Application of smartphone cameras for detecting clinically active trachoma

The WHO is committed to eliminating trachoma as a public health concern by 2020.[1] Since decisions for mass treatment are determined by the prevalence of clinical trachoma in a community, efficient and accurate methods for monitoring clinical activity remain a priority.[2] However, reliability of clinical examination is poor and disagreement between graders is common.[3] Photography of the conjunctiva could reduce variability and improve accuracy of trachoma surveillance. Currently, research studies use single-lens reflex (SLR) cameras to validate field grading.[4] Yet, SLR cameras are expensive and require substantial field training to operate, and thus few trachoma programmes have adopted this technology. A simpler, more affordable camera may increase uptake of this diagnostic technique. In view of growing applications of mobile technology,[5] we examined the use of smartphone imaging in trachoma.

During a recent programme, Partnership for the Rapid Elimination of Trachoma (PRET study) visit in Niger, we performed the clinical examination, SLR, and smartphone photography of the everted right upper tarsal conjunctiva in 61 study participants.[4] Study participants, aged 6 months to 5 years, were from four villages, each of which had received a mass azithromycin distribution one year prior. Clinical examinations were performed by a PRET-certified examiner with 2.5× magnifying loupe and a flashlight. Examiners used the simplified WHO grading scheme, which classifies follicular trachoma (TF) as the presence of at least five follicles ≥0.5 mm in diameter on the upper tarsal conjunctiva, and trachomatous inflammatory-intense (TI) as papillary hypertrophy and inflammatory thickening obscuring over half of the deep tarsal vessels.[6] SLR photographs were taken by a PRET-certified photographer with a handheld Nikon D-40, with a 105 mm f/2.8D AF Macro Nikkor Autofocus lens, using manual settings with the flash engaged. Smartphone images, captured immediately after the SLR photo, were taken with an iPhone four camera using autofocus and without flash in order to minimise glare from the phone's screen. Photos were systematically cropped and resized to match the approximate size of the conjunctiva in the SLR images. Three PRET-certified trachoma graders reviewed the photographs independently and in random order within one sitting and without discussion.

Latent Class Analysis was performed to assess test performance with both cameras and field grades given the absence of a gold standard. Sensitivities and specificities for the latent gold standard were obtained for (i) SLR photography; (ii) smartphone photography and; (iii) clinical field grades. For clinical activity, field grades had similar sensitivity to SLR photos, but higher specificity than both cameras. SLR photos were moderately more sensitive and more specific than the iPhone photos (table 1). While iPhone photos were the least sensitive for TF, compared with both the SLR photos and field grades, iPhone photos were the most sensitive for TI. However, iPhone photos were moderately less specific than both field grades and SLR photos.

The iPhone demonstrated moderate inter-grader reliability (table 1). iPhone inter-grader reliability was higher than SLR for active and TI grades. Inter-grader reliability was the highest for clinically active trachoma with the iPhone photographs. iPhones were less reliable for TF than SLR photos, but more reliable for TI.

The advantages of photographic examinations include reproducible grading by

Table 1 Sensitivity, specificity and inter-grader reliability (κ) for trachoma grading (N=61)

	Active trachoma (TF and/or TI)	TF	TI
Grade assigned N (%)			
iPhone	25 (41.0%)	11 (18.0%)	16 (26.2%)
SLR	24 (39.3%)	20 (32.8%)	11 (18.0%)
Field grade	23 (37.7%)	20 (32.8%)	11 (18.0%)
Sensitivity			
iPhone	78% (63.9–95.3)	41% (26.1–94.4)	91% (82.4–99.4)
SLR	81% (69.0–95.4)	88% (68.0–94.3)	76% (50.5–94.4)
Field grade	81% (66.7–95.6)	88% (68.0–95.0)	76% (53.7–93.8)
Specificity			
iPhone	91% (80.8–100.0)	91% (83.1–100.0)	91% (83.1–100.0)
SLR	97% (89.2–100.0)	98% (88.2–100.0)	96% (90.8–99.4)
Field grade	100% (97.5–100.0)	98% (87.5–100.0)	96% (90.7–99.3)
Inter-grader reliability			
iPhone	0.86 (0.80–0.90)	0.63 (0.57–0.73)	0.83 (0.73–0.86)
SLR	0.78 (0.63–0.83)	0.76 (0.71–0.81)	0.65 (0.55–0.71)

SLR, single lens reflex; TF, follicular trachoma; TI, trachomatous inflammatory-intense.

centres of expertise, auditability, and increased accessibility to official graders. We were unable to demonstrate that the iPhone could be used in lieu of SLR photography, which has been considered costly. However, updates to the camera with newer smartphone models, an external lens attachment, and lighting adjustments could soon make smartphones a viable alternative to SLR photography. The ability to both share images through cellular data and capture relevant information electronically could dramatically facilitate accurate and efficient methods for diagnosis and treatment of blinding trachoma.

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