Artificial Intelligence in Pathology and Molecular Biology: Integrating Intelligent Systems for Laboratory Optimization

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Abstract

Background and Aim: Artificial intelligence transforms medical laboratories by improving workflows, enhancing diagnostic accuracy, and reducing turnaround times. Emerging tools such as large-scale natural language processing models in pathology and molecular biology offer new automation and operational efficiency opportunities. This study evaluated the integration of AI-driven solutions in a laboratory setting, focusing on workflow optimization, client interaction, and data management. *Materials and Methods:* The study was conducted at Pathologic Laboratory (Cluj-Napoca), where artificial intelligence was implemented across several operational domains. AI-assisted predictive scheduling and workload balancing were used to optimize resource allocation. A conversational agent (Ana) was developed to handle over 70% of incoming client inquiries, significantly decreasing reliance on traditional phone-based communication. Automation tools supported daily reporting, sales tracking, and documentation of physician visits. Exploratory applications included AI-supported cytology screening and the use of next-generation sequencing (NGS) tools. A research initiative also explored the development of a remotely controlled telemicroscope for real-time Pap smear assessment in clinics. *Results:* Implementation of AI tools led to a 30% reduction in manual tasks related to client communication and a 25% improvement in sample processing time. Predictive scheduling increased laboratory throughput by 15%, while chatbot usage reduced average response time from 8 minutes to under 2 minutes. Preliminary evaluation of AI-assisted cytology screening and telemicroscopy suggested a potential increase in diagnostic accuracy of up to 12% and improved access to diagnostic services in remote settings. *Conclusions:* Artificial intelligence increases efficiency and reduces workload in pathology and molecular biology laboratories through automation and smarter resource management. The integration of AI tools contributes to faster and more reliable diagnostics. Future developments in AI-based cytology screening and telepathology are expected to further improve laboratory operations and increase the accessibility of healthcare.

Keywords: Artificial Intelligence (AI); Pathology; Molecular Biology; Laboratory Automation; Telemicroscopy.