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Data quality and clinical decision-making: do we trust machines blindly?

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This special issue of *Clinical and Experimental Optometry* contains papers covering the breadth of application of wavefront optics, all of which illustrates how optometry has changed to become more dependent on technology. Beyond wavefront optics, the dependence on technology also occurs in ocular imaging[1] and the measurement of visual function.[2] These technological advances provide us with insights we could have only dreamed of 20 years ago, however, the more we become dependent on technology, the more concerned we should be about the accuracy and precision of the data that the technology supplies. When making clinical decisions based on these data, we need to be as confident as possible of their quality and more importantly, know when not to trust the data. How should we test technology that is available to us and what is required for us to be convinced of its quality?

First, we should recognise that mere commercial availability, even from a well-known company, does not guarantee validity as evidenced by the new technologies that have come and gone, unable to withstand scrutiny. The more mature reader may remember the fanfare that greeted the availability of the Interzeag Lens Opacity Meter 701.[3] The ability of this machine to measure cataract was quickly called into question,[4,5] and this device vanished soon after. Such failures are scattered throughout the history of ophthalmic technology and include corneal topographers, vision testing devices and autorefractors.[6–8]

Second, just because a device measures one thing well, it does not mean that all data produced are valid. For example, one device that has revolutionised anterior segment imaging is the Oculus Pentacam. This device reconstructs the anterior segment of the eye from a series of cross-sectional Scheimpflug photographs. It produces many ocular biometric measurements and excellent pictures of the anterior segment, which have led to its rapid adoption into practice. The Pentacam has been very well studied, in terms of both its repeatability and agreement with other instruments.[9–12] It produces accurate and precise measures of lens opacity, corneal curvature, central corneal thickness and anterior chamber depth, giving the device tremendous clinical utility,[9,11] however, Pentacam measurement of pupil size, peripheral corneal thickness and corneal surface derived wavefront aberrations have been shown to be imprecise or inaccurate.[10–12] The problem with Pentacam-derived wavefront aberrations has affected one of the studies reported in this special issue, which looked at using Pentacam-derived aberrations to characterise the changes seen in keratoconus.[13] This study finds that Pentacam reports posterior cornea-derived aberrations, which are of a magnitude much greater than would be expected given the known optics of the cornea. This illustrates the role of face validity in assessing data quality; data should appear to be sensible at first glance, before being tested in more detail. While the Pentacam may have several shortcomings, it produces many valuable measurements and no doubt Oculus will resolve the problem with calculating wavefront aberrations as the flaw is likely to be in the computations.

The two important basic attributes of data quality are precision and accuracy. Precision is the ability to produce the same result over and over when measuring the same subject. Precision is tested in repeatability or reliability studies.[14,15] Arguably, precision is more important than accuracy because as long as a measurement is precise, it can be adjusted for any deviation in accuracy. Accuracy is the ability of a measurement to appropriately represent the concept under measurement. Testing for accuracy requires comparison with a gold standard. This can be problematic, if it is argued that the new technology is superior to the old gold standard because it is then difficult to know whether to ascribe the inaccuracy to the new or old measure. Usurping an existing gold standard requires more than simple reliability and accuracy studies.[16] Accuracy is usually determined in method comparison studies.[17,18] Reliability and method comparison studies may not be the most interesting studies for subscribers to journals to encounter but without them, we have no way of knowing whether the technology that we are relying on is valid. Our clinical and experimental journals are unquestionably the correct media for publishing such studies and long may they continue to do so. This special issue contains a number of important studies illustrating the reliability of wavefront aberration measurements during tear film and/or accommodative changes as well as how such variability affects the ability to detect change.[19–23]

While it is clear that we want technology to be as accurate and precise as possible, what should we accept? Take subjective refraction, a cornerstone of optometry and essential information for refractive surgery. The repeatability of subjective refraction is poor, being 0.62 to 0.75 D for the spherical equivalent,[16] yet spectacle, contact lens and laser refractive corrections are generated from this imprecise method. As a consequence, not every outcome is perfect, forcing us to accept a range of results with a comparable noise of the measurement precision. Automated and wavefront refractions may be more precise but their accuracy is yet to be established.[16] In wavefront measurement, there remain issues about where the reflection of the probe beam occurs within the retina (which directly impacts spherical error), limitations in locating the pupil centre, physiological variations in pupil centre location with pupil size, the inherent ability to detect the pupil centre accurately and correction for the chromatic aberration between the IR probe beam and the visible spectrum, to name a few.

Finally, we have the problem of assumption; do we really know what we do not know? In our enthusiasm to embrace new technology we must be able to differentiate the theoretical benefit from the proven benefit. Theory is not enough; new treatments or technologies must be proven to be efficacious. Collagen cross-linking for keratoconus is a good example. While based on a sound theory, this treatment has been difficult to prove effective because the rate of progression of untreated keratoconus was actually unknown and has since been shown to be very slow.[24] Thus, while embraced by many, this treatment remains unproven.

Clinicians should embrace the new technology that is changing the face of optometry for it has the potential to improve eye care in many ways but we should not adopt new technology blindly. We should be questioning of the quality of data presented to us and demand that it is independently and rigorously scientifically tested. Once the testing results are in, we need to understand what they mean and the limitations of the instrumentation. Only then can clinical decision-making be helped by technology rather than being left at its mercy.

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