

ABSTRAK

Vaksin merupakan produk biologis yang harus disimpan dan didistribusikan pada rentang suhu 2–8°C untuk menjaga kualitas dan efektivitasnya. Distribusi vaksin di daerah terpencil masih menghadapi kendala, seperti keterbatasan akses listrik, kondisi lingkungan yang kurang mendukung, serta risiko kerusakan fisik pada vial selama proses transportasi. Penelitian ini bertujuan untuk merancang dan mengimplementasikan *Smart Vaccine Carrier* yang mampu memantau suhu penyimpanan vaksin secara *realtime*, memberikan perlindungan terhadap vial, serta mengendalikan sistem pendingin secara otomatis. Penelitian dilakukan melalui tahapan perancangan, implementasi, dan pengujian sistem. Alat menggunakan mikrokontroler ESP32 sebagai pengendali utama, dua sensor suhu DS18B20 sebagai sensor suhu, modul Peltier TEC1-12706 sebagai sistem pendingin, *relay*, *buzzer*, LCD OLED, *Rotary Encoder* KY-040 untuk pengaturan batas suhu minimum dan maksimum, serta voltmeter indikator aki sebagai pemantau kondisi sumber daya. Hasil pengujian menunjukkan bahwa sensor DS18B20 mampu membaca suhu dengan baik, LCD OLED, *buzzer*, *Rotary Encoder* KY-040, dan voltmeter indikator aki berfungsi sesuai dengan perancangannya. Sistem pendingin berbasis modul Peltier mampu menurunkan suhu ruang penyimpanan vaksin, namun belum mampu mencapai suhu target penyimpanan yang diinginkan selama proses pengujian. Dengan demikian, *Smart Vaccine Carrier* berhasil dirancang dan diimplementasikan sebagai prototipe penyimpanan vaksin, tetapi masih memerlukan pengembangan lebih lanjut pada sistem pendingin agar mampu memenuhi standar suhu penyimpanan vaksin.

Kata kunci: *Smart Vaccine Carrier*, ESP32, DS18B20, Peltier, *Rotary Encoder* KY-040, rantai dingin vaksin.

ABSTRACT

Vaccines are biological products that must be stored and distributed within a temperature range of 2–8°C to maintain their quality and effectiveness. Vaccine distribution to remote areas still faces several challenges, including limited access to electricity, unfavorable environmental conditions, and the risk of physical damage to vaccine vials during transportation. This study aimed to design and implement a Smart Vaccine Carrier capable of monitoring storage temperature in real time, protecting vaccine vials, and automatically controlling the cooling system. The research employed a design, implementation, and testing approach. The proposed system utilized an ESP32 microcontroller as the main controller, two DS18B20 temperature sensors for temperature measurement, a TEC1-12706 Peltier module as the cooling system, a relay, a buzzer, an OLED LCD, a KY-040 rotary encoder for setting the minimum and maximum temperature limits, and a battery voltage indicator to monitor the power supply. The experimental results showed that the DS18B20 sensors were able to measure temperature accurately, while the OLED LCD, buzzer, KY-040 rotary encoder, and battery voltage indicator functioned as designed. The Peltier-based cooling system was able to reduce the temperature inside the storage chamber; however, it was unable to achieve the desired vaccine storage temperature during the testing process. Therefore, the proposed Smart Vaccine Carrier was successfully designed and implemented as a vaccine storage prototype, but further improvements to the cooling system are required to achieve the recommended vaccine storage temperature.

Keywords: *Smart Vaccine Carrier, ESP32, DS18B20, Peltier, KY-040 Rotary Encoder, vaccine cold chain.*