by two sample tests of proportion; mild myopia p>0.05

Table 2: Frequency of refractive laser surgery overall and by age group, in all participants with refractive error eligible for surgery, by socio-demographic and social participation factors

	Total					Age										
						40-49			50-59			60-69				
	N	%	Proportion [95% CI]			N	proportion [95% CI]		N	proportion [95% CI]		N	proportion [95% CI]			
Overall	60352		4.05	[3.89, 4.21]		10420	7.60	[7.10, 8.12]		19011	4.15	[3.87, 4.44]		30916	2.77	[2.59, 2.95]
Gender:																
Male	26484	43.88	3.65	[3.42, 3.88]		4332	7.09	[6.34, 7.89]		7970	3.85	[3.44, 4.30]		14181	2.48	[2.23, 2.74]
Female	33868	56.12	4.36*	[4.14, 4.58]		6088	7.97	[7.30, 8.68]		11041	4.37	[3.99, 4.76]		16735	3.01*	[2.76, 3.28]
Age group:																
40-44	4247	7.04	8.64	[7.81, 9.53]												
45-49	6173	10.23	6.88*	[6.27, 7.55]												
50-54	8318	13.78	4.70*	[4.26, 5.18]												
55-59	10693	17.72	3.72*	[3.37, 4.10]												
60-64	17006	28.18	2.93*	[2.69, 3.20]												
65-69	13910	23.05	2.56*	[2.30, 2.84]												
Ethnicity																
White	54843	91.51	3.93	[3.77, 4.10]		8771	7.76	[7.21, 8.34]		16906	4.02	[3.73, 4.33]		29162	2.71	[2.53, 2.91]
Mixed	488	0.81	6.97*	[4.87, 9.60]		185	11.35	[7.17, 16.83]		165	4.24	[1.72, 8.55]		138	4.35	[1.61, 9.22]
Asian or Asian British	1929	3.22	5.86*	[4.85, 7.00]		523	7.07	[5.03, 9.62]		754	6.50*	[4.84, 8.50]		652	4.14*	[2.75, 5.97]
Black or Black British	1623	2.71	3.39	[2.56, 4.39]		549	4.01*	[2.53, 6.00]		627	3.19	[1.96, 4.88]		446	2.69	[1.40, 4.65]
Chinese	297	0.50	5.05	[2.85, 8.19]		96	5.21	[1.71, 11.74]		122	4.10	[1.34, 9.31]		79	6.33	[2.09, 14.16]
Other	752	1.25	5.98*	[4.40, 7.93]		208	9.62	[5.97, 14.46]		306	6.21	[3.78, 9.53]		238	2.52	[0.93, 5.41]
Educational qualification																
None	9049	15.18	3.32	[2.96, 3.71]		371	6.74	[4.41, 9.79]		1677	4.17	[3.27, 5.24]		6999	2.90	[2.52, 3.32]
O level	14961	25.10	4.73*	[4.39, 5.08]		2907	8.19	[7.22, 9.24]		4908	5.01	[4.42, 5.66]		7144	3.09	[2.70, 3.52]
A level	10526	17.66	4.28*	[3.91, 4.69]		1903	8.51	[7.30, 9.86]		3577	4.36	[3.72, 5.08]		5045	2.62	[2.19, 3.10]
Higher level	25074	42.06	3.82*	[3.58, 4.06]		5114	7.02	[6.33, 7.75]		8644	3.56	[3.18, 3.98]		11316	2.56	[2.28, 2.87]
Accommodation tenure																
Council renting	3618	6.11	2.87	[2.35, 3.47]		768	4.95	[3.52, 6.73]		1227	3.10	[2.20, 4.23]		1623	1.73	[1.15, 2.48]
Private renting	2097	3.54	5.29*	[4.37, 6.34]		740	8.24*	[6.36, 10.46]		689	3.92	[2.60, 5.65]		668	3.44*	[2.19, 5.12]
Own mortgage	19244	32.49	5.45*	[5.13, 5.78]		6738	8.13*	[7.49, 8.81]		8094	4.65*	[4.20, 5.13]		4412	2.81*	[2.34, 3.34]
Own outright	34274	57.86	3.31	[3.12, 3.50]		1914	6.90	[5.80, 8.13]		8681	3.78	[3.39, 4.20]		23674	2.82*	[2.61, 3.04]
Income:																
<£18k	11329	21.95	3.49	[3.16, 3.84]		1070	6.45	[5.05, 8.09]		2506	3.67	[2.97, 4.48]		7751	2.99	[2.63, 3.40]
18k-31k	13135	25.45	3.51	[3.20, 3.84]		1546	6.99	[5.77, 8.37]		3422	3.95	[3.32, 4.65]		8166	2.66	[2.32, 3.03]
31k-52k	13083	25.34	4.24*	[3.90, 4.60]		2721	7.57	[6.60, 8.63]		4692	4.03	[3.48, 4.63]		5670	2.82	[2.41, 3.29]
52k-100k	10722	20.77	4.93*	[4.53, 5.36]		2907	8.32	[7.35, 9.39]		4657	4.38	[3.81, 5.01]		3157	2.60	[2.07, 3.21]
>100k	3351	6.49	5.73*	[4.97, 6.57]		1105	8.87*	[7.26, 10.70]		1441	4.93	[3.87, 6.17]		805	2.86	[1.82, 4.26]
employment status																
employed	31832	53.4	4.76	[4.53, 5.00]		9,009	7.68	[7.14, 8.25]		14271	4.19	[3.87, 4.53]		8551	2.63	[2.30, 2.99]

retired	23005	38.59	3.02*	[2.80, 3.25]	32	3.13	[0.08, 16.22]	2002	5.14*	[4.22, 6.21]	20967	2.79	[2.58, 3.03]
unemployed	1252	2.10	3.75	[2.77, 4.96]	321	5.92	[3.60, 9.09]	683	2.93	[1.80, 4.49]	248	3.22	[1.40, 6.26]
unable to work	1481	2.48	4.05	[3.11, 5.18]	270	9.26	[6.08, 13.36]	802	2.99	[1.93, 4.42]	409	2.69	[1.35, 4.76]
other	2042	3.43	4.21	[3.38, 5.18]	649	6.93	[5.10, 9.17]	972	3.40	[2.35, 4.74]	421	1.90	[0.82, 3.71]
Social activities													
Sport club or gym													
No	40538	70.67	3.37	[3.20, 3.55]	6469	6.01	[5.45, 6.62]	12639	3.73	[3.40, 4.07]	21425	2.34	[2.14, 2.55]
yes	16826	29.33	5.21*	[4.88, 5.55]	3521	10.17*	[9.19, 11.21]	5,413	4.73*	[4.18, 5.33]	7892	3.32*	[2.94, 3.74]
Pub or social club													
No	43483	75.80	3.70	[3.53, 3.88]	7606	6.96	[6.39, 7.55]	13647	3.83	[3.51, 4.16]	22227	2.50	[2.30, 2.72]
yes	13881	24.20	4.55*	[4.21, 4.91]	2384	9.14*	[8.02, 10.37]	4,405	4.65*	[4.05, 5.32]	7090	2.92	[2.54, 3.34]
Religious group													
No	47708	83.17	4.20	[4.02, 4.38]	8651	8.00	[7.44, 8.59]	15220	4.29	[3.97, 4.62]	23833	2.74	[2.54, 2.96]
yes	9656	16.83	2.48*	[2.17, 2.80]	1339	4.11*	[3.11, 5.31]	2832	2.61*	[2.06, 3.27]	5484	1.99*	[1.63, 2.39]
Adult education class													
No	52799	92.04	3.92	[3.76, 4.09]	9353	7.53	[7.00, 8.08]	16,866	4.01	[3.72, 4.32]	26576	2.59	[2.40, 2.78]
yes	4565	7.96	3.75	[3.21, 4.34]	637	6.75	[4.93, 8.99]	1186	4.30	[3.22, 5.62]	2741	2.77	[2.19, 2.78]
Other group activity													
No	44121	76.91	4.10	[3.92, 4.29]	8320	7.70	[7.14, 8.30]	14437	4.07	[3.75, 4.40]	21362	2.72	[2.50, 2.94]
yes	13243	23.09	3.26*	[2.97, 3.58]	1670	6.35	[5.23, 7.63]	3615	3.87	[3.27, 4.55]	7955	2.30*	[1.98, 2.65]

*p<0.05 derived by logistic regression comparing each category with the reference (gender: male; age group: 40-44; ethnicity: white; Educational qualification: none; accommodation tenure: council renting; income: <£18k; employment status: employed)

§ 95% CI= 95% Confidence Interval

Table 3: Distribution by demographic and socio-economic factors comparing those reporting laser refractive surgery (total, unilateral and bilateral) and those with refractive errors (i.e. eligible) but not reporting surgery

	Report of laser surgery						Eligible but no report of laser surgery	
	Total		bilateral		unilateral		Total	
	N	%	N	%	N	%	N	%
Overall	2441	100	1892	77.50	549	22.50	57911	
Gender								
Male	966	39.57†	714	37.74†	252	45.90	25518	44.06
Female	1475	60.43	1178	62.26	297	54.10	32393	55.94
Age group								
40-44	367	15.07†	333	17.62†	34	6.23	3880	6.70
45-49	425	17.45	367	19.42	58	10.62	5748	9.93
50-54	391	16.05	310	16.40	81	14.84	7927	13.69
55-59	398	16.34	305	16.14	93	17.03	10295	17.78
60-64	499	20.48	355	18.78	144	26.37	16507	28.50
65-69	356	14.61	220	11.64	136	24.91	13554	23.40
Ethnicity								
White	2156	89.16†	1665	88.89†	491	90.09	52687	91.61
Mixed	34	1.41	30	1.60	4	0.73	454	0.79
Asian or Asian British	113	4.67	92	4.91	21	3.85	1816	3.16
Black or Black British	55	2.27	42	2.24	13	2.39	1568	2.73
Chinese	15	0.62	9	0.48	6	1.10	282	0.49
Other	45	1.86	35	1.87	10	1.83	707	1.23
Educational								
None	300	12.42†	208	11.11†	92	16.94	8749	15.30
O level	707	29.28	564	30.13	143	26.34	14254	24.92
A level	451	18.67	362	19.34	89	16.39	10075	17.62
Higher level	957	39.63	738	39.42	219	40.33	24117	42.17
Accommodation tenure								
Council renting	104	4.34†	71	3.82†	33	6.12	3514	6.18
Private renting	111	4.63	85	4.58	26	4.82	1986	3.49
Own with mortgage	1048	43.74	884	47.60	164	30.43	18196	32.01
Own outright	1133	47.29	817	44.00	316	58.63	33141	58.31
Income								
<£18k	395	18.53†	285	17.22†	110	23.06	12067	22.42
18k-31k	461	21.62	333	20.12	128	26.83	14060	26.12
31k-52k	555	26.03	437	26.40	118	24.74	13810	25.65
52k-100k	529	24.81	433	26.16	96	20.13	10532	19.57
>100k	192	9.01	167	10.09	25	5.24	3361	6.24

Missing data: ethnicity, n=420 (0.70%); educational qualification, n=742 (1.23%); accommodation tenure, n=1119 (1.85%); income, n=8732 (14.47%)

†p<0.001 by Chi Square comparing total, bilateral and unilateral report of laser surgery vs eligible but no report of laser surgery.

Table 4: Distribution of self-report of other eye illnesses, by report of laser refractive surgery

Eye illness	Emmetropes, ineligible for refractive surgery		Eligible but no report of laser surgery		Report of laser surgery	
	N	%	N	%	N	%
cataract	1170	2.39	2186	3.77	218	8.93
eye trauma	207	0.42	326	0.56	41	1.68
diabetic eye disease	558	1.14	604	1.04	81	3.32
glaucoma	604	1.23	994	1.72	62	2.54
retinal problem	30	0.06	72	0.12	18	0.74
retinal artery/ vein occlusion	16	0.03	26	0.04	4	0.16
retinitis pigmentosa	8	0.02	11	0.02	1	0.04
macular degeneration	365	0.75	696	1.20	37	1.52
eyelid problem	179	0.37	300	0.52	19	0.78
eye infection	16	0.03	28	0.05	2	0.08
blepharitis/eyelid infection	32	0.07	49	0.08	1	0.04
optic neuritis	8	0.02	22	0.04	1	0.04
dry eyes	171	0.35	297	0.51	8	0.33
iritis	49	0.10	63	0.11	1	0.04
other	569	1.16	952	1.64	176*	5.12
Total eye illness	3982	8.13	6626	11.44	670	27.45
Total	48964		57911		2441	

*including 51 subjects reporting retinal detachment

Table 5: Distribution by social participation activities and general well-being factors comparing those reporting laser refractive surgery (total, unilateral and bilateral) and those with refractive errors (i.e. eligible) but no reporting surgery

	Report of laser surgery						Eligible but no report of laser surgery	
	Total		bilateral		unilateral		Total	
	N	%	N	%	N	%	N	%
Overall	2441	100	1892	77.50	549	22.50	57911	
Social activities								
Sport club or gym								
No	1,366	60.93†	1055	59.64†	311	65.75*	39172	71.06
yes	876	39.07	714	40.36	162	34.25	15950	28.94
Pub or social club								
No	1610	71.81†	1262	71.34†	348	73.57	41873	75.96
yes	632	28.19	507	28.66	125	26.43	13249	24.04
Religious group								
No	2003	89.34†	1601	90.50†	402	84.99	45705	82.92
yes	239	10.66	168	9.50	71	15.01	9417	17.08
Adult education class								
No	2071	92.37	1646	93.05	425	89.85	50728	92.03
yes	171	7.63	123	6.95	48	10.15	4394	7.97
Other group activity								
No	1810	80.73†	1445	81.68†	365	77.17	42311	76.76
yes	432	19.27	324	18.32	108	22.83	12811	23.24
Health rating								
Excellent	354	15.80*	295	16.67*	59	12.55	7746	14.05
Good	1320	58.93	1041	58.81	279	59.36	32463	58.89
Fair	465	20.76	353	19.94	112	23.83	12452	22.59
Poor	101	4.51	81	4.58	20	4.26	2468	4.48
Health satisfaction								
Extremely satisfied	108	4.82	90	5.07	18	3.85	2666	4.85
Very satisfied	748	33.36	608	34.27	140	29.91	17526	31.86
Moderately satisfied	1074	47.90	833	46.96	241	51.50	27554	50.09
Moderately dissatisfied	229	10.21	185	10.43	44	9.40	5318	9.67
Very dissatisfied	62	2.77	44	2.48	18	3.85	1397	2.54
Extremely dissatisfied	21	0.94	14	0.79	7	1.50	546	0.99
Visit friends or family								
Almost daily	224	10.01*	186	10.53*	38	8.07	5799	10.54
2-4 times a week	673	30.07	501	28.35	172	36.52	16573	30.13
About once a week	851	38.03	693	39.22	158	33.55	19799	35.99
About once a month	321	14.34	258	14.60	63	13.38	7962	14.47
Once every few months	142	6.34	108	6.11	34	7.22	3923	7.13
Never or almost never	19	0.85	14	0.79	5	1.06	829	1.51
No friends/family outside	8	0.36	7	0.40	1	0.21	127	0.23
Happiness								
Extremely happy	106	4.39	86	4.59	20	3.69	3003	5.23
Very happy	926	38.34	720	38.44	206	38.01	21694	37.79
Moderately happy	1273	52.71	981	52.38	292	53.87	29883	52.06
Moderately unhappy	87	3.60	67	3.58	20	3.69	2276	3.96
Very unhappy	19	0.79	17	0.91	2	0.37	421	0.73
Extremely unhappy	4	0.17	2	0.11	2	0.37	127	0.22

Missing data: Health rating, n=2983 (4.94%); Health satisfaction, n=3103 (5.14%); Visit friends or family, n=3102 (5.14%); social activities, n=2988 (4.95%); Happiness, n=533 (0.88%)

*p<0.05 and †p<0.001 by Chi Square comparing total, bilateral and unilateral report of laser surgery vs eligible but no report of laser surgery

Figure 1 legend

Figure 1: Distribution of mean spherical equivalent, by report of laser refractive surgery

Two-sample Kolmogorov-Smirnov test for equality of distribution functions ($p < 0.001$).

