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# A survey of current and anticipated use of standard and specialist equipment by UK optometrists

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**Keywords:** equipment, information technology, optical coherence tomography, optometrist, survey

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## Abstract

*Purpose:* To investigate current and anticipated use of equipment and information technology (IT) in community optometric practice in the UK, and to elicit optometrists' views on adoption of specialist equipment and IT.

*Methods:* An anonymous online questionnaire was developed, covering use of standard and specialist diagnostic equipment, and IT. The survey was distributed to a random sample of 1300 UK College of Optometrists members.

*Results:* Four hundred and thirty-two responses were received (response rate = 35%). Enhanced (locally commissioned) or additional/separately contracted services were provided by 73% of respondents. Services included glaucoma repeat measures (30% of respondents), glaucoma referral refinement (22%), fast-track referral for wet age-related macular degeneration (48%), and direct cataract referral (40%). Most respondents (88%) reported using non-contact/pneumo tonometry for intra-ocular pressure measurement, with 81% using Goldmann or Perkins tonometry. The most widely used item of specialist equipment was the fundus camera (74% of respondents). Optical Coherence Tomography (OCT) was used by 15% of respondents, up from 2% in 2007. Notably, 43% of those anticipating purchasing specialist equipment in the next 12 months planned to buy an OCT. 'Paperless' records were used by 39% of respondents, and almost 80% of practices used an electronic patient record/practice management system. Variations in responses between parts of the UK reflect differences in the provision of the General Ophthalmic Services contract or community enhanced services. There was general agreement that specialised equipment enhances clinical care, permits increased involvement in enhanced services, promotes the practice and can be used as a defence in clinico-legal cases, but initial costs and ongoing maintenance can be a financial burden. Respondents generally agreed that IT facilitates administrative flow and secure exchange of health information, and promotes a state-of-the-art practice image. However, use of IT may not save examination time; its dynamic nature necessitates frequent updates and technical support; the need for adequate training is an issue; and security of data is also a concern.

*Conclusion:* UK optometrists increasingly employ modern equipment and IT services to enhance patient care and for practice management. While the clinical benefits of specialist equipment and IT are appreciated, questions remain as to whether the investment is cost-effective, and how specialist equipment and IT may be used to best advantage in community optometric practice.



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## Introduction

Over the past 20 years there have been major advances in the scope of optometric practice, including the widespread adoption of sophisticated ophthalmic equipment and information technology (IT). It can be argued that the first steps in this transformation of optometric practice in the UK were the introduction of static semi-automated perimetry and non-contact tonometry (NCT) in the 1970s. Since these developments, rapid advances in technology allied to initiatives to improve the detection of glaucoma and quality of referrals to secondary care by community optometrists have contributed to developments in the use and uptake of equipment.[1] In addition to their traditional role in the detection of eye disease optometrists are increasingly becoming involved in community-based co-management/shared care programs for chronic eye disease.[2, 3] In parallel with these developments, greater numbers of optometrists are adopting 'state-of-the-art' equipment for imaging the eye or assessing visual function to enhance the detection and monitoring of eye disease.[4]

The use of IT in practice is key to the adoption of this advanced equipment as many newer systems are supported by computer software which facilitates data capture and provides more in-depth analysis of clinical data. Examples include computer software developed to aid the detection of visual field progression e.g. Guided Progression Analysis for the Humphrey Visual Field Analyzer[5, 6] and automated software analysis integrating normative patient data which is used by advanced imaging systems such as the Heidelberg Retinal Tomograph.[7, 8]

An electronic medical (or health) record is a digital documentation of a patient's medical history and care.[9] A paperless or electronic record facilitates clinical recording, while a practice management system is used to improve the efficiency of practice administration tasks such as functions for appointments and scheduling, billing activities, and communication with patients to generate recalls. Practice management systems can also be used as a marketing tool by filtering patients and sending up-to-date information on products and services to targeted groups. With rapid advancements in technology, practices are now being promoted online by creating a practice website, use of social media, video marketing, online ordering facilities, and use of email or text messages.

Studies comparing the use of electronic and paper-based records have shown electronic records in a favourable light when applied to optometric practice,[10] and generally across primary care.[11] Electronic communication has been widely adopted in the UK National Health Service (NHS), with the ambitious strategic vision for the future set out in Public Health England's *Knowledge Strategy: Harnessing the power of information to improve the public's health* published in October 2013,[12] and driven by targets such as the Department of Health's goal for a 'Paperless NHS by 2018'.[13] Although the efficient electronic collection and sharing of health data is regarded by the NHS as being of paramount importance, electronic communication between primary care optometry and secondary care remains weakly established. The UK College of Optometrists report 'Better data better care'[14] notes that although optometrists are responsible for approximately one million referrals of patients each year to their primary care doctor or hospital eye service, most of these referrals continue to be made via an inefficient paper-based system. This is despite the potential benefits of teleophthalmology, which have been demonstrated in a successful referral scheme in Fife in Scotland.[15] However, initiatives are underway in parts of the UK in an effort to integrate and centralise IT systems.[16] The College of Optometrists report *Healthy Eyes for All* notes that, for example, optometrists in Northern Ireland may in the near future be able to access patients' Electronic Care Records to obtain information from ophthalmology clinics on patients' screening reports and treatment advice given. Also, an electronic Ophthalmic Claims System has been initiated in a number of practices in the province, and optometrists may soon be able to participate in a Clinical Communications Gateway which will, among other benefits, allow eReferrals.[16] Similarly, expansion of electronic referral systems in Scotland is proceeding apace via the Eye Care Integration Programme with the support of Optometry Scotland.[16] *Healthy Eyes for All* reports that pilots of eReferral systems are underway across much of Scotland and there are plans that referrals will eventually be submitted through a Virtual Private Network with optometrists having access to Scotland's centralised internet portal which will link the data systems from primary and secondary care. Progress towards electronic health communication has been slower in England than in the rest of the UK. One factor holding back progress is that optometrists who are not on NHS secure mail are unable to fully utilise the benefits of electronic communication.[14]

Periodically, the College of Optometrists has carried out Clinical Practice Surveys to identify the range of specialist equipment in current use in optometric practice. More recently, Myint *et al.*[4] carried out a national survey of diagnostic tests used by UK community optometrists for the detection of glaucoma, which found increasing use of modern imaging and visual function tests. However, this study was specifically focused on equipment used for glaucoma detection. There has been no national survey of optometric equipment as a whole since the Clinical Practice survey conducted in 2007.[17] Information on the use of IT in UK community practice is particularly scant, with the 2007 survey understandably devoting little attention to what was novel technology at that time. This dearth of information

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on IT use by optometrists was one impetus for the current survey. In addition, the rationale for optometric practices purchasing such equipment and the views of the profession on its impact on patient care have not been previously investigated in the UK.

Hence, the primary aims of this paper are to present the findings of a cross-sectional survey of UK optometrists to determine the equipment and IT currently in use in optometric practice, and to identify anticipated purchases in the near future. Secondary aims were to gather information about the services provided for patients by community optometry practices, and to elicit optometrists' attitudes regarding the adoption of specialist equipment and IT. Analysis of responses will allow enablers and barriers to the uptake of new technology to be identified. Survey questions were developed, validated, and distributed to a randomised sample of UK optometrists. To our knowledge, this is the first cross-sectional survey of UK optometrists aiming to explore the rationale behind the uptake of ophthalmic equipment and IT in community practice.

For the purposes of the current study, 'standard' items of equipment are regarded as those listed in Section B1.02 of the College of Optometrists guideline B1 *Equipment lists for the routine eye examination and dispensing*.[18] Newer technologies used to supplement standard equipment for enhanced clinical detection and monitoring are termed 'specialist'.

## Methods

Ethical approval for this research was granted by the City University London School of Health Sciences Research and Ethics Committee and the research was carried out in accordance with the tenets of the Declaration of Helsinki. Participation in the study was voluntary and informed consent was assumed when a participant attempted the questionnaire.

This anonymous cross-sectional survey was conducted using a self-administered questionnaire. An advisory group of nine members was convened to guide the development of the survey instrument. This group included: academic optometrists, practising optometrists working in independent and multiple practices, professional services directors of major optical chains and members of optometric professional organisations. Each member of the advisory group provided feedback on the first draft of the survey, indicating whether the questions were easily understood and clinically relevant. Minor amendments were made based on their feedback, and the resulting survey underwent further piloting by 23 members of the council of the College of Optometrists to further confirm the questionnaire's face validity. The refinements based on their feedback involved minor changes to the wording and placement of questions, plus a few additional multiple-choice options. Results of the pilot survey were not included in the final analysis.

The finalised survey was distributed by email and posted to a sample of UK-based optometrists from the College of Optometrists' membership database. These optometrists were randomly selected in an effort to provide a representative sample from England, Northern Ireland, Scotland and Wales. The required sample size was calculated using Cochran's formula for continuous and categorical data. Based on a margin for error of $\pm 5\%$ and an alpha level of 0.05[19] the formula determined that for a population of 10 000 a sample of 370 responses was required. Using an anticipated response rate of 30%, based on response rates to previous surveys (see *Table 1*), 1233 questionnaires should be distributed to members of the College of Optometrists. This total was increased to 1300 to account for 'bounce back' of emails from invalid addresses, or as a result of recipients previously having opted out of receiving online surveys from the College.

The College of Optometrists' membership database contains approximately 76% (10 050 of 13 202) of General Optical Council registrants.[26] Of the 1300 members captured in the sampling frame, 1215 optometrists had listed an email address and, therefore, received the survey by an email including a hypertext link to the survey homepage. The online version was hosted by a US provider of online surveys, Survey Monkey (http://www.surveymonkey.com). The remaining 85 members without an email contact address were invited to participate in the survey by post, each receiving a questionnaire with a covering letter. Respondents were asked to return the completed questionnaire in the stamped-addressed envelope enclosed within the invitation pack. Both the explanatory email and covering letter accompanying the online and postal surveys respectively detailed information on the purpose of the research. In an effort to maximise survey responses and to minimise bias the covering letter accompanying the postal invitation included the hyperlink text to the survey homepage to enable the questionnaire to be completed online. Similarly, email recipients were given the option of choosing to complete the questionnaire using a paper version. Settings were adjusted to allow participants to go back to previously completed pages in the survey and update responses. Respondents could exit the survey at any time although all previous responses were automatically saved.

The initial mailing took place at the beginning of February 2013. Two reminder mailings were sent, the first after 10 days and the second after 20 days in an effort to maximise the response rate. As an added incentive, all respondents were also provided with the option of free entry into a prize draw to win one of three sets of shopping vouchers to the value of £100. The use of monetary rewards and reminder mailings has been shown to be an effective way to


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**Table 1.** Features of the present study compared with previous UK-based practitioner surveys, ordered by date of publication

| Survey topic | Number of items | Was survey piloted? | Incentive offered? | Nature of survey | Response rate (%) |
|---|---|---|---|---|---|
| College of Optometrists, Clinical Practice Survey 2001[20] | 8 | Not recorded | No | Post | 46 |
| College of Optometrists, Clinical Practice Survey 2007[17] | 24 | Yes | No | Post & Internet | 30 |
| Therapeutic practice by UK optometrists (Needle *et al.*)[21] | 30 | Not recorded | No | Internet | 24 |
| Referral behaviour among optometrists[22] | 23 | Yes | No | Internet | 12 |
| Attitudes to fitting of rigid gas permeable lenses[23] | 20 | Yes | Not recorded | Post | 45 |
| Diagnostic tests for detection of open angle glaucoma[4] | 27 | Yes | No | Internet | 28 |
| Habits and attitudes to retinoscopy[24] | 23 | Yes | Yes | Internet | 30 |
| Advice for people with or at risk of AMD[25] | 19 | Yes | Yes | Internet | 16 (Optometrists) 6 (Ophthalmologists) |
| College of Optometrists, Workforce Survey[24] | 59 | Yes | Yes | Post & Internet | 34 |
| Present survey | 21 | Yes | Yes | Post & Internet | 35 |

increase survey responses in a Cochrane systematic review.[27] In total, the survey was open for 6 weeks and closed on 15 March 2013 following two consecutive days without responses.

The questionnaire was organized into five sections totalling 21 questions: 'Personal details' (four questions), 'Details of your practice' (four questions), 'Use of standard ophthalmic equipment' (one question), 'Use of specialist diagnostic equipment' (three questions) and 'Use of information technology' (nine questions). Questions within each domain required either Yes/No responses or the use of 5-point Likert scales for those questions relating to barriers and preferences. The survey was designed to be completed within 20 min. The main themes included in the questionnaire and the design of the survey instrument were based on the College of Optometrists' Clinical Practice surveys of 2001 and 2007, together with the outcomes of a literature search of equipment and IT in current use. The surveys administered to optometrists based in England and Northern Ireland, Scotland, and Wales each differed slightly to account for local variations in NHS terminology and differences in the operation of community optometric services across the UK. The final list of questions is summarized in *Table 2*. Section 1 addressed personal demographic information, as well as ascertaining whether the recipient currently practised community-based optometry. Respondents who had never worked in community optometric practice (e.g. hospital optometrists), or had last worked in this capacity more than 5 years prior to the survey were re-directed to Question 20 (Use of the internet in the workplace), skipping the main body of questions relating to the use of equipment and IT in community optometric practice. This was to encourage all respondents, whether they had recently worked in community practice or not, to complete and return the survey. Sections 3, 4 and 5 related to the use of equipment and IT in practice, and in these sections optometrists were asked to indicate whether the respective item was 'Used', or 'Not available in practice'. The questions relating to optometrists' views on the use of equipment and IT used the Likert scale, one of the most commonly used psychometric response scales to obtain degrees of agreement with a set of statements. A 5-point scale with a middle category was chosen to allow respondents to select a neutral response.

Results from the online responses were exported via Survey Monkey into an Excel spreadsheet, and collated with the manually-entered paper responses to facilitate data analysis. Interval data generated using Likert scales were transcribed into grades from 1 to 5, where 'Strongly disagree' was denoted by 1. The gradings were then described using mode, median and interquartile range.

Respondents were provided with several opportunities to add free-text comments in the survey. In particular, they were asked to comment on any additional advantages and/or disadvantages, not captured by the statements already included in the survey, that they felt may result from the use of specialist equipment in community practice. Another free-text box asked for similar comments on any additional advantages and/or disadvantages relevant to the use of IT services in community practice. The final survey question asked for any further comments on any aspect of the use of equipment and technology in optometry to be written in the free-text box. Responses to the free-text

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**Table 2.** Summary of survey questions

| Section | Question number | Question |
|---|---|---|
| About you | 1–4 | Year of qualification |
| | | University at which optometry training was completed |
| | | Gender |
| | | To ascertain whether respondent is currently practising as a community optometrist, or has previously worked in this capacity within the last 5 years |
| About your practice | 5–8 | Principal mode of practice – Independent, multiple/group etc. |
| | | Principal practice location – Country and then divided into inner city, rural etc. |
| | | Practice involvement in enhanced or additional/separately contracted services (with modifications to account for different modes of practice in different countries) |
| Standard Ophthalmic equipment | 9 | Use of standard ophthalmic equipment |
| Specialist equipment | 10–12 | Use of specialist diagnostic equipment |
| | | Views on possible advantages or disadvantages of using specialist equipment (Likert scales) |
| | | Items of specialist equipment respondent anticipates buying during the next 12 months |
| Information Technology | 13–21 | Use of computer software for specific clinical applications |
| | | Use of IT for the management of patient data and patient education |
| | | Use of 'paperless' records and mobile texting for reminders/collections |
| | | Views on possible advantages or disadvantages of using IT (Likert scales) |
| | | IT services respondent anticipates buying during the next 12 months |
| | | Methods of generating a patient referral or notification letter and whether the results of specific clinical tests are sent together with the referral letter. |
| | | Use of internet in the principal workplace |
| | | Use of internet in your professional development |
| N/A | 22 | Additional comments on any aspect of the survey |

responses were coded and assigned to categorical variables by the lead author (PD). The Chi-squared test was used in the statistical analysis. To reduce the risk of a Type I error arising from multiple statistical comparisons a $p$ value <0.01 was deemed statistically significant. Descriptive data analysis was carried out using SPSS 20.0 software (www.ibm.com/SPSS_Statistics).

## Results

A total of 1300 questionnaires were distributed by email and post. The overall response rate was 35% (455/1300), exceeding our anticipated response rate of 30%. Four hundred and thirty-two (out of 455) complete questionnaires were received, representing a completion rate of almost 95%. Data from the 23 incomplete surveys received were not included in the analysis. The remaining 432 respondents were asked to indicate whether they were currently practising as a community optometrist, or had practised in this capacity within the previous 5 years; 16 (4%) of respondents answered 'No' leaving 416 optometrists who answered questions 5 through to 19.

The use of a randomised cohort of optometrists from the College membership database allowed a more representative sample of optometrists to be included in our analysis. A total of 199 male optometrists (46%) and 233 female optometrists (54%) completed the survey, reflecting the 45% male and 55% female gender distribution of registrants on the General Optical Council register for the year 2011–2012.[26]

Of the 416 eligible optometrists who completed the survey, 54% ($n$ = 224) worked in independent practices, 24% ($n$ = 98) in multiple/group practices, 9% ($n$ = 39) in joint venture/franchises, and 12% ($n$ = 51) were locums. Over 75% of these optometrists worked in England (327/416), 11% in Scotland (47/416), and 5% in both Wales (22/416) and Northern Ireland (20/416).

### Provision of services

The remaining analysis is based on the responses from the 416 eligible optometrists who completed the survey. Services provided by optometrists at the time of the survey have been divided into two categories: enhanced services and additional or separately contracted services (*Table 3*). An 'enhanced service' is a locally commissioned scheme to deliver routine or emergency community eye care outside the scope of the standard General Ophthalmic Services (GOS) contract. Enhanced services include PEARS ('Primary Eyecare Acute Referral Service' or 'Primary Eyecare Assessment and Referral Service') schemes, glaucoma referral refinement, cataract direct referral etc. Examples of additional or separately contracted services include domiciliary eye care and screening for diabetic retinopathy.

Enhanced or additional/separately contracted services were provided by 73% (305/416) of respondents (*Table 3*);


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**Table 3.** Provision of enhanced (locally commissioned) and additional/separately contracted services

| | Provision of services | Number of optometrists providing service ($n$ = 416) | Percentage |
|---|---|---|---|
| Enhanced (locally commissioned) services | Glaucoma referral refinement scheme | 93 | 22 |
| | Funded repeat measurement scheme (repeat IOP and/or fields) | 124 | 30 |
| | Monitoring of patients with ocular hypertension (OHT) and/or suspect chronic open angle glaucoma (COAG) | 41 | 10 |
| | Co-management of patients with stable glaucoma | 27 | 6 |
| | Post-operative cataract care | 79 | 19 |
| | Fast-track (Direct referral) cataract programme | 167 | 40 |
| | Adult community optical low vision services | 42 | 10 |
| | PEARS-type scheme | 48 | 12 |
| Additional or separately contracted services | Domiciliary services | 64 | 15 |
| | Formal programme for screening for Diabetic Retinopathy | 59 | 14 |
| | Pre-operative and post-operative management of refractive surgery | 31 | 7 |

however there were marked variations with geographical location. All 22 respondents working in Wales gave a positive response to this question, compared with 85% (40/47), 73% (240/327), and 16% (3/20) of optometrists with practices located in Scotland, England and Northern Ireland respectively (*Figure 1*). Forty-eight per cent (198/416) of respondents utilised fast-track referrals for exudative (wet) age-related macular degeneration (AMD), and 40% (167/416) provided direct referral for cataract surgery. Glaucoma repeat measures services were provided by 30% of respondents (124/416), and 22% (93/416) were involved in referral refinement schemes. Interestingly, the likelihood of undertaking enhanced and additional/separately contracted services was statistically significantly greater for males ($p = 0.003$). Male respondents were in the majority for 8 of the 12 enhanced and additional/separately contracted services listed. A greater proportion of those respondents providing enhanced or additional/separately contracted services reported using specialist items of equipment than those who did not provide these services. Specifically, significantly greater proportions of our sample providing these services used Optical Coherence Tomography (OCT) ($p = 0.008$) and pachymetry ($p < 0.001$) (*Figure 1*). Those participating in enhanced or additional/separately contracted services were also significantly more likely to use electronic delivery for their referrals ($p = 0.007$) *Figure 1*).

### Standard ophthalmic equipment

The majority of respondents (88%, 368/416) indicated that they used NCT for the measurement of intraocular pressure, while 81% (337/416) reported using Goldmann or Perkins contact tonometry (*Table* 4). However, we did not ascertain how regularly these devices were used in clinical practice. Respondents working in independent practices were significantly less likely to use NCT ($p = 0.001$) (*Figure 1*) and an autorefractor compared with optometrists working in multiple/group practices ($p < 0.001$).

### Specialist equipment

The most widely used item of specialist equipment was the fundus camera, which was used by 74% (308/416) of respondents, 54% (165/308) of whom charged patients for fundus imaging. This was followed by anterior segment imaging and FDT perimetry (used by 23% and 20% respectively). Newer imaging modalities are usually among the more expensive items listed in the survey, which is probably reflected by the high proportions of optometrists implementing a charge to the patient for the use of the technology (77%, 48/62, 75%, 9/12 and 76%, 13/17) for use of the OCT, scanning laser polarimeter (SLP), and scanning laser ophthalmoscope (SLO) respectively. The use of OCT was reported by 15% (62/416) of respondents. This device was more likely to be used by respondents working in independent practice compared with multiple/group practices ($p < 0.001$) (*Figure 1*). Practitioners who used OCT were also more likely to use other specialist items of equipment ($p = 0.003$). The proportions of those who used OCT and who also reported using a goniolens ($p < 0.001$), corneal topographer ($p < 0.0001$) and macular pigment analyser ($p = 0.002$) were all significantly greater than those practitioners who did not use OCT. Furthermore, OCT users were significantly more likely to provide enhanced or additionally/separately contracted services than those who did not use OCT ($p = 0.008$) and, specifically, were more likely to provide a glaucoma service alone ($p = 0.006$).

A total of 62 respondents reported using gonioscopy, representing 15% of the total sample. A greater proportion of those respondents working in independent practice reported using a goniolens ($p < 0.001$) and providing

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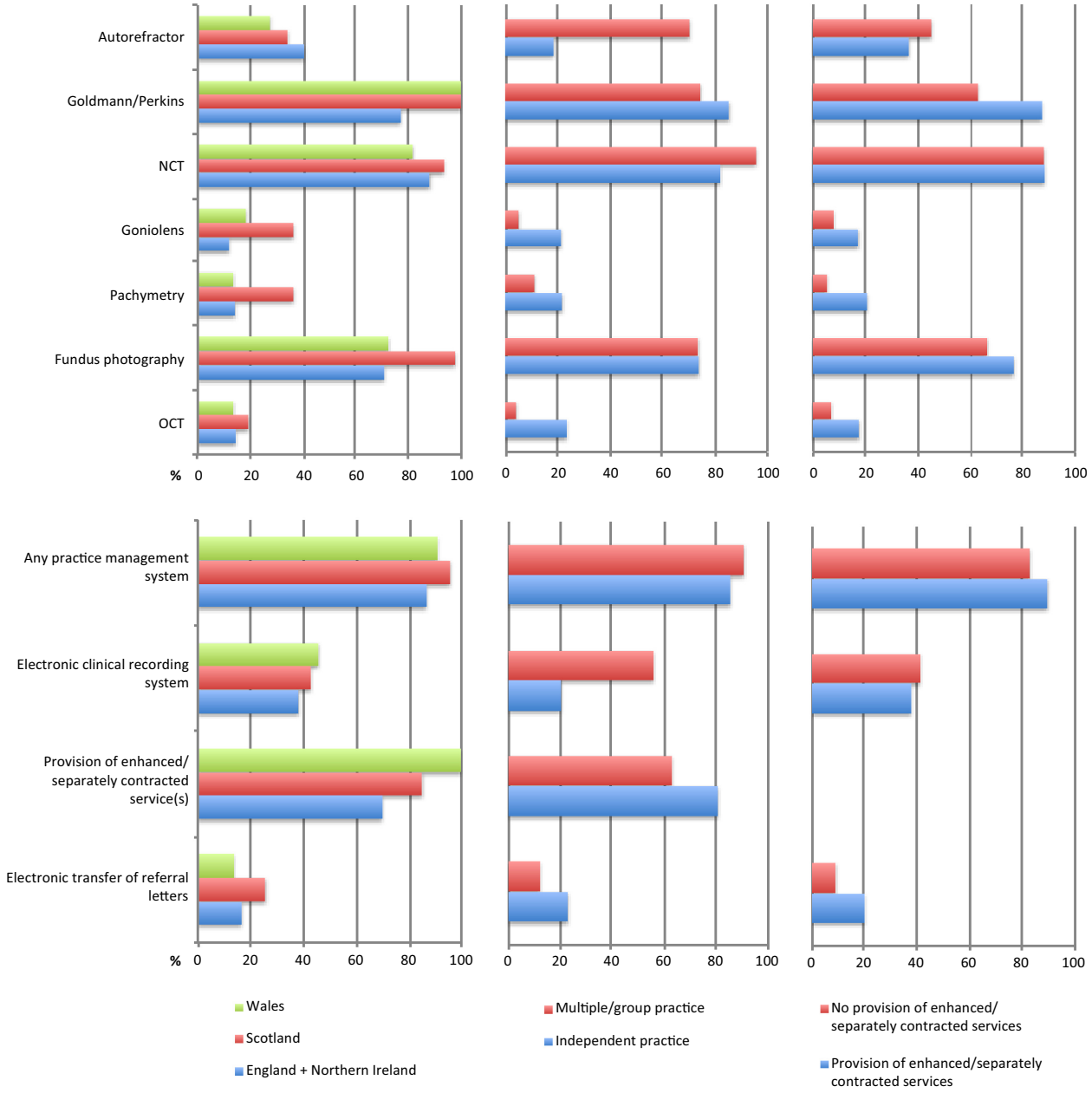


**Figure 1.** Sub-group analysis by country, practice type and provision of services.

enhanced/separately contracted services ($p = 0.001$) than those in multiple/group practice. The proportion of respondents using NCT ($p = 0.001$) and electronic recording ($p < 0.001$) was statistically significantly greater in those working in multiple/group practice than independent practice. Practitioners working in independent practice were also significantly less likely to use electronic recording ($p < 0.001$) than those working in all other types of practice (*Figure 1*).

Of the 84 respondents who detailed items of specialist equipment they anticipated purchasing in the next 12 months, the greatest number ($n = 36$) noted the OCT, followed by the contact tonometer, fundus camera ($n = 9$), and pachymeter ($n = 8$).

## Information technology

'Paperless' records were used by 39% (162/416) of respondents, with a further 59% (246/416) reporting that they employed mobile phone texting for patient reminders and collections. Almost 80% (332/416) of practices use a practice management system, and the computerised test chart


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**Table 4.** Relative frequency of the use of items of equipment and information technology by community optometrists

| Item of equipment or information technology | Frequency item is used in practice ($n$ = 416) | Percentage |
|---|---|---|
| Non-contact/pneumo tonometer (NCT) | 368 | 88 |
| Goldmann/Perkins applanation tonometer | 337 | 81 |
| Optical Coherence Tomographer (OCT) | 62 | 15 |
| Macular Pigment measuring instrument (e.g. MPOD or other) | 21 | 5 |
| Fundus photography | 308 | 74 |
| Anterior segment imaging | 94 | 23 |
| FDT perimetry | 82 | 20 |
| Advanced tonometer (e.g. iCare, ORA or other) | 76 | 18 |
| Pachymetry (optical/ultrasonic) | 69 | 17 |
| Goniolens | 62 | 15 |
| Computerised/projection test chart | 314 | 75 |
| Electronic patient record system/Practice Management System (e.g. Optisoft, Focus, Acuitas or other) | 332 | 80 |

was the most popular IT item listed for clinical use [75% (314/416)]. Notably, optometrists working in independent practices were significantly less likely to use a computerised test chart, 'paperless' records (*Figure 1*) or mobile phone texting compared with multiple/group practices ($p < 0.001$). A further nine respondents commented on the use of the Apple iPad and integrated applications in the 'Other' box for clinical testing, patient education and as a dispensing tool.

### Views on the use of equipment and IT in optometric practice

A summary of the views of our respondents to the questions posed in the survey is presented in *Table 5*. In addition there were a number of free-text comments which are considered in the Discussion.

### Referrals

Most respondents (78%, 324/416) use a standard locally adapted form to generate referral or notification letters, with only 17% (71/416) of respondents sending referrals by electronic transfer Of the respondents using a standard locally adapted form, 58% sent the letter by post/fax (188/324), 17% (54/324) provided a copy of the letter to hand-deliver to the GP/specialist, and a further 24% (77/324) used a combination of these delivery options. One in ten respondents reported not including the results of specific tests, notably fundus images, with referrals, citing a lack of the means to send information efficiently as the main reason. Respondents also commented on the inconvenience and poor cost efficacy of printing the results of imaging tests, as well as indicating that colleagues in secondary care did not require this additional information.

### Use of the internet

This question applied to all respondents who completed the questionnaire, including those who did not work in community optometric practice. Three in four optometrists use the internet in their workplace. The most popular practice-related use for the internet (83%, 358/432) was for continuing education and training/continued professional development. Fewest respondents used the internet for online discussion groups/forums (37%, 158/432).

### Variations between countries

Some variations between countries were observed for the use of specialist equipment. The proportion of respondents using Goldmann/Perkins tonometry, pachymetry and a goniolens in Scotland was statistically significantly greater than in England & Northern Ireland ($p < 0.001$). Respondents from Scotland were significantly more likely to use fundus photography than those from each of the other countries ($p = 0.001$). Respondents working in Wales reported significantly greater provision of enhanced/separately contracted services than in England & Northern Ireland ($p = 0.002$). There was no significant difference between countries regarding the use of electronic record keeping, use of practice management software and electronic transfer of referral letters ($p > 0.1$).

## Discussion

The results of this cross sectional survey show that UK optometrists are increasingly investing in new ophthalmic equipment and IT, including the incorporation of the latest technology into their practices. The purchase cost of new equipment is largely incurred by practice owners. The busi-

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**Table 5.** Views on the adoption of specialist equipment

| | Views on adoption of specialist equipment | Strongly disagree % (n) | Disagree % (n) | Neither agree nor disagree % (n) | Agree % (n) | Strongly agree % (n) |
|---|---|---|---|---|---|---|
| Positive | Enhances clinical assessment, providing a diagnostic tool to aid management and referral decision-making | 2 (7) | 0 (1) | 3 (12) | 40 (166) | 55 (230) |
| | Permits increased involvement in referral refinement and/or co-management schemes | 0 (1) | 2 (9) | 8 (34) | 62 (257) | 28 (115) |
| | Provides an opportunity for promoting your practice | 1 (4) | 1 (5) | 11 (44) | 57 (239) | 30 (124) |
| | Results can be used as defence in medico-legal cases | 0 (2) | 2 (10) | 29 (119) | 53 (219) | 16 (66) |
| | Promotes patient loyalty to the practice | 1 (3) | 2 (9) | 16 (68) | 61 (252) | 20 (84) |
| Negative | Can pose a financial burden on the practice due to initial purchase costs and/or continuing maintenance | 1 (4) | 8 (35) | 13 (54) | 52 (218) | 25 (105) |
| | Poses a risk of replacing core skills reducing the value of optometric qualifications | 22 (91) | 48 (198) | 21 (87) | 9 (36) | 1 (4) |
| | Operator training (initial and on-going) can be inconvenient, time consuming and a drain on resources | 7 (30) | 35 (146) | 33 (136) | 22 (90) | 3 (14) |
| | **Views on adoption of Information Technology** | **Strongly disagree % (n)** | **Disagree % (n)** | **Neither agree nor disagree % (n)** | **Agree % (n)** | **Strongly agree % (n)** |
| Positive | Facilitates more efficient administrative flow (tracking records, computerised referrals etc.) | 0 (1) | 4 (18) | 17 (70) | 61 (252) | 18 (75) |
| | Enables secure exchange of health information between primary and secondary care | 3 (14) | 16 (67) | 34 (140) | 42 (175) | 5 (20) |
| | Gives the impression that the practice is more 'state of the art' | 0 (2) | 3 (13) | 12 (50) | 72 (299) | 13 (52) |
| | Reduces the time taken to record information for a routine patient | 4 (18) | 27 (112) | 31 (131) | 25 (105) | 12 (50) |
| Negative | Dynamic nature of IT necessitates frequent updates and technical support | 0 (1) | 5 (20) | 19 (79) | 59 (246) | 17 (70) |
| | Poses a security risk with storage of confidential patient information online or on databases | 3 (13) | 23 (97) | 42 (174) | 29 (120) | 3 (12) |
| | Use of electronic records could impact negatively on patient-practitioner interaction and relations | 8 (32) | 34 (143) | 33 (139) | 22 (90) | 3 (12) |
| | There is greater risk of losing data | 5 (22) | 27 (113) | 33 (136) | 31 (129) | 4 (16) |
| | Inconvenient to learn new IT skills to operate management systems or software tools | 10 (40) | 40 (167) | 29 (119) | 20 (84) | 1 (6) |

ness model for community optometry relies heavily on cross-subsidisation from sales of optical appliances[28] and the optical market has become a competitive market-driven system for the provision of community eye care. In the UK, optometrists are the first-line eye care providers and play an important role in the detection of early eye disease. Recent developments in ophthalmic equipment, designed for the assessment of structural or functional change have been adopted by community practices to facilitate diagnosis or identify disease progression. In parallel, insufficient capacity and funding issues within secondary care, coupled with the desire to avoid unnecessary referrals and to offer patients care closer to home, have created opportunities to develop new clinical services through the provision of separately commissioned 'enhanced' or 'additional' schemes.[29]

To discuss further how the use of equipment and IT by optometrists has increased over time, data from the current survey have been compared in *Table 6* with findings from previous similar surveys.[17, 20, 30–34] There are limitations to this approach. The mode of distribution of surveys has


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**Table 6.** Relative frequency of the use of equipment in community optometric practice in present and past surveys

| Item of equipment | Frequency of respondents (%) in present survey *n* = 416 Response rate = 35% | Frequency of respondents (%) in 2007 Clinical Practice (College of Optometrists) survey[17] *n* = 2751 Response rate = 30%* | Frequency of respondents (%) in 2001 Clinical Practice (College of Optometrists) survey[20] *n* = 3618 Response rate = 46%* | Frequency of respondents (%) in 1987/88 International Glaucoma Association survey[30–34] *n* = 956 Response rate = 66% |
|---|---|---|---|---|
| Goldmann/Perkins tonometer | 81 | 61 | 48[†] | 47[‡] |
| Non-contact tonometer (NCT) | 88 | 93 | 88[†] | 44 |
| Fundus photography | 74 | 66[§] | 17[†,§] | N/A |
| Central visual field perimeter with threshold control | 98 | N/A | N/A | 41 |
| Autorefractor | 39 | N/A | 31 | N/A |

*Data from the two CP surveys have been modified wherever possible to reflect the differences in questions asked when compared with current survey.

[†]Estimated figures. Actual figures are likely to be higher than this.

[‡]This figure is likely to include practices owning a Schiotz tonometer in addition to Goldmann and Perkins.

[§]Refers to digital and film photography combined.

progressed from being totally paper-based in the International Glaucoma Association survey to largely online in the current survey, a trend which itself reflects the increasing use of computers and the internet in optometric practice. Also, starting with the 2001 College of Optometrists Clinical Practice Survey, all surveys tabulated in *Table 6* have been nationwide in their scope whereas the 1987/88 International Glaucoma Association survey targeted specific areas of the UK, resulting in a different respondent demographic. Furthermore, and perhaps the major limitation, although the questions asked in each survey relate to equipment, these questions have often been phrased differently in surveys, which is understandable given the different focus of each survey. To illustrate this point, the data from the current survey shown in *Table 4* for equipment used in practice were obtained from the following question: 'Which of the following items of ophthalmic equipment are used in your practice?' These responses are seeking a response at the practice level i.e. items of equipment that could be used by any optometrist in the practice or by non-clinical staff. However, in the Clinical Practice survey of 2007 the equivalent question relating to equipment asked: 'Which of the following instruments are used either by yourself or by non-optometric personnel in your practice?' The options are 'Myself', 'Non-optometric personnel', 'Not used', and 'No reply'. These questions were phrased primarily to establish the responses from an individual optometrist rather than for the practice as a whole. In an effort to ensure that data from different surveys are as comparable as possible, the data from previous surveys have been adjusted wherever possible to account for these variations in how questions were phrased. Finally, the frequency of use of equipment data quoted in *Table 4* is based on those 416 respondents who answered this question. However, equivalent data quoted in the College of Optometrists 2007 survey are based on the percentage of the 'base' figure of 2751 respondents who attempted the survey overall, a total which includes a proportion (more than 20% for some questions) who did not attempt individual questions. Therefore, the College of Optometrists 2007 figures have again been adjusted to give percentages based on those who answered each question in order to bring them into line with the current survey.

Despite these limitations comparison between surveys reveals some interesting trends (*Table 6*), with the frequency of use of Goldmann/Perkins tonometry in community practices increasing from 47% in 1987/88 to 61% in 2007 and reaching 81% in 2013. NCT, introduced into the UK in the early 1970s, had increased from 44% in 1987/88 to become almost ubiquitous as early as 2001 when it was already in more than 85% of practices, a figure maintained in the 2013 survey. Even more popular were central visual field screeners with threshold control, which are now found in 98% of practices, having increased from around 40% in 1987/88. There has been a remarkable increase in the penetration of fundus photography into community practices. As recently as 2001 they were to be found in only approximately 17% of practices, but this proportion had increased dramatically to approximately 66% in 2007 and further to 74% in 2013. Indirect evidence from Australia published in 2011, from a survey of management by optometrists of patients with diabetes, suggest that at least 55% of Australian optometrists use a fundus camera.[35] Results from the last two surveys suggest a levelling off in the proportion of practices with fundus cameras, which may reflect the corresponding increase in use of OCT and other more sophisticated imaging systems by community optometrists, who

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may be opting to purchase the newer imaging technologies rather than conventional fundus imaging. Interestingly, there may be evidence of a similar affect in the US, where the probability of a fundus photograph being taken by optometrists in glaucoma patients had also reached a plateau by 2009 while the probability of the patient undergoing ocular imaging (e.g. OCT, SLO) by optometrists had doubled between 2001 and 2009.[36] Some of the factors that have contributed to these trends in equipment usage will be discussed in the following sections.

### Changes in service provision

General Ophthalmic Services provision was essentially uniform across the UK until approximately 10 years ago. However, NHS restructuring, together with the introduction of devolved powers to Scotland and Wales, have led to the development of a greater diversity of provision, with an emphasis on a less prescriptive approach to primary eyecare. These changes are exemplified by the new GOS contract in Scotland, first introduced in 2006, and the Welsh Eye Care Initiative which commenced in 2003, and which has evolved into the Eye Health Examination Wales. All optometrists in Scotland who wished to provide GOS services and those in Wales who joined the Welsh Eye Care Initiative were obliged to provide services for which minimum standards of equipment were stipulated. In Scotland, under the new contract, NHS eye examinations are available to all individuals, not just those belonging to specified groups (i.e. all those over 60 years) as applies in the rest of the UK. Furthermore, the contract stipulates a revised fee structure which includes a fee for supplementary tests to review patients in certain clinical circumstances, notably to carry out Goldmann applanation tonometry, dilated fundus examination and threshold visual fields in glaucoma suspects. Funding was available from NHS Scotland to purchase the equipment needed to allow optometrists to meet the requirements of the new contract. Results from the current equipment survey reflect these GOS changes. The greatest increase in the use of Goldmann/Perkins tonometry was reported by respondents working in Scotland, rising from 29% in 2001[20] to 100% in the present survey, compared with 81% for the UK as a whole. A lesser increase in the use of Goldmann/Perkins tonometry was observed in optometrists working in Wales, rising from 70%[20] in 2001 to 100% in the present survey. A geographical variation across the UK was reported in the 2007 College of Optometrists Clinical Practice survey[17] where 42% of those who responded in London reported using applanation tonometry whereas in Scotland the equivalent figure was 97%.[37] The Welsh Eye Health Examination, and the PEARS schemes were introduced in 2003 under the Welsh Eye Care Initiative. The Welsh Eye Health Examination allowed predefined groups of patients considered at risk of eye disease to be eligible for a free eye examination. Optometrists providing Welsh Eye Health Examination and PEARS services are required to have a minimum standard of equipment, including contact tonometric devices.[38] Both the revised GOS services contract implemented in Scotland, and the Welsh PEARS/Welsh Eye Health Examination initiatives have been shown to be clinically effective, allow more patients to be retained in community practice, and avoid unnecessary referrals to secondary care.[38, 39]

Some variations between countries were observed for the use of specialist equipment. In particular, fewer respondents from England and Northern Ireland reported using Goldmann/Perkins tonometry, pachymetry and a goniolens than in Scotland. A greater proportion of optometrists working in Scotland reported using fundus photography than from any other country. No significant differences were observed between countries for the use of electronic record keeping and practice management software.

### Type of practice

Equipment uptake can be influenced by the practice type, and examples emerging from our study were variations in the use of autorefractors, NCT and OCT with practice type (*Figure 1*). Autorefraction was introduced in the late 1960s and has since become an integral part of many optometric examinations. In our survey 39% of practices used an autorefractor although, interestingly, autorefractor use is more common in Canada and the USA where they are used by over 75% of survey respondents.[40, 41] Notably, in the current survey a statistically significantly greater proportion of optometrists working in multiple/group practices reported use of an autorefractor, electronic clinical recording and computerized test charts when compared with independent practices. In contrast, contact tonometry and specialist diagnostic technologies such as OCT were more widely adopted in independent practices. These findings may reflect the centralized approach to equipment and IT purchase by multiple/group practices, with standardised items distributed across practices. Furthermore, the patterns of use of these devices may be governed by how eye examinations are delivered in multiple/group practices (e.g. multiple/group practices may be more likely to employ optical assistants to undertake autorefraction as part of their standard pre-screening examination).

### Involvement in enhanced and additional schemes for service provision

The publication of the Department of Health review of the GOS in England in 2007 provided another catalyst to change in the uptake of modern equipment and IT in com-


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munity optometric practice.[42] This review set out a three-tiered framework for the commissioning of primary care ophthalmic services. The first tier, or essential services which any eligible contractor must provide, includes the provision of NHS sight tests. The second tier includes additional services which all Primary Care Trusts had to commission, notably domiciliary services. However, it is the third tier, the enhanced services which Primary Care Trusts may choose to commission, that had the greatest potential to influence the equipment used in community optometric practice. Such services did exist pre-2007, for example a telephone survey undertaken in 2006 reported 14 community-based schemes for referral refinement or glaucoma monitoring[43] but since 2007 there has been a steady increase in the number of locally commissioned enhanced schemes. This increase has been facilitated by input from the Local Optical Committee Support Unit which has developed a series of pathways for common eye conditions delivering local eyecare services via Local Optical Committees across England. The extent of this expansion is exemplified by the fact that there was a total of 246 Local Optical Committee Support Unit enhanced schemes in England in July 2013.[44] Many other similar locally-led schemes are run in collaboration with eye hospitals. Enhanced schemes have included repeat measures schemes for glaucoma suspects,[37] ocular hypertension and glaucoma referral refinement schemes.[43, 45, 46] Schemes are not limited to glaucoma, however, and there are PEARS type schemes[47] and direct cataract referral schemes.[2, 48]

All these enhanced/additional service schemes act as potential drivers for practice development, including purchases of advanced equipment and IT. There are obvious advantages to be gained from standardising the equipment used in primary and secondary care clinics to allow more informed comparisons to be made between clinical baseline measurements captured by optometrists and subsequent examinations performed in the hospital setting. Enhanced or additional/separately contracted services were provided by 73% of our UK respondents. This figure is broadly comparable with those from a 2006 survey of US optometrists which reported 65% of their respondents involved in glaucoma, AMD and retinopathy co-management with an ophthalmologist, and 84% who were co-managing cataract and refractive surgery.[49] In the present survey, 30% of respondents reported involvement in glaucoma repeat measures schemes, with 22% involved in referral refinement schemes, and 12% in the monitoring of patients with ocular hypertension, suspect glaucoma or co-management of stable glaucoma in community practice. This exposure to enhanced schemes has led to an upgrade of equipment used by optometrists in practice, partly to meet the requirements of participation in schemes. A greater proportion of our UK respondents providing enhanced or additional/separately contracted services reported using specialist items of equipment (e.g. OCT, pachymetry and goniolens) than those who did not provide these services (*Figure 1*). Furthermore, optometrists increasing involvement in community-based referral refinement schemes[45] or working part-time in general glaucoma outpatient clinics[50] or in optometry-led glaucoma assessment clinics in which optometrists examine glaucoma patients[51, 52] exposes them to modern equipment for the detection of glaucoma which may encourage them to purchase similar equipment for use in their community practices.

### Changes to glaucoma case detection and the influence of the NICE guideline

Primary open angle glaucoma (POAG) and ocular hypertension (OHT) account for the largest proportion of review appointments in secondary ophthalmic care, with approximately one in four patients who attend outpatient clinics attending for glaucoma follow-up,[53] amounting in total to over 1 million outpatient visits per annum.[54] Optometrists are responsible for generating approximately 95% of referrals for suspected glaucoma and OHT for ophthalmological opinion.[55, 56] Community optometrists typically rely on a triad of tests for glaucoma case-finding, comprising assessment of the optic nerve head for structural changes, evaluation of functional visual field loss, and measurement of intraocular pressure.[57] Glaucoma case finding by optometrists presents a diagnostic challenge, as does monitoring for progression of glaucoma in secondary care. Many of the recent developments in equipment for ocular imaging, tonometry and perimetry have been driven by the need to improve glaucoma detection and management (e.g. SITA tests on the Humphrey Field Analyzer/HFA,[58] Henson suite of perimeters,[59] PASCAL Dynamic Contour Tonometer and Ocular Response Analyser tonometer.[60] Optometrists are also aware of the potential risks resulting from failure to detect cases of glaucoma, with glaucoma-related cases accounting for 30% of 50 consecutive clinico-legal cases involving optometrists reported in a study by Woodward in 2006.[61] One driver for equipment purchases by optometrists, including automated perimeters, tonometers, OCTs and pachymeters, has been the desire to protect the optometrist in any potential clinico-legal cases. This is supported by the 69% of respondents to the current survey who agreed or strongly agreed that adoption of specialist equipment could generate results which could be used as evidence in their defence should a case be taken against them.

The College of Optometrists publishes guidance for UK optometrists on the examination of patients at risk of glaucoma based on the standard triad of tests,[62] and the joint guidance from the College of Optometrists and Royal College of Ophthalmologists (2010) gives advice on when to

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refer, based on the results of these three tests together with the patient's age and van Herick estimation of anterior chamber depth.[1] There is evidence that the proportion of optometrists carrying out all three tests has increased in parallel with the increase in practices using this equipment revealed by *Table 1*. In a study of referrals from optometrists for suspected glaucoma published in 1999 only 15% of referrals contained results of all three standard tests.[63] A consistent increase in this proportion has been reported in recent studies e.g. 66% Lockwood *et al.*[64] and 77% Davey *et al.*[65] This increased use of modern equipment by optometrists might be expected to increase the quality of their glaucoma-related referrals. However, this is not necessarily the case, as Vernon reported in 1998, where an increase in those referrals for suspected glaucoma which included a visual field assessment from 28 to 48% over a 5-year period was associated with an increase in the false positive rate.[66] Similarly, Lockwood *et al.*[64] noted that although the number of optometrists carrying out a visual field test prior to referral for suspect glaucoma had increased greatly, the Positive Predictive Value (PPV) remained essentially unchanged. However, it should be noted that increasing the PPV above 40% will always be difficult for a disease with a prevalence as low as that of glaucoma whatever equipment is used.[57]

A survey of UK optometrists investigated barriers to glaucoma case finding.[67] Equipment issues was one of the four major barriers reported to glaucoma case finding, being noted by 23% of respondents from England, 27% from Scotland, 21% from Wales and 13% from Northern Ireland. It is perhaps surprising that equipment was more of an issue in Scotland than elsewhere, given the substantial equipment grants available in Scotland. However, Scottish optometrists were concerned more with the absence of more specialised items of equipment, such as pachymeters and gonioscopes, rather than equipment associated with the usual triad of tests for glaucoma. The current survey aimed to identify the equipment used in community practices but did not investigate specifically which items of equipment in the practice were usually employed in the investigation of either patients in general or specific groups of patients suspected of having a particular condition. This latter issue was the focus of another national survey by Myint *et al.*[4] who investigated the usual equipment optometrists would use in the investigation of a patient who was a glaucoma suspect. Although the current survey identified that Goldmann/Perkins tonometers (81%) and NCTs (88%) were used almost equally in practice (*Table 6*), when the question asked was a different one i.e. the usual method of tonometry carried out for a glaucoma suspect, the vast majority (78%) opted for the NCT with only 16% routinely using Goldmann or Perkins applanation tonometry.[4] It should be noted, however, that the Myint survey was conducted before the publication of the NICE guideline, which reinforces the place of GAT as the current clinical reference standard.[54] Despite this, in a post-NICE study of Glaucoma referrals to the NHS, Khan *et al.*[68] obtained a similar figure to Myint *et al.* for the use of NCT, which was the tonometer used in almost 75% of referrals.

The publication of the NICE Guidelines for 'Glaucoma diagnosis and management of chronic open angle glaucoma and ocular hypertension' in April 2009 was another important driver for the development of UK optometric practice. Notable features of the Guidelines were the validation of a role for optometrists that extended beyond the traditional activities of glaucoma case finding and detection, and provision of further guidelines for optometrists when not working under the supervision of a consultant ophthalmologist.[54] Although the Guidelines provided the possibility for optometrists to extend their traditional roles into, for example, the diagnosis of ocular hypertension and suspect glaucoma,[69] they also unintentionally led to an unprecedented increase in the number of glaucoma-related referrals.[22, 70] For many of these new roles validated by NICE it is essential that optometrists should be able to perform skills such as Goldmann applanation tonometry, gonioscopy and pachymetry. Interestingly, gonioscopy use by optometrists has remained relatively static at 15% compared with 12% in the Myint *et al.*[4] 2008 survey, while pachymetry use has more than doubled from 7 to 17%. This may reflect the increasing importance placed on central corneal thickness when interpreting IOP measurements[1] and the ease with which pachymetry can be included into a routine eye examination. Furthermore, the Ocular Hypertension Treatment Study has highlighted the importance of measuring central corneal thickness for the care of OHT, identifying it as a powerful predictor for the development of primary open angle glaucoma.[71] Increased use of pachymetry by optometrists is also reported in New Zealand where 43% of optometrists reported that the pachymeter was the item of specialist equipment they were likely to acquire in the next 5 years.[72] In 2011 the NICE Glaucoma quality standard was published and recommended that local agreements should be put in place for repeat measures and glaucoma referral refinement.[57] All these NICE-stimulated developments have contributed to increasing the number of optometrists working in both community enhanced schemes and in the UK Hospital Eye Service, with the potential impact on equipment purchase already discussed. Improvement in optometrists' equipment and clinical skills are benefits that have emerged from the NICE guidelines and related publications. Some patients may also have benefitted, with one study reporting increasing absolute numbers of patients detected with glaucoma, and more patients being diagnosed with early disease following the introduction of the NICE referral guidelines.[73]


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### Scope for enhanced diagnosis provided by use of OCT

Optical coherence tomography was first described by Huang in 1991 and this technique has many applications relevant to optometry, including the detection and monitoring of retinal and macular disease and glaucoma. OCT imaging has been established as a clinical diagnostic tool for the non-invasive detection of disorders of the macula and optic nerve that may be difficult to observe using conventional viewing techniques.[74] The upsurge in interest in OCT among UK community optometrists has seen a remarkable rise in its use from a very low base. OCT was available to only 2% of optometrists in a survey conducted in 2008,[4] however by 2013 the respondents in the present survey reported 15% of practices using OCT. Furthermore, OCT was by far the most popular item of specialist equipment that respondents anticipated purchasing within the next year (36/84 or 43%). Interestingly, practitioners who used OCT were also more likely to use other specialist equipment, and to provide enhanced or additionally/separately contracted services than those who did not use OCT. A feature of OCT is that the information derived from a cross-sectional OCT image of the macula may be used by optometrists to screen for early macular disease and, in particular, exudative AMD. OCT has been introduced into shared care schemes in the UK and favourable outcomes of a pilot UK teleophthalmology service based on OCT images have been reported.[75] In this study OCT images were captured by one community optometrist and the sample contained 50 patients with a range of retinal conditions. The quality of the images in every case was rated by the ophthalmologists to be at least as good as those recorded in the hospital. Teleophthalmology is an approach that can facilitate prompt responses and in this study the Hospital Eye Service ophthalmologists provided responses to the community optometrist or to the patient within the next day in 96% of cases. Notably, the ophthalmologists were content for more than one-third of the cases to be managed in community optometry, avoiding unnecessary referrals to secondary care. Fast-track referral services for exudative AMD are used by almost 50% of respondents in the current study, and there is enormous potential to introduce OCT into these schemes.

The rate at which the use of OCT in community optometric practice is increasing suggests it is possible that OCT may follow the example of fundus photography and eventually progress from being classified as an item of specialist equipment to become so widespread in community practices that it can be regarded as almost a standard item. Following the introduction of the fundus camera to clinical practice evidence soon emerged that posterior segment photography for evaluating and monitoring eye disease permits better documentation, study and monitoring of clinical features.[76–79] Early use of film imaging was rapidly superseded by digital imaging, affording the advantage of immediate analysis and facilitating easier storage of data. Optometrists became aware of these advantages and began to invest in fundus cameras from the 1990s onwards. By the time of the 2001 College of Optometrists survey approximately 17% of practices used a fundus camera, increasing to 74% in 2013. This rapid increase was partly due to some multiples/groups making the investment in fundus cameras in all their practices. Further impetus to the advance of fundus cameras came from the introduction in Scotland in April 2009 of NHS-funded digital fundus imaging for patients aged 60 years of age or older, with funding to assist with the purchase of this equipment, providing a further boost to the number of fundus cameras in UK practices.

Two other imaging technologies which can be used for the detection of glaucoma: the SLP (e.g. GDxPro) and SLO (e.g. Heidelberg Retina Tomograph (HRT)) have been used by community optometrists. In 2007 the SLP (GDx) and SLO (HRT) were available to 3% and 2% of optometrists respectively. Unlike OCT, neither SLP nor SLO have gained significant popularity among UK optometry since 2007. The diagnostic capabilities of specialist imaging for the detection of glaucoma have been extensively evaluated, but research establishing how these data can be integrated for use by optometrists is lacking. A literature search revealed a single study in which suprathreshold visual field assessment was substituted by the HRT II to evaluate the effect on glaucoma case-detection by optometrists. The authors did not observe an improvement in the ability of optometrists to correctly identify subjects with glaucoma using the advanced technology.[80] When our findings are compared with those of international surveys of optometrists, it is apparent that preferences for the use of specialist imaging differs widely between countries. In the United States, the SLO is the most popular specialist imaging technology, with almost one in two optometrists surveyed reporting owning this device,[41] while in New Zealand the SLO is the second most popular item of equipment that optometrists were most likely to acquire over the next 5 years.[72] In contrast, UK-based surveys between 2007 and 2013 indicate that only 2–4% of optometrists use a SLO in practice.[4, 17] Indirect evidence for the increased use of ocular imaging devices in US optometric practices emerges from a US analysis of diagnostic tests carried out on glaucoma patients and suspects. Comparing 2009 with 2001, the odds ratios of a glaucoma patient or a glaucoma suspect undergoing ocular imaging by an optometrist (method not stipulated) were 2.53 (CI 2.22–2.88) and 1.82 (CI 1.69–1.97) respectively.[36]

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### IT in optometric practice

There has been a significant move towards adoption of electronic patient record systems and practice management systems by UK optometrists, evident from the 80% of practices in the current survey with access to these systems. Clinical record keeping is a topic in the College of Optometrists 'Code of Ethics and Guidance for Professional Conduct'.[81] The guideline in Section A09 – *Patient records* states 'The optometrist has a duty to ensure that s/he keeps complete, contemporaneous and legible records of the patients under his/her care.' There are also contractual obligations as regards record keeping imposed on contractors under the GOS Terms of Service.[82] Electronic patient records undoubtedly facilitate the maintenance of legible records and easier storage of data. They also have potential for use as clinical guides by prompting the clinician to ask follow-up questions and perform tests based on the patient's presenting complaint. Among our sample, 39% of practices described themselves as 'paperless'. Previous UK data on paperless practices is lacking but data from the 2012 American Optometric Association survey gives a useful comparator. The American Optometric Association survey uses the term 'Complete electronic health records' to incorporate both electronic record cards and electronic patient management systems, and is taken by the authors to be equivalent to 'paperless' practice. Using this definition of paperless practice the proportion of paperless US practices was 49% in 2012 having increased from 41% in the previous American Optometric Association survey in 2011, with a marked increase from 2005 US data which estimated that only 5% of practices were paperless.[83] It is perhaps surprising that paperless practice is almost as common in the UK as the US, especially since government financial support for adopting electronic health records is provided in the US, together with the threat of penalties for non-compliance. Although there are benefits from electronic recording of patient data in eye care there are also challenges, for example electronic patient record systems are also required to accommodate the entry of clinical diagrams, which can be complex. In free-text survey responses from the current survey there were comments on the difficulty of drawing clinical features, using shorthand, or referring to previous recordings when using electronic patient records, with some respondents raising the suggestion of using an iPad to record notes.

Electronic transmission provides a more efficient means of transferring good quality data from automated perimetry and/or specialist diagnostic tests than paper copies. For optometric practice this is particularly relevant for referrals to secondary care. However, the vast majority of referral or notification letters are still generated using a standard or locally adapted form (e.g. GOS 18), with relatively few optometrists using electronic referrals when not part of an enhanced (locally commissioned) or separately contracted service. NHSmail is a secure national email and directory service available to all NHS staff in secondary care hospital units, and more recently to optometrists in Scotland. The system requires access to N3, the national network replacing the earlier NHSnet and approved for the secure transmission of patient data including referrals and reports. However, NHSmail was not widely used by optometrists in England, Wales and Northern Ireland at the time of the survey, possibly accounting for the low reported use of electronic referrals in our cohort (20%). Kelly *et al.*[75] note that the availability of NHSmail to the profession should be more widely publicised and adopted. The benefits of electronic referrals in optometry have been established. In a well-designed pilot study in Fife, the use of a direct electronic referral system, which included transfer of images from optometric practice followed by virtual review of the referrals by a consultant ophthalmologist, was shown to be safe, fast, efficient, and clinically accurate in most cases.[84] Notably, in this study 37% of unnecessary referrals to secondary care were avoided. This successful pilot scheme has been extended across the Fife region and has resulted in reductions in waiting times, in the number of unnecessary referrals, and reductions in patients failing to attend for their appointments which was attributed to the reduced waiting times.[15] Potential cost savings have also been demonstrated but establishing the cost-effectiveness of referral systems of this type is a complex health economics challenge as it is difficult to isolate savings attributed to the use of an electronic referral system alone. By including mandatory fields, standardised electronic referrals may also be used to improve the quality of referrals to secondary care (e.g. reporting on the triad of tests when glaucoma is suspected). The use of electronic medical records could develop into an electronic health record system in which all medical data are stored centrally. Electronic health records can improve the efficiency of healthcare by avoiding duplicate testing, and allowing all clinicians to access medical history that may be relevant to eye conditions.[85–87]

### Views and attitudes regarding equipment and IT

In general the responses given to survey statements which invited optometrists' views and attitudes regarding the use of specialist equipment were most positive. For example, 95% of optometrists 'agreed' or 'strongly agreed' that specialist equipment 'enhanced clinical assessment, providing a diagnostic tool to aid management and referral decision-making'. Similar views were obtained from both a recent survey in New Zealand in which 89% of optometrists reported improved patient care as a benefit of health IT and comparable findings (81%) emerged from a US sur-


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vey.[88] Using the same aggregation of results, a similarly high percentage (81–90%) of UK optometrists agreed that the use of specialist equipment permitted increased involvement in referral refinement and/or co-management schemes, and provided an opportunity to both promote the practice and build patient loyalty to the practice. However, the responses also highlighted the negative financial impact of purchasing and maintaining specialist equipment (77% agreed or strongly agreed), a trend which was observed throughout comments detailed in the free-text boxes. Eight respondents, seven from England and one from Northern Ireland, commented on the lack of adequate National Health Service (NHS) funding and fee provision for supplementary testing. One respondent stated that NHS fees 'bear no relation to the standard of examination provided by optometrists and the time taken', with another respondent commenting that 'England is falling behind Scotland and Wales'. Recouping equipment costs often requires patients to be charged for the use of specialist services, which a few respondents stated to be difficult when 'patients are not always willing to pay', particularly when other 'practices offer similar services free of charge'. Bosanquet[28] highlighted the situation in which NHS sight tests are only viable when subsidised by private patients who purchase spectacles and appliances. This was attributed to underfunding of sight tests in England and Wales, supported by evidence that overall expenditure on GOS has fallen in real terms since the 1950s, a situation not common to any other service provided across the NHS.[28] Concerns about costs are not limited to UK optometrists, as for optometrists in New Zealand costs was the second most commonly stated barrier to adoption of specialist equipment and IT.[72]

Interestingly, no statistically significant difference was observed between the proportions of respondents reporting financial issues as a barrier to the uptake of equipment in England and Scotland, which was perhaps surprising given the different modes of GOS provision which apply. This contrasts with Myint *et al.*'s 2011 study of barriers to detection of POAG in which, although financial issues was one of the four main barriers reported, significantly fewer optometrists in Scotland (34%) reported finance as a barrier than did their English counterparts (50%).[67] However, the barriers question regarding finance referred to practice finances in general and was not limited to equipment as in the current survey, so the higher GOS fees in Scotland could have influenced this 2011 finding. Optometry Scotland, which develops and represents the views of the entire optometry sector in Scotland, negotiated two equipment grants to the sum of £8000 per practice in 2006 and £10 000 per practice in 2008, plus a £1 million training grant.[89] In comparison, optometrists working in England and Wales do not receive funding for equipment, or payment for supplementary repeat testing from the NHS. Even though optometrists can charge patients additional fees for the use of specialist diagnostic equipment, the volume of patients may be insufficient to justify the initial and ongoing investment costs. Another current survey question which alluded to costs was the statement relating to operator training being 'inconvenient, time consuming and a drain on resources'. Responses were more equivocal to this statement than others regarding equipment, with one-third of respondents neither agreeing nor disagreeing. On balance there was more disagreement (42%) than agreement (25%) with this statement, suggesting that the impact of training to use equipment was not a major deterrent to equipment purchase in our sample.

A total of 69% of respondents agreed or strongly agreed that results from specialist equipment could be used as part of the optometrist's defence in any clinico-legal cases. There was minimal disagreement with this statement but 29% of optometrists took the neutral view ('neither agree nor disagree'). This could indicate doubt among these respondees as to whether results of some of these specialist tests would be admissible as evidence. A concern sometimes expressed regarding new specialist equipment is that it can replace existing core skills, thereby reducing the value of optometric qualifications e.g. the use of OCT by optometrists could over time replace assessment of the optic nerve head by ophthalmoscopy. There was little evidence to suggest this is a concern within our sample as only 10% agreed with a statement that core skills could be reduced by new equipment.

Views on statements relating to IT in optometric practice were more mixed. There was widespread agreement with the statements that adoption of IT facilitates administrative flow (79%) and creates the impression that the practice is more 'state of the art' (85%). There is probably an element of understandable practice self-interest here but if this is the case then it does not appear to be a purely UK phenomenon because in the New Zealand survey the vast majority (98%) of their respondents believed that health IT in their practices increased patient confidence that their practice was 'state-of-the-art'.[72] In the current study, enthusiasm was more guarded regarding the statement that IT 'enables secure exchange of health information between primary and secondary care' (with 47% agreement, 19% disagreement and 34% neutral), with the absence of a secure N3 network connection to the NHS being a possible contributory factor to this lack of agreement.

The major negative view on IT related to the need for frequent updates and technical support, a view which found agreement with 76% of respondents and with which only 5% disagreed. Technology updates were the major barrier to health IT adoption reported by optometrists in New Zealand.[72] There is clearly a willingness among UK

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optometrists to learn new IT skills, as evidenced by the minority (21%) of our sample who agreed that they found it inconvenient to learn new IT skills and to operate management systems or software tools.

There was little agreement over the statement that IT reduces the time taken to record information for a routine patient (37% agreed, 31% disagreed, with 31% taking the neutral position). This suggests that on average the time taken to record data for a routine optometric eye examination is probably fairly similar with each of the two methods, which is consistent with the finding in a time and motion study that there was no significant difference between the time taken for paper-based and electronic optometric record keeping.[90] The speed of ophthalmic documentation has also been observed to be slower for keyboard and mouse electronic strategies when compared with paper-based recording.[91] McVeigh *et al.*[10] compared the use of electronic health records and clinical automation with health IT advancements with traditional practice modes in an optometric clinic. No statistically significant difference was found between the automated and traditional modes for the authors' measure of efficiency, which was the time taken for different aspects of the patient journey. The transfer of paper records to an electronic file can in itself be a time-consuming and costly process, and this must be considered when weighing up the costs and benefits of IT in healthcare, as it is a cost which is additional to the initial high investment required for software programs. Responses were equally divided regarding the statements that (1) there is a greater risk of losing data with electronic records (35% agreed, 32% disagreed with 33% neutral) and (2) that there is a security risk associated with storage of confidential patient information online or on databases (32% agreed, 26% disagreed with 42% neutral). Free text comments noted that electronic data must be guarded against destruction, and viruses, with some clinicians fearing loss of data and the implications of complete failure (e.g. power loss) in a practice heavily reliant on IT for daily administration. Another emerging theme from the free-text response analysis ($n = 10$) was the issue of training optometrists to proficiently operate specialist equipment and IT, as well as training them to interpret the results correctly, with suggestions that optometric training institutions may need to make amendments to their curricula to address this training need. A survey by Stolee *et al.*[40] in Canada highlighted the feeling amongst some optometrists of being ill-prepared for the use of IT in practice. A further scoping exercise surveyed an academic staff and student group, including representatives from optometry, to determine whether IT training was adequate. Staff survey results suggested that clinical systems training was not necessarily available for many students in placements (where placements are roughly equivalent to the UK pre-registration period), and 61% of students asked for further training in IT systems during their higher education.[92] Recently qualified UK optometrists are expected to be more proficient with operating IT systems as basic IT skills are honed during education in early years, as well as during undergraduate training. One challenge faced by educationalists and the profession alike is that while an optometrist may be exposed to particular technologies during the course of their university training, this may not necessarily prepare them adequately for community practice, especially since a number of different electronic record keeping systems are used. Ongoing instrument-specific training is an inevitable requirement, particularly in practices where locum staff are employed to cover short-term absences or when trained non-optometric staff perform pre-screening duties. There is scope for optometry continuing education and training to target these training issues, particularly with regard to optometrists who qualified when the undergraduate curricula may not have covered these topics.

It has been argued that the use of electronic records could have a negative impact on patient-practitioner interaction and relations, and this statement was tested in the current survey with 25% in agreement, 42% disagreeing and one-third neutral. The potential risk is that entering examination results on a computer can interrupt eye contact with the patient and generally interrupt the flow of the examination to a greater extent than would occur with the traditional methods of entering data by hand into paper-based records. For three quarters of our sample this was not regarded as a concern but impairment of the patient-practitioner relationship has been reported in other surveys to be an issue associated with the use of electronic patient records.[72]

The generally positive views of optometrists regarding new equipment and the more guarded but still mainly positive attitudes to IT suggest a profession willing and able to embrace new technology and appreciate the benefits it can bring in both clinical and financial terms. As noted in the limitations section below, the nature of a survey on technology is that those most likely to respond are those with a particular enthusiasm for new technology. This could lead to a positive bias towards IT among our sample. We attempted to reduce this bias as much as possible by making the survey available in both paper form and online, to encourage those less technologically adept or with particular antipathy to new technologies to complete the survey on paper.

### Study limitations

This survey was distributed to a randomised group of registrants listed on the College of Optometrists' membership database in an effort to achieve a representative sample of


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optometrists practising in the UK. The survey response rate was 35%, surpassing our anticipated return based on experience from previous questionnaires. Optometrists who had either last worked in community practice more than 5 years prior to the survey date, or who had never worked in this capacity (e.g. hospital optometrists) did not complete the bulk of the survey and their results are not presented in this paper. However, they represented only 3.7% (16/432) of our response sample. While the demographic profile of respondents to our survey broadly reflects that of optometrists listed on the General Optical Council database in terms of gender and geographical distribution, the study findings should be considered in light of potential bias inherent in cross-sectional survey designs. One shortcoming is that respondents self-selected to participate and it is probable that optometrists motivated by an interest in ophthalmic instrumentation were more likely to complete the questionnaire, leading to a possible overestimation in the use of equipment/IT. Also, there is some evidence of sampling bias from the higher proportion of independent practices represented in the sample than in the UK as a whole.

Optometrists completing the survey were asked to respond based on equipment used in their practice and it is probable that a number of the 416 optometrists who responded may have been responding on behalf of the same practice. The anonymous nature of the survey makes it impossible to quantify this effect but the numbers affected are likely to be small and to have limited influence on the results or conclusions of the survey.

Shah *et al.*[93] noted that questionnaires are prone to sampling bias because more conscientious practitioners will be more likely to complete the questionnaire. They comment that another potential source of bias is that human nature may induce replies which will report higher standards of practice than may actually apply. There is evidence to support this view in the optometric domain from Theodossiades *et al.*[94], who discovered that self-reporting frequently overestimates routine tests undertaken in practice, notably for non-mandatory tests such as visual fields. This was established by comparing reported practice in an interview with optometrists with their actual practice, as determined by unannounced standardised patients. Further supporting evidence in the same study came from comparison of results of a national survey in which reported information included in referral letters did not correspond with information actually included in referral letters for tests other than IOP measurement.

## Conclusion

To our knowledge, this is the first snapshot of optometry practices in the UK to address the rationale behind the adoption of new technology, and to explore its impact on community practices. Optometrists in our survey sample are increasingly employing newer equipment and IT services to enhance patient care and for practice management. In particular, there was widespread adoption of anterior and posterior digital imaging, with interest in investment in newer technologies, notably OCT. The use of specialist equipment is inextricably linked with the need for IT to both collect and analyse clinical data. Optometrists appreciate the benefits of specialist equipment for enhancing clinical assessment and diagnosis, for allowing increased involvement in enhanced services, as evidence for the defence in optico-legal cases, in practice marketing and promotion of patient loyalty. The use of IT facilitates administrative flow and helps to project a state-of-the-art image of the practice. Financial issues remain the main barrier to use of equipment and IT. Questions remain as to whether investment in equipment and IT is cost-effective, how it may be best used for community optometric practice, and whether optometrists are trained sufficiently to use these new services?

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## Disclosures

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** Dabasia PL, Edgar DF, Garway-Heath DF & Lawrenson JG. Survey of Equipment and Eye Care. 2014.

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