

**How will the patient with ophthalmic problems be cared for in 30 years' time?**

Connor S. Qiu

Predicting the future can be a foolhardy exercise. 30 years is a very long time, especially in the age of exponential human progress, driven in part by technological advances, and coined by some to be the 'Fourth Industrial Revolution'<sup>1</sup>. Many prominent thought-leaders have made embarrassing and ultimately untrue predictions. For example, former Microsoft CEO Steve Ballmer was interviewed by USA Today saying in 2007 'there's no chance that the iPhone will get any significant market share. No chance,'<sup>2</sup>.

Ophthalmology will be driven by the major trends in society, and at its very fundamentals, the primary needs and wants of the populace of its time. Without seismic geopolitical shifts, there are likely to be some constants. The population will increase to around 10 billion in 2050<sup>3</sup>, our time indoors, doing near-sighted work and on digital screens will also<sup>4</sup>, and our finite healthcare systems will face increasing demand with rising expectations<sup>5</sup>.

This has implications for all facets and subspecialties of ophthalmology. By hazarding our best guess as to how the world will change, what will be in vogue and what will become obsolete in 30 years' time, we may be able to best foresee how the ophthalmic patient will be cared for in the future.

## **Machine Learning and Artificial Intelligence**

Diagnostic accuracy is at the forefront of successful disease management in patients. The vast amount of data being generated and stored, the increasing accessibility of such data, and improvements in computing power have revived a once forgotten field<sup>6</sup>. Now running machine-learning algorithms on large datasets enables automated clinical diagnoses of Optical Coherence Tomography (OCT) scans to a level that surpasses that of expert clinicians. Perhaps a revolution on the revolution that was OCT for the diagnosis and monitoring of the medical retina subclass of diseases, such as age-related macular degeneration and diabetic retinopathy<sup>7</sup>.

Automation of the staple diet of an ophthalmologist, cataract surgery, is likely inevitable in this time frame. Augmentation of surgical ability with advanced bionics is already a reality. The da Vinci surgical system being a well-known example that is being licensed for an ever-wider range of procedures<sup>8</sup>. Ophthalmic surgical tolerances provide technical challenges. Peeling an epithelial membrane to the degree of microns is somewhat beyond say a da Vinci Xi surgical system, but has been shown to be able to assist in simulated cataract surgery<sup>9</sup>. Indeed, the current prevailing wisdom is that technology is not the limitation, it is regulation and ethics that cannot keep pace with fundamental questions such as who or what bears ultimate responsibility if a procedure is unsuccessful<sup>10</sup>. In 30 years' time, governmental institutions and regulatory bodies will be able to develop new frameworks and iterative processes to enable regulation that allows such technology to become pervasive<sup>11</sup>.

It is conceivable that patient pathways will become completely automated, bringing the production line approach to improving efficacy and efficiency touted by lean healthcare theory into new dimensions<sup>12</sup>. A patient-centred approach that does away with the traditional, personal patient-doctor relationship is paradigm shifting. It is commonly believed and somewhat substantiated that the relationship itself is healing<sup>13</sup>. The counterargument is that the future patient population will be digital natives and be accustomed to filtering vast amounts of conflicting information to find the best service for their needs, much like online shopping. Yet, patient satisfaction has been proven time and again to not solely depend on clinical outcomes<sup>14</sup>. Caring at its crux is more complex and involves not only treating physical disease, but also prioritising the mental wellbeing of patients. The barrier to a completely autonomous healthcare system without human involvement, a dystopia or a panacea depending on your worldview, may well be innate human nature<sup>15</sup>. Even if this is the case, patients will receive care from ophthalmologists that have had their bimanual motor skills honed by advances in neuroimaging and gamified training platforms that raise the ceiling for technical skill, and accelerate the pace of learning and teaching<sup>16, 17</sup>.

### **The Genomics Revolution and Preventative Medicine**

Genome sequencing has reached the stage where it is now financially feasible for the Earth BioGenome Project (EBP) to begin the process of sequencing the genomes for all the eukaryotes in the world<sup>18</sup>. It was not long ago when the Human Genome

Project, many orders of magnitude smaller than EBP, was considered to be an impossible mission<sup>19</sup>.

Such advances will enable personal sequencing to become commonplace, and for genetic engineering techniques such as CRISPR-Cas9 targeted genome editing to become a new standard in ophthalmic treatment. It has already been shown that CRISPR-Cas9 is theoretically able to treat myocilin-associated glaucoma, which contributes to around 4% of primary open-angle glaucoma (POAG) cases. POAG being a leading cause of visual loss across the globe<sup>20</sup>. With an estimated 111.8 million individuals affected by POAG in 2040<sup>21</sup>, such treatments have the potential to offer a long-term curative solution.

Myopia is another example. In 2050, it is estimated that 5 billion people will be myopic, representing approximately 50% of the population, and 1 billion will suffer from high myopia (< -5.00 D) – a significant risk factor for glaucoma, retinal detachment and myopic macular degeneration<sup>22</sup>. Preventing the seemingly inevitable exponential growth of the myopia pandemic is unlikely to be as simple as identifying a few myopia susceptibility genes and eliminating them<sup>23</sup>. Indeed, the development of myopia is multifactorial in both genetic and environmental terms<sup>24</sup>. Although corrective lenses offer a ready-made solution for distance vision, they do not solve aforementioned predispositions to complications. Furthermore, poor accessibility to eye examinations and eyewear for certain parts of the world, and user preferences and common disdain for the necessity of their eyewear, particularly

for aesthetic reasons and physical activities, make for a complex and multifaceted problem<sup>25</sup>.

A public health approach to such ophthalmic problems may therefore be mandatory for ideological, economic and practical reasons. The barriers to widespread adoption of innovation, such as nanotechnology and gene therapy, especially germ-line therapy, arguably the most controversial application of such therapeutics, face many scientific unknowns and understandable barriers on ethical fronts<sup>26, 27</sup>. In the case of myopia, perhaps 'glass box' classrooms which have been shown to reduce rates of myopia in schoolchildren provide an answer<sup>28</sup>. Even wearable technology that encourages outdoor activity could unknowingly achieve the same effect<sup>29</sup>. Avant-garde lateral innovations will play a greater part in the overarching caring ecosystem, serendipitously benefiting the future profile of the ophthalmic patient. The success of such targeted interventions and non-intentionally associated cultural trends in the coming years will dictate the prevalence and type of ophthalmic problems that become the focus of the profession, and thus affect the very focus of the umbrella of care that ophthalmic patients will receive.

### **The Divide**

The ophthalmic patient is not homogenous in kind; neither does each patient inhabit an egalitarian world. Different countries and ethnicities face unique ophthalmic challenges. Their problems will be met by different healthcare systems that are private, public or even a mix of the two, with access to differing levels of equipment

and expertise. Resources are finite and progress in ophthalmic care in the developing world has been in recent history, heavily dependent on commendable global initiatives such as Vision 2020<sup>30</sup>. Trachoma, and other preventable causes of blindness can be eliminated and no longer be part of the spectrum of diseases that patients will contend with in 30 years' time<sup>31</sup>. Sadly, unanticipated new diseases could be born, perhaps out of voracious human activities<sup>32</sup>.

The socio-economic divide means that access to beneficial health information, accessible increasingly over the web and through the digital medium, will not necessarily be absorbed and utilised by those that would benefit most<sup>33</sup>. Envisaging a world where the patient becomes more knowledgeable and capable to take overarching responsibility for their care, it may be the case that telemedicine and advanced engineering could replace much of the services of current tertiary centres of distinction in local, primary care settings. In many pockets of the developing world however, it is still conceivable that in 30 years' time, there will still be the need for many more operational centres of excellence that have economies of scale, replicating the current functioning and techniques employed in the Aravind Eye Care System hospitals, only in other geographical localities that have yet to benefit from such a level of care – never mind what the future cutting-edge promises<sup>34</sup>.

It has been the precedent that in this progressive, globalised world, ophthalmologists in developed nations are increasingly female and ethnically diverse<sup>35</sup>. Patients can expect to benefit more from meritocratic talent selection processes, driving ophthalmology on to new frontiers.

## **Conclusion**

Vision will remain a top priority for patients in 30 years' time. This is safe to say. It is a core human sense, and for all the new and yet to be known ways of stimulating it, for example through virtual reality and augmented reality, it is its core, mechanical function that makes us uniquely human<sup>36</sup>. Change is the only certainty when it comes to predicting the future<sup>37</sup>, but in whatever way healthcare changes, ophthalmic patients should rest assured:

Vision will always be profoundly cared for.

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