Abstract

A population-scale diagnostic platform combines high-throughput attenuated-total-reflectance infrared spectroscopy with age-adaptive chemometric modeling to quantify immunoglobulin G and other serum proteins and metabolic markers from ≤5 µL of blood in under 60 seconds. A disposable micro-volume ATR cartridge (tile) self-spreads the sample and is conveyed across an ATR crystal, then sterilized and discarded automatically, enabling ≥1000 tests/hour in one embodiment. Spectral predictions (IgG, IgA, albumin, glucose-equivalent, cholesterol, etc.) are fused with molecular markers such as T-cell receptor excision circles in a Bayesian engine to minimize false negatives due to maternal antibodies. An encrypted cloud data lake retrains calibration models nightly and recalculates age-specific reference intervals per CLSI guidelines, pushing signed model updates to field instruments. The apparatus and method provide a reagent-free, cost-effective triage tool for humoral primary immunodeficiencies and common non-communicable diseases in both high-income and resource-limited settings.