AI-Assisted Electrochemical Biosensor for Mutation-Specific Detection of Antibiotic Resistance and Virulence in Helicobacter pylori Infections From Stool Samples

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Helicobacter pylori infects over 4.4 billion people and is a WHO Group 1 carcinogen linked to gastric cancer. Rising antibiotic resistance, particularly to clarithromycin (>30% in many regions), has led to treatment failure rates of 20–40%. In low-resource settings, clinicians often prescribe antibiotics empirically due to the lack of rapid susceptibility testing. We developed an integrated diagnostic framework combining a multiplex electrochemical DNA biosensor with an AI-based classifier to predict mutation-driven antibiotic resistance and virulence from stool-derived samples. The biosensor is designed to detect 16 key genetic targets associated with resistance and pathogenicity, with primers successfully designed for all targets. Wet-lab validation includes qPCR confirmation of H. pylori detection and probe/primer design for cagA, with ongoing electrochemical validation using synthetic gene fragments and potentiostat-based detection. Additional targets and multi-omic integration are planned as future work. A computational model was used to simulate biosensor behavior and evaluate robustness under varying biological and electrochemical conditions. The AI component, a multi-output Random Forest classifier trained on 10,000 biologically informed synthetic strains, predicts resistance to six antibiotics, MDR status, virulence level, and gastric cancer risk using 29 genomic features. SMOTE was applied to address class imbalance. The model achieved 95% MDR accuracy, >91% per-antibiotic accuracy, and AUC >0.93, with strong generalization on blind testing. This work demonstrates a scalable, low-cost, point-of-care diagnostic approach for precision treatment of H. pylori, with potential extension to other antimicrobial-resistant pathogens.

Awards Won:

Zydus Pharmaceuticals USA Inc.: Second Place Translational Medical Science