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EDITORIAL
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The utility of mHealth in Medical Imaging

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Introduction

Mobile devices are uniquely positioned to make a significant contribution to medical imaging. Portability, computing power, accessibility and built in internet connectivity are well described advantages of mobile devices.[1] There is a growing body of research which supports the use of mHealth technologies for imaging, and a number of novel uses are described in the literature.

Current Evidence

The role of mobile devices in medical imaging has broaden to encompass a broad range of functions including diagnostic purposes, facilitating triage of emergent conditions, improving communication between health care providers to expedite patient care, and providing a feasible system for patient follow-up and self monitoring. The ever increasing capabilities of mobile technologies have also enabled their purpose to expand beyond simply an image capturing tool. This has been reflected in a spectrum of basic sciences, medical and surgical specialties, and public health that are using the imaging capabilities of mHealth to improve access and delivery of patient care.

One of the more novel fields of mHealth emergence is in its role as a diagnostic instrument in the laboratory. Traditionally, laboratory tasks such as microscopy, fluorescent imaging, and enzyme-linked immunosorbent assays (ELISA) require sophisticated and expensive equipment. In this context, the use of mobile technology has been explored as a viable adjunct for laboratory imaging to perform calorimetric analysis of fluid to detect biomarkers of ovarian cancer,[2] microscopy to detect giardia lamblia,[3] and optofluidic assessment for rapidly performing cell counts of body fluid samples.[4]

In the field of radiology the applications of mHealth and imaging largely relate to the ability to transfer and interpret clinical investigations on mobile devices. Most commonly, the literature highlights examples of interpretation of CT images (in specialties such as neurosurgery and trauma) on a smartphone.[5] Novel adaptors have also demonstrated the capacity for smartphones to perform spectrographic analysis of Doppler ultrasound.[6]

Dermatology is a perfect candidate specialty for the application of mHealth as it necessitates an intervention that can encompass diagnostic ability, monitoring and after care of potentially malignant and chronic skin lesions that relies on using an objective measure. Case studies have shown the high sensitivity and specificity of mobile phone teledermoscopy to assess and monitor potentially malignant skin lesions.[7,8] Similarly, the capacity for observing images taken on a smartphone has been extended to monitoring wound care in specialties including plastic surgery,[9] assessment of burns and post-operative wounds.[10] In most cases, studies have shown that with minimal additional training, non-specialist medical workers (doctors in training, nurses, allied health workers) can be trained to perform simple tasks of image capture.[11] This would be of considerable benefit in rural and remote areas where there are distributional challenges and shortages of specialist cadres.

In the field of ophthalmology the application of mHealth has similarly increased the potential to facilitate timely diagnosis and expedite management for sight-threatening conditions. Globally, refractive error remains the leading cause of all vision impairment. To address this, the NETRA, an optical device that is adapted onto a smartphone has been developed to allow individuals to perform subjective auto-refraction. The validation study of this device has been published previously in our

Journal.[12] Smartphones have also been explored as adjuncts to clinical examination for ophthalmic pathology. Commercially available slit-lamp adaptors have been demonstrated to be able to capture adequate quality imaging of the anterior chamber of the eye.[13] Furthermore, given that smartphone cameras have an ever increasing image resolution it is conceivable that in the near future smartphones may provide fundus images to facilitate early referral of patients in low-resource settings.

Whilst the aforementioned specialties account for the largest body of current evidence for mHealth and medical imaging, the versatility of smartphones has expanded to almost all disciplines of health care. In cardiology, a number of applications have been developed to monitor clinically important parameters including heart rate variability and arrhythmias.[14] In neurosurgery, apps that enable clinicians to accurately position ventricular catheters from CT scans have been developed.[15]

Despite the growing body of literature regarding mHealth, recent meta-analyses have shown that there are currently few studies based on high methodological quality.[16] Limitations included the lack of objective clinical outcomes, and the heterogeneity between reported outcomes amongst studies with similar interventions. Additionally, the majority of studies were conducted in high-income countries. This limited the extent to which the results can be contextualized to low-resource settings, where mHealth is positioned to make the biggest impact.

Technology considerations

The imaging sensor is responsible for converting light energy (photons) into the electrical signal that eventually forms an image. Two commonly used technologies are Charge Coupled Device (CCD) and Complementary Metal Oxide Semi-Conductor (CMOS). Compared to traditional cameras, smartphone cameras have a key constraint - physical space. as such, image sensors are often physically smaller, and as a result, image quality can be degraded. It is also important not to focus on the "Megapixel" count of a camera, as this represents only one aspect to image quality. Other factors and features such as lens quality, dynamic range, backside illumination and image stabilisers are all equally important to consider, and can considerably enhance image quality. Ultimately, it is important to keep in mind that the quality of the camera required depends largely on the intended purpose of the image, and for many purposes the latest generation of smartphone cameras produce images which are of far higher quality than required.

The key advantage that smartphone cameras have over regular cameras is the computational power available from powerful processors to manipulate the captured image. For example, rapid diagnostic tests (RDT) which detect a variety of diseases such as HIV, malaria and tuberculosis have been developed which use a smartphone camera, specially designed RDT strips and a special adapter. After capturing the image of the test strip, the software on the smartphone then takes this image, converts it to grayscale, and automatically enhances the picture. It is then able to perform an algorithmic calculation on the image in order to produce a diagnosis. The whole process is done locally on the device, and does not require any connectivity.[17] In the low resource setting, this can be especially helpful, where lab tests can be performed cheaply, with minimal hardware costs, on a device that is highly portable. Another example highlighting the advantages of smartphone cameras is the development of software image stabilisers, which use the accelerometers and gyroscopes already included in smartphones to correct image blur resulting from long exposure times.[18]

Conclusion

The use of mobile devices for medical imaging is rapidly growing, with many traditional imaging techniques being challenged. With increasing image quality, and software designed to take advantage of the computational power of smartphones, combined with rapidly declining costs, mHealth imaging has the potential to change the future of medical image capture.

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