TEAM M040

Autonomous Care Unit

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ICS EE CHE 5 ME COE

BACKGROUND

⁙ Minor injuries such as cuts, scrapes, and burns are common in schools.
⁙ First-aid response is often manual, time-intensive, and dependent on staff availability.
⁙ In many cases, schools do not have immediate access to a nurse or trained medical support.
⁙ This can lead to delayed or inconsistent care for non-life-threatening injuries.
⁙ The Autonomous Care Unit (ACU) was proposed as a school-focused system to provide standardized, non-diagnostic first-aid support for minor injuries.

PROBLEM STATEMENT

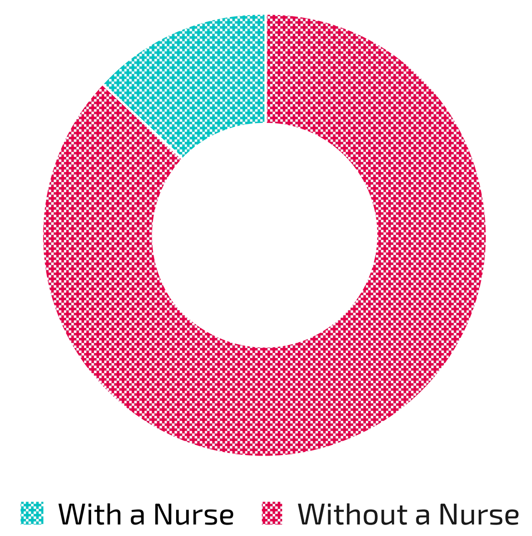
⁙ In Riyadh, only 15% of non-medical professionals have formal first-aid training.
⁙ Combined with limited nurse availability in schools, this creates a clear gap in immediate first-aid support.
⁙ Minor injuries may therefore be treated late, inconsistently, or with unnecessary escalation.
⁙ The project addresses this gap through a fast, school-safe, non-diagnostic first-aid system.

Regulatory Context

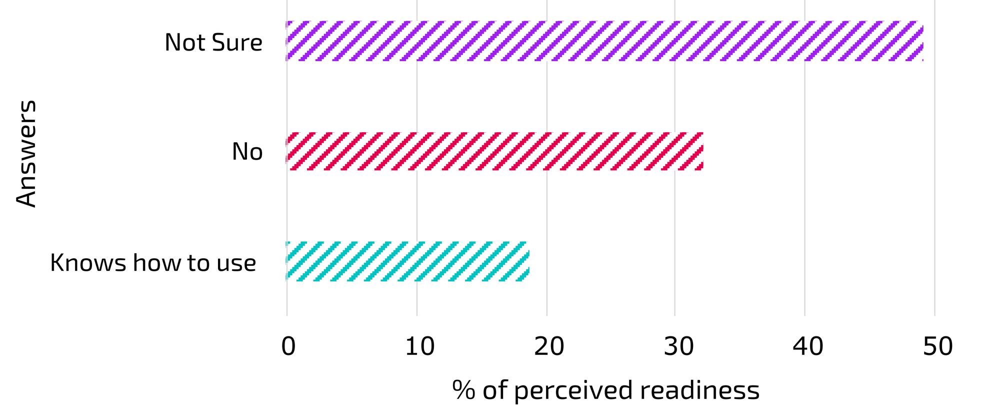
The ACU is intentionally limited to minor, non-life-threatening injuries (Class 1 & 2). Which do not require reporting to the Ministry of Education within 6 hours. (According to the Saudi School Safety Regulations, section 6)

WHY IT MATTERS?

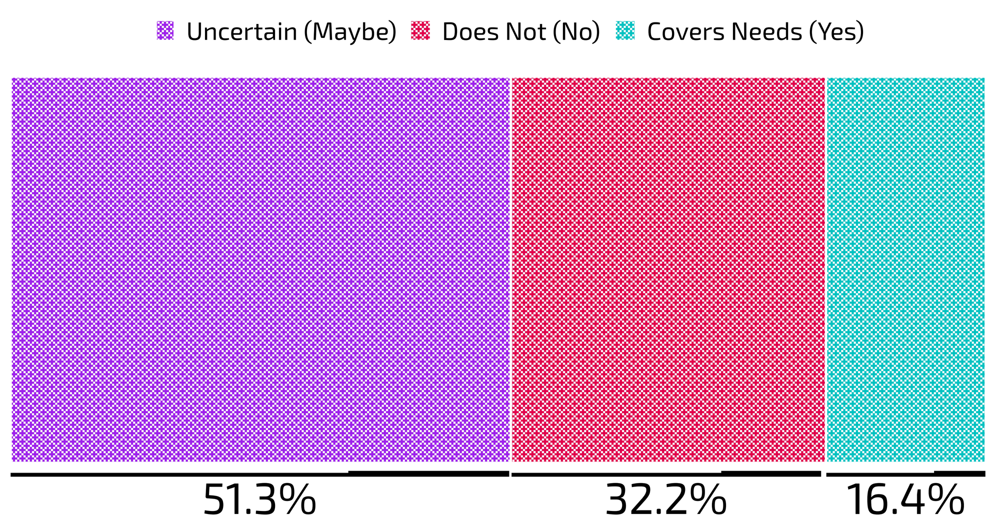
Schools With a Nurse vs Without in Riyadh



School Staff Preparedness to Use a First-Aid Ki

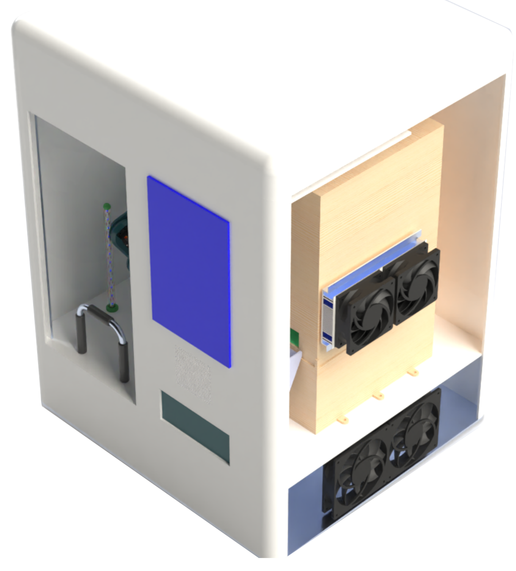


Perceived Adequacy of the School's First -Aid Kit

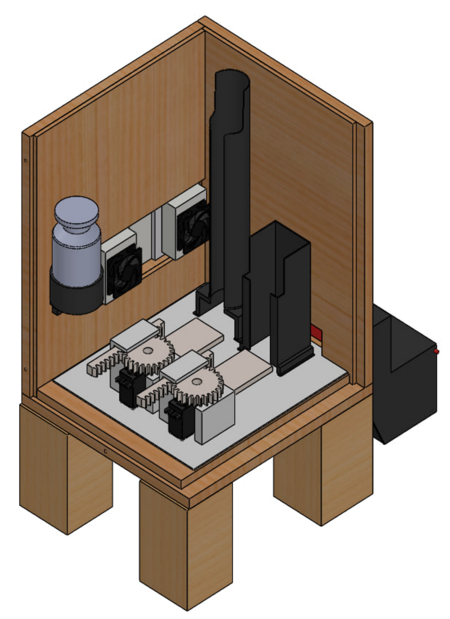


PROTOTYPE DESIGN

The selected concept balanced safety, maintainability, and school suitability better than alternative designs.



Render of the protoype.



Internal dispensing mechanism.

HOW IT WORKS

1. The student starts a session through the touchscreen.
2. The system captures image and sensor data.
3. A Jetson-based AI module classifies the minor injury.
4. The user confirms the suggested treatment.
5. The ESP32 executes low-level control for dispensing and actuation.
6. The treatment bay is sanitized, and the session either closes or escalates.

VALIDATION

Prototype validation showed several promising results:

1. Worst-case sensing and processing delay: 82.6 ms, below the 150 ms target.
2. Jetson–ESP32 communication: 100% success over 400 cycles, with no retries.
3. Chemical retention after 14 days: average 88.9%, exceeding the 80% threshold used in prototype validation.
4. Waste containment: all trials passed without leakage or structural damage.
5. Privacy verification: raw images were not permanently retained, and logs were stored in protected form.
6. Emergency Whatsapp message in < 10 seconds.
7. Up time was tested by sending server checks from another devise every 2 min.
8. Power was maintained at 0.5 kWh
9. The System runs on a maximum of 19 V.
10. Cost was 11,543 SAR.
11. The footprint measured to be 55x50 cm.
12. Storage reached below 18 °C.
13. The system is able to treat 51 students.
14. Only camera, proximity, and temperature sensor.
15. Nozzle pressure was measured to be 146.7 Pa
16. 30 seconds till treatment starts.
17. No toxic, corrosive, or flammable chemicals allowed under normal conditions.
18. Sensor error rate was measured to be 1.185%
19. 89% accuracy identifying injuries.
20. Waste disposal follows local regulations.
21. AES-128-CBC encrypted communication.
23. ACU was Saudi School regulation complaient.
24. <100 ms for 99% of user interactions.

CONCLUSION

The Autonomous Care Unit demonstrates that a school-focused robotic first-aid station is technically feasible. The prototype shows how AI, embedded control, safe dispensing, and privacy-aware software can be integrated to provide fast, standardized support for minor injuries without attempting diagnosis. The ACU can help reduce response delays, support staff during emergencies, and improve confidence in school safety systems. Future iterations can reduce cost and improve manufacturability by using more standardized enclosures and optimized components.

RECOMMENDATIONS

⁙ Disposable nozzles for hygiene
⁙ Tube flushing to prevent hardening/clogging
⁙ Replace custom kiosk with lower-cost COTS enclosure
⁙ Use DFM, local sourcing, and early procurement/fabrication
⁙ Test subsystems before full integration

FUTURE WORK

⁙ Lower cost
⁙ Optimize motors
⁙ Use localized open-source ML

REFERENCES

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CONSTRAINTS AND SPECIFICATION

⁙ Cost ≤ 12,000 SAR
⁙ Safe chemicals + compliant waste disposal
⁙ Nozzle pressure ≤ 50 kPa
⁙ Electrical safety: ≤ 24 V DC
⁙ No permanent PII/image storage; encrypted comms/logs
⁙ Sensors limited to camera + proximity + temperature
⁙ Power < 1 kWh/day
⁙ Sensor delay < 150 ms; sensor error < 5%; comms success > 90%
⁙ UI latency ≤ 300 ms (95% of interactions); software uptime > 90% ± 5%
⁙ Footprint < 60 × 60 cm
⁙ Medicine storage 15–30°C temperature
⁙ UV-C sterilises ≥ 80% of pathogens in 5 min
⁙ Consumables ≥ 80% potency after 14 days
⁙ Waste containment: 50-student cycle, no leakage
⁙ Injury identification rate of ≥ 85%
⁙ Treatment execution > 90%
⁙ Correct medicine/dose ≥ 90%
⁙ Treatment start < 120 s
⁙ Emergency alert ≤ 10 s
⁙ Refill interval: >50 treatments

SUBSYSTEMS

Mechanical: robotic arm, dispensing hardware, guarded enclosure.
Software: touchscreen UI, finite-state workflow, privacy controls, escalation logic.
Computer engineering: Jetson Orin Nano for AI and high-level processing, ESP32 for real-time control.
Electrical: protected 24 V power distribution with separate regulated branches.
Chemical: safe consumable storage, sealed waste handling, UV-C sterilization.