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Cost Minimization Analysis of Analgesics for Tooth Extraction

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ABSTRACT
Tooth extraction remains a common dental procedure in Indonesia owing to the increasing prevalence of oral health problems. Despite standard operating procedures and analgesics, pain management following tooth extraction remains a challenge. By analyzing different analgesic options and their associated costs, this study seeks to provide valuable insights for healthcare providers and patients in selecting the most effective and affordable pain management strategies. This study aimed to assess the cost-effectiveness of analgesic drugs for pain management after tooth extraction. This cross-sectional study was conducted on 92 patients who underwent dental extractions in Pabatu Hospital, Serdang Bedagai. Secondary data from the medical records were analyzed to assess patient demographics, diagnoses, analgesics used, pain levels, and treatment costs. Cost minimization analysis (CMA) was employed to compare the direct medical costs associated with different analgesics. The analysis highlighted that the combination of paracetamol and Na-diclofenac had the lowest average cost per patient (IDR 238,150.00), making it a financially viable option for both healthcare providers and patients. In contrast, the average cost of ibuprofen was significantly higher (IDR 433,954.97), suggesting that it may not be the best choice when considering both effectiveness and expense. Approximately 80% of the total direct medical costs for all three analgesics are attributed to procedure and treatment expenses, indicating that the choice of analgesics has a relatively small impact on overall costs. These findings advocate the use of cost-effective analgesic combinations in clinical practice, particularly in settings in which budget constraints are a concern.

Kata kunci:
pencabutan gigi;
manajemen nyeri;
analgesik;
analisis biaya

Pencabutan gigi masih menjadi prosedur perawatan gigi yang umum dilakukan di Indonesia karena meningkatnya prevalensi masalah kesehatan gigi dan mulut. Meskipun sudah ada prosedur operasi standar dan analgesik, manajemen nyeri setelah pencabutan gigi masih menjadi tantangan. Dengan menganalisis pilihan analgesik yang berbeda dan biaya yang terkait, penelitian ini berusaha untuk memberikan wawasan yang berharga bagi penyedia layanan kesehatan dan pasien dalam memilih strategi manajemen nyeri yang paling efektif dan terjangkau. Penelitian ini bertujuan untuk menilai efektivitas biaya obat analgesik untuk manajemen nyeri setelah pencabutan gigi. Studi potong lintang ini dilakukan terhadap 92 pasien yang menjalani pencabutan gigi di Rumah Sakit Pabatu, Serdang Bedagai. Data sekunder dari rekam medis dianalisis untuk menilai demografi pasien, diagnosis, analgesik yang digunakan, tingkat nyeri, dan biaya perawatan. Analisis minimalisasi biaya digunakan untuk membandingkan biaya medis langsung yang terkait dengan analgesik yang berbeda. Kombinasi parasetamol dan na-diklofenak memiliki biaya rata-rata terendah per pasien (Rp 238.150,00), sehingga menjadi pilihan yang layak secara finansial baik bagi penyedia layanan kesehatan maupun pasien. Sebaliknya, biaya rata-rata ibuprofen secara signifikan lebih tinggi (Rp 433.954,97), yang menunjukkan bahwa ibuprofen mungkin bukan pilihan terbaik ketika mempertimbangkan efektivitas dan biaya. Sekitar 80% dari total biaya medis langsung untuk ketiga analgesik tersebut disebabkan oleh biaya prosedur dan pengobatan, yang menunjukkan bahwa pilihan analgesik memiliki dampak yang relatif kecil terhadap biaya secara keseluruhan. Temuan ini menganjurkan penggunaan kombinasi analgesik yang hemat biaya dalam praktik klinis, terutama dalam pengaturan di mana keterbatasan anggaran menjadi perhatian.

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INTRODUCTION

Dental and oral health problems in Indonesia are increasing from year to year, with a prevalence of 57.6% (Kementerian Kesehatan Republik Indonesia, 2018). The high number of cases of oral health problems in Indonesian society indicates a potential increase in the need for tooth extraction as an effort to overcome the complications that arise (Malik et al., 2020; Maulanti et al., 2021). Severe dental caries, tooth fractures, and infection around the tooth root are conditions that commonly require tooth extraction (Abbott, 2019; Broers et al., 2022; Gadhia & Pepper, 2023). In addition, tooth extraction is often performed as part of denture treatment or to correct uneven tooth position (Baxi et al., 2023). Furthermore, another indication for tooth extraction procedures is in cases where the oral problem may lead to odontogenic diseases, including periodontal abscesses, cysts, and periapical diseases (Jain, 2021).

Every health facility, both at the first and advanced levels, has a standard operating procedure for tooth extraction, which aims to minimize pain during dental treatment. Nevertheless, pain during the tooth extraction process cannot be denied; therefore, it is a challenge for the dentist in charge to be able to immediately diagnose and provide appropriate management to identify the source of pain (Shukla & Mehrotra, 2020). Pain during the tooth extraction procedure is a form of activation of pain receptors in the dental pulp by various stimuli ranging from thermal, mechanical, chemical, or electrical (Hossain et al., 2019; Yam et al., 2018). Pain management in tooth extraction procedures can be provided both before and after tooth extraction, while during tooth extraction procedures, local anesthesia is used with anesthetic techniques tailored to the patient's medical condition (Pasternak & Woroń, 2020).

Analgesics play a crucial role in managing postoperative pain, swelling, and trismus associated with third molar extraction, which can significantly impact patients' quality of life (Duarte-Rodrigues et al., 2018). Generally, analgesics in the form of non-steroidal anti-inflammatory drugs (NSAIDs) are the main choice for pain management in patients undergoing dental extraction procedures. Some examples of commonly used anti-inflammatory drugs are mefenamic acid, diclofenac sodium, ibuprofen, or a combination of paracetamol, which is an antipyretic analgesic with opioid analgesics (Raja et al., 2020; Treede, 2018; Wang & Meng, 2021).

Several studies have been conducted to explore the effectiveness of various analgesics in tooth extraction procedures. A recent systematic review concluded that tramadol can effectively reduce pain but not as effectively as non-steroidal anti-inflammatory drugs. Although tramadol has minimal side effects, its effect on reducing pain is not as strong as that of other drugs (Gounari et al., 2023). Another study also showed that mefenamic acid administration before surgery was more effective than that after surgery. However, there was no significant difference in the effectiveness between mefenamic acid and other analgesics (ibuprofen and paracetamol) used in this study (Kumar et al., 2020). Other studies have shown that diclofenac is more effective in relieving pain and has a longer duration of effect than paracetamol (Thenarasu et al., 2018).

For systemically ill patients undergoing tooth extraction, a combination of analgesics and antibiotics has exhibited statistically significant benefits in preventing infection and promoting oral health (Dhanasekaran et al., 2024). Although many methods of managing post-dental extraction pain have been developed, few studies have analyzed the cost-benefit aspects of pain

medications in depth. Therefore, this study aimed to evaluate the cost-effectiveness of various types of pain relievers administered after dental extraction.

RESEARCH METHOD

This was an observational study with a cross-sectional design conducted from May to July 2024 at Pabatu Hospital under PT. Prima Medica Nusantara. This study aimed to assess the cost-effectiveness of analgesic drugs for pain management after tooth extraction procedures. The population in this study included all patients who had undergone dental extraction procedures by 2023. The study sample consisted of 92 participants. The calculation was performed using the formula $n = (Z\alpha)^2pq/d^2$, where $Z\alpha$ represents the critical alpha score (1.96), p is the proportion of dental extractions from a previous study (0.576), q is 1 - p, and d is the margin of error (0.1). The sampling technique used was consecutive sampling, where all patient medical records that met the research criteria during the study period were included. This method ensures that every eligible case within the defined timeframe is considered without the need for randomization.

This study utilized secondary data from outpatient medical records that met the research criteria. It included patients who underwent dental extraction procedures at the dental polyclinic between January and December 2023. The medical indications for the extractions were documented in the medical records and the patient's informed consent forms prior to the procedure. The data were then collected and tabulated on a prepared sheet. This study measured various aspects ranging from patient demographic data, types of diseases, and types of drugs given to treatment costs. These data were collected from the patient's medical records. The demographic data measured included age and sex. Furthermore, clinical data consisted of medical diagnosis, analgesics, and VAS Score. Medical diagnoses that served as indications or justifications for dental extraction procedures were categorized as dentinal caries, pulpitis, or dental abscesses based on medical record data. Analgesics referred to in this study were the types of analgesics administered, such as paracetamol, ibuprofen, and others, recorded in medical records. The patient's pain level was assessed using the Visual Analog Scale (VAS), with a score ranging from 1 to 10, and recorded during each medical session in the Integrated Patient Progress Notes within the medical record. Meanwhile, this study collected direct medical costs, including procedure and treatment fees, physician fees, analgesic costs, other medication costs, and outpatient administration fees, as determined by the hospital. These costs were uniformly applied across all healthcare payment systems without price differentiation. Furthermore, physician fees and outpatient administration fees were categorized as fixed costs, while procedure and treatment fees, analgesic costs, and other medication costs were classified as variable costs.

Data on sample characteristics, types of analgesics, direct medical costs, and length of patient treatment were analyzed using descriptive statistics. Then, the analysis was continued to assess the minimization of direct medical costs of each analgesic by measuring the CMA value with the following formula. CMA or cost minimization analysis can be used to compare two or more health interventions (drugs) that provide the same results and compare on one side in the form of costs (Thomas et al., 2019).

RESULTS AND DISCUSSION

In this study, the medical records of 92 patients who underwent dental extraction procedures were analyzed. Most respondents were aged between 26-35 years (59.8%), followed by the 17-25 years age group (28.3%). The oldest age group, 36-45 years, accounted for only 12% of the total respondents. The majority of the respondents were male (77.2%), while females accounted for only 22.8%. The results of this study are not much different from those of a study conducted by (Sari et al., 2020), who reported that more male patients underwent dental extraction procedures. This could be caused by the lifestyle of men who are more at risk of experiencing dental health problems, one of which is smoking. Furthermore, awareness of dental health in men is also low, thus increasing the risk of men experiencing more severe dental health problems, which ultimately require patients to undergo dental extraction procedures (Makeeva et al., 2024; Rajeh, 2022).

Table 1. Characteristics of Respondents (n= 92)

Characteristics	n	%
Age		
17-25 years	26	28.3
26-35 years	55	59.8
36-45 years	11	12.0
Gender		
Male	71	77.2
Female	21	22.8
Indication for Tooth Extraction		
Necrosis Radix	31	33.7
Caries Reaching Pulp	28	30.4
Mobility	22	23.9
Persistence	11	12.0
Type of Tooth Extracted		
Incisivus	35	38.0
Caninus	9	9.8
Premolar	33	35.9
Molar	15	16.3
Type of Analgesic		
Mefenamic Acid	53	57.6
Ibuprofen	29	31.5
Paracetamol and Na-Diclofenac	10	10.9
Type of Antibiotic		
Amoxicillin	44	47.8
Cefadroxil	37	40.2
Clindamycin	11	12.0

Necrosis radix (33.7%) was the main reason for tooth extraction, followed by caries that reached the pulp (30.4%). In addition, tooth mobility and persistence were also indications for extraction at 23.9% and 12%, respectively. Another study also reported similar results, where the most common indications for tooth extraction were gangrene of the pulp (30.8%) and radix (32.6%) (Evy Eida Vitria & Jeanie Cornelia, 2023; Sari et al., 2020). In adulthood, teeth are generally more susceptible to various diseases, such as pulpitis and irreversible pulp necrosis. However, at an older age of > 40 years, the cause of tooth extraction is related to periodontal disease. In adulthood, dental health is also related to oral hygiene and the level of knowledge of health issues regarding dental health. In addition, with increasing age, the tooth

structure also changes, and the tooth is more prone to fracture (Arini et al., 2020; Tanu et al., 2019).

The most commonly extracted teeth were incisors (38%), followed by premolars (35.9%), molars (16.3%), and canines (9.8%). A study found that the mandibular first molars (22.2%) and maxillary third molars (15.2%) were the most frequently extracted. Dental caries and periodontal diseases are the main causes of tooth extraction (Shareef et al., 2020).

In this study, it was found that the majority of analgesics most widely used in patients after tooth extraction were mefenamic acid. Previous studies have reported that various pain management modalities can be provided before and after dental surgery in patients. In postoperative pain management, options that can be given are non-steroidal anti-inflammatory drugs (NSAIDs), such as ketorolac, ibuprofen, diclofenac, aspirin, or paracetamol (Sheth et al., 2020; V et al., 2023). This is related to the cause of pain caused by scars or wounds in the tissue due to dental surgery, so the use of NSAIDs or non-steroidal anti-inflammatory drugs is the right choice in this case, as it can relieve inflammation or inflammatory reactions in wounds or tissue injuries that ultimately prevent the activation of pain receptors in the form of nociceptors by prostaglandins (Hersh et al., 2020; Malamed, 2023).

The most commonly used analgesic was mefenamic acid (57.6%), followed by ibuprofen (31.5%) and a combination of paracetamol and diclofenac sodium (10.9%). The most commonly prescribed antibiotic was amoxicillin (47.8%), followed by cefadroxil (40.2%) and clindamycin (12%). Amoxicillin is an antibiotic from the beta-lactam group that works by inhibiting the formation of bacterial cell membranes (Ahmadi et al., 2021; Akhavan et al., 2023).

Based on Table 2, the median cost of analgesics for mefenamic acid, ibuprofen, paracetamol, and Na-Diclofenac was IDR 335,000, with a range of IDR 420,000. Among the types of analgesics, mefenamic acid and ibuprofen had the same median cost, whereas paracetamol and diclofenac sodium had a lower median cost of IDR 145,000 (with a range of IDR 0). Regarding other cost components, the median physician fee was IDR 50,000 for all types of analgesics. The analgesic costs were higher for ibuprofen (IDR 5,825) than for mefenamic acid (IDR 4,212), paracetamol, and Na-Diclofenac (IDR 7,285). The median cost of other medications was IDR 15,865 for mefenamic acid, paracetamol, and Na-Diclofenac, and IDR 10,903 for ibuprofen. Outpatient administration fees were consistently IDR 20,000 across all types of analgesics. When considering total direct medical costs, mefenamic acid and ibuprofen had similar costs (IDR 420,115 and IDR 421,728, respectively), while paracetamol and Na-Diclofenac had a significantly lower cost of IDR 238,150.

Table 2. Comparison of Direct Medical Costs of Several Types of Analgesics

Cost Component	Analgesic Type, IDR [Median (Range)]			p
	Mefenamic Acid	Ibuprofen	Paracetamol and Na-Diclofenac	
Procedure and Treatment	335,000 (420,000)	335,000 (420,000)	145,000 (0)	< 0.001
Physician Fees	50,000 (0)	50,000 (0)	50,000 (0)	1.000
Analgesic Costs	4,212 (0)	5,825 (0)	7,285 (0)	< 0.001
Other Medication Costs	15,865 (6,751)	10,903 (4,962)	15,865 (6,751)	0.067
Outpatient Administration Fees	20,000 (0)	20,000 (0)	20,000 (0)	1.000
Total Direct Medical Costs	**420,115 (424,962)**	**421,728 (424,962)**	**238,150 (0)**	**0.001**

This finding strongly suggests that the observed variation in direct medical costs is a direct result of the significant differences in these cost components. The results of this study align with the economic concept of opportunity cost, which is the value of the best alternative that must be abandoned when making a choice. In the context of healthcare, opportunity costs include not only direct healthcare costs but also other related costs borne by the patient (Hübner et al., 2018; Sittimart et al., 2024). A study reported that approximately 6.82% of the total costs incurred by patients were non-medical costs, such as transportation and significant meals (6.82%). In addition, the indirect costs due to the loss of income of the patient's parents during treatment reached 2.31% (Hadning et al., 2020). Other studies have shown that the average ambulatory medical visit in the US takes 121 min, including travel and clinic time, with an associated opportunity cost of $43 per visit (Ray et al., 2015). These opportunity costs can influence patients' willingness to pursue interventions and should be considered in cost-effectiveness analyses.

Furthermore, a shortage of doctors may lead to longer wait times and increased travel distances, resulting in higher time and travel costs for patients (Rothstein et al., 2017). In the process of providing health services, cost accounting distinguishes between various types of costs, including average and marginal costs, fixed and variable costs, and ancillary costs. Fixed costs are costs that remain constant in the short term, regardless of the volume of services provided, whereas variable costs vary proportionally with changes in the volume of services. Examples of variable costs in this context include sales commissions and drug costs (Reiter & Song, 2020; Špacírová et al., 2020).

From Figure 1, it can be seen that the most influential variable costs in the amount of direct medical costs for patients undergoing dental extraction procedures are additional costs and treatments. Hence, the bar chart illustrating the cost of action and treatment and direct medical costs displays a similar pattern.

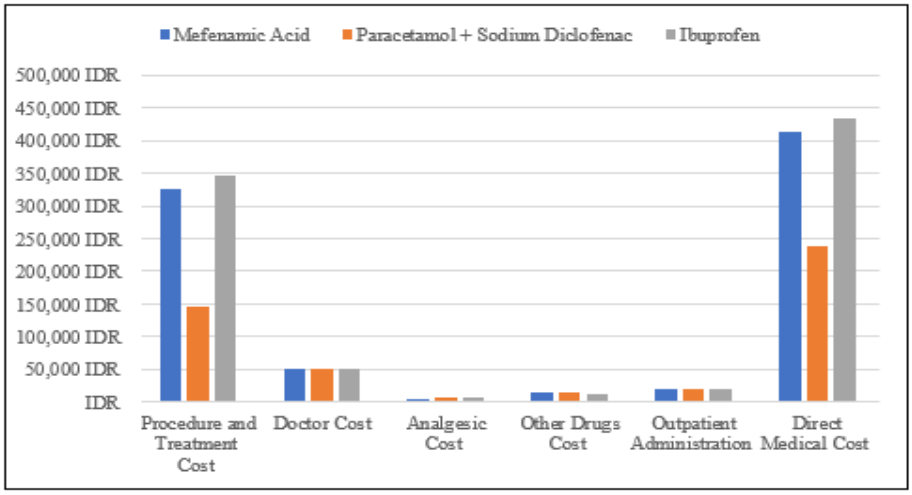

Figure 1. Cost Overview of Analgesic Use in Tooth Extraction Procedures

In addition to direct medical costs, pharmacoeconomic evaluations require a comparison of the effectiveness of various therapeutic regimens. This study delineated the analgesic efficacy

for pain relief in patients who underwent tooth extraction procedures by employing the visual analog scale (VAS) three days after post-analgesic administration. Table 3 shows that there was no difference in the VAS Score after three days of administration of various types of analgesics in patients undergoing dental extraction procedures. This is reflected in the p-value, which was greater than 0.05. Therefore, the administration of analgesics, either mefenamic acid, ibuprofen, or paracetamol + Na-diclofenac, exhibited no difference in pain effectiveness. All analgesic regimens were able to reduce post-tooth extraction pain with a VAS Score of 2 for all analgesic regimens.

Similar results have also been reported in other studies. Analgesics have a positive impact on acute pain management after tooth extraction, but there is no significant difference in the effects of paracetamol, ibuprofen, and mefenamic acid on pain relief (Kumar et al., 2020). A review of the literature concluded that paracetamol and ibuprofen are the analgesics' first choice for dental pain. Paracetamol has minimal anti-inflammatory activity and is safer for gastrointestinal and cardiovascular organs than other NSAIDs. Ibuprofen is also effective for mild or moderate dental pain and has a relatively low risk of side effects. Although naproxen has a stronger anti-inflammatory effect, it poses a higher risk to the gastrointestinal organs (Kim & Seo, 2020). As a single dose has a similar effect, a combination of analgesics is used as an alternative to improve outcomes. A previous study reported that administering a combination of ibuprofen and paracetamol before dental surgery was more effective in reducing postoperative pain than paracetamol alone (Manuapo, 2019).

Table 3. Visual Analogue Scale Scores After Three Days

Type of Analgesic	VAS Score After 3 Days [Median (Min-Max)]	p
Mefenamic Acid	2 (1-3)	
Ibuprofen	2 (1-3)	0.633*
Paracetamol and Na-Diclofenac	2 (1-3)	

**Kruskal-Wallis*

Table 4 shows that the lowest average direct medical costs were found in patients who received analgesics in the form of a combination of paracetamol and diclofenac sodium, with an average direct medical cost of IDR 238,150.00, followed by those who received analgesics in the form of mefenamic acid at IDR 414,529.62. The highest average direct medical costs were found in the group of patients who received analgesics in the form of ibuprofen, which amounted to IDR 433,954.97.

Table 4. Mean Cost Components and Cost Minimization Analysis of Analgesic Use in Tooth Extraction Procedures

Cost Component	Type of Analgesic, IDR		
	Mefenamic Acid (n= 53)	Ibuprofen (n= 29)	Paracetamol and Na-Diclofenac (n= 10)
Procedure and Treatment	326,886.79	345,344.83	145,000.00
Physician Fees	50,000.00	50,000.00	50,000.00
Analgesic Costs	4,212.00	5,825.00	7,285.00
Other Medication Costs	14,109.11	12,785.14	14,238.08
Outpatient Administration Fees	20,000.00	20,000.00	20,000.00
Total Direct Medical Costs	**414,529.62**	**433,954.97**	**238,150.00**

The results revealed that the mean total direct medical costs were highest for ibuprofen (IDR 433,954.97), followed by mefenamic acid (IDR 414,529.62), and paracetamol and Na-diclofenac (IDR 238,150.00). The main cost drivers were the procedure and treatment costs, which accounted for approximately 80% of the total direct medical costs for all three types of analgesics. The analgesic costs were also significantly different among the three types of analgesics. Mefenamic acid had the lowest analgesic costs (IDR 4,212.00), followed by ibuprofen (IDR 5,825.00), and paracetamol and Na-diclofenac (IDR 7,285.00). In conclusion, the analgesic used in tooth extraction procedures can have a significant impact on the total direct medical costs. Ibuprofen is the most expensive analgesic, followed by mefenamic acid, paracetamol, and sodium diclofenac. The main costs of drivers are procedure and treatment costs.

Overall, the study suggests that while the analgesic used in tooth extraction procedures can influence the total direct medical costs, the primary cost drivers are related to the procedure and treatment itself rather than the specific analgesic chosen. This implies that factors like the complexity of the procedure, the facility where it is performed, and the physician's fees have a more substantial impact on costs than the analgesic.

CONCLUSION

All types of analgesics had almost the same effectiveness in reducing pain. In terms of cost, the combination of paracetamol and Na-diclofenac had the lowest analgesic cost, averaging IDR 238,150.00 per patient. In contrast, ibuprofen was the highest cost analgesic, averaging IDR 433,954.97 per patient. Cost-minimization analysis uncovered that the combination of paracetamol and Na-diclofenac was the most effective and efficient option. At the lowest cost, this combination of drugs was able to reduce the patient's pain level to an acceptable level (VAS Score ≤ 3). It can be concluded that the use of analgesics and antibiotics after extraction aligns with medical standards, and the combination of paracetamol and Na-diclofenac has proven to be the most effective and efficient choice for reducing patient pain at a relatively affordable cost.

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