Pre-filled syringes in anaesthesiology: a quantitative assessment of economic and organizational outcomes

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Rationale of the study

- **Medication safety as a dual concern**: injectable drugs pose risks not only to patients, but also to healthcare professionals, with complex administration processes increasing the likelihood of errors, some of which can have severe or fatal consequences
- **High incidence of preparation errors**: evidence shows that syringe swaps and mislabeling account for nearly half of all reported medication errors, highlighting the need for safer and standardized solutions
- **Strategic role of pre-filled syringes (PFSs)**: PFSs reduce preparation time, handling steps, and contamination risks, while enhancing safety, organizational efficiency and compliance with regulatory requirements
- **Closing a knowledge gap**: despite international recommendations for PFSs use, their adoption remains limited in Italian clinical settings, requiring robust evaluation of their real-life economic and organizational benefits

Objective

To evaluate the economic and organizational benefits associated with the introduction of PFSs into clinical practice, focusing on ephedrine and atropine, to identify their key strengths and value-added aspects

Methods

An **economic and organizational assessment** was conducted from the perspective of a hospital in Piedmont Region (Italy), over a 12-month period

Two scenarios were compared: the current practice (manual preparation of syringes) *versus* PFSs use

A **Time-Driven Activity-Based Costing** approach was applied, including direct medical costs (personnel time, protective equipment, consumables), fixed overheads, and the economic burden of drug waste and medication errors

The **organizational impact was assessed by evaluating time savings and potential resources reallocation**

Conclusions

Although PFSs implementation requires an initial investment, the benefits in terms of patient safety, workflow efficiency and waste reduction generate long-term economic and organizational value, thus supporting their integration into anesthesiology practice

Strengths	Weaknesses
• **Reduced preparation time** • **Decreased medication errors**, thanks to standardized dosing and traceability • **Reduced drug waste** due to single-dose packaging • **Enhanced safety for healthcare staff and patients**, with lower risk of contamination and injuries • **Standardized production processes** • **Improved organizational efficiency and workflow** • **Compliance with safety regulations and traceability requirements for medical devices**	• **Device acquisition costs** • **Need for dedicated training** for personnel involved in the use PFSs • **Dependence on suppliers** for the availability of PFSs
Opportunities	**Threats**
• **Potential for integration with digital systems** to enhance medication management • **Possibility of adopting PFSs containing other active compounds**, given the demonstrated benefits for atropine and ephedrine • **Increased perceived quality of care**, enhancing the reputation of healthcare facilities • **Adaptability of the technology** to diverse healthcare and clinical settings	• **Resistance to change among staff** • **Logistical complexity in the distribution and management of PFSs stock**

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Results

What are the implications from an economic perspective?

From an economic perspective, **per-dose costs increased by 137%** (manual atropine: €2.30 vs. PFSs: €5.46) **and 141%** (manual ephedrine: €2.29 *vs* PFSs: €5.51), mainly due to higher acquisition and material costs

Atropine	Manual	PFSs	Difference (Euro)	Difference (%)
Preparation Costs	2.11 €	5.17 €	3.06 €	145%
Administration Costs	0.19 €	0.29 €	0.10 €	53%
Totale Costs	***2.30 €***	***5.46 €***	***3.16 €***	***137%***
Ephedrine	**Manual**	**PFSs**	**Difference (Euro)**	**Difference (%)**
Preparation Costs	2.06 €	5.21 €	3.15 €	152%
Administration Costs	0.22 €	0.29 €	0.07 €	31%
Totale Costs	***2.29 €***	***5.51 €***	***3.22 €***	***141%***

Considering the annual volume of hospital preparations (3,600 atropine and 3,696 ephedrine syringes, with respective wastage rates of 75% and 58%), **switching to PFSs would result in an overall economic saving of 15%** (€–2,312.65), including a drug waste reduction valued at €10,132.98

When including the costs associated with medication errors, often associated with longer patient hospital stays, **potential savings could reach €76,896.50**

	AS IS	TO BE	Difference (Euro)	Difference (%)
Preparation_Atropine	7,597.34 €	4,712.61 €	-2,884.73 €	-38.0%
Administration_Atropine	175.59 €	266.08 €	90.49 €	51.5%
Total_Atropine	***7,772.93 €***	***4,978.70 €***	***-2,794.24 €***	***-35.9%***
Preparation_Ephedrine	7,632.06 €	8,006.64 €	374.59 €	4.9%
Administration_Ephedrine	342.43 €	449.43 €	107.01 €	31.3%
Total_Ephedrine	***7,974.48 €***	***8,456.08 €***	***481.59 €***	***6.0%***
Total costs	**15,747.42 €**	**13,434.77 €**	**-2,312.65 €**	**-14.7%**
Impact on patients due to medication errors	79,805.54 €	5,221.69 €	-74,583.86 €	-93.5%
Total costs, including the impact on patients	**95,552.96 €**	**18,656.46 €**	**-76,896.50 €**	**-80.5%**

And what are the implications from an organizational perspective?

From an organizational perspective, the use of PFSs would lead to a **time reduction of 41% for per-dose atropine and 47% for per-dose ephedrine**

Atropine	Manual	PFSs	Difference (min)	Difference (%)
Preparation Time [min]	0.92	0.11	-0.82	-89%
Administration Time [min]	0.42	0.68	0.26	62%
Totale Time [min]	***1.34***	***0.79***	***-0.56***	***-41%***
Ephedrine	**Manual**	**PFSs**	**Difference (Euro)**	**Difference (%)**
Preparation Time [min]	0.96	0.10	-0.86	-90%
Administration Time [min]	0.49	0.67	0.18	38%
Totale Time [min]	***1.45***	***0.77***	***-0.68***	***-47%***

In assessing the **annual organizational benefit for the hospital**, routine adoption of PFSs would result in an organizational advantage equivalent to **6,103 minutes of staff effort** related to drug preparation and administration, to be reallocated toward higher-value clinical activities

	AS IS	TO BE	Difference (min)	Difference (%)
Preparation Time_Atropine [min]	3,320.00	96.27	-3,223.73	-97.1%
Administration Time_Atropine [min]	385.07	623.20	238.13	61.8%
Total Time_Atropine [min]	***3,705.07***	***719.47***	***-2,985.60***	***-80.6%***
Preparation Time_Ephedrine [min]	3,552.27	153.60	-3,398.67	-95.7%
Administration Time_Ephedrine [min]	750.93	1,032.53	281.60	37.5%
Total Time_Ephedrine [min]	***4,303.20***	***1,186.13***	***-3,117.07***	***-72.4%***
Total Time [min]	**8,008.27**	**1,905.60**	**-6,102.67**	**-76.2%**