Comparative Analysis of Paperless vs. Hybrid Workflow: Enhancing Efficiency and Sustainability in Nuclear Medicine and Theranostics Department

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1 Introduction

In order to increase operational effectiveness, save costs, and foster sustainability, healthcare organizations are quickly moving toward digital solutions. Paper-based operations frequently result in environmental waste, data handling mistakes, and administrative delays. The Nuclear Medicine and Theranostics Department at DUHS integrated all patient data digitally and started a completely paperless workflow. This supports global sustainability goals and is in line with several UN Sustainable Development Goals (SDG-3, SDG-8, SDG-9, SDG-12, and SDG-13).

2 Objective

- To valuate the effectiveness of a paperless workflow compared with a conventional hybrid system.
- To analyze cost-effectiveness, time efficiency, manpower utilization, and environmental sustainability.
- To establish a replicable model for sustainable digital transformation in healthcare.

3 Methodology

The Nuclear Medicine and Theranostics Department at Dow University of Health Sciences (DUHS) carried out this cross-sectional comparison study between April and July of 2025. A recently established paperless system was used to examine 220 patients per month (2640 annually), and the results were compared with a hybrid system in use at another private nuclear medicine center in Karachi.

Digital patient appointments, consent forms, procedure details, and medical history forms were all part of the paperless process, which was connected to the hospital's IT system via a safe internal server. The hospital's digital database was used to gather data, which was then cross-checked for correctness using manual records.

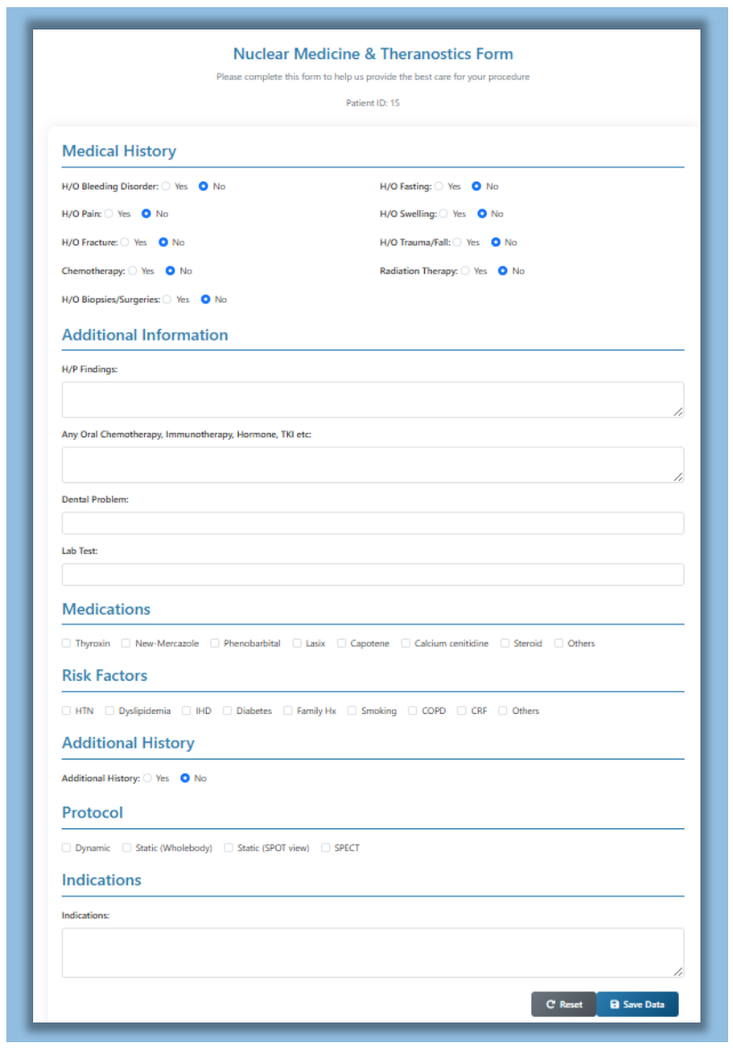
Key performance indicators (KPIs) included:
Time efficiency: appointment scheduling, consent completion, report sign-off.

Cost analysis: per-patient cost, implementation, and maintenance cost.

Manpower utilization: reduction in administrative workload.

Environmental metrics: reduction in paper usage, CO_2 emissions, and water consumption.

Statistical analysis was performed using Microsoft Excel and SPSS, and significance was determined using independent t-tests with $p < 0.05$ considered statistically significant.



4 Results

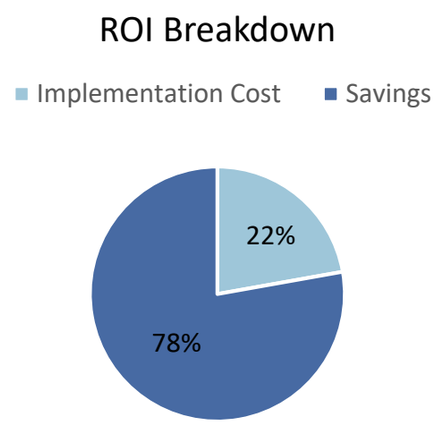
The transition to a fully paperless workflow produced substantial improvements in operational efficiency, cost reduction, and environmental sustainability.

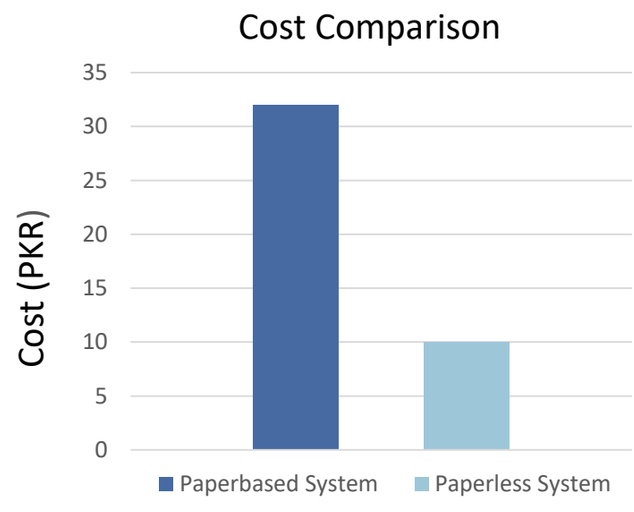
Time Efficiency:
Significant decreases were observed across all administrative tasks:

Task	Traditional (minutes)	Paperless (minutes)	Time Saved (% reduction)	p - value
Appointment Processing	15	5	66.67 %	< 0.05
Consent form Completion	20	7	65 %	< 0.05
Report Finalization	30	10	66.67 %	< 0.05

Average turnaround time for complete patient workflow reduced by 65–67%, improving staff productivity and patient experience.

Cost Effectiveness:
- Per-patient cost decreased from PKR 1212 (hybrid) to PKR 379 (paperless), resulting in a 68% cost reduction ($p < 0.05$).
- The annual cost saving was estimated at PKR 3,237,600, against a one-time implementation cost of PKR 1,000,000.
- This equates to a Return on Investment (ROI) of 223.76%, demonstrating strong economic feasibility and long-term benefit.





Environmental Impact:
The department completely eliminated 500 reams (~250,000 sheets) of paper per year, leading to:

- 3,000 kg CO_2 emissions avoided (≈3 metric tons).
- 2,500 liters of water saved annually from paper production processes.
- Reduced physical storage and waste disposal requirements.

2 Conclusion

The paperless workflow significantly enhanced operational efficiency, reduced costs, and minimized environmental impact. It demonstrated strong statistical and practical evidence for sustainable healthcare management.
This comparative model serves as a scalable framework for full departmental adoption and future digital health innovations.

4 Discussion

Clear advantages in terms of cost savings, time efficiency, and environmental sustainability were shown by the paperless workflow. Its economic worth is confirmed by a 223.76% ROI, and the removal of 500 reams of paper per year decreased waste and carbon emissions. These results are in line with UN SDGs that support ethical and sustainable healthcare as well as international digital health initiatives. Although there was some initial pushback from the workers, focused training increased flexibility. The study reaffirms that paperless solutions are useful, scalable, and essential for the current transformation of healthcare.