

RESEARCH ARTICLE

Antibiotic prescription patterns for treating dental infections in children among general and pediatric dentists in teaching institutions of Karachi, Pakistan

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Abstract

Background

Antibiotics are regularly prescribed by dental professionals in their practice, for the purpose of dental treatment as well as for the prevention of infection. The inappropriate use of antibiotics is a significant factor in the rise of antibiotic resistance. There is an immediate need for the advancement of prescribing guidelines and instructive polices to encourage the rational and appropriate utilization of medications especially antibiotics in dentistry.

Objective

The aim of this study was to identify the frequency of antibiotic prescription for treating dental infections in children among dentists in teaching institutions of Karachi, Pakistan and whether they are adhering to the prescribed international guidelines.

Methods

A cross-sectional study was conducted in three private and two public colleges of Karachi. After taking written informed consent and checking the inclusion criteria, a total of 380 participants were interviewed using a pre-designed validated questionnaire which included demographic profile and clinical case scenarios. Data were entered and analyzed on SPSS version 20. Inferential analysis was performed using chi-square test. The significance level was set at 0.05.

Results

Of the 380 subjects, a majority (71.3%) treated 15 or less children per month (n = 271) while 28.7% of dentists (n = 109) treated more than 15 children per month. Overall adherence to American Academy of Pediatric Dentistry guidelines was low from 26.1% to 44.2%. The difference between adherence of dentists with low and high volume of pediatric patients was

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significantly different for case scenarios 1, 3, 4 and 5 ($p < 0.001$ for all) where dentists who treated 15 or less children per month were more likely to be adherent to standard antibiotic prescription guidelines than those who treated more than 15 children per month.

Conclusions

This study shows that majority of dentists, particularly dentists with high volume of pediatric patients lacked adherence to professional guidelines for prescribing antibiotics for treating dental infection in children. There seem to be a lack of harmony between the recommended professional guidelines and the antibiotic prescribing pattern of dentists. Regular updates and continuing medical education for the health professionals regarding comprehensible and specific professional guidelines may lead to improved adherence of antibiotics prescription amongst dentists.

Introduction

During the last few decades one of the most common drugs prescribed in both children and adults has been antibiotics as they significantly reduce human mortality and morbidity [1]. From 2000 to 2015, the global antibiotic consumption in terms of defined daily doses has seen an increase of 65%, mainly in low middle income countries, such as Pakistan [2]. Thus use of antibiotics in developing countries has been observed to be much higher compared to the developed world [3–5]. One probable cause could be extended as well as unnecessary use of broad spectrum antibiotics in these countries [6,7]. Prescription of broad-spectrum antibiotics to attain the patient's satisfaction even if antibiotics are not indicated is also common in these places [8]. Inappropriate prescription of antibiotics leads to adverse drug reaction and emergence of drug resistant organisms, stretching the already limited health care resources in developing countries [9, 10]. This leads to human sufferings along with substantial added economic burden [11]. Some health care professionals only concentrate on treating the present symptoms without concern about future antibiotics resistance aggravating the problem [12, 13].

The growing threat of antibiotic resistance is linked to a wide range of factors and does not simply indicate that the body is becoming vulnerable to infections, rather micro-organisms are becoming resistant to the antibiotics used to eliminate them [14]. Antibiotic resistance takes place when microorganisms adapt and evolve as "superbugs" against antibiotics, making previous medications ineffective to kill them and continue to survive in the body becoming a danger of spread to other people [15]. Inadequate and extravagant utilization of antibiotics is one of the significant factors in the rise of antibiotic resistance [16]. The increasing emergence of antibiotic-resistant bacteria is becoming one of the major threats to public health in the 21st century and with this global rise there is need for appropriate and proper use of antibiotics [17]. Antibiotic resistance has been recognized as a major issue in health care and improper prescription of anti-microbial substances (antibiotics) by experts is a major concern in medical as well as dental specialties [18]. The awareness about the threat of antibiotic resistance among healthcare workers, particularly dentists who frequently prescribe antibiotics for treatment and prevention of various dental infections is not uniform. Antibiotics are commonly used in dental practice due to anticipation of contaminating dental procedures because of infections and a majority of dental prescriptions in UK happen to be for antibacterial drugs [19].

The literature provides evidence of inadequate practices by dentists, manifested by over-prescribing antibiotics due to inadequate knowledge or social factors [20]. Another survey done in UK reported that around 15% of dentists recommended antibiotic use on daily basis while 40% of the dentists prescribed antibiotics somewhere around three cases per week [21]. Another cross-sectional survey conducted in Saudi Arabia amongst dentists on prescription patterns of antibiotics showed extensive variety of recommending antibiotics among dentists [22]. Similarly, in Istanbul-Turkey a study showed conflicting antibiotic prescription with unnecessary anti-microbial utilization and inadequate drug usage in patients without following any professional guidelines [23]. A survey done in America on assessing antibiotic use for treating dental infections in children, showed only a quarter of dental professionals and pediatric dentists adhered to the professional American Academy of Pediatric Dentistry (AAPD) guidelines for endorsing antibiotics [24]. A propensity for overuse of antibiotics, without clinical indication, has thus been reported among members of the American Academy of Pediatric Dentistry [25].

Similar trends are also observed in developing countries, where a substantial proportion of dentists prescribe antibiotics for non-indicated clinical conditions [26]. Regionally an Indian survey on the use of antibiotics showed that there was over antibiotics endorsing in the absence of following any expert rules, which could be a precedent leading to the global issue of antibiotic resistance [27]. Most dental infections in children are bacterial in origin but only a limited number require antibiotics since most of these infections respond very well to operative procedures such as removing the source of infection and when antibiotics are needed, they are used as an adjunct to the operative therapy instead of been used as the only line of treatment [28]. It was observed in a study done in Saudi Arabia that while recommending antibiotics for odontogenic infections in children, there was an absence of constant adherence to the professional guidelines amongst the dentists [24]. Abuse in prescription of antibiotics, such as inappropriate dosing regimens and longer than needed periods of prescription might contribute to the emergence of antibiotic resistance among children. As a result oral cavities of very young children have also been reported to have multidrug resistant bacteria [29, 30]. Unfortunately, there is scarcity of resources on dental antibiotic prescribing guidelines in general and for children particularly.

In this study we hoped to measure the frequency of antibiotics prescription for treating dental infections in children among dentists in teaching institutions of Karachi, Pakistan. We also aimed to assess if the dental health professionals were following the recommended professional guidelines such as the AAPD guidelines, so as to develop more improved and unambiguous antibiotic prescription guidelines especially for children if needed.

Materials and methods

A cross-sectional study was carried out at five public and private tertiary care dental teaching institutions of Karachi from November 2018 to May 2019 namely Baqai Dental College, Altamash Institute of Dental Medicine, Bahria University and Dental College, Abbasi Shaheed Hospital and Dow International Medical College. Ethical clearance was obtained from the parent institution with reference number No. FHM30a-2019/MPH student/ Batch26. Using the percentage frequency of antibiotic prescription among dentists from a previous study i.e. 44.2%, with 95% confidence level and 5% precision, the minimum required sample size was calculated to be 380 participants using the formula ' $n = z^{2*}(p)(1-p)/c^2$ ' where $z = 1.96$ for 95% CI, $p = 0.442$ and $c = 0.05$. Dentists who were registered with the National Dental Council and gave informed consent were included in the study whereas those who refused to give written

informed consent were excluded from the study. After checking eligibility, the dentists were approached using convenient sampling technique for inclusion in the study.

Dentists were considered as having high volume of pediatric patients if they used to see more than 15 children per month or as having low volume of pediatric patients if they saw 15 or less children per month. The participants were asked to fill a pre-tested and validated questionnaire designed to record socio-demographic details and information related to their antibiotics prescribing pattern. The questionnaire was taken from an earlier study done by Cherry WR et al in 2012 [24]. The questionnaire consisted of two main sections; the first section consisted of demographic variables while the second section consisted of five different clinical case scenarios developed by the American Academy of Pediatric Dentistry (AAPD) to explore the rationality of antibiotics use [24]. These clinical case scenarios are as follows: Case 1—A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant. On clinical examination, you notice a deep carious lesion on tooth number 85 (mandibular right primary second molar); Case 2—A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant and a fever of 101 F. On clinical examination, you notice a deep carious lesion on tooth number 85 (mandibular right primary second molar); Case 3—A healthy (ASA I) 9-year-old child, who is a patient of record, visits your office during regular business hours with tooth pain in the lower right quadrant. The child has no fever. On clinical examination, you notice a deep carious lesion on tooth number 85 (mandibular right primary second molar) along with a draining fistula; Case 4—The parent of a healthy (ASA I) 9-year-old child, who is a patient of record, calls you on a Saturday afternoon because the child has a chief complaint of tooth pain in the lower right quadrant; and Case 5—The parent of a healthy (ASA I) 9-year-old child, who is a patient of record, calls you on a Saturday afternoon and reports that the child has pain on the lower right quadrant with some warmth of the skin and some swelling that she noticed that morning. The adherence of the participating dentists to AADP guidelines was assessed by means of interview and evaluating their responses regarding antibiotic prescription in each of the five different clinical case scenarios described for being in line with the AADP guidelines.

Data were entered and analyzed in statistical package for social science (SPSS) version 20 whereas graphs and tables were made by MS (Microsoft) Excel. Descriptive analysis such as frequencies and percentages were generated for categorical variables while means and standard deviation were calculated for continuous variable. Inferential analysis was performed using chi square test to explore associations of studied independent variables with the study outcome. The significance level was set at 0.05.

Results

A total of 380 participants were included in the study with a response rate of 100%. [Table 1](#) shows the demographic and practice characteristics of the participating dentists in the study. The mean age of the participants was 25.12 ± 3.4 years while 69.7% ($n = 265$) of them were females. Majority (71.3%) of them treated 15 or less children per month ($n = 271$) while 28.7% of them ($n = 109$) treated more than 15 children per month. Moreover, 63.9% ($n = 342$) of the dentists were seeing patients in outpatient department in public sector and 55.0% ($n = 209$) were working in hospital dentistry. The table also shows the general pattern of antibiotics prescription with 19.7% ($n = 75$) of the dentists prescribing antibiotics daily while 48.9% ($n = 185$) of them were prescribing it weekly. The most commonly prescribed antibiotic in this study was amoxicillin ($n = 349$, 91.8%).

Table 1. Demographic and practice characteristics of study sample (n = 380).

| Variables (n = 380) | Frequency(%) |
|---------------------------------------|--------------|
| Age (Years) | 25.12±3.4 |
| Age Group | |
| <25 Years | 230(60.5) |
| 25 Years or Above | 150(39.5) |
| Gender | |
| Male | 115(30.3) |
| Female | 265(69.7) |
| Educational qualification | |
| General dentists | 338(88.9) |
| Pediatric dentists | 42(11.1) |
| Child treated per month | |
| ≤15 | 271(71.3) |
| >15 | 109(28.7) |
| Public practice | |
| No | 137(36.1) |
| Yes | 243(63.9) |
| Academic practice | |
| No | 166(43.7) |
| Yes | 214(56.3) |
| Hospital dentistry | |
| No | 171(45.0) |
| Yes | 209(55.0) |
| Primary health centers | |
| No | 365(96.1) |
| Yes | 15(3.9) |
| How often prescribe antibiotic | |
| Daily | 75(19.7) |
| Weekly | 185(48.9) |
| Monthly | 88(23.2) |
| Hardly ever | 31(8.2) |
| Antibiotic type amoxicillin | |
| No | 31(8.2) |
| Yes | 349(91.8) |
| Antibiotic type penicillin | |
| No | 211(55.5) |
| Yes | 169(44.5) |
| Antibiotic type clindamycin | |
| No | 317(83.4) |
| Yes | 63(16.6) |
| Antibiotic type cephalixin | |
| No | 349(91.8) |
| Yes | 31(8.2) |

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Table 2 presents dentists response to the five clinical case scenarios as per AAPD professional guidelines. Case 1 represents the collective symptoms of facial swelling, pain and radiographic evidence of pathology. Overall, 26.8% of dentists in the study were in adherence with the professional guidelines. When fever was added to the list of symptoms as in Case 2, the

Table 2. Responses to clinical scenarios: Adherence to professional guidelines.

| Clinical Scenarios and Correct Responses | Overall Adherence to Guidelines (n = 380) | Dentists with low volume of pediatric patients (≤ 15 children treated per month) (n = 271) | Dentists with high volume of pediatric patients (> 15 children treated per month) (n = 109) | p |
|---|---|--|--|--------|
| | Frequency (%) | Frequency (%) | Frequency (%) | |
| Case 1 Prescribe antibiotics only for pain, facial swelling and radiographic evidence of pathology | 102(26.8) | 88(32.4) | 14(12.8) | <0.001 |
| Case 2 Prescribe antibiotics only for pain, facial swelling and radiographic evidence of pathology | 99(26.1) | 77(28.4) | 22(20.2) | 0.098 |
| Case 3 Prescribe antibiotics only for pain, facial swelling and radiographic evidence of pathology | 140(36.8) | 115(42.4) | 25(22.9) | <0.001 |
| Case 4 Would see patient before prescribing antibiotics and prescribe antibiotics only for pain and facial swelling | 168(44.2) | 148(54.6) | 20(18.3) | <0.001 |
| Case 5 Would see patient before prescribing antibiotics and prescribe antibiotics only for pain and facial swelling | 129(33.9) | 117(43.1) | 12(11.0) | <0.001 |

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overall adherence was similar at 26.1%. When local swelling was added and fever removed from symptoms as in Case 3, overall adherence to the professional guidelines increased to 36.8% in the study. Case 4 and Case 5 were considered as weekend cases with overall 44.2% of the dentists in case 4 adherent with the professional guidelines where you would see the patient before prescribing antibiotics and prescribe antibiotics only for pain and facial swelling. While in Case 5 adherence with the professional guidelines decreased to 33.9% for the dentists in the study when warmth of skin was included. Moreover, it was also seen that the difference between adherence of dentists with low and high volume of pediatric patients was significantly different for case scenarios 1, 3, 4 and 5 ($p < 0.001$ for all) where dentists who treated up to 15 children per month were more likely to be adherent to standard antibiotic prescription guidelines than those who treated more than 15 children per month.

Discussion

This study investigated the trends in antibiotic prescription pattern and the awareness of antibiotic prescribing guidelines among dentists in various dental colleges of Karachi, Pakistan and assessed their adherence to the AAPD professional guidelines for children.

We found that over seventy percent dentists treated up to 15 children per month and as such were considered as dentists with low volume of pediatric patients as compared to those who treated more than 15 children per month (28.7%) and termed as dentists with high volume of pediatric patients for the purpose of this study, but unfortunately it was seen that overall adherence to the AAPD guidelines was low with respect to prescribing antibiotics for treating dental infections in children. Our findings showed a lack of consistency between the manner in which dentists with low and high volume of pediatric patients treat dental infection in children which was similar to that seen in other studies [22, 24, 25].

This study shows overall adherence to professional guidelines ranging from 26.1% to 44.2% while William R. Cherry et al. in 2012 reported a similar low percentage of adherence to professional guidelines ranging from 10% to 42% [24]. K Al-Johani et al. also reported in 2017 that overall adherence to the professional guidelines ranged from 9.5% to 45% [22]. Similar findings were seen in other studies in the USA and this clearly demonstrates the increased

misuse of antibiotics by dentists that may contribute to global antimicrobial resistance (AMR) [22, 25].

Yee Chen Wong et al. in 2016 reported a lack of harmony among guidelines and the antibiotic prescribing practices of dentists, in each of the clinical case scenarios according to the AAPD guidelines ranging from 15.7% to 43.5% [40]. Looking at the AAPD guidelines case scenarios in our study, in the first case only 26.8% dentists choose to prescribe antibiotics only for pain and facial swelling with radiographic evidence of pathology, which is consistent with the AAPD guidelines results seen in a study done in USA [24]. For case 2, when fever was added to the scenario, the adherence rate was still around 26.1% in our study which was much higher than seen in other studies [22, 24]. For case 3, when fever was absent, but draining fistula was added to the scenario, the adherence rate was 36.8% in our study which was slightly higher than seen in other studies done in USA and Saudi Arabia [22,24]. Scenarios 1, 2 and 3 were in-office cases and scenario 4 and 5 were weekend cases in the AAPD five case scenarios questionnaire. For case 4 and 5, the adherence rate was 44.2% and 33.9% respectively in our study which is very high to that seen in other studies [22, 24].

We hypothesized that there would be a difference in antibiotic prescribing pattern between the dentists with low and high volume of pediatric patients with later being more adherent to AAPD guidelines [22, 24], but when we compared the AAPD guideline adherence in these two groups we saw that contrary to other studies overall adherence was low in dentists with high volume of pediatric patients as compared to dentists with low volume of pediatric patients in all case scenarios in our study, probably because the later are less influenced by social factors such as family pressures of the child for quick treatment response, leading to unnecessary antibiotic use in pediatric dentists. The results of this study showed poor adherence to professional guidelines and a lack of harmony between the antibiotic prescribing patterns of dentists.

Publications have suggested that inappropriate use of antibiotics has brought about antibiotic resistance which needs to be addressed [31]. The World Health Organization (WHO) has developed strategies and provided recommendations to curb irrational use of antibiotics [32, 33]. Various studies have given proof of inappropriate practices by dentists highlighting a number of reasons, varying from insufficient updated information to social factors etc [20–25].

Locally in Pakistan, the available research on prescription patterns of antibiotics is limited at best [34–38]. One such study demonstrated the need of creating guidelines by relevant health agencies on accessible literature to modulate adequate use of antibiotics and its dissemination [39]. Whilst it is important to understand factors influencing the practitioners' attitudes towards antibiotic prescribing, it is also necessary to provide clear guidelines based on sound clinical knowledge.

Although infectious diseases are more common in developing countries, such as Pakistan, due to poor hygienic condition of hospitals, the surgeons usually overprescribe broad spectrum antibiotics which may add to the burden of AMR [40]. A study done in Ethiopia where national antibiotic prescription guidelines were mostly not followed showed that lack of the knowledge of local resistance patterns is probably the reason for injudicious antibiotic prescription pattern seen in the developing world, [41].

Because of the absence of standard guidelines for prescribing prophylactic antibiotics in dental procedures, we used AADP guidelines to evaluate the rationality of antibiotic prescription. Programs are needed to update antibiotic prescription practices and this study highlighted the need to make such these guidelines accessible to the dentists in our country as well as across the world. Continuing dental education programs are a much needed resource for dental healthcare professionals and these will have an impact on the prescribing practices leading to reduced antibiotic resistance. Naveen N et al. in 2015 reported that out of the

proportion of participants who had attended continued dental education program on antibiotics in India, 36% were adherent to professional guidelines [42]. Another Indian study reported that over ninety percent of dentists admitted that over endorsing of antibiotic use will result in antimicrobial resistance and similar number routinely upgrade themselves by studying some current methodical information preceding to the utilization of antibiotics in dentistry [43].

In spite of absence of a national infection control policy, Pakistan has recently been more active on the front of tackling antimicrobial resistance [44, 45]. Comprehensive and more specific professional guidelines education is urgently needed in Pakistan that may eventually lead to improved adherence to antibiotics among health professionals including dentists. This study highlights the need to ensure that dentists are included at the time for formulating and bringing into action comprehensible guidelines to arrest further antibiotic abuse by both medical practitioners and dentists. There is an immediate need for the proper dissemination of information regarding prescribing guidelines as well as instructive strategies to encourage the proper and suitable utilization of medications in dentistry.

Conclusion

This study highlights the fact that there is an urgent need to generate professional awareness regarding the risks of injudicious use of antibiotics among dentists as majority of our participant dentists did not follow the AAPD guidelines for prescription of antibiotics. It is recommended that appropriate professional guidelines for antibiotic use and misuse should be specified to counter drug resistance along with regular continuing dental education programs to update and revise the pattern of antibiotic prescription.

Supporting information

S1 Appendix.
(DOCX)

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Author Contributions

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References

1. Esposito S.; Castellazzi L.; Tagliabue C.; Principi N. Allergy to antibiotics in children: An overestimated problem. *Int J Antimicrob Agents*. 2016, 48, 361–366. <https://doi.org/10.1016/j.ijantimicag.2016.08.000> PMID: 27554439
2. Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA, et al. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proc Natl Acad Sci U S A*. 2018 Apr 10; 115(15):E3463. <https://doi.org/10.1073/pnas.1717295115> PMID: 29581252
3. Malik AZ, Qasim A. Surgical Site Infections after Elective Surgery in Pakistan: SURGIPAK Study. *J Rawalpindi Med Coll*. 2015; 19(3):209–14.
4. Malik ZI, Nawaz T, Abdullah MT, Waqar SH, Zahid MA. Surgical site infections in general surgical wards at a tertiary care hospital. *Pak J Med Res*. 2013; 52(4).
5. Saleem Z, Hassali MA, Godman B, Hashmi FK, Saleem F. A multicenter point prevalence survey of health care-associated infections in Pakistan: findings and implications. *Am J Infect Control*. 2019; 47(4):421–4. <https://doi.org/10.1016/j.ajic.2018.09.025> PMID: 30471976
6. Fonseca SN, Kunzle SR, Junqueira MJ, Nascimento RT, de Andrade JI, Levin AS. Implementing 1-dose antibiotic prophylaxis for prevention of surgical site infection. *Arch Surg*. 2006; 141(11):1109–13. <https://doi.org/10.1001/archsurg.141.11.1109> PMID: 17116804
7. Van der Sandt N, Schellack N, Mabope L. Prescribing practices of antibiotic prophylaxis used for surgical procedures in paediatric patients at Dr. George Mukhari Academic Hospital (DGMH) and a Private Hospital. Sefako Makgatho Health Sciences University; 2016.
8. Butler CC, Rollnick S, Pill R, Maggs-Rapport F, Stott N. Understanding the culture of prescribing: qualitative study of general practitioners' and patients' perceptions of antibiotics for sore throats. *BMJ*. 1998; 317:637–42. <https://doi.org/10.1136/bmj.317.7159.637> PMID: 9727992
9. Cosgrove SE. The relationship between antimicrobial resistance and patient outcomes: mortality, length of hospital stay, and health care costs. *Clin Infect Dis*. 2006; 42(Suppl. 2):S82–9.
10. Marquet K, Liesenborg A, Bergs J, Vleugels A, Claes N. Incidence and outcome of inappropriate in-hospital empiric antibiotics for severe infection: a systematic review and meta-analysis. *Crit Care*. 2015; 19(1):63.
11. Prokuski L. Prophylactic antibiotics in orthopaedic surgery. *J Am Acad Orthop Surg*. 2008; 16(5):283–93. <https://doi.org/10.5435/00124635-200805000-00007> PMID: 18460689
12. Metlay JP, Stafford RS, Singer DE. National trends in the use of antibiotics by primary care physicians for adult patients with cough. *Arch Intern Med*. 1998; 158:1813–8. <https://doi.org/10.1001/archinte.158.16.1813> PMID: 9738612
13. McManus P, Hammond ML, Whicker SD, Primrose JG, Mant A, Fairall SR. Antibiotic use in the Australian community, 1990–1995. *Med J Aust*. 1997; 167:124–7. PMID: 9269265
14. Centers for Disease Control and Prevention. About Antimicrobial Resistance. <https://www.cdc.gov/drugresistance/about.html> [Accessed 8th February 2019].
15. Montero-Aguilar M. Antimicrobial Resistance: What Should Dentists be Doing? *Odovtos-Int J Dent Sci*. 2017 Jan 15; 18(1E):10–4.
16. Weber JT, Courvalin P. An emptying quiver: antimicrobial drugs and resistance. *Emerg Infect Dis*. 2005; 11: 791–3. <https://doi.org/10.3201/eid1106.050471> PMID: 15971372
17. Komolafe OO. Antibiotic resistance in bacteria—an emerging public health problem. *Malawi Med J*. 2003; 15:63–7. <https://doi.org/10.4314/mmj.v15i2.10780> PMID: 27528961
18. Garg AK, Agrawal N, Tewari RK, Kumar A, Chandra A. Antibiotic prescription pattern among Indian oral healthcare providers: a cross-sectional survey. *J Antimicrob Chemother*. 2013 Sep 29; 69(2):526–8. <https://doi.org/10.1093/jac/dkt351> PMID: 24080499
19. Hurley S, Westgarth D. When David met Sara Part 2. *Br Dent J*. 2015 Nov 27; 219(10):477. <https://doi.org/10.1038/sj.bdj.2015.880> PMID: 26611300

20. Dar-Odeh NS, Abu-Hammad OA, Al-Omiri MK, Khraisat AS, Shehabi AA. Antibiotic prescribing practices by dentists: a review. *Ther Clin Risk Manag*. 2010; 21:301–6.
21. Lewis MA. Why we must reduce dental prescription of antibiotics: European Union Antibiotic Awareness Day. *Br Dental J*. 2008; 205:537–8.
22. Al-Johani K, Reddy S G, Al Mushayt A S, El-Housseiny A. Pattern of prescription of antibiotics among dental practitioners in Jeddah, KSA: A cross-sectional survey. *Niger J Clin Pract*. 2017; 20:804–10. <https://doi.org/10.4103/1119-3077.196072> PMID: 28791973
23. Sermet S, Akgün MA, Atamer-Simsek S. Antibiotic prescribing profile in the management of oral diseases among dentists in Istanbul. *Clin Exp Neurol*. 2011; 1(1):35.
24. Cherry WR, Lee JY, Shugars DA, White RP Jr, Vann WF Jr. Antibiotic use for treating dental infections in children: A survey of dentists' prescribing practices. *J Am Dent Assoc*. 2012 Jan 1; 143(1):31–8. <https://doi.org/10.14219/jada.archive.2012.0015> PMID: 22207664
25. Sivaraman SS, Hassan M, Pearson JM. A national survey of pediatric dentists on antibiotic use in children. *Pediatr Dent*. 2013 Nov 15; 35(7):546–9. PMID: 24553280
26. Kouidhi B, Zmantar T, Hentati H, Najjari F, Mahdouni K, Bakhrouf A. Molecular investigation of macrolide and Tetracycline resistances in oral bacteria isolated from Tunisian children. *Arch Oral Biol*. 2011 Feb 1; 56(2):127–35. <https://doi.org/10.1016/j.archoralbio.2010.09.010> PMID: 20950793
27. Kaul R, Angrish P, Jain P, Saha S, Sengupta AV, Mukherjee S. A Survey on the Use of Antibiotics among the Dentists of Kolkata, West Bengal, India. *Int J Clin Pediatr Dent*. 2018; 11(2):122–127. <https://doi.org/10.5005/jp-journals-10005-1497> PMID: 29991865
28. Palmer NO. Pharmaceutical prescribing for children. Part 3. Antibiotic prescribing for children with odontogenic infections. *Prim Dent Care*. 2006 Jan; 13(1):31. <https://doi.org/10.1308/135576106775193941> PMID: 16393495
29. Ready D, Bedi R, Spratt DA, Mullany P, Wilson M. Prevalence, proportions, and identities of antibiotic-resistant bacteria in the oral microflora of healthy children. *Microb Drug Resist*. 2003 Dec 1; 9(4):367–72. <https://doi.org/10.1089/107662903322762806> PMID: 15000743
30. Abu-zineh R, Dar-Odeh N, Shehabi A. Macrolide resistance genes and virulence factors of common viridans Streptococci species colonizing oral cavities of patients in Jordan. *Oral Health Dent Manag*. 2015; 14:337–41.
31. Faizullah M, Rahman N, Umar MI, Anwar M, Sarfraz M. A cross-sectional study on knowledge, attitude and practices of medical doctors towards antibiotic prescribing patterns and resistance in Khyber Pakhtun Khawah, Pakistan. *J Appl Pharm Sci*. 2017 Dec; 7(12):38–46.
32. World Health Organization. Improving the Containment of Antimicrobial Resistance. http://www.searo.who.int/entity/medicines/topics/wha_58_27.pdf [Accessed June 18, 2018].
33. World Health Organization. World Health Day 2011. http://www.who.int/mediacentre/news/statements/2011/whd_20110407/en/ [Accessed June 18, 2018].
34. Saleem Z, Hassali MA, Versporten A, Godman B, Hashmi FK, Goossens H, et al. A multicenter point prevalence survey of antibiotic use in Punjab, Pakistan: findings and implications. *Expert Rev Anti Infect Ther*. 2019; 17(4):285–93. <https://doi.org/10.1080/14787210.2019.1581063> PMID: 30755077
35. Khan MS, Ahmed Z, Jehan S, Fasseh-uz-Zaman, Khan S, Zaman S, et al. Common trend of antibiotics usage in a tertiary care hospital of Peshawar, Pakistan. *J Ayub Med Coll Abbottabad*. 2010; 22(1):118–20. PMID: 21409921
36. Atif M, Azeem M, Saqib A, Scahill S. Investigation of antimicrobial use at a tertiary care hospital in Southern Punjab, Pakistan using WHO methodology. *Antimicrob Resist Infect Control*. 2017; 6(1):41.
37. Nausheen S, Hammad R, Khan A. Rational use of antibiotics—a quality improvement initiative in hospital setting. *J Pak Med Assoc*. 2013; 63(1):60. PMID: 23865133
38. Baig MT, Sial AA, Huma A, Ahmed M, Shahid U, Syed N. Irrational antibiotic prescribing practice among children in critical care of tertiary hospitals. *Pak J Pharm Sci*. 2017 Jul; 30(4 (Suppl.)):1483.
39. Saadat S, Mohiuddin S, Qureshi A. Antibiotic prescription practice of dental practitioners in a public sector institute of Karachi. *J Dow Univ Health Sci*. 2013; 7(2):54–58.
40. Riaz H, Malik F, Raza A, Hameed A, Ahmed SK, Shah PA, et al. Assessment of antibiotic prescribing behavior of consultants of different localities of Pakistan. *Afr J Pharm Pharmacol*. 2011; 5(5):596–601.
41. Tekleab AM, Asfaw YM, Weldetsadik AY, Amaru GM. Antibiotic prescribing practice in the management of cough or diarrhea among children attending hospitals in Addis Ababa: a cross-sectional study. *Pediatric Health Med Ther*. 2017; 8:93–98. <https://doi.org/10.2147/PHMT.S144796> PMID: 29388610
42. Naveen N, Guru Suhas P, Vanishree N, Patnaik S, Bharath C, Keerthi Prasad KS, et al. Current Trends in Prescription of Antibiotics among Dentists Working in Various Dental Colleges of Bangalore City, India- A Cross Sectional Study. *Int J Oral Health Med Res*. 2015; 2(2):8–14.

43. Vardhan T H, Lakhshmi N V, Haritha B. Exploring the pattern of antibiotic prescription by dentists: A questionnaire-based study. *J NTR Univ Health Sci.* 2017; 6: 149–53.
44. Saleem Z, Hassali MA, Hashmi FK. Pakistan's national action plan for antimicrobial resistance: translating ideas into reality. *Lancet Infect Dis.* 2018; 18(10):1066–7. [https://doi.org/10.1016/S1473-3099\(18\)30516-4](https://doi.org/10.1016/S1473-3099(18)30516-4) PMID: 30303099
45. Ministry of National Health Services. Antimicrobial Resistance: National Action Plan of Pakistan. <https://www.nih.org.pk/wp-content/uploads/2018/08/AMR-National-Action-Plan-Pakistan.pdf> [Accessed 20th October 2019].