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# Service innovation in glaucoma management: using a web-based electronic patient record to facilitate virtual specialist supervision of a shared care glaucoma programme

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## ABSTRACT

**Aim** To assess the importance of specialist supervision in a new model of glaucoma service delivery.

**Methods** An optometrist supported by three technicians managed each glaucoma clinic. Patients underwent testing and clinical examination before the optometrist triaged them into one of five groups: 'normal', 'stable', 'low risk', 'unstable' and 'high risk'. Patient data were uploaded to an electronic medical record to facilitate virtual review by a glaucoma specialist.

**Results** 24 257 glaucoma reviews at three glaucoma clinics during a 31-month period were analysed. The clinic optometrists and glaucoma specialists had substantial agreement ( $\kappa$  0.69). 13 patients were identified to be high risk by the glaucoma specialist that had not been identified as such by the optometrist. Glaucoma specialists amended 13% of the optometrists' interim decisions resulting in an overall reduction in review appointments by 2.4%.

**Conclusions** Employing technicians and optometrists to triage glaucoma patients into groups defined by risk of blindness allows higher risk patients to be directed to a glaucoma specialist. Virtual review allows the glaucoma specialist to remain in overall control while reducing the risk that patients are treated or followed-up unnecessarily. Demand for glaucoma appointments can be reduced allowing scarce medical resources to be directed to patients most in need.

## INTRODUCTION

The United Kingdom Hospital Eye Service (HES) is responsible for diagnosing and managing glaucoma including ocular hypertension and glaucoma-suspects. Due to an ageing population, earlier detection of cases and new referral recommendations from the National Institute for Health and Care Excellence,<sup>1</sup> there has been a dramatic increase in the number of patients requiring review. This is a pattern that will further increase as the population ages. There are about 1.2 million glaucoma patients in England who require approximately 2.4 million review appointments per annum.<sup>2</sup> An additional 500 000 patients are likely to be brought into the system within the next few years (JM Sparrow, personal communication, 2011).

HES glaucoma departments are struggling to review glaucoma patients at their planned interval, as demonstrated by an alert from the National Patient Safety Association, suggesting that patients

have come to harm because their glaucoma review appointments were delayed.<sup>3</sup> In an attempt to cope with the increasing workload, several HES glaucoma departments have outsourced review of their patients to community optometrists.<sup>4</sup> Appropriately trained optometrists have previously been shown to safely assess glaucoma patients.<sup>5–7</sup> Three potential concerns with such a system are: (1) failure to identify at-risk patients who require urgent attention for life or sight threatening complications, (2) over-treatment of patients who do not have glaucoma and (3) there is anecdotal evidence that optometrists may have a more conservative approach to review appointments; which could result in overservicing of patients and an increase in demand on an already stretched service. We look at the role of glaucoma specialist virtual-supervision of community-based optometrists.

In summer 2007, the Bristol Eye Hospital (BEH) invited a private company (Newmedica) to review a backlog of 4000 glaucoma patients who were overdue for their review appointment (by up to 2 years). Newmedica provided optometrists, technicians, equipment and support infrastructure. Patients were recruited from the general follow-up pool and were not 'cherry-picked' to exclude complex patients. All clinical data including history, examination findings, visual fields and colour optic disc images were uploaded to a web-based electronic patient record (EPR) (EMMA, New Medical Systems, London, UK). The clinic was initially run within the BEH precinct but was subsequently re-engineered to run from a mobile unit sited in the community. The clinic continued to function after the initial 4000 patients were seen and additional clinics were established in other centres including Nuneaton and Kingston.

The optometrist assessing the patient categorised them according to a five-step glaucoma management algorithm. The algorithm was designed after consultation between three senior glaucoma consultants to differentiate between patients with glaucoma of varying degrees of severity (figure 1):

1. 'Normal', with no evidence of glaucoma (to be discharged).
2. 'Stable', glaucoma with a low risk of lifetime blindness (to be reviewed in 12 months).
3. 'Low risk', stable glaucoma with a moderate risk of lifetime blindness (to be reviewed 6 months).
4. 'Unstable' glaucoma (requiring prompt evaluation by a glaucoma specialist within 6 weeks).



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A NORMAL	B STABLE	C LOW RISK	D UNSTABLE	E HIGH RISK
<p>A normal patient who has no strong evidence of glaucoma at present</p> <p>Glaucoma suspects on the basis of two or more unreliable visual fields but with no other signs, nor high-risk factors for glaucoma</p> <p>Glaucoma suspects on the basis of mildly suspicious optic nerve heads but with no other signs, nor high-risk factors for glaucoma</p> <ul style="list-style-type: none"> <li>Including those patients who have not experienced any change in optic nerve appearance over a two year period when compared to baseline optic disc images</li> </ul> <p>Mild ocular hypertensive patients (not on treatment) with no other signs, nor high-risk factors for glaucoma</p> <ul style="list-style-type: none"> <li>Including individuals who have been observed for two years because of mild elevation of intraocular pressure in whom the IOP has not exceeded 25mmHg on any occasion (except for patients where the CCT is less than 555 micrometers)</li> </ul>	<p>A stable glaucoma patient at low risk of significant visual loss during their lifetime</p> <p>Individuals with ocular hypertension (not including those listed as Normal above)</p> <ul style="list-style-type: none"> <li>Ocular hypertensive patients who are on medical treatment</li> <li>Ocular hypertensive patients who are not on treatment but are being observed for development of glaucoma</li> </ul> <p>Glaucoma suspects (not including those listed as Normal above)</p> <p>Glaucoma patients where the IOP is controlled</p> <ul style="list-style-type: none"> <li>Where the IOP is below the 'target' level</li> <li>Where a target IOP is not identified this will be an IOP below 21 mmHg</li> </ul> <p>Glaucoma patients where visual field loss is mild and stable</p> <ul style="list-style-type: none"> <li>The visual field loss is &lt; -10 dB</li> <li>Where a reliable visual field defect has not changed by &gt; 5 dB</li> </ul> <p>Glaucoma patients where central vision is not threatened</p> <ul style="list-style-type: none"> <li>Where no new spots of field defect (at the 5% level) have appeared within 5 degrees of fixation</li> <li>All para-central points (within 5 degrees) have a total deviation of &lt; -10 dB</li> </ul> <p>Glaucoma patients where the optic nerve head is thought to be stable when compared to previous optic disc images</p>	<p>A stable glaucoma patient who may be at some risk of significant visual loss during their lifetime</p> <p>Glaucoma patients aged under 70 years</p> <p>Glaucoma patients with a visual acuity of 0.5 (6/12) or worse in their better eye</p> <p>Glaucoma patients with worse than -10 dB defects in either eye</p> <p>Glaucoma patients where central vision may be threatened</p> <ul style="list-style-type: none"> <li>Where one or more para-central (within 5 degrees) spots have a total deviation of -11 dB or worse</li> <li>Where one new spot of field defect (at the 5% level) has appeared within 5 degrees of fixation</li> </ul>	<p>An unstable patient who is at risk of significant visual loss (from glaucoma or another condition)</p> <p>Glaucoma patients where the IOP is not controlled</p> <ul style="list-style-type: none"> <li>Where the IOP is over the target level</li> <li>Where a target IOP is not specified this shall be an IOP over 21 mmHg</li> </ul> <p>Glaucoma patients where the visual field loss is progressing</p> <ul style="list-style-type: none"> <li>Where a reliable mean deviation has changed by &gt; -5 dB</li> </ul> <p>Glaucoma patients where central vision is threatened</p> <ul style="list-style-type: none"> <li>Where two or more new spots of visual field defect (at the 5% level) have appeared within 5 degrees of fixation</li> </ul> <p>Glaucoma patients where the optic disc cup is thought to be progressing when compared to previous optic disc images</p> <p>Other problems which merit early review from an ophthalmologist include:</p> <ul style="list-style-type: none"> <li>Where the best corrected visual acuity has deteriorated by two or more Snellen lines</li> <li>Where there are significant local or systemic complications from glaucoma medications</li> <li>Where other ocular pathology is a cause for concern</li> <li>Where the Glaucoma Monitoring Service optometrist is concerned for any other reason not defined above</li> </ul>	<p>A patient deemed to need urgent medical review</p> <p>Glaucoma patients where the IOP is very poorly controlled</p> <ul style="list-style-type: none"> <li>Where the IOP is &gt; 35 mmHg</li> </ul> <p>Glaucoma patients where there is actual or incipient angle closure</p> <ul style="list-style-type: none"> <li>Where the anterior chamber angle is thought to be closed or in imminent danger of closing – phakic eyes without iridotomy with an angle measured at less than one (Van Herick)</li> </ul> <p>Patients where there is any other condition deemed to be an emergency by the Glaucoma Monitoring Service optometrist</p> <ul style="list-style-type: none"> <li>Eg wet macular degeneration, retinal break or detachment, vascular occlusion etc</li> </ul>
DISCHARGE	ANNUAL REVIEW	ROUTINE REVIEW	EARLY MEDICAL REVIEW	EMERGENCY REVIEW
N/A	12 MONTHS	6 MONTHS	6 WEEKS	24 HOURS

Figure 1 Five-step glaucoma management algorithm.

5. 'High-risk' glaucoma (requiring urgent assessment by a glaucoma specialist within 24 h).

The clinical information was uploaded to a web-based EPR. Within 1 week of the clinic appointment, a glaucoma specialist would perform a virtual review by accessing the EPR over the internet. Patients were advised that the interim outcome might change after a glaucoma specialist reviewed their clinical data. After reviewing all the clinical data, the specialist would either confirm the optometrists' interim outcome or change it if clinically indicated (Figure 2).

Virtual review represents a new model of care in which optometrists manage patients within the community and receive online supervision from glaucoma specialists. We assessed the correlation between optometrist and glaucoma specialist to determine whether this extra level of review is required. During development of the model, it was argued that glaucoma specialist supervision would be important in two main areas. (1) Safety: by identifying high-risk patients who might be missed by the optometrist. (2) Efficiency: by re-evaluating the diagnostic category of a patient and decreasing the number of unnecessary review appointments generated. We evaluated data collected over a 31-month period to determine if this was indeed the case.

## MATERIALS AND METHODS

We collected data from 1 September 2010 to 28 March 2013 from Bristol, Nuneaton and Kingston. For all visits to the mobile clinic optometrist during this period, the category assigned by the optometrist and that assigned by the glaucoma specialist in the virtual review clinic were entered into SPSS V21. Ophthalmologists were aware of the category assigned by the optometrist when they made their decision. Mobile clinical units would generally see about 20 patients in a half-day

session. Ophthalmologists review electronic records at a rate of approximately 15–20 per hour.

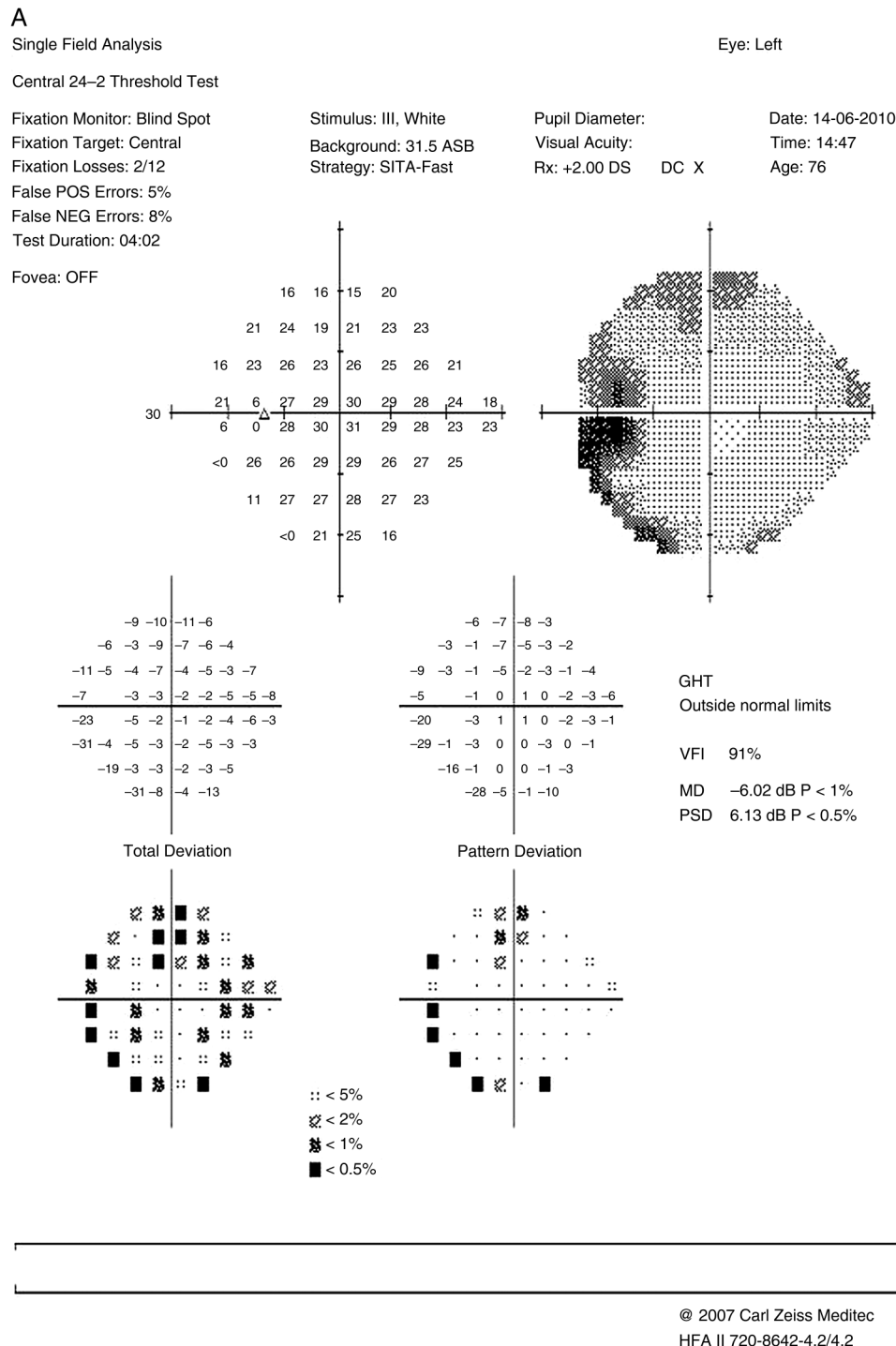
Kappa coefficient was used to measure inter-observer agreement between the category assigned by the optometrist and that assigned by the glaucoma specialist. All patients who were considered high risk were assessed to determine if there was a safety issue with optometrists missing potential sight threatening cases. Finally, we compared the number of visits generated by optometrists grading as opposed to the number of visits generated by glaucoma specialist grading. This was an audit of a programme that is currently delivering routine patient care. No identifiable patient data were collected; therefore, ethics approval was not required.

## RESULTS

Data were analysed for all patients seen in clinics in Bristol, Nuneaton and Kingston during the study period. A total of 24 257 patient assessments were performed. The category assigned by the optometrist and that assigned by the glaucoma specialist are shown in table 1. The kappa statistic for inter-observer agreement was 0.69. There was agreement on 19 542 (87%) of occasions and disagreement on 4715 (13%) of occasions.

The virtual review process identified 13 patients who were deemed high risk by the glaucoma specialist but not by the optometrist; 5 of these patients had been categorised as low risk by the optometrist.

Glaucoma specialists tended to classify patients into less urgent categories reducing the number of review appointments required. Overall, 378 patients who were thought to have glaucoma by the optometrist were said to be normal by the glaucoma specialist and discharged from the system. In all, 3084 patients were classified into less severe categories by the



**Figure 2** Examples of visual field defects which could be classified as 'stable' and 'low risk'.

specialist and 1631 were classified into a more urgent category. The more conservative categorisation created by the glaucoma specialist reduced the number of additional visits that may have been required by 1248 or 2.4% of the total number of visits (table 2).

## DISCUSSION

Healthcare spending in the UK will fall in real terms over the next several years and glaucoma specialists will need to provide more care with less money. To achieve this and continue to deliver high quality care to glaucoma patients, new models of

care will be required. One such model is described herein and uses an internet-based virtual clinic to enable a glaucoma specialist to review all the clinical information and confirm or alter the interim clinical decision made by the assessing optometrist. We analysed the inter-observer agreement between optometrists and glaucoma specialist to determine if this specialist supervision provided an additional benefit to community-based optometrist assessment alone. There was substantial agreement between each group as represented by a Kappa statistic of 0.69.

Ensuring patient safety is a critical consideration in the development of any new model of care. We assessed patient safety by

## B

Single Field Analysis

Eye: Right

Central 24-2 Threshold Test

Fixation Monitor: Blind Spot

Fixation Target: Central

Fixation Losses: 11/13 xx

False POS Errors: 4%

False NEG Errors: 0%

Test Duration: 05:56

Fovea: OFF

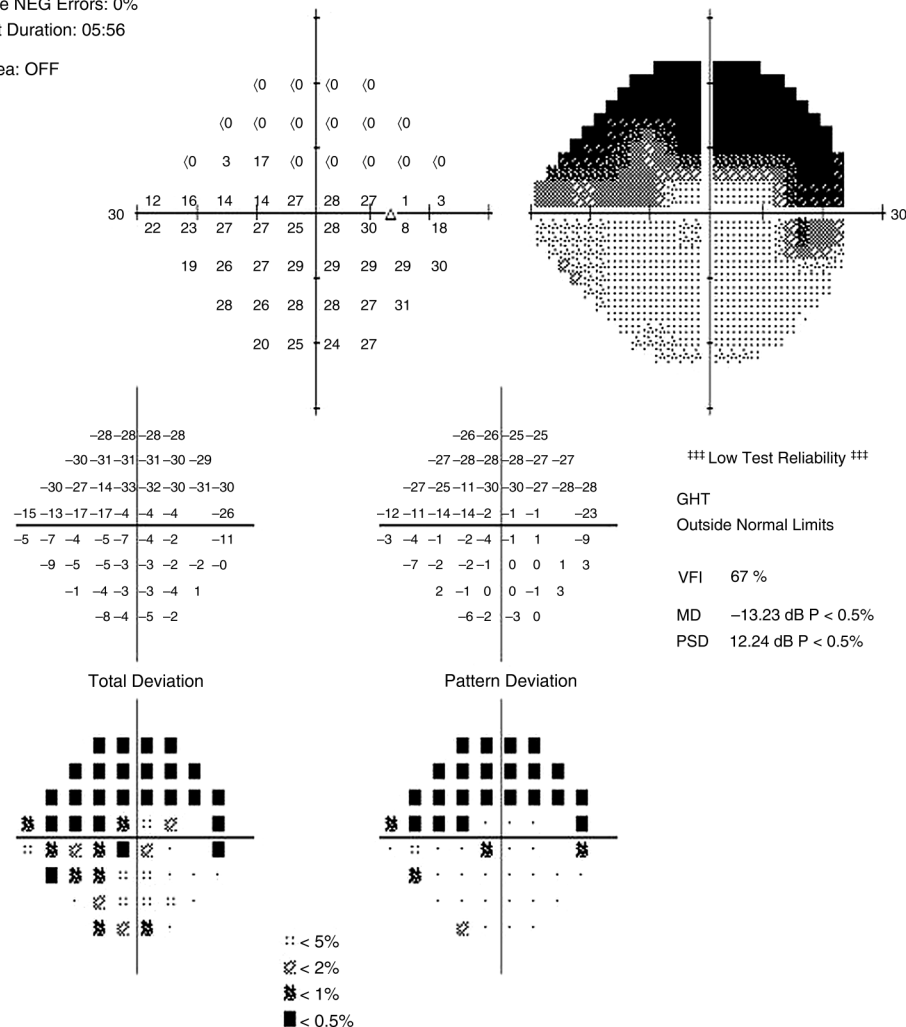
Stimulus: III, White  
Background: 31.5 ASB  
Strategy: SITA-FastPupil Diameter:  
Visual Acuity:  
Rx: +4.00 DS DC XDate: 21-08-2014  
Time: 09:07  
Age: 70© 2010 Carl Zeiss Meditec  
HFA II 720-40820-5.1.2/5.1.2

Figure 2 Continued.

determining if any high-risk patients were identified by the glaucoma specialist who had not been identified as high risk by the assessing optometrist. While there were only a small number of high-risk patients missed by the optometrist (13), each of these clinical situations can potentially result in a missed opportunity to prevent blindness and this is a benefit that must not be underestimated, particularly if public confidence in the system is to be maintained. With any novel health intervention, patient safety is paramount; these data demonstrate that consultant supervision catches a relatively large number of patients who were underdiagnosed by the optometrist. In all, 15% of patients diagnosed as normal by an optometrist were actually found to have

glaucoma (94 of 625) and a similar number (13.5% 691 of 5120) of patients who were said to be stable by the optometrist were actually considered to be at higher risk after ophthalmic review. However, potentially the greatest risk to patient safety was the 6.5% (838 of 12 892) of patients thought to be low risk by the optometrist who were actually found to be unstable and thus requiring a clinical review within 6 weeks. Delay in these patients seeking a prompt face-to-face consultation with a glaucoma specialist could result in delayed treatment and unnecessary loss of vision.

The purpose of outsourcing is to streamline clinics and maximise the quality of care that can be delivered within an inelastic



**Table 1** Data relating to interim diagnostic category (after the patients had been classified by the optometrist) and final diagnostic category (after the patient data has been re-evaluated by a consultant in the 'virtual clinic')

Assigned categories						
	Glaucoma specialist					
Count	Normal	Stable	Low risk	Unstable	High risk	Total
Optometrist						
Normal	531	49	28	17	0	625
Stable	267	4162	542	149	0	5120
Low risk	90	1303	10 661	833	5	12 892
Unstable	21	66	1334	4067	8	5496
High risk	0	0	0	3	121	124
Total	909	5580	12 565	5069	134	24 257

budget. An important part of this involves reviewing patients at intervals appropriate to their risk of blindness. There was an understandable tendency among optometrists to be 'risk-averse' and to review patients more frequently than was thought necessary by glaucoma specialists.

Table 2 shows data pertaining to the total number of annual review appointments required based upon the assumption that 'normal' patients are discharged, that 'stable' patients are seen once per annum, 'low-risk' patients are seen twice per annum and 'unstable' patients seen four times per annum. It can be seen that the virtual review process reduces the overall number of patient review appointments per annum.

By identifying this overservicing and reducing the overall number of reviews by 2.4%, glaucoma specialists created an additional cost saving into the programme. A reduction of 2.4% in reviews extrapolated to 2.4 million glaucoma attendances throughout England equates to 57 600 fewer glaucoma review appointments per year and a saving to the National Health Service (NHS) of nearly £3 million (assuming a net additional cost of about £50 per appointment and including cost of the virtual review). However, it must be noted that this study does not include a cost-benefit analysis and no comment can be made about the cost-benefit of a virtual glaucoma clinic compared with traditional in-hospital care.

This study has several limitations. It was a retrospective analysis of an operational programme that has been running in the Bristol region and elsewhere for 6 years and therefore selection of patients was not controlled. Data therefore may not be applicable

to other populations. However, it does suggest that virtual clinics conducted over the internet by glaucoma specialists are an important safety oversight where community optometrists may otherwise be managing glaucoma patients in isolation. Furthermore, such virtual clinics potentially cut the cost of delivering glaucoma care in the community by reducing the number of unnecessary review visits. The model described optimises use of resources by using technicians to collect data and optometrists to triage patients before directing only those patients deemed at-risk of visual loss to be seen by specialist medical staff within the hospital. We see this model as an important tool in the delivery of glaucoma care in much the same way that diabetic screening services have evolved to screen for diabetic retinopathy, allowing only those at high risk to be referred for specialist consultation within the HES.

This is the first publication on a novel approach to dealing with the very large number of glaucoma patients that threaten to swamp the NHS. We have suggested that virtual supervision is an appropriate and cost effective part of such a service innovation. Ophthalmic supervision of optometrists provides a useful feedback loop that can assist the optometrist to develop their clinical skills. We have preliminary data that suggest an increase in the kappa score over time as optometrists improve their skills. Further questions need to be addressed in order to maximise cost and resource efficiency. Is the ophthalmic supervision required once optometrists reach a certain level? Are optometrists required or can technicians upload the data for ophthalmic review? Can we use more modern progression analysis software to improve detection of patients who are deteriorating? Can this system be transferred to developing regions where there is a shortage of eye care professionals?

**Correction notice** This article has been corrected since it was published Online First. A new version of Figure 2 has been used.

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**Contributors** HRW contributed to the analysis of data and writing of the paper. JPD contributed to collection and analysis of data and writing of paper.

**Competing interests** JPD is a director of New Medical Systems (Newmedica).

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**Table 2** Number of review appointments required per year based upon one appointment per annum for 'stable' patients, two appointments for 'low-risk' patients and four appointments for 'unstable' patients

Reviews generated				
Category	Optometrist		Ophthalmologist	
	Number seen	Reviews	Number seen	Reviews
Normal	625	0	909	0
Stable	5120	5120	5580	5580
Low risk	12 892	25 784	12 565	25 784
Unstable	5496	21 984	5069	20 276
High risk	124	0	134	0
Total reviews		52 888		51 640

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