What Role will home-monitoring technologies play in managing Chronic Eye Disease in an Ageing Birmingham population?

Introduction

Chronic eye diseases such as glaucoma, age-related macular degeneration (ARMD) and diabetic retinopathy represent significant causes of irreversible visual impairment amongst older adults.[1] These progressive conditions require lifelong monitoring to detect changes early and to avoid vision loss. Glaucoma involves the gradual degeneration of the optic nerve, often due to elevated intraocular pressure (IOP), resulting in peripheral vision loss. ARMD affects the macula, which causes central vision loss, while diabetic retinopathy can occur due to vascular damage to the retina from prolonged hyperglycemia.[1] These disorders represent a major public health challenge for ageing populations, where early detection and good follow-up are critical for maintaining good outcomes.

Home monitoring technologies, including home Optical Coherence Tomography (OCT), portable retinal cameras, wearable sensors and smartphone applications, are reshaping chronic eye disease management.[2] These tools allow patients to monitor changes from home, enabling more frequent assessment outside clinical settings. These innovations align with the NHS Long Term Plan by reducing avoidable visits and supporting patient-centred care.[3]

The need for such innovation is especially necessary in Birmingham, one of the UK's most rapidly ageing and ethnically diverse cities. The city faces disproportionately high rates of diabetes and hypertensive disease, which increases susceptibility to conditions such as retinopathy and glaucoma.[4] As the population aged 65 and over continues to grow, demand for ophthalmic services has risen sharply. Nationally, ophthalmology is the busiest NHS outpatient speciality, accounting for roughly 8.5% of all appointments.[5] Many hospital services report delays, which can lead to preventable visual loss. The COVID-19 pandemic further exacerbated these pressures, limiting the in-person care delivered and accelerating the adoption of telemedical models across the NHS.

With the increased pressure on healthcare services, home-monitoring technologies have emerged as a practical response to workforce shortages and mounting caseloads. By facilitating earlier detection and allowing for remote triage, they have the potential to reduce significant pressure on clinical services. Their effective integration within Birmingham's rapidly ageing population may redefine chronic eye disease management in the future.

Local context

Birmingham provides a particularly relevant setting for examining home-monitoring technologies in chronic eye disease as it combines rapid population ageing, marked health inequalities and a sustained demand on ophthalmology services. Although it is younger than many UK cities overall, Birmingham's older population is rising substantially: the number of residents ages 65 years or older is projected to increase by 29%, from 150,600 in 2020 to 194,100 by 2040.[6] This demographic shift is important because the prevalence of glaucoma, ARMD and diabetic retinopathy increases strongly with age.[1] Birmingham also has high levels of diabetes and cardiovascular risk factors, which further exacerbate the burden of chronic eye disease.[4]

The city is very ethnically diverse, which adds another important dimension.[7] Birmingham has a large Black African/Caribbean community, who have a higher risk of primary open-angle glaucoma and earlier disease onset. Similarly, South Asian communities have a higher risk of diabetic retinopathy.[8] Earlier screening and regular monitoring are therefore especially relevant locally. Moreover, socioeconomic deprivation remains a major challenge across many areas in Birmingham.[4] Deprivation is associated with lower uptake of routine eye examination, reduced digital access and a more advanced disease at diagnosis. These factors can worsen avoidable sight loss if care pathways rely solely on hospital attendance.

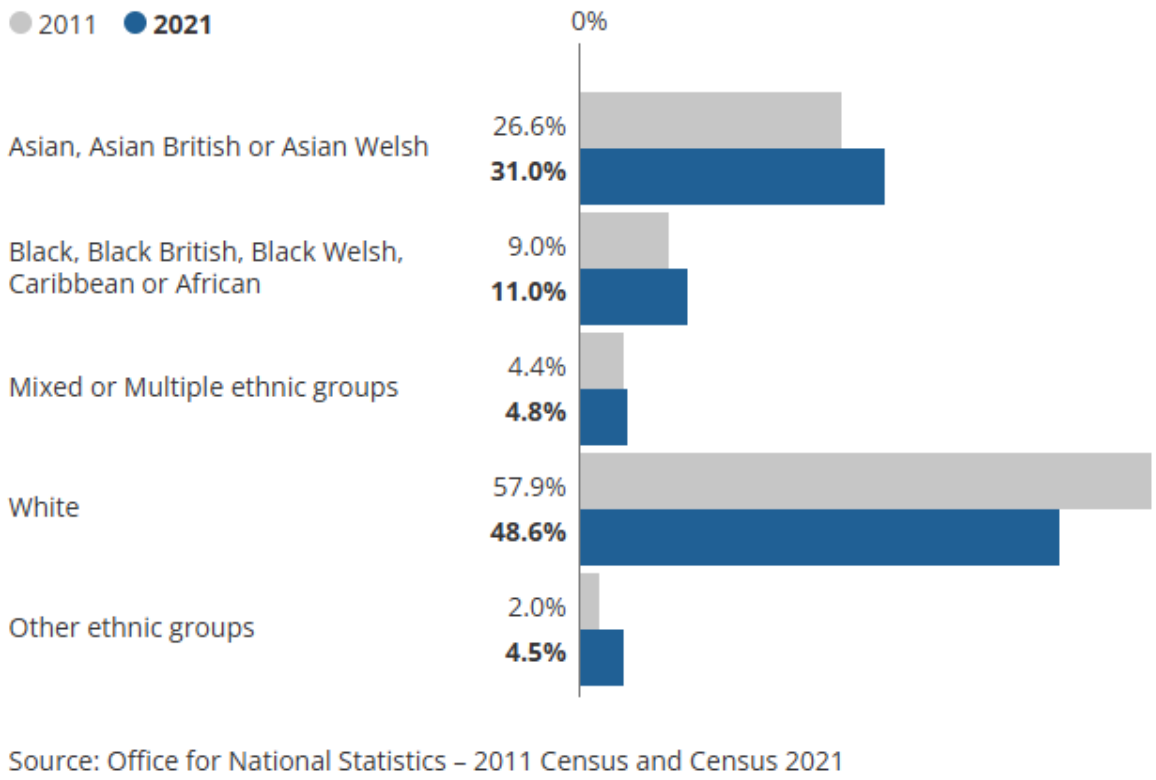


Figure 1: *Percentage of residents by ethnic groups in Birmingham*[7]

Nationally, sight loss affects more than two million people in the UK, with ARMD, diabetic eye disease and glaucoma being common irreversible causes.[8] Royal National Institute of Blind People (RNIB)A forecasts further increases over the next decade as the population ages. Meanwhile, NHS services continue to experience waiting-list pressures and diagnostic backlogs, with ophthalmology remaining one of the busiest outpatient specialities.[5]

Sight Loss Cause	2021	2025	2030
Early-stage AMD	37,400	39,900	42,900
Late-stage dry AMD	2,720	2,900	3,190
Late-stage wet AMD	5,660	6,050	6,660
Total late-stage AMD	7,960	8,510	9,360
Cataract	8,740	9,350	10,300
Ocular hypertension	20,000	20,900	21,800
Glaucoma	9,090	9,660	10,400
Diabetes	62,100	64,900	68,100
Diabetic retinopathy	21,800	22,500	23,300
Severe retinopathy	2,010	2,070	2,140
Totals	169,100	177,690	188,300

Key: AMD Age-related Macular Degeneration

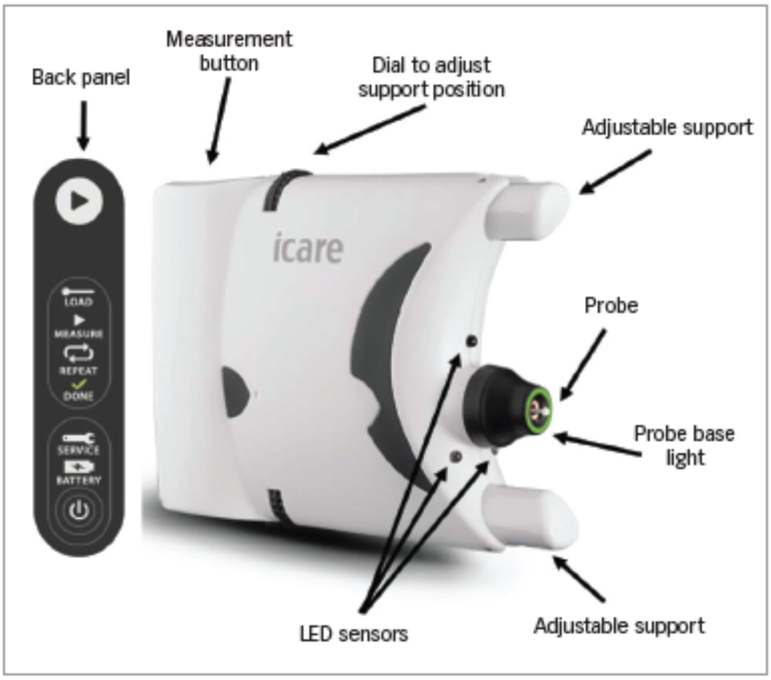
Table 1: *Predicted numbers living with sight loss conditions in Birmingham*[8]

With this context, Birmingham is an ideal city in which to evaluate home monitoring. Technologies such as home tonometry for glaucoma, app-based vision testing for ARMD and remote retinal surveillance for diabetic retinopathy could reduce unnecessary hospital visits and prioritise high-risk patients. However, successful implementation will depend on overcoming barriers such as digital exclusion and ensuring fair access across Birmingham's diverse communities.

Overview of home monitoring technologies

Glaucoma

Several home-based technologies are now available for glaucoma monitoring. One key area is IOP monitoring, as elevated IOP remains the main modifiable risk factor for the condition. Devices such as the iCare HOME tonometer are handheld rebound tonometers that allow patients to self-measure eye pressure by briefly contacting the cornea with a small disposable probe.[9] Unlike single clinic readings, repeated measurements taken at different times of day can help identify pressure spikes and daily fluctuation patterns.



LED = light-emitting diode.
Icare HOME (TA022; ICare Finland Oy, Vanda, Finland.)

Figure 2: *the iCare HOME tonometer*[2]

Another major development is home visual field testing, which measures peripheral vision loss. Melbourne Rapid Fields is a software programme that presents light stimuli on a screen and records the patient's responses to map functional vision loss.[9] It generates reports comparable to standard automated perimetry used in clinics. Eyecatcher is a similar tablet-based system but uses the front-facing camera and eye-tracking technology rather than a handheld response button. The patient only needs to look toward any stimulus they detect, making it potentially easier for older adults or those with limited dexterity.

Additional supportive tools include smartphone applications for visual acuity testing, such as Peek Acuity, which uses optotype letters like a Snellen chart to assess vision at home. Smartphone adaptors such as D-Eye can also attach to a phone camera to capture images of the optic nerve head for remote review.[9]

Evidence suggests patients generally find these technologies acceptable and easy to use, with high adherence reported in several short-term studies. In one study, 100% of participants (n = 20) successfully completed home visual field testing and obtained acceptable intraocular pressure readings.[10] Overall, barriers remain, including digital literacy and reliability. Some older adults may require training or assistance to use devices effectively, which makes it less feasible under the current NHS model. [9]

Macular degeneration

Home monitoring technologies are becoming increasingly important in the management of ARMD. ARMD often progresses silently, and delayed recognition of the disease can lead to irreversible vision loss. This is especially relevant when dry ARMD converts to neovascular (wet) ARMD, or when wet ARMD reactivates during treatment. Home monitoring aims to detect these changes earlier while reducing the burden of repeated hospital visits.

One of the earliest validated systems was ForeseeHome, which uses Preferential Hyperacuity Perimetry (PHP).[11] This device assesses subtle visual distortion, which may occur before noticeable symptoms develop. Patients complete regular self-tests at home, with results transmitted remotely for review. In the large HOME randomised control trial (n = 1520), ForeseeHome enabled earlier detection of conversion to wet ARMD compared with standard care, helping preserve better visual acuity at the point treatment began.[12]

More recent advances include home OCT devices. OCT is the gold standard imaging method for detecting retinal fluid and monitoring response to anti-VEGF treatment in wet ARMD. Portable home OCT systems allow patients to self-scan the macula, with images analysed using artificial intelligence (AI) to detect fluid recurrence.[11]

These technologies could be particularly valuable in Birmingham's ageing population, where ARMD prevalence and demand for retinal services are likely to rise. Earlier detection and fewer unnecessary clinic visits may improve efficiency and patient outcomes.

Diabetic Retinopathy

Home-monitoring technologies for diabetic retinopathy are less established than for glaucoma or ARMD, but digital systems are increasingly used to improve surveillance and earlier detection.

Emerging home-based approaches mainly involve smartphone applications that assess changes in vision between routine appointments. Systems such as Checkup Vision Assessment and myVisionTrack allow patients to test visual acuity and detect distortion suggestive of diabetic macular oedema, a potentially serious complication.[13] In one study, the Checkup Vision Assessment app showed strong agreement with clinic-based testing (Pearson correlation coefficient r = 0.96), suggesting potential value for remote follow-up. [14]

These approaches are part of a broader shift towards a model of care that integrates telemedicine and artificial intelligence. In this model, data collected through smartphone applications and home-based tools can be transmitted remotely and analysed using AI algorithms to support early detection and triage.[13] This creates a more continuous form of monitoring compared to traditional episodic clinic visits and allows clinicians to prioritise patients at higher risk.

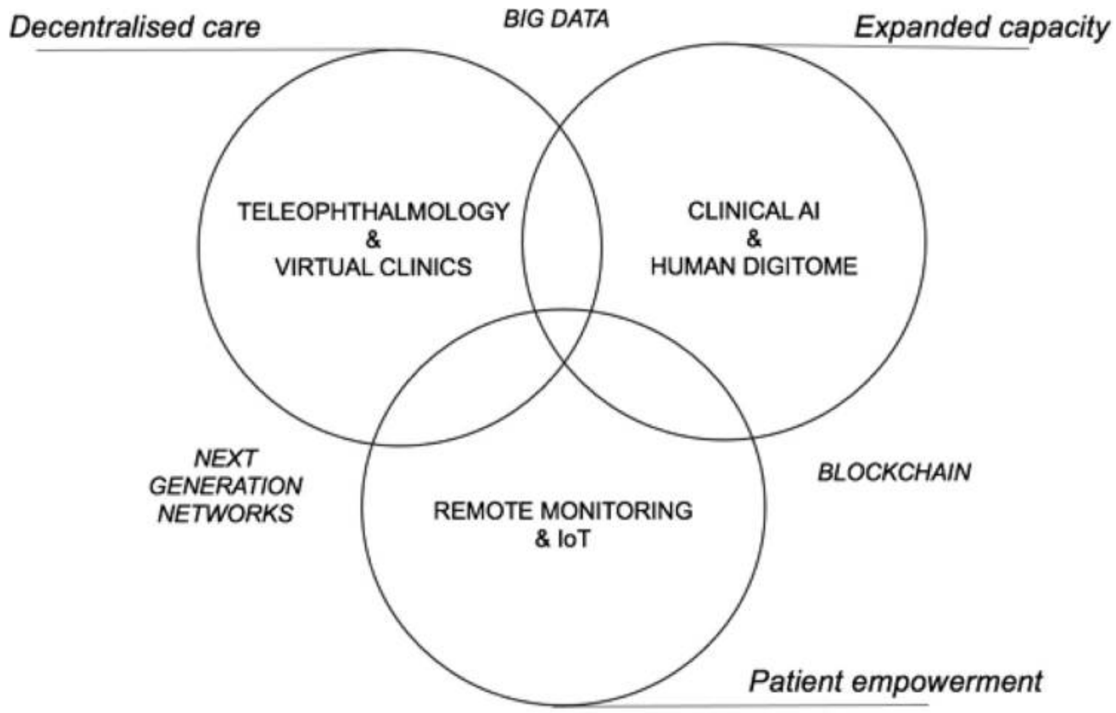


Figure 3: *Essential building blocks for AI-assisted DR teleophthalmology screening*[13]

Another developing area is portable retinal imaging using smartphone-based fundus cameras. These low-cost devices may eventually allow retinal photographs to be taken at home or with minimal assistance and uploaded for remote interpretation.[13] Similar digital retinal imaging methods have demonstrated strong diagnostic performance, with reported 96% sensitivity and 89% specificity for detecting diabetic retinopathy using two-field colour fundus photography.[15]

However, barriers remain, including image quality and access to devices. Overall, fully home-based diabetic retinopathy monitoring is still evolving, but smartphone vision testing and portable retinal imaging may become valuable adjuncts to routine diabetic eye care in Birmingham's ageing population.

Cataract

Smartphone-based home monitoring may offer a simple method for early cataract detection, particularly for older adults with reduced access to optometry services. In this study, images from 100 model eyes (50 cataract, 50 healthy) were analysed using a luminance-based algorithm that identified lens clouding across different lighting conditions, distances, angles and smartphone types.[16] Diagnostic performance was strong, with 96.6% accuracy, 93.75% sensitivity and 93.4% specificity. Environmental factors such as camera distance or angle had minimal impact (around 2–3%), suggesting practical home usability. However, findings were based on artificial eye models rather than real patients, so clinical validation is still required. If validated, such tools could help improve early cataract detection and reduce pressure on eye services in Birmingham communities.

Benefits of home monitoring

Earlier Detection of Disease Progression

A key advantage of home monitoring is the ability to provide continuous assessments, which can enable earlier detection of disease progression. In ARMD, the ForeseeHome system has demonstrated that 83–94% of patients present with visual acuity ≥20/40 at diagnosis, compared to significantly lower rates with traditional monitoring. Earlier detection is also associated with smaller lesion size and improved prognosis.[12]

This principle is equally important in glaucoma, where disease progression can be easily missed. Simulation data using home-based perimetry showed that weekly home monitoring detects rapid visual field progression within one year, compared to 2.5 years with 6-monthly clinic testing. Additionally, specificity exceeds 90% within weeks, allowing reliable early identification of true progression. These findings highlight how frequent measurements capture fluctuations, such as intraocular pressure variability and functional decline, that clinic "snapshots" fail to detect.[17]

Reduced Hospital Burden

Home monitoring can significantly reduce reliance on outpatient services, a crucial consideration given NHS backlogs and workforce pressures. By identifying progression earlier, clinicians can prioritise patients who require urgent intervention while reducing unnecessary routine follow-ups. In glaucoma, home monitoring enables differentiation between stable and rapidly progressing patients, while in ARMD, it ensures timely referral only when conversion occurs. This approach supports more efficient use of limited ophthalmology resources.

Patient Empowerment and Engagement

Home monitoring promotes active patient involvement in disease management. High compliance rates have been demonstrated, with ARMD patients performing around 5.2 tests per week, and glaucoma models suggesting the feasibility of weekly testing supported by reminders.[12,17] Regular testing fosters awareness of disease status and may improve treatment adherence.

Teleophthalmology also improves access to care, particularly for older adults with mobility or transport limitations. This reduces loss to follow-up and supports continuity of care. Studies report generally high patient satisfaction, and services can be delivered by trained non-specialists, making care more accessible.[18]

Cost-Effectiveness

Home monitoring offers potential cost savings through reduced clinic visits and lower travel burden. Teleophthalmology improves efficiency by enabling remote triaging, reducing unnecessary appointments and specialist workload.

Use of portable, tablet-based devices lowers equipment costs compared to traditional systems. However, additional costs such as data management and the inevitable investment needed for monitoring services must be considered. Evidence suggests cost-effectiveness is greatest in high-risk populations, though uncertainty remains in very elderly groups. Overall, home monitoring represents a promising, scalable approach to the management of chronic eye conditions.[18]

Limitations of home monitoring

Despite promising advances in home-monitoring technologies for chronic eye disease, significant limitations currently restrict their widespread implementation.

A major concern is accuracy and reliability, especially when compared to gold-standard clinical testing. Across home-based visual field and retinal monitoring systems, test–retest variability is consistently higher than in clinic-based assessments, with reliability reported at approximately 65% for home testing versus 85% for Humphrey Visual Field analysis.[10] Some devices demonstrate measurement error exceeding 3 dB, raising concerns about consistency in longitudinal monitoring. In addition, systematic errors have been reported, including overestimation of nasal field loss and underestimation of temporal defects, suggesting that home devices may not yet fully replicate the spatial precision of standard automated perimetry.[10] Similar concerns are evident in intraocular pressure self-monitoring, where variability compared with Goldmann applanation tonometry limits their use as a direct substitute. Overall, this suggests that current home-monitoring tools are best viewed as supporting systems alongside standard assessment.

A further limitation is data overload and interpretation burden. Continuous or high-frequency monitoring generates large datasets, which can overwhelm clinicians. Although artificial intelligence offers potential solutions, integration into clinical workflows is inconsistent. This raises concerns about whether current NHS ophthalmology services have the capacity to safely interpret and act upon increasing digital data streams.

Patient-related factors present another major barrier. Adherence to home monitoring declines over time, with studies reporting that only around three-quarters of patients maintain long-term engagement despite initial enthusiasm.[19] Factors such as reduced motivation and cognitive decline influence this, which can be particularly relevant in an ageing Birmingham population.

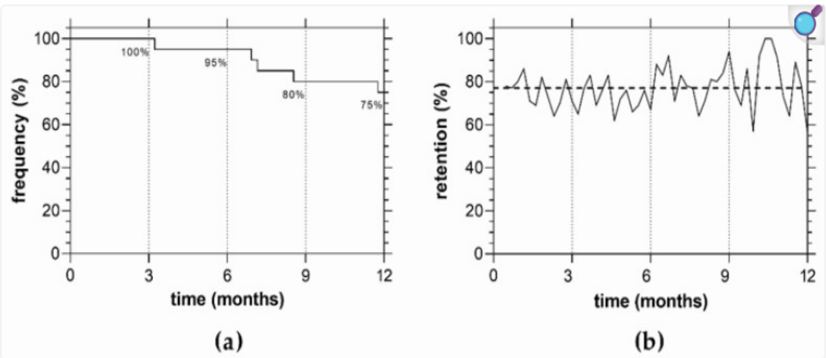


Figure 4: *Longitudinal adherence and retention in home-based visual field telemedicine using Melbourne Rapid Fields (MRFh) over 12 months. (a) Decline in participant retention over time, demonstrating progressive dropout from 100% to 75% by 12 months. (b) Weekly compliance to the recommended testing schedule among active users, showing fluctuating but generally sustained engagement with home monitoring in retained participants.* [19]

Similarly, there is also the issue of digital exclusion, which is especially important in Birmingham due to its socioeconomic diversity. Older adults are less likely to be confident with digital interfaces, and disparities in access to broadband, smartphones or tablets risk widening existing health inequalities. This creates a situation where those most at risk of vision loss may be least able to benefit from home monitoring technologies.

From a system perspective, cost and accessibility remain major constraints. Advanced devices such as ultra-wide-field cameras, OCT-based home systems, and AI-integrated platforms are expensive and not widely available within routine NHS pathways. In addition, many systems require specialised infrastructure and secure data transmission, which is an extra cost for the NHS. While they may offer a long-term solution, they are unlikely to provide a short-term relief, particularly given the NHS's already constrained resources and competing priorities, which limit the capacity for large upfront investment.

Overall, while home-monitoring technologies represent a major step forward in ophthalmic care, their current limitations in accuracy, usability and system integration mean they are not yet ready to replace traditional care. Instead, they are better considered as part of a hybrid care model alongside existing technology.

Future directions

A major determinant of future adoption is NHS feasibility, which extends beyond just clinical effectiveness to cost and scalability as well. While home-monitoring technologies are often presented as cost-saving in the long term, they require substantial upfront investment in devices, digital infrastructure and staff training. In a resource-constrained system, the NHS typically prioritises interventions that deliver immediate, population-level benefit at relatively low cost. As a result, widespread deployment of individual home devices, particularly more expensive technologies such as home OCT or continuous monitoring systems, is quite unlikely in the short term.

Scalability is another key issue. For adoption across a large and diverse population such as Birmingham, technologies must be simple, reliable and usable without much training or technical support. Systems that rely heavily on patient engagement or have a complex setup may struggle to translate from trial settings into routine care. In contrast, lower-cost, smartphone applications or passive monitoring tools that can be deployed at scale are more aligned with NHS priorities.

Workforce implications must also be considered. Although home monitoring has the potential to reduce clinic visits, it may increase clinician workload due to the need to review incoming data from more potential patients. Without effective AI triage and clear clinical pathways, this could increase system burden on clinicians.

Importantly, NHS decision-making is guided by evidence-based frameworks such as those from NICE, which require robust data on any new intervention.[20] Many home-monitoring technologies are still supported by relatively small or selective studies, limiting confidence in their generalisability. Until large-scale trials demonstrate a clear benefit over existing care pathways, adoption is likely to remain unlikely.

Overall, while home monitoring aligns with long-term NHS goals of community and preventative care, its implementation will likely be very gradual. Currently, low-cost and scalable options such as smartphone-based visual acuity and portable retinal imaging integrated into existing diabetic screening pathways are most likely to be adopted. In contrast, more complex technologies such as home OCT and home tonometry are likely to remain limited to selected high-risk patient groups.

Conclusion

In conclusion, home-monitoring technologies have the potential to significantly transform the management of chronic eye disease in an ageing Birmingham population by enabling earlier detection and reducing pressure on overstretched ophthalmology services. However, current limitations in accuracy, adherence and digital accessibility restrict widespread implementation. In a diverse and socioeconomically varied city such as Birmingham, there is also a risk that unequal access to technology may widen existing health inequalities if not carefully addressed. In the short term, low-cost, scalable solutions are most likely to be adopted, while more advanced technologies remain targeted to high-risk groups. Ultimately, home monitoring will play an important, but mainly complementary role within a model of care that combines both digital innovation and traditional outpatient services.

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