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Evaluating the cost and wait-times of a task-sharing model of care for diabetic eye care: a case study from Australia

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ABSTRACT

Objectives To determine whether a collaborative model of care that uses task-sharing for the management of low-risk diabetic retinopathy, Community Eye Care (C-EYE-C), can improve access to care and better use resources, compared with hospital-based care.

Design Retrospective audit of medical and financial records to compare two models of care.

Setting A large, urban tertiary Australian publicly funded hospital.

Intervention C-EYE-C is a collaborative care model, involving community-based optometrist assessment and 'virtual review' by ophthalmologists to manage low-risk patients. The C-EYE-C model of care was implemented from January to October 2017.

Participants New low-risk patient referrals with diabetes received at a tertiary hospital ophthalmology unit.

Primary and secondary outcomes Historical standard hospital care was compared with C-EYE-C for attendance, wait-times, outcomes and costs. Clinical concordance between the optometrist and ophthalmologist diagnosis and management was assessed using weighted kappa statistic.

Results There were 133 new low-risk referrals, managed in standard hospital care (n=68) and C-EYE-C (n=65). Attendance rates were similar between the models of care (72.1% hospital vs 67.7% C-EYE-C, p=0.71). C-EYE-C had shorter appointment wait-time (53 vs 118 days, p<0.01). In the C-EYE-C model of care, 68.2% of patients did not require hospital appointments and costs were 43% less than hospital care. There was substantial agreement between optometrists and ophthalmologists for diagnosis (κ=0.64, CI 0.47–0.81) and management (κ=0.66, CI 0.45–0.87).

Conclusion This Australian study showed that collaborative eye care resulted in reduced patient waiting times and considerable cost-savings, while maintaining a high standard of patient care compared with traditional hospital-based care in the management of low-risk hospital referrals with diabetic eye disease. The improved access and reduced costs were largely the result of better task allocation through greater utilisation of primary eye care professionals to provide services for low-risk patients. Better resource use may free up further resources for other eye care services.

Strengths and limitations of this study

- This is the first Australian study to assess the relative costs of collaborative care pathways compared with standard hospital pathways for the management of low-risk diabetic retinopathy.
- An observational pre-post design was used as randomising patients to the different care pathways was not possible since the models of care were implemented over consecutive time periods in real world complex healthcare settings.
- Generalisability to other contexts may be limited since this case study was based in one hospital and one jurisdiction of Australia.
- Sensitivity analyses demonstrated the robustness of findings to variations in key parameters lending support for broader interpretation to inform further implementation of the model of care.
- More research is needed to investigate the longer-term health and service outcomes of this model of care, such as disease progression, hospital avoidance and the longer-term associated costs for patients.

INTRODUCTION

Diabetic retinopathy (DR) is a chronic eye disease affecting 35% of people diagnosed with diabetes mellitus[1] and is a leading cause of vision loss globally.[2] The global burden of diabetes is rising rapidly with projections of prevalence rates in 2030 (366 million) to be around two times those reported in 2000 (171 million).[3] The rising prevalence is further compounded by the growing proportion of people aged over 65 years[3] who are also at greater risk of developing chronic conditions, including chronic eye diseases: glaucoma and cataract.[4 5]

The increasing pressure ageing populations will place on health systems globally in coming decades is a widely recognised concern, as is the scope and need for improved organisation and coordination of services to cater for these demographic changes.[6] One strategy

to improve efficiency and reduce costs is to increase the utilisation of non-medical or primary healthcare professionals through task-sharing of services designated for specialty care (often referred to as community, collaborative, shared care or task-sharing approaches).[7 8] In the eye care sector, the need for such workload allocation and task-sharing has been highlighted by the fact that there is a significant shortfall of ophthalmologists that are required to service growing population needs and long hospital wait lists reported in developed nations across the world, including Australia.[9–12]

Improvements in ocular imaging technology (such as retinal photography and optical coherence tomography (OCT)) over the past decade have greatly facilitated collaborative eye care approaches through the field of telemedicine. This is where imaging can be captured remotely by non-specialist staff and transmitted to an eye care specialist for virtual review. For diabetic eye care, such collaborative care models can be used to enhance eye care delivery in two major ways. One is to increase the rate and coverage of diabetic screening in a population. This would improve early detection rates which would in turn lead to improved management and reduce preventable vision loss.[13] Additionally, collaborative care could be used by specialists for referral refinement schemes, where patients on specialist wait lists who could alternatively be managed by their primary eye or healthcare provider, are identified and redirected to community providers. These schemes could free up specialist appointments and reduce wait-times for those more in need of specialist or hospital care and offer potential cost and time savings for both the patient and the tertiary care centre.

There have been a number of studies reporting the benefits of using telemedicine or collaborative care to screen populations for DR,[13 14] and a more recent study has demonstrated that collaborative care models can be used in the Australian setting to assist hospitals to improve efficiencies and reduce costs for existing referral wait lists for low-risk glaucoma.[15] However, there have been relatively few reports to quantify ways in which such collaborative care models would perform for DR.

This study aimed to determine whether task sharing through a new collaborative care model in Australia (Community Eye Care/C-EYE-C)[16] could improve efficiency and reduce costs compared with a traditional hospital-based model in the management of low-risk hospital referrals with diabetic eye disease.

METHODS

This study was conducted at Westmead Hospital Eye Clinic, an urban publicly funded hospital ophthalmology outpatient department located in western Sydney, Australia. It is governed by the Western Sydney Local Health District which is funded by the jurisdictional (State) government. In Australia, patients with diabetes can access subsidised eye care through their primary care providers and funded through the government's Medicare Benefits Scheme. Optometrists may conduct a comprehensive dilated eye examination with retinal photography, whereas general practitioners (GPs) may conduct a more basic screening, with or without non-mydriatic retinal photography. Access to tertiary care (ophthalmologist) for management and treatment is based on clinical indication as set out in the national guidelines for management of DR,[17] and requires a referral, usually initiated primary care following a screening. At the beginning of 2017, the Westmead Hospital Eye Clinic introduced a collaborative eye care model of care, called (C-EYE-C, which altered the standard hospital care pathway for patients with low-risk DR.[16]

The study sample was patients attending ophthalmology services from 2016 to 2017 to cover periods of care before and after the C-EYE-C model of care was introduced. The different models of care are described in detail later.

Participants in this study were identified through a consecutive, retrospective review of the hospital referral log for new patients who were referred to the ophthalmology outpatient department for diabetic review by primary care or other eye care providers. Referrals which identified the patients to be at low-risk or have low-level DR were eligible for inclusion in the study. Table 1 summarises the referral clinical inclusion and exclusion criteria. Criteria were based on the risk level appropriate for co-management by optometrists as described in national guidelines[17] and consultation with local optometrists, ophthalmologists, GPs, ophthalmic nurses, policy makers and health managers.[16] Those not meeting the study inclusion criteria or declining a scheduled appointment (hospital or community) were excluded from this retrospective study.

Since the model of care was implemented in real-life hospital settings, there was a period of transition where referrals were being allocated to both models of care simultaneously while C-EYE-C was being introduced and while processes were under development. Therefore, the analytic dataset was a subsample of referrals allocated to each model of care to compare the referred patients. They were defined by the time period in which the referral was received (figure 1). Referrals to C-EYE-C during the transition period (starting with a few referrals in April 2016) were excluded to ensure that measurement of wait-time was not impacted by the delayed start of C-EYE-C which commenced operation in January 2017. By April 2017, C-EYE-C had completely superseded standard hospital care for eligible patients. The study analysis periods were also seasonally matched to ensure that referral volume or appointment wait-times were not impacted by the reduced services which occur over holiday periods. Therefore, a total of 131 referrals were excluded from the analysis. Details of the included referrals and each model of care are detailed below.

Model A: standard hospital care

For referrals received between April 2016 and September 2016, patients received the standard hospital

Table 1 Study clinical inclusion and exclusion criteria for new referrals with low-risk diabetes

Clinical criteria	Diabetes
Inclusion	► No retinopathy (diabetic screening) ► Mild non-proliferative diabetic retinopathy—microaneurysms only AND good vision (6/9 or better) ► Moderate non-proliferative diabetic retinopathy—microaneurysms and mild retinal pathology, for example, haemorrhages, cotton wool spots AND good vision (6/9 or better)
Exclusion	► Diabetic macular oedema or clinically significant macular oedema (new hard exudates) ► Severe non-proliferative diabetic retinopathy—numerous microaneurysms, haemorrhages, reduced vision. ► Proliferative diabetic retinopathy—abnormal vascular proliferation is seen in one or more sites; iris, optic or elsewhere ► Vitreous haemorrhage, pre-retinal haemorrhage, severe retinal haemorrhage ► Vision worse than 6/9 without clear reason, for example, cataract
Additional exclusion criteria	► Patients requiring interpretation services ► Justice health patients ► Patients ineligible for Medicare*, such as non-residents ► Patients with known infectious disease, for example, tuberculosis ► Patients unable to cooperate, for example, dementia ► Hospital inpatients ► Patients <16 years of age

*Medicare is Australia's universal healthcare scheme which covers all Australian residents for public healthcare services. It includes cover for eye examinations by optometrists and was the funding model used by optometrists for Community Eye Care examinations. Patient's ineligible for Medicare would continue to be seen at as private patient in the public hospital system.

ophthalmology outpatient clinic model of care. Standard hospital care is the traditional care pathway which is delivered at the hospital outpatient clinic by an ophthalmologist with support from nurses and orthoptists. Patients in this model of care were allocated a hospital appointment between April 2016 and September 2017.

Model B: C-EYE-C

All referrals received between April 2017 and October 2017 were booked for a C-EYE-C appointment. Patient appointments for these referrals were attended from June 2017 to November 2017.

In the C-EYE-C model,[16] preliminary assessment and diagnosis were conducted at two community-based optometry practices within the Local Health District. The participating optometrists completed the examination, retinal imaging after 0.5% mydriacyl dilation with two field retinal photography of each eye (Zeiss Visucam, Zeiss, Germany) and OCT (Cirrhus, Zeiss, Germany),

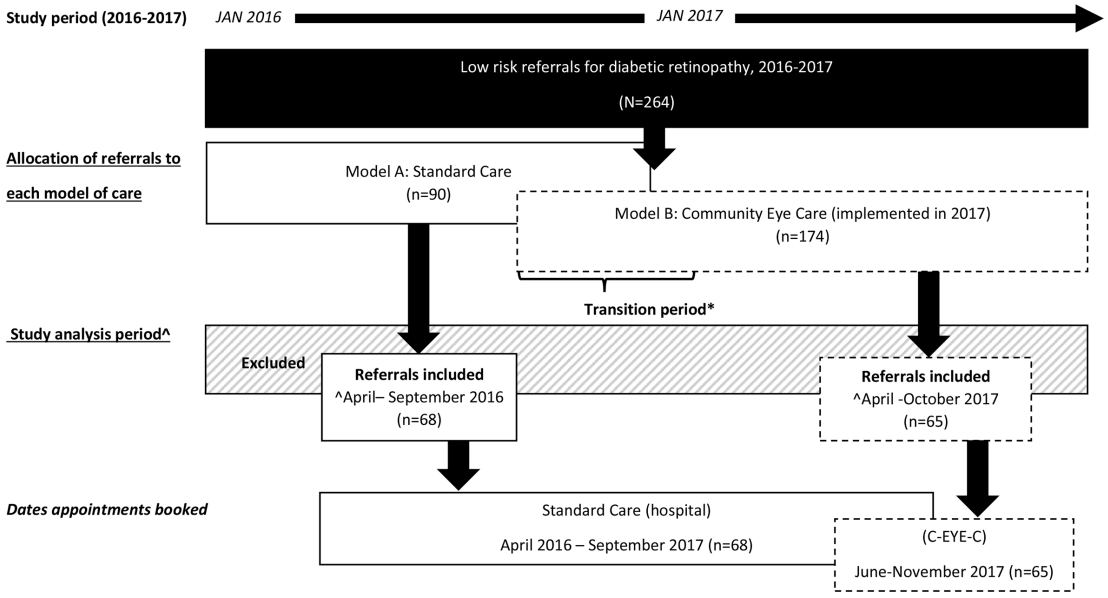

Figure 1 Flow diagram of referrals for low-risk diabetic retinopathy received between 2016 and 2017, and the inclusion and exclusion of referrals in study analysis.

and made a preliminary decision regarding the diagnosis and management. The optometrists communicated their preliminary diagnosis and management recommendation to the patients and advised the patients that they would be contacted by the hospital if a further hospital specialist appointment was necessary. The optometrists' examination findings for all C-EYE-C patients were batch transferred to the hospital using electronic store-and-forward technology (using portable document format for imaging and the proforma) for a telemedicine 'virtual' review by a consultant ophthalmologist to confirm patient diagnosis and management outcomes, or amend as necessary. Only those that required further ophthalmological treatment or evaluation were contacted by the hospital and booked for ophthalmological care.

The two models of care for new low-risk patients with diabetes are detailed in figure 2.

Both models involved referral triage and clerical processing by hospital staff. The models differ in terms of the personnel that conducted the history-taking, imaging and eye examination, as well as the mechanism of ophthalmologist involvement (face to face vs a 'virtual' review of patient records).

Deidentified patient data were collected for this study from the medical records[16] including age, gender, attendance, wait-time, diagnosis and management. All audit data were stored in a Microsoft Access Database. The primary outcomes of this study were attendance rates, median wait-times, clinical and management outcomes, and health system costs compared across the two models of care.

The average cost per patient encounter for each model of care was calculated from a health system perspective in 2017 Australian dollars. The cost of an ophthalmology outpatient encounter at the hospital was obtained from hospital finance records via the New South Wales (NSW) Health Activity-Based Management Portal (V.4.5–Build 18.1).[18] The method used to calculate these costs, including staff resourcing is described elsewhere by the Independent Hospital Pricing Authority.[19] Costs include clinical and non-clinical staff salaries and overheads, imaging equipment, medical supplies and infrastructure. Time required per patient activity for hospital staff could not be obtained from the Independent Hospital Pricing Authority report, and since this retrospective study was not recorded directly, thus hospital managers who have experience in delivering these tasks were asked to make informed time estimates for each activity item. Salary costs (including overheads) were calculated using midpoint industry award rates.[20]

To calculate the average cost per encounter for the C-EYE-C model, staff salary and operational costs for the hospital and optometrist clinics were apportioned for each patient visit. Following discussion with optometry practices, it was determined that the optometry practices had capacity to assess up to 150 patients per week, based on 20-minute appointments and 50 business hours of operation. Salary costs for optometrists were obtained using the national median income for optometrists in 2016[21] and indexed for 2017.[22] Commercial estimates for rent and utility costs of the optometry clinics were collected from the clinic business managers and apportioned per encounter. The costs for imaging equipment (OCT and retinal camera) have been reported previously[23] and were depreciated over 5 years to match hospital asset-management practices.

The difference in attendance rate and wait-time from referral to first appointment was compared between models as well as hospital wait-list avoidance. Wait-list avoidance was calculated using the number of patients who attend C-EYE-C appointments that did not require a hospital follow-up appointment for ophthalmologist examination.

As a secondary outcome of the study, clinical concordance was evaluated for the C-EYE-C model by evaluating the agreement between the optometrist diagnosis and management recommendation and the ophthalmologist virtual review evaluation.

The difference in the average cost per patient encounter was compared between models of care. For the C-EYE-C model, patients requiring a follow-up for ophthalmologist intervention (ie, <3 months) at Westmead Eye Hospital Clinic incurred an additional cost of an abbreviated hospital visit, excluding imaging which had been conducted previously. If a patient needed review in a period of greater than 3 months, this would be considered a new encounter and not included in the initial encounter costs. One-way sensitivity analyses were conducted on key parameters.

Statistical analysis was conducted using STATA software V.15.1. χ^2 or Fisher's exact tests were used for comparison of categorical data including patient attendance and diagnosis. Medians and IQR were used to describe wait-times for the models of care since they had non-normal distributions. Continuous data were compared using the Mann-Whitney U test. Absolute and weighted proportional agreement and a weighted kappa statistic with a 95% CI were used to assess inter-rater agreement between the optometrist and ophthalmologist. This was deemed to be substantive if the kappa correlations were above 0.61.[24]

Public and patient involvement statement

The C-EYE-C model of care was initiated following consultation with clinical providers and community organisations. This consultation was facilitated by government-funded organisations (the Ophthalmology Network of NSW Agency for Clinical Innovation and Westmead Hospital Ophthalmology Department), which have a purpose to improve and deliver healthcare services to the public in NSW and Western Sydney, respectively. A steering committee consisting of representatives of the hospital/health system teams, research organisations and public providers guided the implementation of the model of care and research design to ensure that priorities

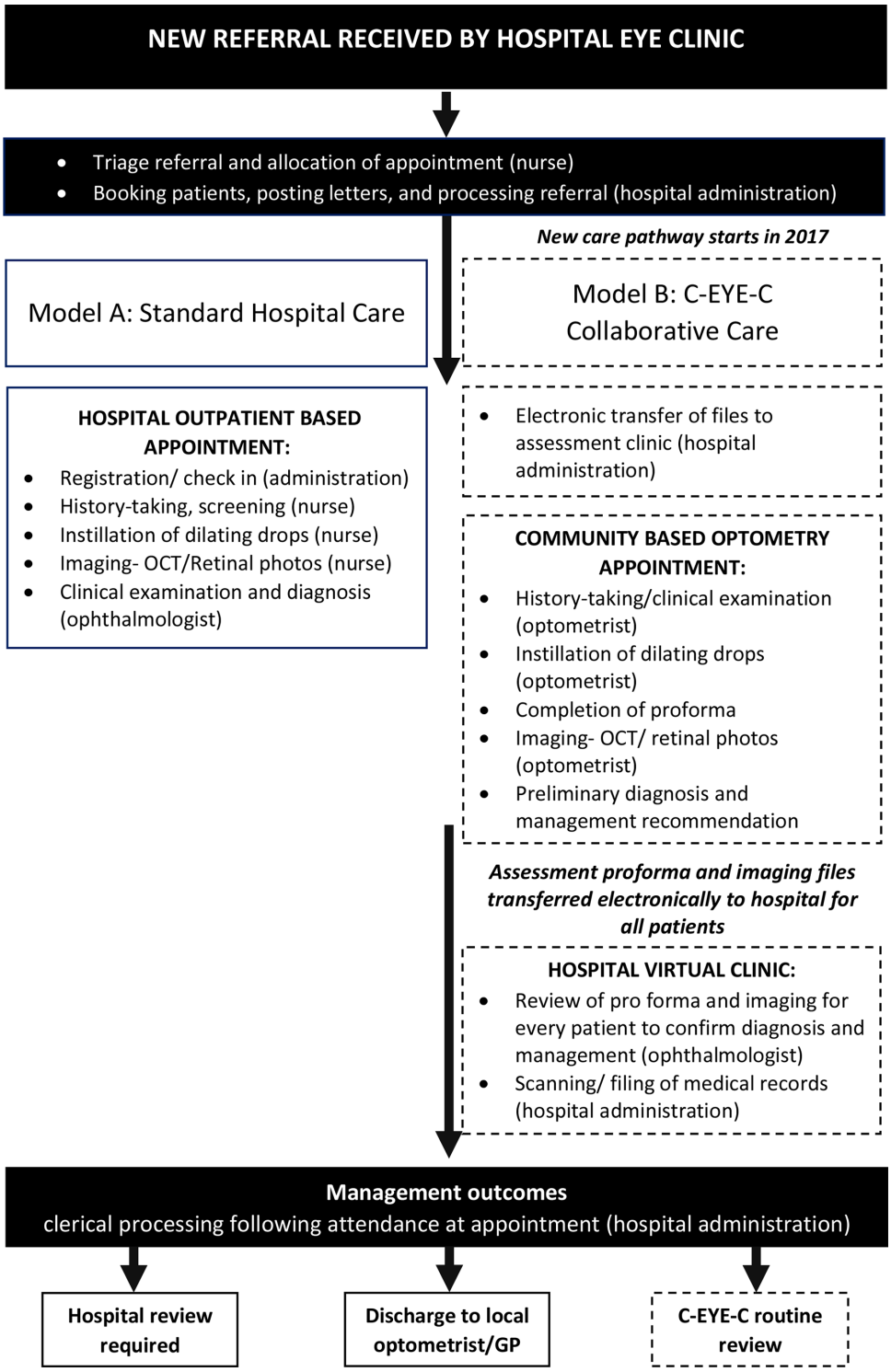

Figure 2 The two models of care for new low-risk patients with diabetes. C-EYE-C, Community Eye Care; GP, general practitioner; OCT, optical coherence tomography.

for delivering safe and effective healthcare were met. Patients with low-risk disease were receiving healthcare following provider-initiated referral to a public hospital. Patient data which were recorded in hospital medical record databases as part of routine consultation were used as study data collected in a retrospective audit, and there was no additional time or burden for patient involvement.

RESULTS

Between 2016 and 2017 a total of 264 new patients met the inclusion criteria (table 1). Patients booked outside of the study time periods were excluded from these analyses, and the final analytic dataset comprised 133 patients who had appointments made for diabetic eye examinations in either model of care during the date restrictions of this study. Of these, 68 received standard hospital care

Table 2 Outcomes of new low-risk referrals with diabetic eye disease under two models of care

	Standard hospital care	C-EYE-C	P value
New referrals	68	65	
Appointment attendance (n, %)	49 (72)	44 (68)	0.71*
Median wait-time between referral and first appointment (days, IQR)	118 (80–171)	53 (34–69)	p<0.01†
Final diagnosis	%	%	p<0.01*
No diabetic retinopathy (DR)	10.2	52.3	
Mild NPDR	32.7	11.4	
Moderate NPDR	10.2	13.6	
Severe NPDR	8.2	4.5	
Proliferative DR	0.0	0.0	
Macular oedema	8.2	9.1	
Unexplained vision loss or retinal detachment	0.0	0.0	
Other	8.2	6.8	
Not recorded	22.4	2.3	p<0.01*
Management outcome	%	%	p<0.01*
Urgent hospital (<1 month)	16.3	9.1	
Hospital management required (<3 months)	24.5	20.5	
Routine management (>3 months)	32.7	65.9	
Hospital review for another ocular condition	12.2	2.3	
Discharge from service	6.1	0.0	
Not recorded	8.2	2.3	

*p value: Fisher's exact used for categorical data.
†Mann-Whitney used for continuous non-parametric data.
C-EYE-C, Community Eye Care; NPDR, non-proliferative diabetic retinopathy.

and 65 received care through the C-EYE-C model. Referrals mainly came from GPs (55.6%) and optometrists (33.8%). There was no significant difference between the models of care in relation to the referral source (p=0.21).

The mean age of patients attending was similar for standard hospital care (57.5 years±19.2) and C-EYE-C (62.9 years±12.4) (p=0.11). The proportion of men to women was similar for the two models for patients referred (57% men for standard hospital care and 62% men for C-EYE-C, p=0.72) and patients attending (57% men for standard hospital care and 61% men for C-EYE-C, p=0.67).

Attendance was similar between the two models of care (72.1% for standard hospital care vs 67.7% for C-EYE-C, p=0.71). Reasons for non-attendance were not captured.

Table 2 presents patient attendance, wait-times and visit outcomes for each model of care.

The C-EYE-C model demonstrated a significantly shorter median wait-time from referral to first appointment compared with standard care (p<0.01, table 2). This was an average reduction of 65 days (or 9.3 weeks).

Overall a significant difference in the proportion of patients recorded for each diagnosis category between the two models of care was observed (p<0.001, table 2). There was also a significant variation between the two models of care for patient management (p<0.001, table 2). Standard care also had a higher ratio of patients with no recorded diagnosis compared with C-EYE-C (p<0.01, table 2).

Only 14/44 (31.8%) patients that attended the C-EYE-C required a face-to-face hospital follow-up (ie, required urgent hospital review <1 month, hospital management <3 months). The remaining 68.2% of patients that attended the C-EYE-C clinic did not require a hospital outpatient appointment for the first encounter (including those who required additional hospital review for another ocular condition, eg, cataract). The proportion of patients requiring a hospital follow-up was not significantly different between the models of care (p=0.19). Assuming that the hospital outpatient DR clinic has 5 appointments available each week for new patients, then 6 weeks of hospital appointments were freed up by assessing patients off-site at C-EYE-C.

For clinical concordance of the C-EYE-C optometrists' real-time assessment versus the virtual ophthalmology assessment, the absolute agreement for diagnosis was 78.9% and weighted agreement was 92.4% (κ=0.64, CI 0.47–0.81, p<0.01). For patient management, absolute agreement was 79.8% and weighted agreement, 93.2% (κ=0.66, CI 0.45–0.87, p<0.01). This is considered substantive agreement.[24]

Table 3 Health system costs per patient encounter for newly referred patients with diabetic eye care in the standard hospital care and C-EYE-C models

	Hospital care		Community Eye Care (C-EYE-C)		
				Cost per patient encounter	
Cost item	Staff time per patient (min)	Cost per patient encounter ($AUD)	Staff time per patient (min)	C-EYE-C clinic ($AUD)	Hospital follow-up if required (<3 months) ($AUD)
Staffing	63	119.00	65	35.15	116.00
Administration	13	21.00	18	11.11	21.00
Nurse	25	13.00	2	1.53	13.00
Optometrist	0	–	20	15.62	
Ophthalmologist	25	73.00	2	3.45	73.00
On costs*		12.00		3.44	9.00
Equipment		3.00		2.42	
Imaging (OCT, retinal camera, iCARE)		3.00		2.42	
Infrastructure		38.00		8.70	38.00
Pharmacy (goods and services and pathology, including dilating drops)		10.00		3.59	10.00
Other costs combined†		28.00		–	28.00
Rent+utilities (optometrist only)		–		5.11	–
Cost per patient (by clinic type)		160.00		46.27	154.00
Average cost per patient		160.00		90.80	

*On costs=superannuation, worker's compensation, long service leave and annual leave.
†Other costs combined=averaged costs per visit for operating room, pathology, prosthesis, ward supplies.
OCT, optical coherence tomography.

For cases where the optometrists' recommendation was changed, 11% required more urgent care and 5% less. There were 10 cases where the diagnoses were changed by the ophthalmologist; 5 Mild cases were re-graded to Moderate, 4 Mild and Moderate cases were regraded to include Clinically Significant Macular Oedema or OCT Macular Oedema, and one case graded as No DR was changed to Other.

The average cost per patient encounter was $AUD 160.00 for the hospital model, and $AUD 90.80 for C-EYE-C (table 3).

The lower cost of C-EYE-C was mostly driven by lower personnel costs through task sharing from the ophthalmologist to optometrist. Equipment costs were similar, and administration was centralised at the hospital for both models.

The results of the sensitivity analysis are presented in table 4. The cost estimates were most sensitive to increases in the proportion of C-EYE-C patients requiring hospital follow-up (<3 months), since this would directly incur more hospital costs.

DISCUSSION

This study found improved efficiency in the C-EYE-C model of care compared with standard hospital care in terms of waiting times and overall costs for newly referred, low-risk patients with diabetic eye disease. The C-EYE-C model reduced patient waiting times by 15 weeks (taking into account both hospital avoidance and reduced referral wait-times) and resulted in a 43% reduction in health system costs. We found that

Table 4 Sensitivity analyses of the Community Eye Care (C-EYE-C) model per patient encounter

Cost variable tested	Range tested	Cost per C-EYE-C patient encounter ($AUD)	Proportional change in cost relative to hospital patient encounter
Proportion of patients requiring hospital follow-up <3 months	20%–60%	77.15–138.75	–51.8% to –13.3%
Optometrist clinic appointments available per week	±50%	88.97–95.63	–44.4% to –40.2%
Changes to salary (hospital administration)	±20%	87.30–94.12	–44.0% to –42.7%
Changes to salary (all staffing)	±20%	76.98–104.44	–43.5% to –43.2%

around two-thirds of patients referred to the hospital for ophthalmological assessment could be eliminated from hospital ophthalmology waiting lists, freeing up those appointments for those more in need of specialist care while also reducing health system costs. The reduction in health system costs is largely the result of task sharing and hence reduced ophthalmologist time for lower-risk patients.

This study shows a high standard of patient care can be maintained through appropriate task sharing while saving time and money. This was evident not only through the high level of clinical concordance found between the models of care for diagnosis and management (which is consistent with findings from other studies on diabetic tele-ophthalmology)[13] but also because, regardless of the model, all patients' clinical examination findings were ultimately reviewed by an ophthalmologist for verification of the final diagnosis. There may be other aspects of quality of care which are not quantified in this study that may be enhanced through the C-EYE-C model. This includes the relative availability and accessibility of optometrists for patient interaction and communication around eye disease. While patient satisfaction was not captured in this study, studies in other settings have found high levels of patient satisfaction using tele-ophthalmology versus ophthalmologist-based screening in DR,[25 26] including patients from remote areas of Australia reporting ease of access, improved efficiency and reduced indirect costs of care associated with tele-ophthalmology screening.[27] Future studies are needed to explore the patient experience of tele-ophthalmology within Australian metropolitan cities.

A number of international studies have reported the benefits of collaborative care to increase rates of screening and detection of eye disease in the general population. While the implementation of such models is designed to bring better outcomes for individuals, the practical reality of their success would be to further increase patient access to overburdened tertiary care providers. This is especially needed since hospitals will be grappling with ways to face the increasing burden that the ageing population will bring in future.[6] Hence more evidence on strategies to improve efficiencies, such as those presented in this study, are needed to assist tertiary care providers to best manage the current and ever-growing service provision needs of the population with diabetes.

Despite the growing need, other studies investigating ways to streamline hospital wait-lists for DR care are limited. One similar study[9] has undertaken in the UK and interestingly, they found a similar proportion (ie, two-thirds) of patients could avoid face-to-face visits with an ophthalmologist when a 'virtual' clinic was established to evaluate low-risk hospital referrals with DR. However, this study did not report the cost-savings of the virtual clinic. The role of virtual clinics and collaborative care in referral refinement is better documented in glaucoma care[28–30] with wait-lists reportedly reduced by around 50%,[29] high levels of clinical agreement reported between optometrists and ophthalmologists,[29–31] and lower costs found in community settings.[32]

One of the limitations of this study was that patients were not randomly allocated a model of care as the two models were not simultaneously operating for an appropriate length of time. While randomised controlled studies are regarded most highly for evidence quality, such study designs tend to be less practical in real-world situations for complex health system evaluations. In this study, we found differing proportions of patients with various levels of DR in the C-EYE-C model of care compared with the hospital model of care, and an overall difference in the management outcomes. This was unanticipated since the clinical criteria (table 1) used to determine whether a patient qualified as a low-risk patient for this study was the same for both models. It is possible that more referrals were managed in the C-EYE-C model which would otherwise have been sent back to a primary care provider due to incomplete referral information. Previous audit of referrals in this setting has shown that there are gaps in the quality and completeness of referrals and this highlights the importance of feedback to practitioners, to improve targeting of referrals.[33] Although a difference was observed in the patient case-mix encountered in each model, the total proportion of patients requiring a hospital review was not significantly different between the models of care. The impact of varying the number of patients requiring a hospital review, as well as key cost parameters, was tested through the sensitivity analyses conducted and suggested that cost and waiting time of the C-EYE-C model of care held across a range of scenarios improving the robustness of our findings to inform future scale-up of the model.

Another limitation of this study is the clinical concordance assessment was through a virtual rather than live review. Therefore, the ophthalmology assessment was reliant on quality imaging. Kortuem *et al*[9] found a high proportion (35%) of face-to-face referrals were necessary due to poor image quality for images captured by trained nurses. However, poor image quality was not recorded as a reason for hospital follow-up in this study. This may be due to the relatively high level of training and expertise of Australian optometrists in retinal imaging, use of multiple imaging modalities for example, OCT, which can penetrate opaque media, and that images were captured with dilation which results in improved image quality. However, more research is needed to investigate such effects.

While this study only evaluated new low-risk patients, it would be worthwhile for future studies to examine longer-term outcomes such as disease progression, hospital avoidance and the longer-term associated costs for patients and broader implementation and scalability. Patient preferences of such models also should be considered. In Australia, the successful adoption and scalability of the collaborative care

approach has been demonstrated for other integrated models of clinical care such as antenatal care which is shared between GPs or midwives and hospital obstetricians.[34] This model is long standing and is supported by national pregnancy guidelines[35] and funding for participating practitioners under the national health insurance scheme.[36]

CONCLUSION

Collaborative eye care can result in considerable cost-savings and reduced patient waiting times while maintaining a high standard of care compared with traditional hospital-based care in the management of low-risk hospital referrals with diabetic eye disease. The improved access and reduced costs are largely the result of task sharing and increased utilisation of primary eye care professionals (ie, optometrists) to provide services for low-risk patients.

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