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Original Research Article

# An audit on the amount of drug wastage and the cost related to the disposal of unused intravenous agents in the operating theatres in a tertiary care hospital

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ABSTRACT

**Background**: This manuscript presents an audit focused on assessing the extent of drug wastage and associated costs linked to the disposal of unused intravenous agents within the operating theatres of a tertiary care hospital. The study aims to carefully look at drug wastage, figure out why it happens, and propose strategies for optimizing resource utilization and cost-efficiency in clinical settings.

**Materials and Methods**: This audit is a prospective observational study carried out in a tertiary care hospital. The amount of drug loaded preoperatively, the amount of drug utilized, the amount of drug unutilized and discarded, the total quantity of drug wasted, and the cost related to the wastage were calculated in percentage.

**Results:** The maximum wastage of loaded drugs was seen with atropine (100%), followed by ephedrine (93.6%), propofol (52.5%), phenylephrine (35.2%), atracurium (28.6%), dexmedetomidine (27.8%), fentanyl (16.8%), vecuronium (16.2%) and morphine (6.4%). The cost analysis revealed that 36.3% of the total loaded drugs were wasted amounting to Rs.46903.54. The cost of wastage of propofol was maximum with Rs.14006 which is 29.8% of total cost wastage followed by atracurium 21%(Rs.9856), dexmedetomidine 18.4%(Rs.8687.5), ephedrine 14.7%(Rs.6919), phenylephrine 10.4%(Rs.4910), fentanyl 3.7%(Rs.1780), atropine 1.9% (Rs.906), vecuronium 1.2% (Rs.563.76), Morphine 0.18% (Rs.85.28).

**Conclusion**: In our audit, the maximum drug wastage was observed with atropine (100%) amounting to Rs.906, and the cost of wastage was maximum with propofol amounting to Rs.14006 which was 29.8% of the total cost of wastage. Our audit underscores the importance of proactive management of drug wastage and disposal costs in healthcare settings, particularly within operating theatres where intravenous agents play a crucial role in patient treatment. By conducting a comprehensive audit and proposing targeted interventions, healthcare institutions can optimize resource utilization, enhance sustainability, and ultimately improve patient outcomes.



## 1. Introduction

In the modern healthcare landscape, efficient resource management is paramount to ensure quality patient care while optimizing costs. Advanced development of anesthetic drugs, equipment, and techniques over the past decade has led to a considerable rise in the cost of anesthesia.[1] Anesthetic drug expenses comprise more than a third of the non-professional costs associated with anesthesia care, representing a significant portion of hospital expenditures, around 10-13%.[2] In the current landscape of rising healthcare costs, implementing cost-saving measures

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becomes increasingly imperative. By optimizing the utilization of drugs and materials without compromising patient care standards, we can alleviate the financial strain associated with healthcare expenses.[3] Numerous anesthetic drugs carry inherent risks of environmental toxicity and contamination.[4,5] However, the majority of anesthesia and healthcare professionals lack awareness regarding the cost of drugs and the level of waste they generate individually.[6,7]

Efficient resource management in healthcare, especially regarding drug usage, directly impacts financial savings. This study is an audit conducted within the operating theatres of a tertiary care hospital, focusing on the amount of drug wastage and the financial implications of disposing of unused IV agents. This study aims to quantify the amount of drug wastage and the associated cost of wastage. Identifying areas where wastage occurs excessively can lead to significant financial savings for the hospital. By auditing drug wastage in operating theaters, the study seeks to ensure that resources are used optimally. This optimization is crucial for meeting patient needs effectively while minimizing unnecessary expenses. This audit highlights the importance of efficient resource management in healthcare, specifically focusing on drug wastage in operating theaters.

The audit aims to provide insights into current practices, identify areas for improvement, and propose strategies to minimize wastage and reduce anesthesia costs without compromising the quality of care.

Each day, the operating room is stocked with emergency drugs and intravenous (IV) anesthetic agents. Unfortunately, a significant portion of these supplies, including many emergency drugs and some intravenous agents, are often discarded either unused or partially utilized. While the previous research audits in the literature touched on drug wastage in anaesthesia care broadly, this study narrows its focus specifically to IV agents used during general anaesthesia. By delving into this specific area, this audit helps to quantify the wastage and cost related to it precisely in a more standardized manner. Overall, this audit adds to the existing literature on drug wastage and cost optimization in anesthesia care by offering a focused quantitative analysis with clinically relevant insights and actionable recommendations for practice improvement.

## 2. Materials and Methods

This audit entails a prospective observational study that was carried out in the operating rooms involving major surgical procedures under general anesthesia from August 2023 to October 2023 at Saveetha Medical College and Hospital after getting approval from the institutional review board.

Operation rooms with surgeries involving patients aged more than 17 years belonging to the American Society of Anaesthesiologists (ASA) I to III were included in the audit. Un-utilized and partially utilized discarded intravenous drugs were included. Syringes of unutilized drugs were also included. As we observed only the IV drug wastage during general anaesthesia, the surgical procedures done under local anaesthesia and regional anaesthesia were excluded. The paediatric and the adolescent population require less IV drug dosage when compared to adults, so to standardize our study surgical procedures in patients with an age less than 18 years were not included. As the drug requirement, selection of drugs, and need for the use of emergency drugs in patients belonging to ASA IV and above varies widely when compared to others, Patients with ASA IV and above were excluded from the study. For the methodological consistency of our audit, emergency procedures were excluded as the need for lifesaving is not the same between elective and emergency cases. Syringes of partially utilized drugs were not considered as waste. We conducted our audit in the operating theatres involving the surgical procedures satisfying the above criteria.

The anesthesiologist conducting the case, who was not aware of the study, prepared the drugs for administration. After the conclusion of the case, a separate anesthesiologist, uninvolved in the proceedings, gathered data on drug wastage. From the drug inventory register, the data on the quantity of medication loaded in the syringe in each case as well as the breakage of ampoules or vials, if any, were obtained. The dosage of medication administered to the patient was recorded upon completion of the surgery, as documented in the anesthesia chart. The remaining drugs in syringes, vials, and ampoules (partially utilized and discarded) following each case were accounted for in the study as waste. The study also encompassed drugs loaded into syringes but left entirely unused (unutilized and discarded). After 6 hours of opening, the vial of propofol was discarded, and any remaining drug within the vial was categorized as waste. From the gathered drug data, each drug was tabulated into four columns partially utilized, partially unutilized, unutilized, and utilized. From this table, the percentage of drug wastage was calculated as follows:

Percentage of drug wastage for drug ‘X’ = total ml of ‘X’ wasted (Partially unutilized + Unutilized) / total ml of ‘X’ loaded.

Where Partially unutilized = drug left unused in the syringe at the end of surgery

Unutilized = Drug loaded but not used at all.

Cost estimation of the wasted drugs was then done, in which the cost of syringes containing unutilized drugs was also included.

Cost estimation was done using the following formulae

Cost of amount of drug utilized = Amount of drug utilized X cost per unit value of that drug.

Cost of the amount of drug unutilized = Amount of drug unutilized X cost per unit value of that drug.

Cost of unutilized drug per case = Cost of drug unutilized in study / Number of cases in which that drug was loaded.

% Of cost of a particular unutilized drug = Cost of unutilized drug / Total cost of unutilized drug X 100.

During the study period, an estimate of the percentage of the cost of waste due to a particular drug to the total wastage during the study period was done. An analysis was conducted to determine the proportion of waste costs attributed to each specific drug relative to the total waste incurred during the study period. Potential areas for reducing drug wastage were identified, and corresponding measures to mitigate wastage were proposed.

## 3. Results

A total of two hundred cases were included in the study. The data was transferred and analyzed utilizing Microsoft Excel (version Microsoft 365 2023) software. The demographic details are presented in Table 1.

**Table 1:** Demographic data

| Variables | Frequency | Percentage |
|---|---|---|
| **Gender** | | |
| Male | 118 | 59 |
| Female | 82 | 41 |
| **Age (year)** | | |
| <18 | 34 | 17 |
| 18-60 | 105 | 52.5 |
| >60 | 61 | 30.5 |
| **Variables** | **Frequency** | **Percentage** |
| **Gender** | | |
| Male | 118 | 59 |
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| **Age (year)** | | |
| <18 | 34 | 17 |
| 18-60 | 105 | 52.5 |
| >60 | 61 | 30.5 |

In our audit, the maximum drug wastage was observed with atropine (100%) amounting to Rs.906, and the cost of wastage was maximum with propofol amounting to Rs.14006 which was 29.8% of the total cost of wastage.

In contrast to previous research audits that addressed drug wastage in anesthesia care broadly, this study provides a more focused examination by narrowing its scope specifically to intravenous (IV) agents used during general anesthesia. By delving into this specific area, the audit aims to precisely quantify the extent of wastage and the associated costs in a standardized manner.

Our audit uncovered a range of drug wastage percentages, spanning from 7.4% to 100%. The maximum percentage waste of loaded drugs was seen with atropine (100%), followed by ephedrine (93.6%), propofol (52.5%), phenylephrine (35.2%), atracurium (28.6%), dexmedetomidine (27.8%), fentanyl (16.8%), vecuronium (16.2%) and morphine (6.4%) in that order as presented in Figure 1. Atropine and ephedrine contributed the most to wastage, primarily due to their non-utilization after being loaded into syringes. The drugs contributing to wastage due to partial unutilization, listed in descending order, were propofol, atracurium, fentanyl, phenylephrine, and dexmedetomidine.

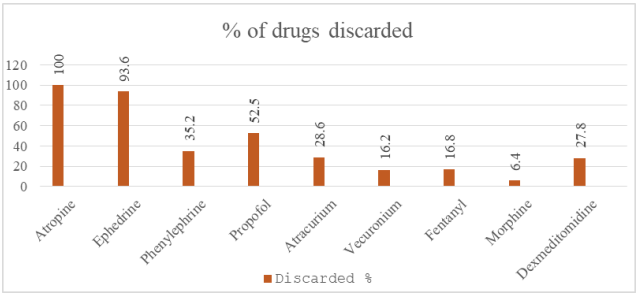


**Figure 1:** Total percentage waste of each drug

Table 2 gives the price list of various drugs during the study period. The content of each drug in its ampoule/vial is given in Table 3.

The cost analysis uncovered that 36.3% of the total loaded drugs were wasted totaling Rs. 46,903.54. The highest cost of wastage was attributed by propofol, amounting to Rs. 14,006. Which is 29.8% of total cost wastage followed by atracurium 21% (Rs.9,856), dexmedetomidine 18.4% (Rs.8,687.5), ephedrine 14.7% (Rs.6,919), phenylephrine 10.4% (Rs.4,910), fentanyl 3.7% (Rs.1,780), atropine 1.9% (Rs.906), vecuronium 1.2% (Rs.563.76), Morphine 0.18% (Rs.85.28) in that order as depicted in Figure 2. The details of the cost analysis are given in Table 4.

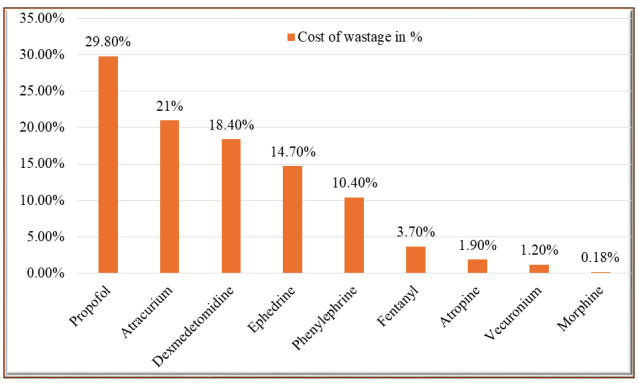


**Figure 2:** Graph depicting the cost of wastage of each drug in percentage

## 4. Discussion

In contrast to previous research audits that addressed drug wastage in anesthesia care broadly,[1,8] we narrowed our scope specifically to intravenous (IV) agents used during general anesthesia. By delving into this specific area, the audit precisely quantified the extent of wastage and the

**Table 2:** The market price of various drugs

| Drug | Cost of 1ampoule/Vial (Rs) | Cost/ml (Rs) | Cost/mg (Rs) |
|---|---|---|---|
| Atropine | Rs.4.53 | 4.53 | |
| Ephedrine | Rs.37 | 37 | 1.23 |
| Phenylephrine | Rs.279 | 279 | 2.79 |
| Propofol (20ml) | Rs.149 | 7.45 | 14.9 |
| 50 ml | Rs.364 | 7.28 | 36.4 |
| Atracurium (2.5ml) | Rs.160 | 64 | 6.4 |
| 5ml | Rs.319 | 63.8 | 31.9 |
| Vecuronium (4mg) | Rs.69.60 | | 17.4 |
| 10mg | Rs.109.90 | | 10.9 |
| Fentanyl | Rs.56.40 | 28.2 | 0.S64 |
| Morphine | Rs.26.6S | 26.65 | 2.7 |
| Midazolam | Rs.59 | 5.9 | S.9 |
| Glycopyrrolate | Rs.14.58 | 14.58 | |
| Succinyl choline | Rs.55 | 5.5 | 0.11 |
| Neostigmine | Rs.5 | 5 | |
| Emeset | Rs.11 | 5.5 | 5.5 |
| Dexamethasone | Rs.11 | 5.5 | 1.37 |
| Myopyrrolate | Rs.112 | 22.4 | 67.06 |
| Lox 2% | Rs.3S | 1.75 | 1.16 |
| Loxicard | Rs.59 | 1.18 | 2.19 |
| Thiopentone | Rs.50.10 | | |
| Dexmedetomidine | Rs.625 | 625 | 6.2S |
| Tramadol | Rs.23 | 11.5 | 0.26 |
| Lignocaine with adrenaline | Rs.29 | 0.97 | 0.97 |
| Hydrocortisone | Rs.41 | | |

**Table 3:** Content of each drug

| Name of the drug | Ampoule/vial (ml) | mg or mcg | mg per ml |
|---|---|---|---|
| Atropine | 1 | 0.6mg | 0.6 |
| Ephedrine | 1 | 30mg | 30 |
| Phenylephrine | 1 | 10mg | 10 |
| Propofol | 20 | 200mg | 10 |
| | 50 | 500mg | 10 |
| Atracurium | 2.5 | 25mg | 10 |
| | 5 | 50mg | 10 |
| Vecuronium | | 4mg | |
| | | 10mg | |
| Fentanyl | 2 | 100mcg | 50mcg |
| Morphine | 1 | 10mg | 10 |
| Midazolam | 10(vial) | 10mg | 1 |
| Glycopyrrolate | 1 | 0.2mg | 0.2 |
| Succinylcholine | 10(vial) | 500mg | 50 |
| Neostigmine | 1 | 0.5mg | 0.5 |
| Ondansetron | 2 | 4mg | 2 |
| Dexamethasone | 2 | 8mg | 4 |
| Myopyrrolate | 5 | 3mg | 1.67 |
| LOX 2% | 20 | 600mg | 30 |
| Loxicard | 50 | 1365mg | 27.3 |
| Thiopentone | | 500mg | |
| Dexmedetomidine | 1 | 100mcg | 100mcg |
| Tramadol | 2 | 100mg | 50 |
| Lignocaine with adrenaline | 30 | 600mg | 30 |
| Hydrocortisone | | 100mg | |

**Table 4:** Cost analysis

| Drug | Cost of drug-loaded (Rs) | Cost of drug used (Rs) | Cost of drug wasted (Rs) | Cost wasted of total wastage (%) | Cost of wasted drug per case (Rs.) |
|---|---|---|---|---|---|
| Atropine | 906 | 0 | 906 | 1.93 | 4.53 |
| Ephedrine | 7400 | 481 | 6919 | 14.7 | 34.5 |
| Phenylephrine | 13950 | 9040 | 4910 | 10.4 | 98.2 |
| Propofol | 26671 | 12665 | 14006 | 29.8 | 70.03 |
| Atracurium | 33495 | 23639 | 9856 | 21.0 | 131 |
| Vecuronium | 3480 | 2916.24 | 563.76 | 1.2 | 22.55 |
| Fentanyl | 10600 | 8820 | 1780 | 3.7 | 8.9 |
| Morphine | 1332 | 1246.72 | 85.28 | 0.18 | 10.9 |
| Dexmedetomidine | 31250 | 22562.5 | 8687.5 | 18.4 | 347.48 |
| Total | 129084 | | 46903.54 | | |

associated costs in a standardized manner. The period of observation was five nonconsecutive weeks in one study,[3] and six consecutive weeks in another study[9] where as our observation period was 13 consecutive weeks which aided us to analyse the drug wastage and the cost related to it in almost all types of surgeries done under general anaesthesia.

In our audit, the highest percentage of wastage among loaded drugs was observed with atropine and ephedrine, with wastage rates of approximately 100% and 93.6%, respectively. Regarding the cost of wastage, it was maximum with propofol Rs.14,006 which amounted to 29.8% of total cost of wastage followed by atracurium Rs.9,856 (21%). Suggestions to reduce this wastage from the literature are as follows. A budget impact analysis done by Benhamou et al. revealed that despite the higher cost of atropine prefilled syringes (PFS) compared to the atropine conventional method of syringe preparation (CMP), its utilization would result in substantial cost savings.[10] In our audit, in each case, as a prophylactic measure against intraoperative bradycardia, one ampoule of atropine was loaded in a 2 ml syringe preoperatively. PFS could have reduced this wastage. In all our cases, ephedrine was loaded in a 5ml syringe preoperatively as a prophylaxis to intraoperative hypotension. An observational study on the economic impact of ephedrine prefilled syringes concluded that prefilled syringes not only enhanced safety measures but also significantly saved nursing time when compared to conventional methods of preparation.[11]

In our observation, propofol has contributed to the highest cost of wastage. It was observed that during induction, none of the patients required more than 15ml of propofol. Hence, a prudent strategy would involve loading up to the upper limit range for induction (2.5 mg/kg), typically equating to less than 20 ml for an average 60–70 kg patient and loading the remaining drug for another patient. This strategy helps prevent wastage due to leftover drugs in the syringe. Depending on the patient's weight, the use of 10 ml vials can be considered to minimize leftover drugs in the vial. The Propofol waste reduction quality improvement project conducted by Jennifer et al. demonstrated that implementing an internally derived systematic approach for ordering and preparing propofol can effectively reduce its wastage, leading to significant cost savings for the organization.[12] Furthermore, propofol will not get degraded by nature, leads to contamination, and is toxic to aquatic life, and there exists a need to avoid wastage and in turn pollution.[4] The second highest cost-related wastage was with atracurium. Atracurium wastage can be mitigated by accurately loading the drug for each case based on the patient's body weight.[1] Neuromuscular blocking drugs have been identified as comprising 30% of the total anesthetic drug budget in certain countries.[13] Given their significant cost and expense, they warrant substantial attention as a key area of cost consideration.

One strategy to reduce the wastage of expensive drugs such as dexmedetomidine and phenylephrine is to administer them only when medically necessary and to employ judicious dosing based on weight-based calculations. Additionally, any remaining drug in the ampoule can be transferred to a sterile syringe and utilized for other cases. Furthermore, for phenylephrine, opting for prefilled vials containing lesser dosage, instead of ampoules can be a cost-effective alternative. Drug doses should be calculated individually for each case scheduled in the operating theater, considering the patient's weight and the typical dose range of the drug for the specific procedure. Before the start of the case, the calculated dose may be displayed on the machine. This would aid in estimating the drug requirements for the patient during that procedure and facilitate appropriate loading, thereby helping to prevent wastage.

From the cost analysis, we came to know that 36.3% of the total loaded drugs were wasted amounting to Rs.46,903.54. The highest cost of wastage was associated with propofol (29.8%), atracurium (21%) and dexmedetomidine (18.4%). This underscores the importance of raising awareness regarding drug wastage and the necessity for prudent management strategies.

This audit on anaesthetic agents conducted within the operating theatres of our tertiary care hospital has provided valuable insights into the utilization patterns, wastage, and associated costs of these critical medications. The following segment delves into several key aspects illuminated by the audit findings, addressing implications for clinical practice, resource management, and healthcare economics.

### *4.1. Utilization patterns*

The audit revealed notable variations in the utilization of different anaesthetic agents across surgical procedures. Understanding these patterns is essential for optimizing inventory management and ensuring adequate supply while minimizing wastage.[1] For instance, identifying procedures that frequently result in unused portions of specific agents can inform targeted interventions, such as adjusting ordering quantities or implementing dose optimization strategies.

### *4.2. Factors contributing to wastage*

Several factors contribute to the wastage of anaesthetic agents, including vial or infusion bag size relative to required doses, patient-specific dosing adjustments, and the expiration of unused portions. By identifying these factors, healthcare providers can implement measures to mitigate wastage, such as utilizing prefilled syringes[14] or ampoules for medications with high wastage rates or adopting just-in-time inventory management strategies.

### *4.3. Implications for patient safety*

While minimizing drug wastage is important for optimizing resource utilization, patient safety remains paramount. The audit findings underscore the need to balance efficiency with ensuring adequate supply to meet patient needs during surgical procedures. Strategies aimed at reducing wastage should prioritize patient safety and adherence to clinical guidelines to avoid under-dosing or compromising the quality of anesthesia delivery.[15]

### *4.4. Financial considerations*

The financial implications of anaesthetic drug wastage extend beyond the cost of the medications themselves. Disposal costs, including hazardous waste disposal fees and labor expenses, contribute significantly to overall expenditure.[16] By quantifying the financial impact of drug wastage, healthcare institutions can identify opportunities to streamline processes and reduce associated costs, ultimately contributing to improved cost-effectiveness and resource allocation.[8]

### *4.5. Education*

The audit highlights the importance of educating healthcare professionals regarding utilization, wastage, and costs involved. A recent clinical audit reported the lack of knowledge on biomedical waste management among healthcare professionals which is necessary to ensure environmental safety.[17] Proper knowledge of hazardous waste disposal is mandatory.[16]

### *4.6. Opportunities for improvement*

The audit findings highlight several opportunities for improvement in the management of anaesthetic agents within operating theatres. These may include enhancing communication and collaboration between clinical teams to optimize medication selection and dosing,[9] implementing standardized protocols for medication preparation and administration, and leveraging technology solutions such as automated inventory tracking systems to enhance efficiency and accuracy.

### *4.7. Future directions*

Moving forward, ongoing monitoring and evaluation of anaesthetic drug utilization and wastage will be essential to track the effectiveness of interventions implemented based on audit findings. Additionally, future multicentric research studies are needed to explore innovative approaches to anaesthetic drug delivery and administration aimed at further reducing wastage while maintaining patient safety and quality of care.

Conducting an audit on drug wastage and related costs adds to the body of knowledge in healthcare management. It provides valuable data that can be used by other healthcare facilities facing similar challenges, thus contributing to the broader understanding of resource management in healthcare.

Findings from various drug audits help in formulating policy decisions aimed at improving resource management practices in healthcare settings. This could involve developing guidelines or protocols for drug administration and disposal to minimize wastage and associated costs.

## 5. Limitations

We carried out our audit in a single tertiary care centre, we didn't address the supply chain issues that could impact drug wastage, such as procurement practices, inventory management, or supplier reliability. Delays or shortages in drug supply could lead to increased wastage due to expired or unusable medications. The differences in drug handling techniques, preparation methods, or administration protocols among providers may contribute to variability in wastage levels that were not captured in the study.

## 6. Conclusion

This audit on IV anaesthetic agents reports a significant amount of drug wastage and the financial impact of

such wasted drugs within the operating room. Future research firstly should explore the impact of implementing real-time inventory monitoring systems and automated drug delivery technologies to reduce drug wastage in anesthesia care, secondly, the practical interventions should include standardizing drug dosing protocols, optimizing drug storage and expiration management, and implementing staff training programs on efficient drug handling practices and thirdly the collaboration between anesthesia providers, healthcare administrators, and supply chain managers is essential to develop and implement targeted strategies for reducing drug wastage and optimizing resource utilization in anesthesia care settings.

## 7. Source of Funding

None.

## 8. Conflicts of Interest

The authors declare no conflicts of interest.

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