The Changing Landscape of Global Ophthalmology: Technology, Innovation, Advocacy, and Education

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The Changing Landscape of Global Ophthalmology: Technology, Innovation, Advocacy, and Education

- COVID-19 pandemic
  - Clinical care
  - Research
  - Education
  - Advocacy

- Telemedicine and Tele-Education


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Abstract

Background The coronavirus disease-2019 (COVID-19) pandemic has affected academic ophthalmology departments globally, causing changes in educational, research, and clinical operations in the short and long term. Healthcare workers are at higher risk of contracting the disease and given early reports suggestive of transmission through the tear film in COVID-19 cases with conjunctivitis, close proximity during examination, eye care providers in particular may be at increased risk.

Objective To provide the experience from a single academic ophthalmology program in responding to the COVID-19 pandemic.

Methods This article describes the changes executed in the Department of Ophthalmology and Visual Sciences at the University of Illinois at Chicago, Illinois Eye and Ear Infirmary, with emphasis on the implementation of a tele-triage process for urgent visits.

Results In response to the pandemic, our department made rapid changes in its departmental protocols for education, research, and patient management. Early measures focused on limiting face-to-face interactions among patients, staff, residents, and faculty, decreasing the risk of exposure to disease while also providing access for patients in urgent need of care.

Conclusion We hope that the UIC experience will assist other academic tertiary referral centers in maximizing their opportunities to deliver excellent patient care while minimizing risks to patient and provider, all while continuing to provide a quality graduate medical educational experience during and beyond the pandemic.

Keywords
- coronavirus
- SARS-CoV-2
- teletriage
- telehealth
- resident education
- medical education

COVID-19 PANDEMIC

What are the opportunities for AI in Ophthalmology Research?

Are there opportunities for AI in Ophthalmic Education?
- Machine and deep learning techniques being developed for COVID-19 tracking and forecasting, diagnosis, contact tracing, vaccine and therapy development, and patient management.

Adapting from artificial intelligence radiology studies that use lung computed tomography (CT) and X-ray scans, retinal images can present with COVID-19-specific ocular features that can be extracted for classification and prediction tasks.

Table 1  Artificial intelligence applications on lung computed tomography scans and chest X-rays for COVID-19 diagnosis

<table>
<thead>
<tr>
<th>Patient population</th>
<th>Task</th>
<th>Type/number of images</th>
<th>Methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,222 patients from six medical centers in Wuhan, Shandong, Beijing, and Shenzhen, China [5]</td>
<td>Classification for detecting COVID-19-positive cases</td>
<td>4356 2D chest CT scans</td>
<td>Deep learning model, COVID-19 detection neural network (COVNet)</td>
<td>AUC 0.96 (P-value &lt; 0.001)</td>
</tr>
<tr>
<td>905 patients from 10 medical centers in 13 provinces in China [8]</td>
<td>Rapidly diagnose patients who are COVID-19 positive by integrating chest CT findings with clinical symptoms, exposure history, and laboratory testing</td>
<td>Chest CT scans</td>
<td>Three AI algorithms: CNN for only CT scans; ML-SVM, Random forest for clinical data; joint CNN model combining CT scans and clinical data</td>
<td>AUC 0.92 AUC (95% CI 0.887–0.948) joint CNN model</td>
</tr>
<tr>
<td>125 COVID-19-positive cases from open source chest X-ray dataset. Negative cases from another dataset (32,717 unique patients with disease labels) [7]</td>
<td>Binary classification (COVID vs. no findings) and multiclass classification (COVID vs. no findings vs. pneumonia)</td>
<td>1000 Chest X-ray images</td>
<td>Deep learning, DarkNet architecture</td>
<td>AUC 0.98 for COVID vs. no findings and 0.87 for multiclass (COVID vs. no findings vs. pneumonia)</td>
</tr>
<tr>
<td>454 patients in the Netherlands (223 positive cases and 231 negative cases) [8]</td>
<td>Classification for detecting COVID-19 cases</td>
<td>24,675 Chest X-ray images</td>
<td>AI system (CADCOVID)</td>
<td>AUC 0.93</td>
</tr>
<tr>
<td>1186 patients: 551 COVID-19 positive cases from Rhode Island Hospital and 9 Hospitals in Hounan Province, China; 665 with non-COVID-19 pneumonia from Rhode Island Hospital, University of Pennsylvania and Xiangya Hospital [9]</td>
<td>Classification of COVID-19 cases</td>
<td>1186 CT scans, 132,583 CT slices</td>
<td>EfficientNet B4 deep neural network architecture after lung segmentation, followed by two-layer fully connected neural network to pool slices together</td>
<td>AUC 0.96 (95% CI 0.92–0.98)</td>
</tr>
</tbody>
</table>

• Natural language processing methods (NLP) can be utilized to analyze the increasing influx of COVID-19 scholarly articles to improve our understanding in ophthalmology patient care and practice management, viral transmission, ocular manifestation and treatment.

• COVID-19 ophthalmology-related articles have stressed two main findings: the potential presence of SARS-CoV-2 in ocular tissue or secretions and the risk of transmission; and the importance of adequate protection and strategies to prevent transmission in ophthalmic practices.

FIGURE 1. Distribution of SARS-CoV-2 and COVID-19 topics in ophthalmology scholarly related articles.
The transition to telemedicine during COVID-19 has been swift. **Artificial intelligence for telemedicine applications can address the high demand, prioritize and triage patients, improve at home monitoring devices, as well as secure data-sharing mechanisms.**

- Digital technology has provided platforms for adaptation and resources to continue essential operations for patients and healthcare workers during COVID-19. We expect that in the post COVID-19 era, there will be expanding central roles for artificial intelligence and telemedicine in ophthalmology.

**TELE-EDUCATION**

**iTeleGEN – Telemedicine and Tele-Education System**

- Cloud-based system for telemedicine, tele-education, and data management.
- Suitable for a wide range of applications
  - **Intelligent Tutoring Systems**

**i-ROP DL and Vascular Severity Score**

- Utilization of the i-ROP DL system for telemedicine diagnosis and training
- Potential for i-ROP DL score to assist trainees and practicing ophthalmologists in ROP diagnosis
- **Can information generated by AI improve education and access to care?**
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Fundamentals of Retinopathy of Prematurity (ROP)

By the end of this course you will be able to:

1. Describe the magnitude of retinopathy of prematurity, its risk factors, classifications and techniques for screening, care and follow up
2. Describe and apply the principles of retinopathy of prematurity screening, both in person and via telemedicine
3. Describe the principles of the different types of treatment for retinopathy of prematurity
4. Describe the expected visual outcomes for retinopathy of prematurity by stage
5. Describe effective patient communication techniques related to consent, visual prognosis and low vision rehabilitation, retinopathy treatment and follow-up

1,818 individuals from 130 countries/territories enrolled in the new Cybersight ROP course launched in 2021
CYBERSIGHT AI

- Only available in LMIC and is part of a larger mentoring consultative process - not autonomous
- Multiple flavors:
  - Integrated with Cybersight Consult/Orbis EMR
  - “Refer”: coarse-grained screening
  - “Clinical”: fine-grained clinical analysis
- Machine Mentoring - Walk the consulting eye health professional through the algorithm
- Studies planned or underway in:
  - Rwanda
  - Bangladesh
  - China
  - Vietnam
Implementation of Technology and Artificial Intelligence Potential Implementation Gap

- **EFFECTIVE INNOVATION**
  - Evidence in "real world", heterogeneous, and any intended target populations
  - Evidence on target camera/devices
  - Analysis of built-in bias
  - Analysis & understanding of diagnostic errors

- **EFFECTIVE IMPLEMENTATION**
  - Understanding local context for implementation (e.g. patient & provider preference)
  - Analysis of infrastructure
  - Regulatory environment
  - Determination of liability
  - Analysis of human-computer interaction

- **SUSTAINABLE ENVIRONMENT & SCALABILITY**
  - Needs to align with a company’s strategic goals
  - Identifying appropriate reimbursement models
  - Evidence of cost-effectiveness
  - Negotiation with payers
  - Needs to be repeated in each cultural, regulatory, and insurance context

**Fewer people go blind**

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Artificial Intelligence to Reduce Ocular Health Disparities: Moving From Concept to Implementation
Implementation of Technology and Artificial Intelligence ROP Program Collaborations (2006 to 2021)
Addressing the Third Epidemic of Retinopathy of Prematurity Through Telemedicine and Technology: A Systematic Review

Tala Al-Khaled, MD; Nita G. Valikodath, MD, MS; Samir N. Patel, MD; Emily Cole, MD, MPH; Margaret Chervinko, MLIS; Christina E. Douglas, MD; Andrew S.H. Tsai, MBBS; Wei-Chi Wu, MD, PhD; J. Peter Campbell, MD, MPH; Michael F. Chiang, MD; R. V. Paul Chan, MD, MSc, MBA

ABSTRACT
The rising prevalence of retinopathy of prematurity (ROP) in low- and middle-income countries has increased the need for screening at-risk infants. The purpose of this article was to review the impact of telemedicine and technology on ROP screening programs. Adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a systematic review was performed using PubMed, ProQuest, and Google Scholar bibliographic search engines. Terms searched included retinopathy of prematurity, telemedicine, and tele-ophthalmology. Data regarding internet access and gross domestic product per capita were obtained from the World Bank. Information was also obtained about internet access, speeds, and costs in low-income countries. There has been increasing integration of telemedicine and technology for ROP screening and management. Low-income countries are using available internet options and information and communications technology for ROP screening, which can aid in addressing the unique challenges faced by low-income countries. This provides a promising solution to the third epidemic of ROP by expanding and improving screening and management. Although telemedicine systems may serve as a cost-effective approach to facilitate delivery of health care, programs (especially in low- and middle-income countries) require national support to maintain its infrastructure. [J Pediatr Ophthalmol Strabismus. 2021;58(4):261-269.]

Economic Development

Telemedicine Infrastructure and ROP

TABLE II
Framework of Previously Established ROP Telemedicine Programs

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Telemedicine Infrastructure and ROP

Economic Development

Telemedicine Infrastructure and ROP
Ophthalmology is well positioned for Web-based learning and Tele-Mentoring
Collaboration with neonatology, ophthalmology, nursing, and Orbis International to implement ROP screening program in Mongolia

Collaboration to develop the infrastructure to manage children at risk for ROP in Mongolia

- Workforce development
- Implementation of technology for diagnosis, management, and education
- Advocacy with key stakeholders

1. Collaboration to implement ROP screening program utilizing telemedicine
   • Implementation of technology for diagnosis, management, and education
   • Advocacy with key stakeholders

2. Next Steps:
   • Expansion to district-level hospital
   • Integration of mobile-phone technology
   • Artificial intelligence assisted diagnosis
Implementation of Technology and Artificial Intelligence
Aravind Eye Hospital, Coimbatore, India (ROP Eradication Save Our Sight Project)

• Telemedicine screening for ROP
  • iTeleGEN

• Plans to investigate the use of AI for screening
  • i-ROP DL

Images courtesy of Dr. Narendran Venkatapathy
The key findings are the following:

(1) At the individual eye examination level, the system revealed **high diagnostic accuracy as a screening device for treatment requiring ROP**.

(2) At the population level, looking at individual NCUs, the **ROP severity was higher in NCUs that did not have the resources to monitor and titrate oxygen**.

**Proof of principle that AI may be used to improve the efficiency of ROP screening and also as an epidemiological tool for monitoring NCU-level ROP severity across geography and time.**

Tech that detects cause of preemie blindness gets federal nod

Artificial intelligence algorithm receives FDA breakthrough device status

By Franny White  January 30, 2020  Portland, Oregon

The FDA Breakthrough Device Program aims to accelerate development - and potentially approval - of medical devices for “more effective treatment or diagnosis of life-threatening or irreversibly debilitating diseases.”

The algorithm, called the i-ROP DL system, diagnoses retinopathy of prematurity, or ROP. Every year up to 16,000 prematurely born U.S. infants are affected by the disorder, which causes abnormal blood vessel growth near the retina, the light-sensitive portion in the back of an eye. About 600 U.S. babies go blind from ROP annually, making it a leading cause of childhood blindness in the U.S. and worldwide. Musician Stevie Wonder is blind as a result of ROP.

The algorithm diagnoses the condition in images of infant eyes with comparable or better accuracy than today’s standard method, which involves an examination by expertly trained ophthalmologists.

A 2018 study in JAMA Ophthalmology showed the technology diagnoses the condition 91% of the time, compared with 82% for trained ophthalmologists. Subsequent studies in 2019 described how the algorithm can be used to quantitatively measure the condition’s severity and help physicians evaluate how well treatment is working against the disease.

Oregon Health & Science University and Massachusetts General Hospital led the technology’s development, with support from Northeastern University and the University of Illinois at Chicago as well as the Imaging & Informatics in ROP (i-ROP) consortium.

OHSU and MGH are developing a commercialization plan for the technology, in the hope that it will be used by ophthalmologists and neonatologists worldwide to better diagnose and treat retinopathy of prematurity.
Trans-pars-planar illumination enables a 200° ultra-wide field pediatric fundus camera for easy examination of the retina

Devrim Toslak,¹,² Felix Chau,³ Muhammet Kazim Erol,² Changgeng Liu,¹ R. V. Paul Chan,³ Taeyoon Son,¹,⁴ and Xincheng Yao¹,³,⁴
Introduction to Artificial Intelligence in Ophthalmology

This page was enrolled in the Residents and Fellows contest.

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AAO Leadership Development Programs (LDP)
The Changing Landscape of Global Ophthalmology: Technology, Innovation, Advocacy, and Education

Original IPOSC ROP Task Force Committee

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- J. Peter Campbell – Pediatric Retina (USA)
- Kalpana Narendran (India)
- Lily Nyamai (Kenya)
- Ogugua Okonkwo – Retina (Nigeria)
- Narendran Venkatapathy – Retina (India)
1. Ophthalmology and technological innovation for improving access to care – AI can be part of the solution
   - Expand workforce for screening and treatment
   - Education important for managing ROP through "low-tech" solutions e.g. screening with indirect ophthalmoscopy
   - Follow up care
   - Cost effective models
   - Address potential gaps in health equity
   - Regulatory issues need to be addressed

2. Tele-Mentoring and Education

3. Advocacy and strong partnerships to train workforce