

WHAT AVIATION CAN TEACH US ABOUT AI

Retina specialists looking to integrate new technology should seek a digital copilot, not autopilot.

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AI is rapidly transforming medicine, and few specialties illustrate this evolution better than retina.¹ Modern retina care generates enormous quantities of data through OCT imaging (including OCT angiography), fundus photography, and fluorescein angiography. These highly standardized datasets are ideally suited for machine- and deep-learning applications. This has facilitated the development of AI algorithms with remarkable performance in detecting diabetic retinopathy, AMD, glaucoma, and numerous other diseases. Despite these impressive achievements, retina specialists know that clinical decision making rarely

depends on imaging alone. Treatment decisions require consideration of symptoms and functional deficits, systemic disease, previous therapeutic responses, patient preferences, and subtle clinical findings that extend beyond image analysis.

AI therefore represents an important complement—not a replacement—for clinical expertise. While AI developments promise substantial improvements in efficiency and patient care, they also raise an important question: How can we safely integrate AI into clinical practice without eroding physician expertise?

Aviation faced a remarkably similar challenge decades ago. The introduction of increasingly sophisticated automation dramatically improved flight safety and operational efficiency. However, experience also revealed unintended consequences, including reduced manual proficiency,

overreliance on automated systems, and diminished situational awareness.² These lessons provide valuable guidance as medicine enters the era of AI-assisted health care.

THE AUTOMATION PARADOX

The term *automation paradox*, first defined by cognitive psychologist Lisanne Bainbridge in 1983, describes an unexpected phenomenon: As automation becomes increasingly capable, human operators become progressively

KEY TAKEAWAYS

- ▶ In aviation, the introduction of automation improved safety and efficiency but introduced increased reliance on automated systems and diminished situational awareness—and a similar phenomenon is beginning to emerge in medicine.
- ▶ To avoid the negative consequences of AI in medicine, the authors recommend viewing AI not as an autopilot capable of independently managing patient care, but as a digital copilot.
- ▶ Just as modern aviation combines automation with skilled pilots, the next generation of retina specialists should strive for a partnership in which AI enhances, rather than diminishes, human expertise.



less engaged, leading to a deterioration of manual skills precisely when they are needed most.³ Paradoxically, more automation then is required to compensate for the skill loss.

Commercial aviation offers several well-known examples of disasters engendered by the automation paradox. Modern aircraft are extraordinarily safe, largely because of automation. However, accident investigations repeatedly demonstrate that pilots who relied excessively on automated flight systems were sometimes slower to recognize unexpected situations or less prepared to take manual control when automation failed.⁴

A similar phenomenon is emerging in medicine. While AI's capabilities undoubtedly improve efficiency, excessive dependence could weaken independent diagnostic reasoning. Recent studies suggest that clinicians exposed to AI assistance may experience declining diagnostic performance once AI support is removed. In gastrointestinal endoscopy, for example, endoscopists regularly using AI-assisted adenoma detection showed reduced detection rates when subsequently performing examinations without AI assistance.⁵ Although other longer-term studies are limited, the possibility of AI-induced *deskilling* deserves careful attention.

FROM DESKILLING TO NEVER SKILLING

An equally important concept is *never skilling*, recently discussed in *Nature Medicine* to describe a potential risk for future physicians.⁶ Unlike deskilling, which refers to the gradual erosion of established skills in experienced clinicians,⁷ never skilling describes a trainee's failure to acquire foundational clinical reasoning skills due to a reliance on AI.

Again, aviation provides an important contrast. Before pilots can rely on autopilot, they must master manual flying, repeatedly demonstrate proficiency under simulated emergency conditions, and undergo repeated training throughout their careers.⁸ Automation therefore augments an already established skill set rather than replacing its acquisition.

Medicine currently lacks such safeguards. If ophthalmologists routinely rely on AI during their training to interpret OCT scans or formulate differential diagnoses before developing these competencies independently, they may appear proficient while lacking the expertise required when AI is unavailable or produces incorrect recommendations. Although never skilling remains a theoretical concept that has not yet been demonstrated empirically, it reinforces an important lesson from aviation: Automation is safest when it builds upon, rather than substitutes for, fundamental human expertise.

FROM AUTOPILOT TO DIGITAL CO-PILOT

In our recent perspective article,² we examined the lessons medicine could learn from the field of aviation regarding optimized safety in the age of automation. One of the most important lessons was that automation should support and not replace human expertise.

Rather than viewing AI as an autopilot capable of independently managing patient care, a more appropriate model may be that of a digital co-pilot. Just as airline pilots remain ultimately responsible for every flight despite sophisticated automation, physicians should retain responsibility for clinical judgement while AI provides additional information, consistency, and efficiency. This collaborative model is particularly relevant in retinal practice. Although AI may accurately segment retinal layers, quantify intraretinal or subretinal fluid, identify imaging biomarkers, predict disease progression, or generate patient reports, the ophthalmologist remains responsible for integrating these findings into the broader clinical context.

This partnership combines complementary strengths. AI excels at rapid image analysis, consistency, and recognition of subtle pathological patterns. Physicians contribute contextual understanding, clinical reasoning, ethical judgement, communication skills, and the ability to interpret findings based on individual patient circumstances.

The future of retina care lies not in replacing clinicians with algorithms, but creating high performing human-AI teams.

BEYOND IMAGE ANALYSIS: THE NEXT GENERATION OF AI IN RETINA

The role of AI in retina is already expanding beyond image interpretation. Generative AI has the potential to transform clinical workflows by automatically generating structured reports from electronic health records, producing referral letters, drafting scientific documentation, and creating patient-friendly explanations of complex retinal diseases. Such systems could significantly reduce administrative burden while improving communication between specialists, referring physicians, and patients.⁹

At the same time, advances in high-resolution retinal imaging allow entirely new biological information to be extracted from the eye and are reshaping the emerging field of oculomics, which seeks to derive systemic health information from the eye.¹⁰ Coupled with AI, these imaging modalities have the potential to enable earlier disease detection, more accurate patient stratification, and therapy monitoring in a number of diseases. These developments illustrate an important principle: The greatest effect of AI may not simply be faster diagnosis, but enabling clinicians to measure previously inaccessible biological processes.

Equally important is AI literacy. Retina specialists do not need to understand every mathematical detail of neural networks, but they should understand how AI systems are trained, their limitations, and when their outputs require careful scrutiny. Recognizing uncertainty and knowing when to question AI recommendations may become as important as interpreting retinal images themselves.

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LOOKING AHEAD

Retina is uniquely positioned to lead the safe integration of AI into ophthalmic care. The specialty has embraced digital imaging earlier than most other fields, possesses standardized datasets ideally suited for AI development, and already benefits from a number of clinically validated and regulator-approved algorithms.

The future of ophthalmology will not be defined by algorithms alone. It will be shaped by how effectively clinicians and AI work together. Just as modern aviation combines highly sophisticated automation with skilled pilots, the next generation of retina specialists should strive for a partnership in which AI functions as a trusted digital co-pilot—enhancing, rather than diminishing, human expertise. ■

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