RESEARCH

Appropriateness of antibiotic prescribing among patients treated for dental diseases in Mekelle city, Northern Ethiopia: a cross sectional study

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Abstract

Background Local operative treatments are generally preferred for most dental diseases, with antibiotics only recommended as an adjunct in specific cases. Misuse and overuse of antibiotics has been shown to significantly contribute to the development of resistant bacteria. However, the antibiotic prescribing practices of dentists in Ethiopia have not been thoroughly studied. This study aimed to assess the appropriateness of antibiotic prescribing for patients with dental diseases at dental clinics in Mekelle City, Northern Ethiopia.

Methods A cross sectional study was conducted in April and May 2020 among patients visiting dental clinics in Mekelle City. Data were collected through patient medical record reviews and dentist interviews. The appropriateness of antibiotic prescription was evaluated based on guidelines from the American Dental Association and the European Society of Endodontology. Data were analyzed using SPSS Statistics, version 29. Binary logistic regression analysis was performed, and the results were presented as odds ratios with 95% confidence intervals. A p value less than 0.05 was considered statistically significant.

Results Two hundred and thirty-one patients with dental diseases participated in the study. The mean age was 30.6 years with a standard deviation of 16.1. Most participants had dental pulp related disease. 89% of patients were prescribed antibiotics, with amoxicillin being the most common. Inappropriate antibiotic prescribing was identified in 175 (75.8%) of the study participants. The most common inappropriate prescribing was unnecessary antibiotic prescribing for dental conditions without systemic signs, assessed in 141 (80.1%) participants. Patients diagnosed with pulp related disease without systemic signs and those who had tooth extractions were significantly associated with inappropriate antibiotic prescription (p value < 0.001).

Conclusions The study findings show that antibiotics are over-prescribed for dental conditions in this resource constrained setting, especially in patients who have had tooth extractions. Dentists need training on appropriate antibiotic use and antimicrobial stewardship interventions should be implemented in dental setting to reduce unnecessary antibiotic prescriptions and prevent antibiotic resistance development.

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Background

Dental infections can originate in a dead dental pulp or its supporting structures and spread to the surrounding tissues. Most dental diseases can be treated without antibiotic by removing the cause and draining the infection [1]. Dental procedures such as dental fillings, root canal treatment, scaling, root planning, extraction or abscess drainage are considered the gold standard for treating dental conditions [2, 3]. However, antibiotics are recommended as complement to dental procedures for immunocompromised patients or immunocompetent patients with severe, spreading infections and systemic signs such as facial swelling (cellulitis), fever, and tachycardia [1, 3, 4].

Antibiotic misuse and overuse are widespread problems in both outpatient and inpatient clinical settings. The Centers for Disease Control and Prevention (CDC) estimates that about 30% of all outpatient antibiotic prescriptions are unnecessary, when adding inappropriate selection, dosing and duration, approximately 50% of all outpatient antibiotic use is inappropriate [5]. Antibiotics account for the majority of medicines prescribed by dentists [6], who are responsible for about 15% of antibiotic prescriptions in primary care settings [7]. Studies in developed countries have shown that 14–28% of antibiotics prescribed for dental diseases [8, 9] and about 80% of prophylactic antibiotics prescribed before dental procedures [10, 11] were inappropriate. Evidence on the appropriateness of antibiotic prescribing among dentists in developing countries like Ethiopia is limited.

Antimicrobial misuse and overuse are major factors contributing to the development of resistant bacteria [12], which pose urgent threats to the healthcare system. The consequences of inappropriate antibiotic use and resistance can be severe leading to deaths, unnecessary health care costs, treatment failures and adverse drug effects [12–14]. This study aimed to evaluate the appropriateness of antibiotic prescribing for patients with dental diseases visiting dental clinics in Mekelle city.

Methods

Study setting and period

This study was conducted in five dental clinics located in Mekelle city, two from governmental hospitals and three from private dental clinics. Mekelle is the capital city of Tigray, the northern most region of Ethiopia, located 783 km away from Addis Ababa. With a population estimated at 480,000 [15], it has three governmental hospitals and ten private dental clinics. The study was conducted in April and May, 2020.

Study design and participants

A cross-sectional study design was used and data were collected through a review of prescriptions and patients' medical records, as well as interviewing dentists. The study participants were patients who underwent dental procedures in the randomly selected dental clinics during the study period. Participants or their care givers were asked about their willingness to participate in the study, and those diagnosed with either pulpitis (inflammation of the tooth pulp) or periodontitis (gum disease) were included, regardless of age and sex. All antibiotic prescriptions given within seven days of a planned procedure or after the procedure were included. Incomplete and unreadable prescriptions or medical records as well as prescription orders containing only medical supplies like syringes, needles, catheters were excluded from the study.

Sampling size determination and sampling procedure

The sample size required for this study was calculated using a single proportion sample size estimating formula $no = \frac{z^2 p (1-p (0.5))}{d^2}$, where, n_o is the desired sample size, z is the standard normal deviation (1.96), p is the proportion in the target population (50%), and d is the degree of accuracy desired (0.05). Accordingly, the initial sample size calculated was 384. However, since the total source population with dental disease in Mekelle city during the study period was less than 10,000, a correction formula was required to adjust the sample size. Using the formula, $n = (no \times N))/((N + (no - 1))$, where n is the adjusted sample size and N is the source population size in the study setting. Based on the data obtained about the average daily patient flow for dental reasons in the study clinics, the source population size (N) expected during two-months period was approximated at 500. Therefore, the sample size (n) calculated was 217, and with a 10% allowance, the final sample size determined was 238.

The governmental dental clinics had almost 10 times the patient flow compared to the private dental clinics. Based on patient flow, we classified the dental clinics into two groups: high and low patient flow. The selection of study participants to be included into the sample was done randomly by using alternative day data collection for the high and low patient flow groups of clinics. In the two-month period, the data collection took 20 working days for each group of clinics. Considering the inclusion criteria, we included all patients who visited the dental clinics during the data collection days.

Data collection

Data were collected using a pretested, structured data abstraction format by pharmacy graduating class students trained for this purpose. Information about the study was provided to the participants (patients and their care givers), and the dentists working in the dental clinics. The data abstraction format had parts to record patient demographics, diagnosis, type of dental procedure and medications.

During the data collection processes, the diagnosis of each patient in the prescription and medical record was further clarified through interviewing the dentists to categorize as pulpitis (inflammation of the tooth pulp) with or without signs of infection, and periodontitis (gum disease) with or without signs of infection. The appropriateness of each antibiotic prescription was assessed by reviewing evidence-based clinical practice guidelines on antibiotic use from the American Dental Association [3] and the European Society of Endodontology [4].

Assessment of the appropriateness of antibiotic prescription

Inappropriate antibiotic prescribing includes unnecessary prescribing of antibiotics (overprescribing), prescribing the wrong antibiotic or antibiotic combination (inappropriate selection) as well as giving the wrong dose or duration [5]. For the assessment of the appropriateness of antibiotic prescribing in this study, we utilized guidelines from the American Dental Association [3] and the European Society of Endodontology [4]. The investigators engaged in detailed case by case discussion to categorize the appropriateness of antibiotic prescribing. According to these guidelines, the criteria for indications

and contra-indications for systemic antibiotics in Endodontics are listed in Table 1.

According to these guidelines, a 3 to 7-day course of Beta-lactam antibiotics (penicillin V and amoxicillin) or metronidazole is recommended for the initial treatment of endodontic infections. If penicillin was used previously and therapy is ineffective, a combination of penicillin V/amoxicillin with metronidazole or amoxicillin with clavulanic acid is recommended [3, 4]. Therefore, our first criterion for considering inappropriate antibiotic prescribing was having a diagnosis listed under Table 1 as a 'contra-indications for systemic antibiotics'. The second criterion was having a diagnosis listed under Table 1 'indications for systemic antibiotics' with a duration shorter or longer than recommended or using a combination of amoxicillin and metronidazole as initial treatment.

Statistical analysis

The collected data were checked for completeness and consistency before processing, then edited, coded, and cleaned. The data were double entered into SPSS Statistics version 29 for analysis. Descriptive statistics were used to obtain the frequencies and percentages. Binary logistic regression analysis was done to identify factors associated with the dependent variable. The independent variables were sex, age, type of dental clinic, diagnosis and type of dental procedure performed. The dependent variable was the appropriateness of antibiotic prescription. The results of the logistic regression were expressed as odds ratios (OR) with 95% confidence intervals (CI). A p value of less than 0.05 was considered statistically significant.

Results

In this study, 231 participants who underwent dental procedures in the dental clinics of Mekelle City were included. The mean age of participants was 30.6 years with a standard deviation of 16.1. Participants' ages ranged from 2 to 85 years old. The majority of the study participants were urban residents visiting governmental hospitals with tooth pulp related diseases who underwent tooth extraction (Table 2). None of the participants had any comorbid heart diseases or immunodeficiencies like diabetes, cancer and HIV.

About 89% of the study participants were prescribed antibiotics, with amoxicillin being the most commonly prescribed. The majority of the antibiotic prescriptions (75.5%) were provided after the dental procedure. Almost all participants had taken therapeutic doses of antibiotics for a median treatment duration of seven days. The antibiotic prescribing pattern was found to be inappropriate in 175 (75.8%) of the study participants. The most common inappropriate prescribing practices were

Table 1 Indications and contra-indications for systemic antibiotics in endodontics [3, 4]

Indication for systemic antibiotics	Contra-indications for systemic antibiotics
1. Acute apical abscess in medically compromised patients; 2. Acute apical abscess with systemic involvement (localized fluctuant swellings, elevated body temperature > 38 °C, malaise, lymphadenopathy, trismus; 3. Progressive infections (rapid onset of severe infection in < 24 h, cellulitis or a spreading infection, osteomyelitis) where onward referral to oral surgeons may be necessary; 4. Replantation of avulsed permanent teeth. In these cases, topical administration of antibiotics may also be indicated 5. Soft tissue trauma requiring treatment (e.g.sutures, debridement)	1. Symptomatic irreversible pulpitis (pain, with no other symptoms and signs of infection); 2. Pulp necrosis; 3. Symptomatic apical periodontitis (pain, pain to percussion and biting and widening of periodontal ligament space); 4. Chronic apical abscess (teeth with sinus tract and periapical radiolucency); 5. Acute apical abscess without systemic involvement (localized fluctuant swellings). 6. Tooth fractures, concussion, subluxation, luxation injuries and extrusion.

Table 2 Demographic, clinical and treatment characteristics of patients with dental disease visiting dental clinics in Mekelle city, 2020 (*N* = 231)

Variables		Number	Percent
Sex	Male	100	43.3
	Female	131	56.7
Residence	Urban	193	83.5
	Rural	38	16.5
Type of institution	Governmental	207	89.6
	Private	24	10.4
Type of dental disease	Endodontic (tooth pulp disease)	206	89.2
	Periodontal (Gum disease)	25	10.8
Diagnosis	Pulpitis without systemic signs *	158	68.4
	Pulpitis with systemic signs^	48	20.8
	Periodontitis with signs of infection£	8	3.5
	Periodontitis without signs of infection	17	7.4
History of dental procedure	Yes	61	26.4
	No	170	73.6
Type of procedure	Tooth Extraction	153	66.2
	Endodontic treatmentsγ	57	24.7
	Scaling and root planning	18	7.8
	Orthodontic treatment	3	1.3
Antibiotics prescribed	Yes	205	88.7
	No	26	11.3
Type of Antibiotics	Amoxicillin	161	78.6
	Amoxicillin + Metronidazole	37	18.0
	Metronidazole	2	1.0
	Others**	5	2.4
Duration of Antibiotic treatment	5 days	46	22.4
	7 days	154	75.1
	10 days	3	1.5
	1 day	2	1.0
Other Medications used	Yesα	189	81.8
	No	42	18.2

* Reversible pulpitis, symptomatic irreversible pulpitis with or without symptomatic apical periodontitis, pulp necrosis, symptomatic apical periodontitis, localized acute apical abscess

^ Pulp necrosis and acute apical abscess with systemic signs (facial swelling, cellulitis, fever, and lymphadenopathy)

£ Periodontal abscess, necrotizing ulcerative periodontitis and rapidly progressing periodontal disease

** Metronidazole + Ceftriaxone/Cloxacillin/Doxycycline, Amoxicillin and clavulanate, Doxycycline, Ceftriaxone

α Other medications: Nonsteroidal anti-inflammatory drugs, Acetaminophen, lidocaine, hydrocortisone, diazepam, chlorhexidine

γ Endodontic treatments such as removal of the pulpal tissue, filing and shaping the root canals

unnecessary prescribing of antibiotics for dental conditions without systemic signs assessed in 141 (80.1%) of the participants followed by prescribing a combination of amoxicillin and metronidazole in patients with irreversible tooth pulp related diseases with systemic signs of infection and without a history of previous dental procedures when either antibiotic alone would have been sufficient, assessed in 31(17.7%) of the participants (Fig. 1).

Two hundred and four participants that fit into the logistic regression model were included in the final analysis. Binary logistic regression indicated that diagnosis (OR = 0.146, 95%CI: 0.062–0.348) and type of dental procedure (OR = 0.181, 95% CI:0.076–0.434) showed a statistically significant association with the appropriateness of antibiotic prescribing. Patients diagnosed with tooth pulp related diseases with systemic signs were 85.4% less likely to receive inappropriate antibiotic prescriptions compared to patients diagnosed with tooth pulp related diseases without signs of infection. Additionally, patients who underwent endodontic treatments such as removal of the pulpal tissue, filing and shaping root canals were 81.9% less likely to receive inappropriate antibiotic prescriptions compared to patients who underwent tooth extraction (Table 3).
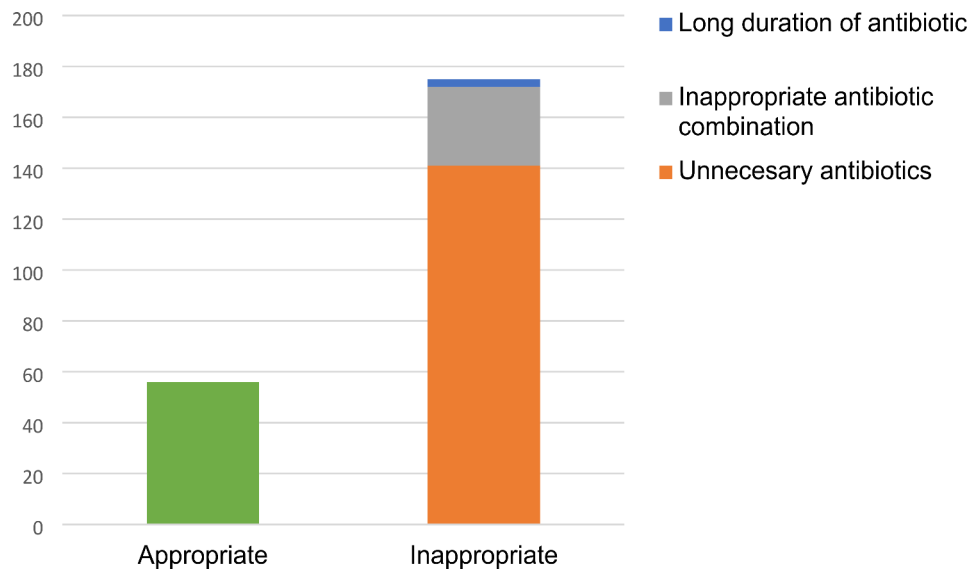
Fig. 1 Appropriateness of antibiotic prescribing among patients with dental disease visiting dental clinics in Mekelle city in 2020 ($N=231$)

Table 3 Binary logistic regression analysis of patients with dental disease visiting dental clinics in Mekelle city in 2020 ($N=204$)

Variables		Appropriate	Inappropriate	OR (95%CI)	P value
Age (years)	Mean (SD), 30.6 (15.8)	42/204 (20.6)	162/204(79.4)	1.017 (0.986–1.048)	0.282
Sex	Female	25/42 (59.5)	95/162 (58.6)	0.538 (0.233–1.240)	0.146
Residence	Rural	7/42 (16.7)	27/162 (16.7)	0.584 (0.180–1.903)	0.373
Type of health institution	Private	4/42 (9.5)	15/162 (9.3)	1.597 (0.433–5.895)	0.482
History of dental procedure	No	36/42 (85.7)	114/162(70.4)	0.358 (0.127–1.011)	0.052
Diagnosis	Pulpitis with systemic signs^	21/42 (50.0)	25/162 (15.4)	0.146 (0.062–0.348)	$<0.001^{\pi}$
Type of dental procedure	Endodontic treatments	20/42 (47.6)	35/162 (21.6)	0.181 (0.076–0.434)	$<0.001^{\pi}$
	Scaling and root planning	2/42 (4.8)	3/162 (1.9)	0.353 (0.038–3.246)	0.357

^ Pulp necrosis and acute apical abscess with systemic signs (facial swelling, cellulitis, fever, tachycardia and lymphadenopathy)

$^{\pi}$Statistical significant association

OR, Odds Ratio; CI, Confidence Interval; N, Number; SD, standard deviation

Discussion

The Ethiopian healthcare system is structured in a three-tier decentralized health service system: primary level health care, secondary level (general hospitals) and tertiary (specialized hospitals) with the goal of providing preventive and promotive health care, equitable and acceptable standards of health service that will reach all segments of the population within the limited resources [16]. Delivery of health care service was owned by the government for years, but in recent years the private sector has shown significant growth. Dental care service in Ethiopia is available in tertiary hospitals, general hospitals and private dental clinics confined to major cities.

Despite Ethiopia's impressive progress in health care delivery infrastructure and the development of the health workforce [17], Ethiopia still lacks in ensuring access to good quality healthcare for all in need. Most of the population in Ethiopia does not have insurance coverage [18], and health care costs are increasing over time, making essential health services unaffordable. Infectious diseases like diarrheal diseases, lower respiratory tract infections, and tuberculosis remain the leading causes of mortality in the country following neonatal disorders [19]. In Ethiopia, antimicrobials account for 50 to 60% of all prescriptions [20–23]. Studies are limited to understand the level of inappropriate antimicrobial prescribing practices in the country. One study has reported inappropriate antimicrobial prescribing in about 30% of antibiotic prescriptions [24], while another study reported it at 86.6% [25].

Surgical extraction or endodontic treatments are the mainstay of treatments for most dental diseases. Antibiotics are recommended as an adjunct to operative interventions in certain cases where dental conditions can lead to infections with severe consequences [1, 3, 4]. There is evidence that antimicrobial prophylaxis used before dental procedures in selected patients is effective in reducing systemic infections such as infection of the heart valves [26, 27]. In our study, approximately 89% of the participants were prescribed antibiotics, with amoxicillin being the most common choice. The majority of

the study participants in our research were patients who underwent tooth extraction without any known concomitant heart conditions or immunodeficiency. Most dentists in our study prescribed antibiotics for a median duration of seven days, without distinguishing between prophylactic and therapeutic antibiotic use. Consistent with our findings, several studies have shown that amoxicillin is a commonly prescribed antibiotic in dentistry [10, 28–31] and the rate of antibiotic prescription after tooth extraction was above 80% in some studies in Eastern Asia [32, 33].

According to the guideline recommendations from the American Dental Association [3] and the European Society of Endodontology [4], the antibiotic prescribing pattern in the current study was deemed inappropriate in approximately 76% of the participants. Many of them received unnecessary prescriptions or a combination of amoxicillin and metronidazole when either antibiotic alone would have sufficed. Similar to our findings, other studies have also shown a high rate of inappropriate antibiotic prescribing. Two studies based on clinical case scenarios found that 73% of dentists were nonadherent to professional guidelines [28, 34]. In India, there was a reported antibiotic overprescribing trend of 92.4% among oral healthcare providers [31]. Additionally, a cohort study from the United States found that over 80% of antibiotics prescribed for infection prophylaxis before a dental procedure were unnecessary [10]. Conversely, other studies from both developing and developed countries reported a lower proportion of inappropriate antibiotic prescriptions (ranging between 14 and 28%) [8, 9, 35]. These studies were either retrospective cohorts analyzing prescriptions or surveys conducted among dentists to assess their prescribing habits. The variation in the proportion of inappropriate antibiotic use may be attributed to our study solely focusing on patients undergoing dental procedures where antibiotic prescribing is common, whereas the other studies included all patients visiting the dental clinic. Additionally, biases in disclosing prescribing habits during interviews with dentists may have contributed to the lower reported rates of inappropriate antibiotic prescriptions in other studies.

Our statistical analysis revealed that patients diagnosed with tooth pulp related diseases without systemic signs (reversible pulpitis, symptomatic irreversible pulpitis with or without symptomatic apical periodontitis, pulp necrosis, symptomatic apical periodontitis, localized acute apical abscess) and those who underwent tooth extraction were statistically associated with inappropriate antibiotic prescription (p value < 0.001). Consistent with our findings, a national survey found that antibiotics, such as narrow-spectrum penicillin, were prescribed in 65% of common dental diagnoses (unspecified disorders of teeth and supporting structures, periapical abscess,

and dental caries) [36], in which a dental procedure alone rather than antibiotics could have been sufficient in most of these cases.

The current study highlights critical gaps in the responsible usage of antibiotics among dental practitioners in a resource-limited setting posing a threat to the development of antibiotic resistance. Despite the presence of policies on antimicrobial resistance in Ethiopia focusing on raising awareness, improving education, surveillance, research, infection prevention and control, and optimizing the use of antimicrobials [37], its implementation is inadequate. Major drivers of antimicrobial resistance in Ethiopia include incorrect and inappropriate use of antimicrobials by healthcare providers and unskilled practitioners, inadequate surveillance and inappropriate usage of antimicrobials by patients [38]. Several studies have documented training gaps in antimicrobial usage and antimicrobial resistance among health science students and health care professionals in Ethiopia [39–43]. Interventions addressing training needs should be implemented by incorporating rational antimicrobial use into the curriculum of all health disciplines including dentistry and providing in-service trainings to dental professionals. Furthermore, antimicrobial stewardship interventions are needed in the study setting as dentistry accounts for a significant share of antimicrobial prescriptions, with the majority of these being prescribed inappropriately.

The main limitation of our study is the absence of bacteriological tests to confirm the presence of infection, which may have led to misclassification of some diagnoses and potential overestimation of inappropriate antibiotic prescriptions. The sample size was small especially samples taken from private clinics, limiting the strength of association that could have been observed between the dependent variable and variables such as the site of care. A potential future research avenue is to investigate the impact of inappropriate antibiotic prescribing on clinical outcomes such as the development of resistance or treatment success using a multicenter prospective cohort study.

Conclusion

The proportion of inappropriate antibiotic prescriptions for dental conditions was high, at 75.8%. The most common inappropriate prescribing practices were unnecessary antibiotic use for dental conditions without systemic signs and prescribing antibiotics for tooth extraction. To reduce the consequences of unnecessary antibiotic prescriptions particularly the development of resistant microorganisms, there is an urgent need to train dentists about appropriate antibiotic use and implement antimicrobial stewardship interventions. This can be achieved through the development and implementation

of comprehensive guidelines, clinical audits, as well as providing training and behavior change interventions.

Abbreviations

AWaRe	Access, Watch and Reserve
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
N	Number
OR	Odds Ratio
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

Data availability
The data supporting the conclusions of this study are presented in the main manuscript. Any additional data can be obtained by contacting the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted after obtaining official approval from the Mekelle University, College of Health Science, School of Pharmacy, Ethical Committee. An official letter was sent from School of Pharmacy to each health facility. Participants' prescription and medical records were reviewed after obtaining verbal consent from themselves or their care givers and from the dental professionals. Prior to obtaining consent, the study aims, benefits and risks of participation in the study were discussed with each participant. Participants were assured of the confidentiality of their data by omitting identifications such as patients name and health facility name. All methods used in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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