Strengthening the signal: Advancing oculomics research for systemic health insights

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Oculomics, the study of how ocular structure reflects systemic health, is poised to become an integral tool for predicting, triaging, and diagnosing a wide range of diseases. By analysing data from the eye, particularly the retina, healthcare providers can gain valuable insights into a patient's overall health status. This approach holds significant promise for enhancing preventive care and improving patient outcomes across various medical fields [1,2].

One compelling aspect of oculomics is its accessibility within the community. More people attend their optometrist for eye checks than general health check-ups with their primary care physicians [3,4]. This presents a unique opportunity to leverage routine eye checks to identify individuals at risk of systemic diseases and direct them for further investigations.

Beyond community settings, retinal imaging has potential applications in primary care and specialised clinics such as neurology, psychiatry, and obstetrics and gynaecology [5–9]. In these environments, ocular biomarkers could assist in monitoring neurological conditions, assessing mental health disorders, and predicting pregnancy-related complications. For instance, retinal imaging in neurology clinics could aid in the early detection of neurodegenerative diseases like Parkinson's or Alzheimer's disease.

In low-resource settings where access to blood tests and advanced diagnostics may be limited, oculomics offers a valuable alternative. During community diabetic retinopathy screenings, retinal images could be used to identify patients at risk of chronic kidney disease (CKD). This approach enables earlier interventions and management strategies in populations that might otherwise lack comprehensive medical testing [10].

To realise the full potential of oculomics, further research is essential. Strengthening our data through updated retrospective studies and new prospective initiatives will enhance the reliability and applicability of oculomics in clinical practice. The following sections explore the necessary steps to advance oculomics research and bring its benefits to patients worldwide.

Strengthening our data

1. Opportunities from retrospective studies

Retrospective studies like AlzEye, where retinal imaging data from >150,000 patients at Moorfields Eye Hospital attending between 2008 and 2018 has been linked with systemic diagnoses from hospital admissions, have been instrumental in identifying associations between ocular biomarkers and systemic diseases. Analysis of high-dimensional data in AlzEye enabled researchers to uncover patterns related to cardiovascular and neurodegenerative conditions [11]. Building upon this strong foundation, there is an opportunity to enrich the dataset by including more recent patient data and expanding collaborations with additional ophthalmic centres. This will increase the sample size and diversity of the population studied, enhancing the robustness of analyses and providing more comprehensive insights.

These updated retrospective studies offer several advantages. They are cost-effective, utilising existing data without the need for expensive and time-consuming data collection processes. Moreover,

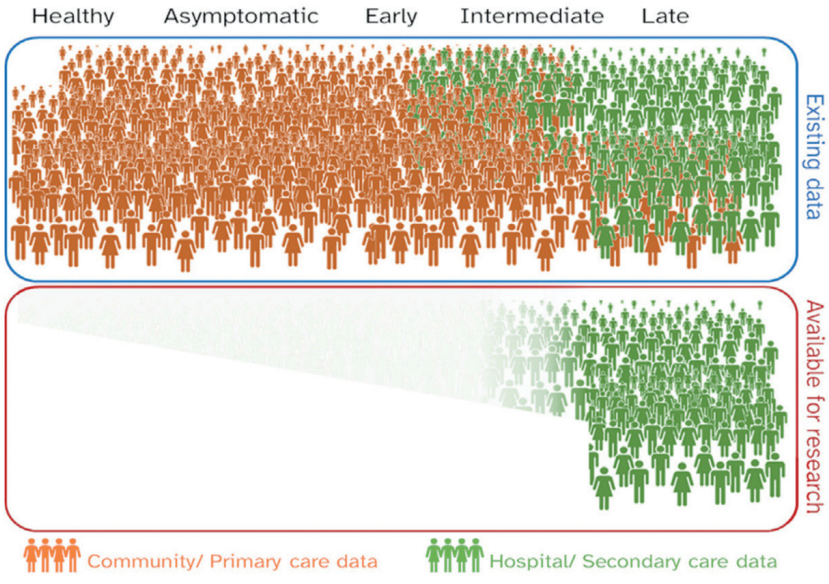

Figure 1: Disparities in Research Data Availability Across Healthcare Settings. Image Courtesy of Action Against AMD and Foresight Research Ltd.

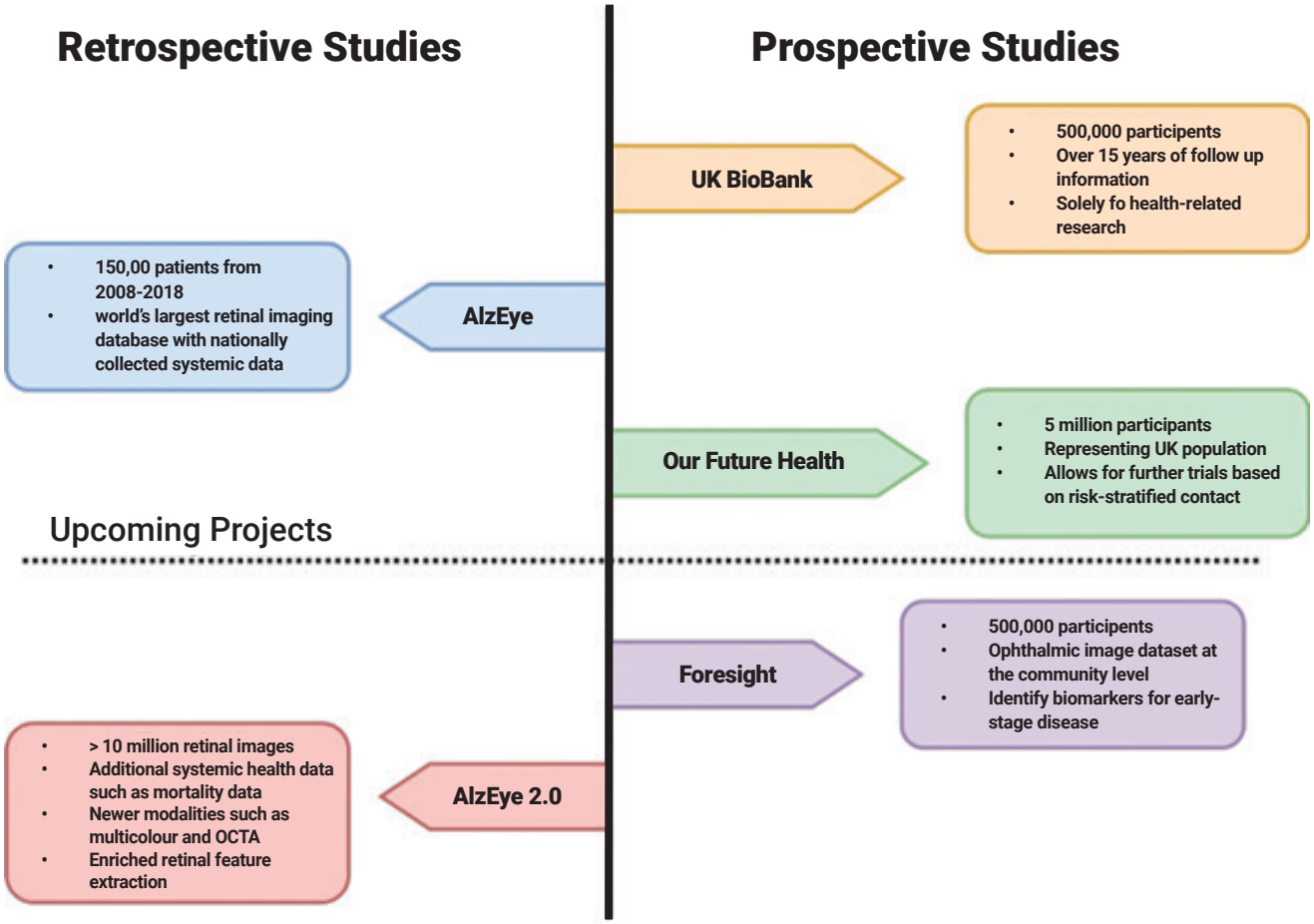

Figure 2: Comparison and timeline of retrospective and prospective studies in large-scale ophthalmic and systemic health research.

hospital-based datasets like AlzEye can capture a wide spectrum of health statuses, complementing volunteer-based cohorts like the UK Biobank, where participants are healthier than the average person and may not be representative of the general population [12,13]. By maximising the use of available data, we can continue to generate valuable findings that reflect real-world clinical settings.

2. Focusing on specific conditions through targeted prospective studies

While retrospective studies provide valuable insights, prospective studies are essential for supporting causal inference, providing robust ground truths, and exploring new research areas. For specific conditions where we aim to gain deeper understanding, we can initiate targeted data collection directly from relevant patient populations. For example, by incorporating retinal imaging into psychiatry clinics, we can gather real-time data on patients with conditions like schizophrenia or bipolar disorder. Collecting detailed information, such as the medications patients are using, is crucial because certain psychiatric medications are known to cause changes in the retina [14,15]. Studying ocular biomarkers alongside psychiatric assessments and medication histories may reveal correlations between retinal changes, neurochemical imbalances, and treatment effects.

Collecting data in these specific settings enhances our ability to generate accurate and focused insights, helping to overcome limitations associated with volunteer-based studies. Longitudinal data from these studies can provide information on disease progression and treatment effects, which are crucial for developing predictive models and improving patient care.

3. Launching wide-scale ophthalmic prospective population studies

To broaden the applicability of oculomics findings, large-scale prospective population studies with comprehensive biological and imaging data are necessary. The ForeSight Project exemplifies this effort by aiming to collect 500,000 eye scans from members of the public through community optometrists and link them to systemic health records [16,17]. By capturing data at a community level, the project aims to assemble a more heterogeneous cohort that includes healthy individuals, asymptomatic people, and those with mild disease. This contrasts with hospital datasets, which typically contain data from patients with more advanced stages of disease. Collecting information from a broader spectrum enhances the reliability and generalisability of research findings, supporting the development of robust predictive models.

Led by eye charity Action Against Age-related Macular Degeneration, the ForeSight Project is made possible through collaboration with the NHS, national initiatives, and the charitable sector. Such partnerships foster trust and honest brokerage, encouraging public participation and facilitating ethical data sharing.

4. Linking to national cohort studies for genetic insights

Integrating ophthalmic data with national cohort studies that include genetic information offers a unique opportunity to explore the interplay between genetics, ocular biomarkers, and systemic diseases. The Our Future Health initiative aims to

recruit five million UK volunteers and collect extensive genetic and health data [18]. Linking ophthalmic data to this cohort presents an unparalleled opportunity for oculomics. Researchers can study the genetic underpinnings of ocular biomarkers and their associations with systemic diseases on an unprecedented scale. Additionally, participants in Our Future Health can be re-contacted based on risk stratification, enabling researchers to invite individuals identified as being at higher risk for certain conditions to participate in further studies. For ophthalmology, this allows us to recruit specific groups of patients for ophthalmic assessment to further investigate ocular biomarkers and validate predictive models.

Conclusion

By strengthening the findings in oculomics research through updated retrospective studies and new prospective initiatives, we can unlock the full potential of this promising field. Enhancing our data resources enables us to develop more accurate predictive models and gain deeper insights into the mechanisms linking ocular biomarkers to systemic health.

We are optimistic that fortifying the results from oculomics through rigorous research will eventually translate these findings into clinical practice. While there are still hurdles to overcome, such as developing safe artificial intelligence tools and navigating the practical steps from research to clinical implementation, the advancements made through these focused studies bring us closer to a future where the eye truly becomes a window to overall health. This progress promises to usher in a new era of personalised medicine and preventive care, ultimately improving patient outcomes on a global scale.

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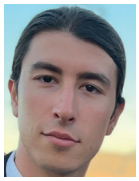

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