Validation of a *In Silico* Model For Optical Dosimetry in Lung Therapies Using Energy-Efficient Monte Carlo Simulation

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This study investigates the potential use of IR-NIR wavelengths to deliver energy through the thoracic wall for the treatment of lung infections, with a specific focus on pneumonia. Lung infections, including pneumonia, represent a significant global health concern. To investigate the behavior of light interaction with the chest wall, before being delivered to the lungs, a light propagation model considering the volumetric tissue optical properties, has been developed. Given the substantial volume of this thoracic region, the model aids in extracting crucial dosimetry parameters, including irradiance, fluence, and exposure time to know the feasibility of possible treatments such as photodynamic therapy. To address this, the study uses a novel, energy-efficient Monte Carlo algorithm tailored for use with ARM architecture-based processors such as Apple's M-family chipsets, which offers a more sustainable approach to simulating light transport. Our numerical framework involved image segmentation and reconstruction of detailed voxelized input from a CT scan and associating their optical properties for Monte Carlo simulations. An interval of illumination wavelengths (660, 750, 808, 850, and 980 nm) were explored, assessing the delivery of light energy deposition in various lung regions. Notably, the 808 nm wavelength demonstrated the best performing energy delivery into the lungs. These findings offer valuable insights in the design of lung therapies, particularly for the treatment of pneumonia through photodynamic therapy using external illumination. This research contributes to the development of more effective treatments for lung infections and photobiomodulation, highlighting the potential of IR-NIR wavelengths and energy-efficient simulation techniques for therapeutic applications in the thoracic cavity region.

Keywords: Lung infections, infrared near-infrared radiation, Image segmentation, Monte Carlo, Light Dosimetry, Photon transport.