



Design and Development of a Low-Cost Multifunctional Medical Device with Integrated Syringe Pump and Remote Access

H.L. Subasinghe¹, G.G.G. Rajith Gihara², G.G.Y.C. Amarakoon^{2}, R.M.T.R. Rajakaruna², P.B.S. Wijerathna², R.G.I.S. Munasinghe²*

¹ RUGENX (Pvt) Ltd

² Faculty of Technology, University of Ruhuna

**Corresponding author: gihara@fot.ruh.ac.lk*

Contemporary healthcare technologies for patient monitoring and precision drug delivery have proliferated globally, yet their elevated costs render them inaccessible in resource-constrained settings. This research introduces a low-cost, multifunctional IoT-enabled medical device that seamlessly integrates an automated syringe pump with real-time monitoring of vital parameters—body temperature, heart rate, and blood oxygen saturation (SpO₂)—alongside remote control capabilities. By unifying these functions into a single platform, the device eliminates equipment multiplicity, streamlines clinical workflows, and facilitates efficient management during routine care and emergencies. The system leverages a microcontroller-driven motor with a lead screw mechanism for syringe actuation, coupled with cost-effective off-the-shelf sensors, ensuring high precision and affordability. Rigorous validation against international standards confirmed superior performance: the syringe pump delivered $\pm 1.67\%$ volumetric accuracy and $\pm 3.94\%$ temporal accuracy (IEC 60601-2-24 compliant), while monitoring achieved heart rate precision of ± 1.82 bpm, SpO₂ accuracy of ± 0.85 – 0.92% , and temperature accuracy of ± 0.56 – 0.85°C (ISO 80601-2-61 compliant). All safety protocols, including occlusion detection and emergency stops, demonstrated 100% reliability. This innovation provides a scalable, accurate solution to enhance patient safety and care accessibility in low-resource healthcare environments.

Keywords: IoT-enabled syringe pump, Patient vital monitoring, Low-cost medical device, Remote healthcare, Resource-limited settings