Spatial-Textural Machine Learning for Noninvasive Detection of Malarial Anemia Using Conjunctival Images (Year 2)

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Malaria is among the earliest documented infectious diseases in humans and remains a major global health challenge. In malaria-endemic regions, anemia substantially worsens outcomes, and severe malarial anemia is a medical emergency in children and pregnant women with parasitemia. In holoendemic settings, more than half of deaths occur within the first 24 hours of hospital admission, underscoring that delays in recognition can be fatal. Yet malarial anemia is often missed because rapid, noninvasive point-of-care tools for fast-track detection are limited. In resource-limited settings, separate malaria and anemia tests can fail to flag an imminent emergency and miss the narrow window for life-saving transfusion. Here, we present spatial and textural (radiomic) analyses of smartphone photographs of the palpebral conjunctiva (inner eyelid), coupled with hyperparameter-optimized neural networks, to directly detect malarial anemia noninvasively. This approach leverages readily accessible microvascular changes in peripheral tissue using images captured with unmodified smartphone cameras, offering practical advantages including ease of acquisition and direct visualization of microvasculature. Using data collected in malaria-endemic regions of Rwanda, our radiomics-based model demonstrates reliable performance in distinguishing malarial anemia from non-infected healthy cases. A supervised model optimized for direct malarial anemia detection outperforms an AND-gate combination of independent malaria and anemia detection models. Conjunctival smartphone imaging may enable scalable screening and support rapid triage and management of malarial anemia in resource-limited settings in sub-Saharan Africa.

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