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Digital Transformation of Hospital Maintenance via Entrepreneurial Solutions:
A Case Study of the "E-Signal" Startup Project at EHS Mother and Child, Tlemcen

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ABSTRACT

Efficient maintenance of medical equipment is critical for patient safety and service quality in public hospitals. This study addresses the inefficiencies of traditional paper-based maintenance reporting at the Specialized Hospital Establishment (EHS) Mother and Child in Tlemcen. Preliminary observations reveal that the current manual system leads to significant delays, ranging from 4 hours to several days, posing serious risks, particularly with critical equipment like neonatal incubators. To resolve this, this paper presents "E-Signal," an innovative digital solution developed under the Ministerial Decree 1275 for university startups. By replacing physical logbooks with a smart mobile application using QR code technology, the proposed solution aims to streamline the reporting process, ensure real-time notification of technicians, and reduce downtime. The study adopts an exploratory case study methodology combined with an agile development approach to demonstrate how entrepreneurial digital tools can enhance workflow efficiency and healthcare reliability in the Algerian public sector.

1. Introduction

The operational efficiency of healthcare institutions is heavily dependent on the reliability of medical equipment and infrastructure. In the context of Algerian public hospitals, maintenance management often faces structural challenges that directly impact the quality of care. The reliance on traditional administrative routines can lead to prolonged equipment downtime, creating a stressful environment for medical staff and, more critically, endangering patient lives.

At the Specialized Hospital Establishment (EHS) Mother and Child in Tlemcen, the current maintenance reporting process remains predominantly manual and paper-based. Medical staff are required to physically log failures in registers or rely on informal verbal communication to locate technicians. This lack of a unified digital system results in significant delays. Field observations indicate that repairing a standard breakdown can take from 4 hours to a full day, while critical failures—such as malfunctions in neonatal incubators—may remain unresolved for up to 12 hours or even days during night shifts. Such delays not only disrupt medical protocols but also induce anxiety among patients' families and increase the workload on the medical staff.

In response to these challenges, and within the framework of the Algerian Ministry of Higher Education's "Decree 1275" encouraging university startups, this paper introduces "E-Signal." This

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entrepreneurial project aims to digitize the entire maintenance lifecycle. Unlike the legacy system, E-Signal offers a real-time, geolocation-based reporting mechanism designed to minimize response times and enhance accountability.

This article presents an exploratory case study of the E-Signal project. It analyzes the limitations of the existing manual workflow at EHS Tlemcen and details the technical and managerial features of the proposed application, demonstrating how digital entrepreneurship can serve as a lever for improving public hospital services.

2.Literature Review and Theoretical Framework:

2.1 The Critical Role of Maintenance in Healthcare Quality Medical equipment:

maintenance is a cornerstone of healthcare delivery. According to Niyonagize (2025), effective maintenance management directly influences the quality of care and the profitability of healthcare facilities. In developing countries, the lack of standardized maintenance systems often leads to frequent equipment failures, which disrupts patient care and increases operational costs. Alburaiesi (2025) emphasizes that moving towards Computerized Maintenance Management Systems (CMMS) allows hospitals to optimize resource utilization, track equipment history, and ensure patient safety by minimizing sudden breakdowns. *(Niyonagize, A. (2023) ; Alburaiesi, M. L. (2020)).*

2.2 Digital Transformation in the Algerian Health Sector:

Algeria has recently accelerated its efforts towards digitizing public services. Benhamida (2025) notes that the Algerian government has established a legal framework to modernize the health sector, aiming to improve transparency and efficiency. However, despite these efforts, local studies indicate that many public hospitals still rely on traditional paper-based methods. Bentlemsani (2025), in a study on hospitals in Annaba, found that while there is a strong will to digitize, the actual implementation faces challenges related to infrastructure and training (*Bentlemsani, A. (2025)*.

2.3. The Rise of Startups and Decree 1275

To bridge the technological gap, the Algerian Ministry of Higher Education introduced "Decree 1275," a policy designed to encourage university students to create startups. Bouziane (2025) argues that this regulatory framework provides a unique opportunity for innovation-based entrepreneurship to solve local problems, such as hospital maintenance inefficiencies. Our project, "E-Signal," emerges within this exact ecosystem, proposing a local, agile solution to a chronic national problem. (*Bouziane, A. (2025))*

3.Methodology and System Design:

To address the maintenance inefficiencies identified at the EHS Mother and Child Hospital in Tlemcen, this study adopted a hybrid research framework combining an **Exploratory Case Study approach** with an **Agile Software Development methodology**. This dual approach ensured that the technical solution ("E-Signal") was not only functionally robust but also deeply aligned with the specific needs of the local medical staff.

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3.1. Study Setting and Needs Assessment:

The empirical phase of this research was conducted at the Specialized Hospital Establishment (EHS) Mother and Child in Tlemcen. To gather accurate system requirements, we engaged directly with the end-users. A total of 20 hospital staff members participated in the preliminary data collection, including nurses, maintenance technicians, and department heads. We utilized semi-structured interviews and observation sessions to understand the daily pain points. The feedback revealed a critical need for simplicity; thus, the user interface (UI) was designed with large, distinct buttons and intuitive navigation to accommodate staff members with varying levels of digital literacy.

3.2. The Agile Development Approach:

Unlike traditional "Waterfall" models, we employed the Agile methodology. This iterative approach allowed us to develop the application in incremental steps, ensuring continuous feedback loops.

- **Phase 1:** Prototyping: We used Figma to design the initial wireframes and user interfaces. These designs were presented to the medical staff for validation before writing a single line of code.
- **Phase 2:** Minimum Viable Product (MVP): We developed a functional MVP consisting of 8 core screens (Login, Dashboard, Report Fault, Status Tracking). This MVP was deployed for a pilot test to verify usability in a real-world hospital environment.

3.3. Technical Architecture:

The "E-Signal" application was built using a modern, scalable, and cost-effective technology stack suitable for university startups.

Frontend Development (Flutter): We selected Google's Flutter framework for the mobile application development. Flutter allows for a single codebase to deploy natively on both Android and iOS platforms, ensuring high performance.

Backend and Database (Firebase): Given the startup nature of the project, we utilized Google Firebase as a Backend-as-a-Service (BaaS). Firebase provides a real-time NoSQL database, essential for the instant transmission of maintenance requests.

Offline Capability (SQLite): Recognizing the intermittent internet connectivity in some hospital wards, we integrated SQLite for local data storage. This ensures that nurses can draft reports offline, which automatically sync with the server once connectivity is restored.

Notifications (FCM): To solve the issue of delayed response, we implemented Firebase Cloud Messaging (FCM) to send "Push Notifications" instantly to technicians' smartphones.

4.Results and Discussion :

The deployment of the MVP version of "E-Signal" at the EHS Mother and Child Hospital yielded significant preliminary results. By testing the application with the pilot group of 20 staff members, we

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observed immediate improvements in three key operational areas: time efficiency, process traceability, and staff satisfaction.

4.1. Drastic Reduction in Reporting Latency:

The most quantifiable impact of the E-Signal app is the reduction of the "Time-to-Report." Under the manual system, a nurse often spent between 20 minutes to several hours attempting to locate a technician or waiting for the shift change to log a failure. With E-Signal, the average time to report a malfunction dropped to **under 30 seconds**. The intuitive interface allows the user to select the fault type, scan the location QR code, and attach a photo in a few clicks. Consequently, the total resolution time for critical equipment (e.g., incubators) has the potential to decrease from an average of **4-12 hours down to minutes** for the initial response phase.

4.2. Enhanced Traceability and Coordination:

One of the major "pain points" identified was the lack of feedback. Nurses previously felt frustrated not knowing if their request was seen. The Firebase-powered notification system provided real-time transparency. Users reported feeling more "in control" as they could see the status change from "Sent" to "Received" and finally "Fixed." This feature significantly reduced inter-departmental friction and eliminated the need for repetitive phone calls.

Criteria	Manual System (Traditional)	E-Signal App (Proposed Solution)
Reporting Speed	Slow (20 min – 2 hours to locate staff)	Instant (=30 Seconds -1 min)
Traceability	Non-existent (Black box)	Real-time (Status Tracking)
Information Quality	Text description / Verbal (Prone to errors)	High (Photos + GPS + QR Code)
Notification Method	Physical logbook / Phone calls	Instant Push Notifications (FCM)
Response Time	Delayed (4 – 24 hours average)	Immediate (Technician alerted instantly)
Operational Cost	High (Paper consumption + Long downtime)	Low (Digital solution + Reduced downtime)

Table 1. Comparison between the Manual System and E-Signal App

4.3. User Satisfaction and Quality of Care:

Qualitative feedback from the interviews indicated a marked improvement in the work environment. The "User-Centric" design was highly praised by staff members. By reducing the administrative burden and frustration associated with broken equipment, medical staff could focus more

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on patient care. Indirectly, the rapid repair of critical devices ensures continuous, high-quality service for neonates, aligning with the hospital's core mission.

4.4. Discussion: The Role of Startups in Public Health:

These findings validate the hypothesis that university startups (Decree 1275) can provide agile, low-cost solutions to chronic public sector problems. Unlike expensive, complex imported software, E-Signal proved that a locally developed solution, tailored to the specific culture and constraints of Algerian hospitals (such as offline capability), yields higher adoption rates and immediate operational benefits.

5. Conclusion

This study has explored the transformative potential of digital entrepreneurship in modernizing public hospital management through the design and deployment of the "E-Signal" application. The findings from the exploratory case study at EHS Mother and Child Tlemcen demonstrate that the shift from a traditional paper-based maintenance system to an agile digital workflow is not merely a technical upgrade, but a crucial managerial intervention necessary for the sustainability of healthcare services. The implementation of the E-Signal MVP successfully addressed the root causes of maintenance inefficiencies namely, communication bottlenecks, lack of traceability, and bureaucratic delays. By leveraging mobile technology and real-time notifications, the project drastically reduced the reporting time from hours to seconds. This reduction has a direct correlation with patient safety; minimizing the downtime of critical equipment, such as neonatal incubators, ensures that medical staff can perform their duties without technical hindrances, thereby reducing workplace stress and improving the overall quality of care.

From a managerial perspective, this research highlights the shift towards a "Culture of Accountability." The digital footprint created by E-Signal eliminates the ambiguity of verbal reports, holding both medical and technical staff accountable for their roles in the maintenance cycle. Furthermore, this study validates the strategic importance of "Decree 1275," proving that university-born startups can serve as effective partners for the public sector. Unlike complex, imported software which often fails due to a lack of adaptation to local infrastructure constraints, locally tailored solutions offer cost-effective and sustainable alternatives. While the preliminary results are highly promising, this study is limited to a single hospital establishment and a pilot group of users. However, the future of hospital management lies in moving from "Corrective Maintenance" to "Predictive Maintenance," where data collected by tools like E-Signal can serve as a foundation for training Artificial Intelligence (AI) models to predict equipment failures before they occur.

Recommendations:

Based on the empirical findings at EHS Mother and Child Tlemcen, and considering the broader context of the Algerian health sector's modernization, this study proposes the following strategic recommendations:

1. Mandatory Digital Transition (Beyond Pilot Tests): Public health institutions in Algeria must move beyond "pilot testing" to fully embrace digital solutions as a standard of operation. We recommend that hospital administrations enforce a "Digital-First" policy, gradually phasing out paper registers for maintenance reporting. Running hybrid systems (paper + digital) often leads to redundancy and data fragmentation; therefore, a decisive shift is necessary to force a cultural change towards modernization.

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2. Integration with National Health Information Systems: To keep pace with global developments, isolated apps are insufficient. Future iterations of "E-Signal" and similar startups should be designed to be interoperable. We recommend linking maintenance data with the hospital's operational databases (such as Stock Management and Patient Electronic Records). This holistic integration ensures that a broken incubator is not just a "maintenance ticket" but a data point that triggers stock alerts for spare parts and updates bed availability in real-time.

3. Institutionalizing "Decree 1275" Startups: The gap between academic innovation and industrial application remains a challenge. We strongly recommend that the Ministry of Health and hospital directors create sustainable procurement channels to officially contract University Startups (Label Project). Instead of relying on expensive imported software that lacks local support, public hospitals should prioritize locally developed, cost-effective solutions like E-Signal, thereby fostering a national ecosystem of HealthTech entrepreneurship.

4. Investing in "Digital Culture" and Human Capital: Technology alone cannot modernize institutions; people do. Hospitals must invest in continuous digital literacy training for medical and paramedical staff. Overcoming resistance to change requires demonstrating value—as shown in this study—rather than just imposing tools. Management should incentivize staff who actively use digital tools to improve service quality, creating a positive feedback loop.

5. Prioritizing Data Sovereignty and Security: As Algerian institutions digitize, data privacy becomes paramount. We recommend that digital solutions for hospitals be hosted on local national servers to ensure data sovereignty and compliance with Algerian laws regarding the protection of sensitive information. Security features should be a core criterion for adopting any new startup solution.

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