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The impact of automation in hospital pharmaceutical logistics management: economic analysis in Europe

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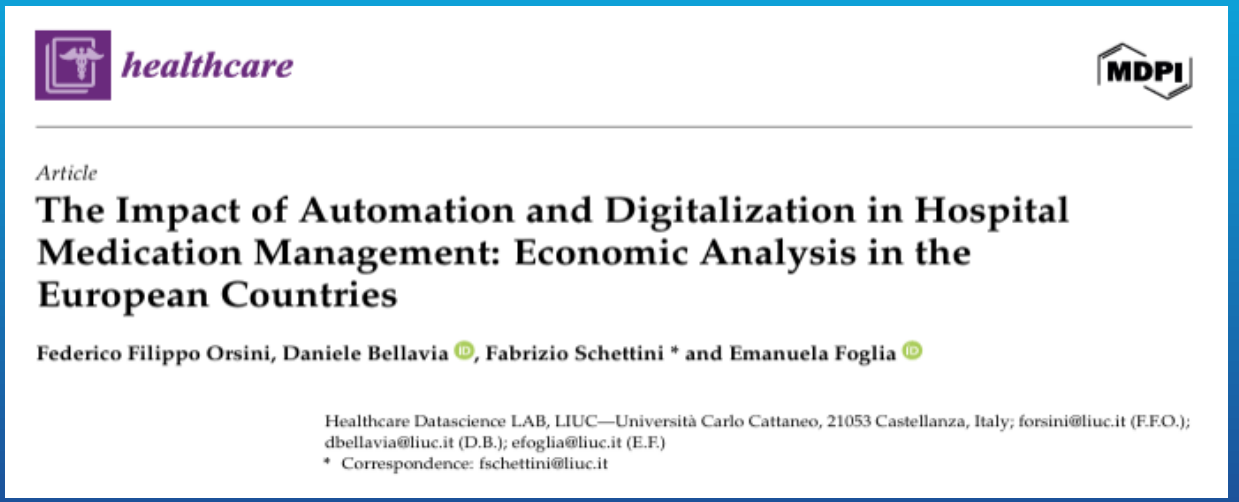

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Article

The Impact of Automation and Digitalization in Hospital Medication Management: Economic Analysis in the European Countries

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Context

- In European hospitals, up to **0.1% of all doses are affected by medication errors,** leading to longer hospital stays and **higher costs**
- Studies prove that **automation reduces errors** by 50–100%, depending on the technology
- European healthcare systems are **increasingly adopting automation** and digital solutions to improve efficiency and safety in medication management.
- Despite this growing interest, adoption remains **limited due to high upfront costs** and the complexity of integrating new technologies into existing hospital infrastructures.
- A major barrier is the **lack of robust, large-scale economic evidence** demonstrating return on investment.
- The **EU Regulation** 2021/2282 on **Health Technology Assessment** (HTA), fully enforced as of January 2025, calls for **stronger economic data** to support **investment** decisions in health technologies.

Objective

Actionable Evidence

The study aimed to assess the economic and organizational impact of medication management automation across Europe.

Financial Sustainability

Assessed long-term investment viability

Standardized Hospital Model

Adopted a standardized hospital dimension for a comparison across Nations

27 EU Countries plus UK

The analysis covered all **27 EU countries plus the UK**, using a standardized hospital model to ensure comparability.

Five Key Technologies

It evaluated **five key technologies** implemented in **acute care hospitals** over a **10-year period** (2024–2034).

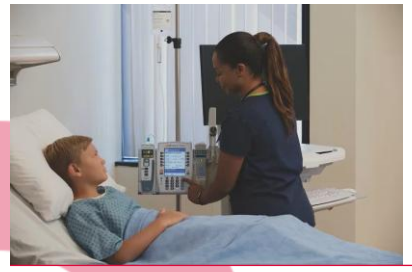
The goal was to provide actionable evidence to hospital managers and policymakers on the long-term financial sustainability of these investments.

Technologies under assessment

Inventory Robot – Automates storage and retrieval in the central pharmacy; improves stock control and reduces picking errors.

Unit Dose System (UDDS) – Prepares individually packaged doses for each patient; enhances traceability and reduces preparation errors.

Automated Dispensing Cabinets (ADCs) – Secure ward-based cabinets; enable on-demand access to medicines with real-time documentation.



Smart Infusion Pumps with Dose Error Reduction System (DERS) – Standardizes infusion parameters in ICUs; prevents dosage mistakes.

Oncology Medication Traceability Platform – Tracks the entire chemotherapy process (prescription → preparation → administration); ensures safety in high-risk therapies.

Methodology

- The analysis was built around a standardized model of a **561-bed acute care hospital**, representative of the average facility size across EU countries
- **Initial investment** and **operational savings** were estimated using **country-specific data**
- Economic drivers assessed: staff time savings, drug wastage reduction, optimized inventory, and fewer medication errors
- Results were then **scaled to the national level** based on the number of hospital beds and adjusted for **current technology penetration** in each country
- Financial metrics — **Return on Investment (ROI)**, **Net Present Value (NPV)**, and **Payback Time (PBT)** — were calculated to evaluate long-term economic sustainability
- A **sensitivity analysis** tested model robustness by simulating variations in hospital size and discount rates

ROI, NPV and PBT

- ROI (Return on Investment): indicates the profitability of an investment by calculating the relationship between net profit generated and capital invested.

$$\text{ROI} = \frac{(\text{Total Costs} - \text{Total Savings})}{\text{Total costs}}$$

- NPV (Net Present Value): measures the net present value of future cash flows generated by an investment, discounted at the required interest rate. A positive NPV indicates economic viability.

$$\sum_{t=2024}^{2034} \frac{\text{Net Cash Flow}}{(1 + \text{inflation rate})^t}$$

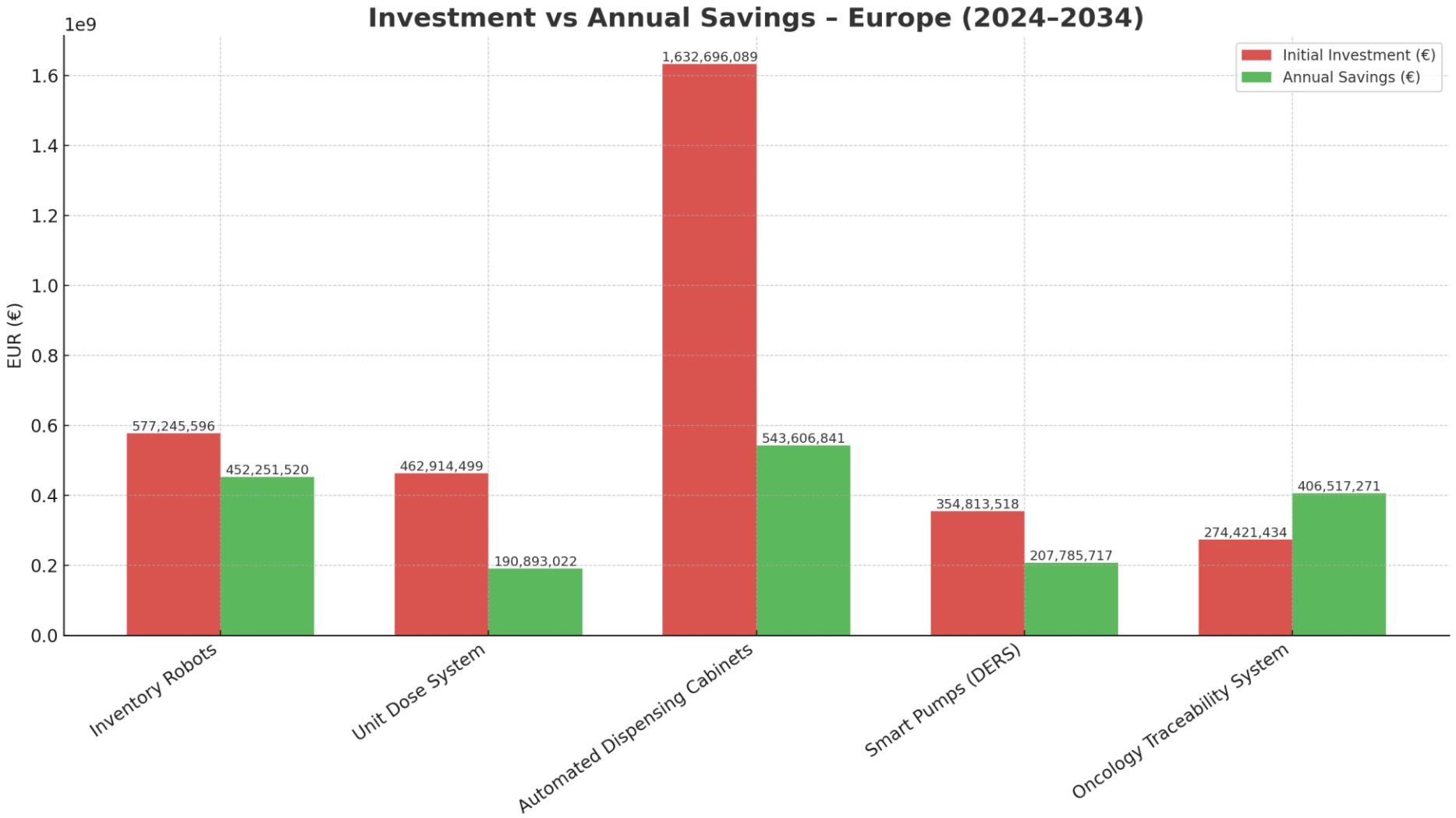
- PBT (Payback Time): represents the time needed to recover the initial investment through generated cash flows, without considering the time value of money.

Methodology

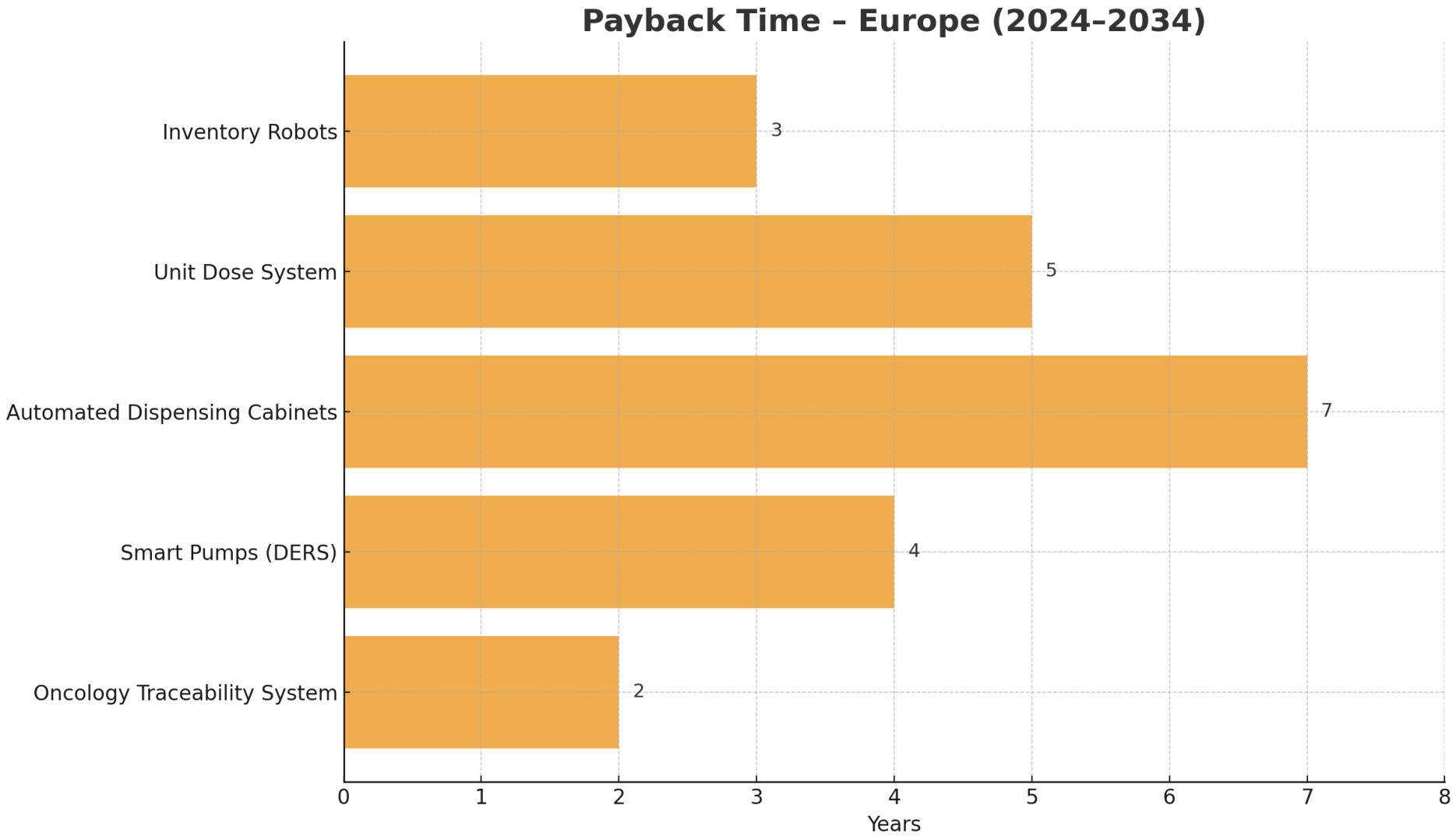
The clinical and organizational benefits of automation technologies were identified from the scientific literature, then valued using the Activity-Based Costing (ABC) technique, by estimating the time and resources saved at each phase of the medication cycle.

Technologies	Reduction of wasted medications	Stock reduction	Reduction of medication errors	Reduction of processing time
Inventory robots	−100% (Ahtiainen et al., 2020)	−26.4% (Giménez et al., 2019)	−16 % (Franklin et al., 2007)	−31.4% (technicians) (Ahtiainen et al., 2020)
Unit Dose System (UDDS)	−100 % (Herrmann et al., 2024)	0 % (supposed)	−53 % (Berdot et al., 2016)	−5.8% (nurses) / −10% (technicians) (Herrmann et al., 2024)
Automated Cabinets (ADC)	−100 % (Cousein et al., 2014)	−60.6% (Chen et al., 2022)	−53 % (Berdot et al., 2016)	−80% (nurses) / −50% (pharmacists) (Mathy et al., 2020)
Smart pumps with DERS	—	—	−100 % (Kastrup et al., 2012; Waterson & Bedner, 2019)	−69.8% (nurses) (Kastrup et al., 2012)
Oncological Traceability System	−100 % (Ferrario et al., 2020)	−21 % (Terkola et al., 2017)	−75–89 % (Reece et al., 2016; Sarfati et al., 2015; Aita et al., 2013)	−44% (pharmaceuticals) (Ferrario et al., 2020)

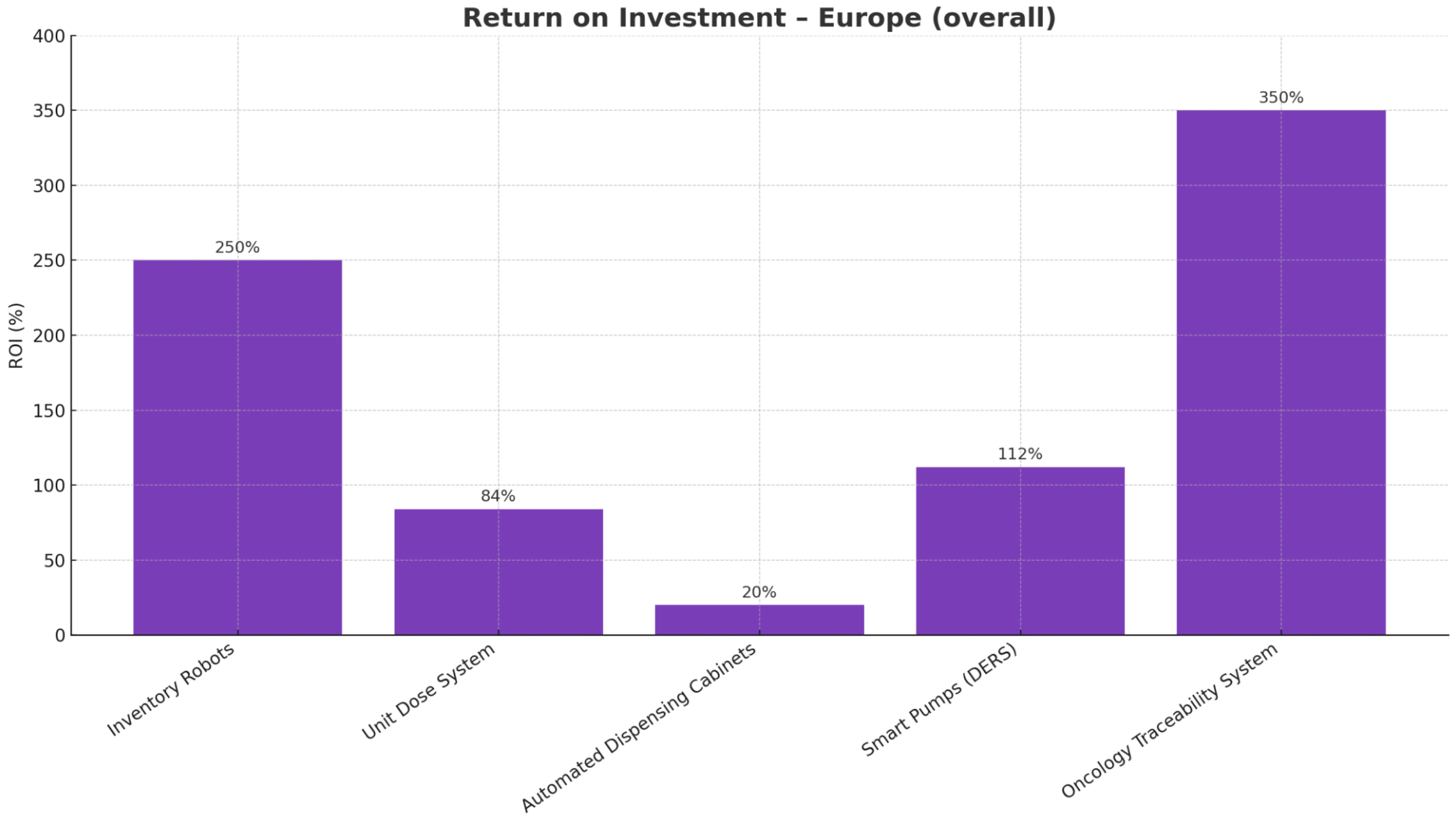
Investment and annual savings



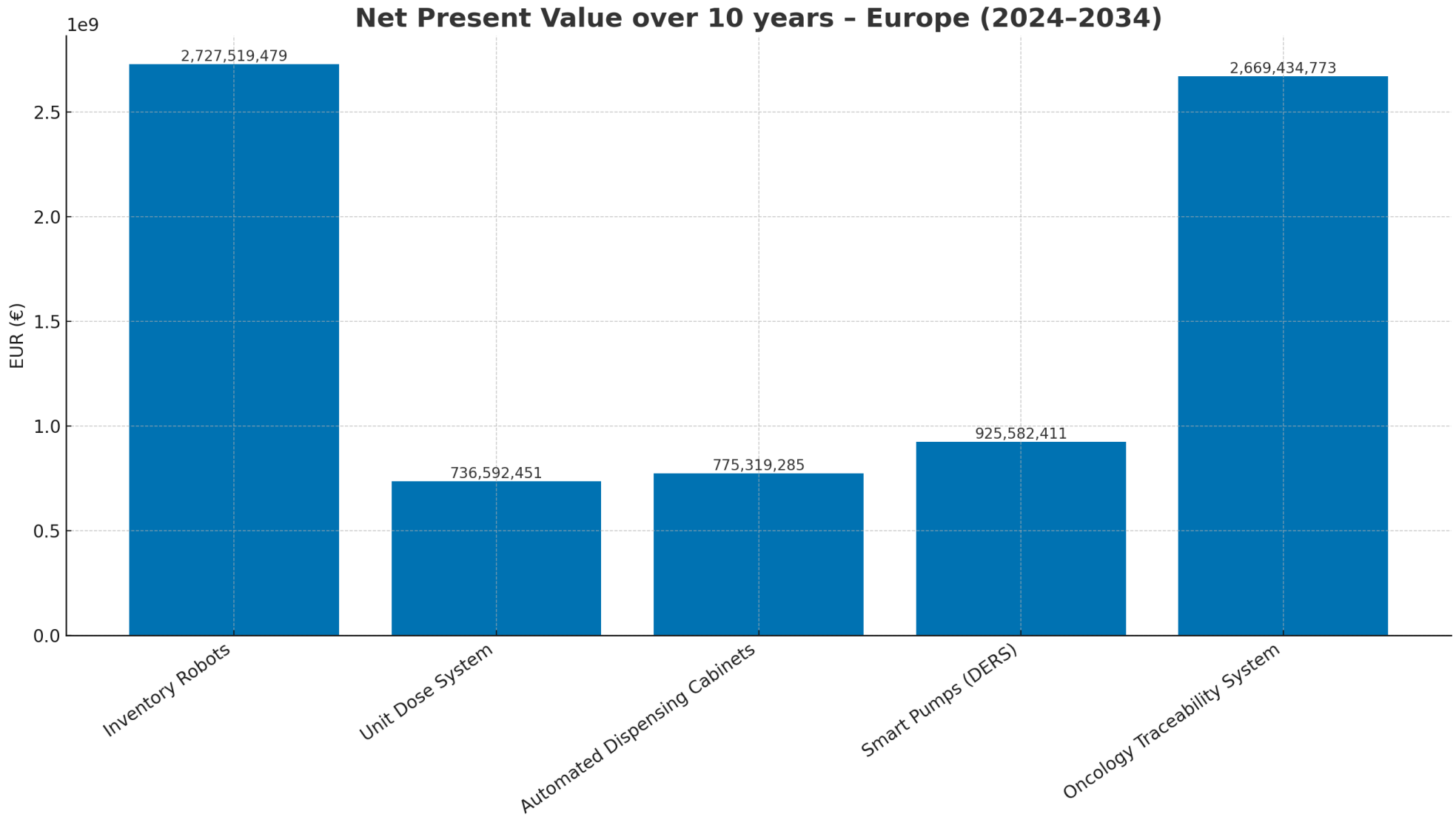
Repayment time



Return On Investment



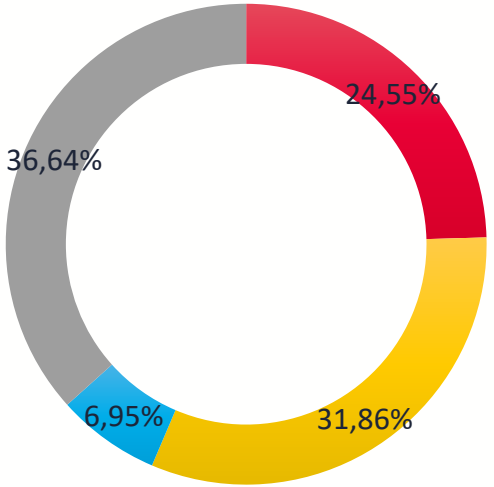
Net Present Value



Savings Breakdown

Technology	HR efficiency savings	Wastage reduction savings	Inventory reduction savings	MAE reduction savings (indirect benefit)	Total Annual savings
Inventory Robot	99.885.092 €	285.117.237 €	58.838.174 €	8.411.016 €	452.251.520 €
UDDS	89.280.038 €	88.988.291 €	0 €	12.624.694 €	190.893.022 €
ACDs	90.510.064 €	167.674.950 €	66.408.609 €	219.013.218 €	543.606.841 €
DERS	18.075.228 €	0 €	0 €	189.710.489 €	207.785.717 €
Oncology	144.405.207 €	31.993.020 €	0 €	230.119.044 €	406.517.271 €
TOTAL	**442.155.629 €**	**573.773.498 €**	**125.246.782 €**	**659.878.461 €**	**1.801.054.370 €**

Distribution of savings among cost drivers



Overall Results – EU 27

EU 27	Total Investment	Total annual savings	ROI 10- year	NPV	Payback
Inventory Robots	-577.245.596 €	452.251.520 €	250%	2.727.519.479 €	3
Unit Dose System	-462.914.499 €	190.893.022 €	84%	736.592.451 €	5
ADC	-1.632.696.088 €	543.606.841 €	20%	775.319.285 €	7
Smart pumps with DERS	-354.813.517 €	207.785.717 €	112%	925.582.411 €	4
Oncology	-274.421.434 €	406.517.271 €	350%	2.669.434.773 €	2
TOTAL	**-3.302.091.136 €**	**1.801.054.370 €**	**167%**	**7.834.448.398 €**	**4,2**

Limitations and robustness

Standardized assumptions: the model uses an “average” 561-bed hospital and assumes homogeneous medication-use processes. Local variations in workflows (e.g., oncology protocols) may lead to different impacts.

Use of averages: country-level estimates rely on mean values for salaries, drug prices, and adoption rates; this introduces approximation and may not capture local heterogeneity.

Scaling up: extrapolation from hospital to national/EU level adds uncertainty, especially in smaller facilities or lower-GDP countries.

Sensitivity analysis: varying hospital size (±20%) and discount rate (±20%) confirmed the overall robustness: ROI and Payback remained stable

Conclusions

Clinical and economic value
Our analysis confirms that automation in hospital medication management is not only clinically valuable in terms of patient safety, but also financially sustainable for healthcare systems.

Rapid return on investment
On average, the technologies pay back in less than five years, with a mean ROI of 167%. This demonstrates that the upfront costs can be recovered relatively quickly, even in resource-constrained settings.

Generalizability beyond Europe
The framework is adaptable to other systems. By adjusting parameters such as labor costs, drug prices, and technology penetration, the approach can inform decisions in different national contexts.

Decision support for investments
The study provides evidence for decision-makers, ensuring that limited resources are used for solutions that are both clinically effective and economically sustainable, aligned with international HTA principles.