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The Effect of a Pharmacist-Led Educational Intervention on Rational Antibiotic Prescribing in an Outpatient Emergency Department

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Abstract

Background: Educational interventions are effective methods for promoting knowledge and awareness among physicians to reduce irrational antibiotic prescriptions.

Objectives: This study was designed to evaluate the effect of an educational intervention conducted by pharmacists on rational antibiotic prescribing in an outpatient emergency department (ED).

Methods: This pre-post pilot intervention study was conducted in the outpatient ED of Shahid Bahonar Hospital, affiliated with Kerman University of Medical Sciences, Kerman, Iran, from February to June 2020. Non-random (convenience) sampling was used. All patients sent to the outpatient ED at triage who were prescribed antibiotics were included in this study. The pre-intervention phase was observational, during which a pharmacist assessed irrational antibiotic prescriptions over one month. Educational topics were determined based on the most common diagnoses related to irrational antibiotic prescriptions, in consultation with a clinical pharmacist and an infectious disease specialist. An educational video was then prepared and provided to the doctors prescribing antibiotics. Subsequently, the post-intervention phase was conducted in the same manner as the pre-intervention phase for one month.

Results: During the pre-intervention phase, out of 314 prescriptions, 100 (31.85%) contained antibiotics. In the post-intervention phase, among a total of 235 prescriptions, 100 (42.55%) contained antibiotics. The mean age of the patients was 36.65 ± 15.73 years in the first phase and 37.30 ± 15.71 years in the second phase. Analyses revealed that the educational intervention had a statistically significant effect on reducing irrational antibiotic prescribing with respect to indication (P = 0.0001), dose (P = 0.005), and duration (P = 0.0001).

Conclusions: The pharmacists' educational intervention effectively reduced irrational antibiotic prescribing in the outpatient ED.

Keywords: Anti-bacterial Agents, Education, Pharmacists, Prescriptions

1. Background

The rational use of antibiotics is an important issue worldwide, especially in low-income and middle-income countries. Irrational antibiotic use can lead to the emergence of antibiotic-resistant bacteria, increased patient morbidity and mortality, and a heightened economic burden. Notably, antibiotics are among the most commonly prescribed drugs globally (1, 2). The high rate of antibiotic prescriptions (68.2%) compared with the World Health Organization (WHO) ideal prevalence of antibiotic prescribing (20 - 26.8%) is a critical issue in both outpatient and inpatient settings in Iran (3). Significantly, the emergency department (ED) is a high-risk area for inappropriate antibiotic prescriptions due to its fast-paced, high-pressure, and unpredictable nature (4). In line with relevant guidelines, the irrational prescription of antibiotics is defined as inappropriate antibiotic prescribing concerning indication, drug selection, administration route, usage, dosage form, dosage, duration, interactions, incompatibility, and cost (5, 6). The primary reasons for irrational antibiotic prescriptions include patients' demand for antibiotics, physicians' attitudes, inadequate knowledge, prescribing behavior to satisfy patients, and suspicion of unproven infections (1, 7).

Educational interventions are effective methods for promoting knowledge and awareness among physicians to reduce irrational antibiotic prescriptions (8). Another strategy to enhance this knowledge and awareness is the involvement of clinical pharmacists and pharmacists in antibiotic stewardship teams, as previous studies have demonstrated their importance in this area (9-11). Clinical pharmacists play a vital role in evaluating antibiotic prescriptions for both outpatients and inpatients and in providing educational programs (10). Pharmacists are also often involved in antibiotic stewardship programs by developing and revising antibiotic guidelines, educating medical staff, and monitoring antibiotic use and expenditure (11).

2. Objectives

Considering the above, this study was designed to evaluate the effect of an educational intervention led by pharmacists on rational antibiotic prescribing in an outpatient ED.

3. Methods

3.1. Ethical Considerations

This study (99000168) was approved by the Ethical Committee of Kerman University of Medical Sciences under the number IR.KMU.REC.1399.384. In the present study, all patients provided written informed consent. Additionally, the confidentiality of all patients' and physicians' data was strictly maintained.

3.2. Study Type, Setting and Patients

This pre-post intervention study was conducted in the outpatient ED of Shahid Bahonar Hospital, affiliated with Kerman University of Medical Sciences, Kerman, Iran, from February to June 2020. Non-random (convenience) sampling was employed. All patients referred to the outpatient ED at triage and those prescribed antibiotics were included in this study.

3.3. Medical Doctors

In the outpatient ED, ten medical doctors (MDs) worked in rotating 8-hour shifts. Among them, 2 (20.00%) were female, and 8 (80.00%) were male. Their mean age was 41.60 ± 6.04 years. Before the study commenced, all the doctors were informed about the research and agreed to participate in conducting the study.

3.4. Study Design

This study was divided into two phases: Pre-intervention and post-intervention. In the first phase (pre-intervention), which was observational, a pharmacist was present in the doctor's office during the morning shift (8:00 AM to 4:00 PM) for one month. The pharmacist observed the process of prescribing antibiotics for patients and recorded key details, such as the duration of antibiotic use. All the doctors were asked to write their final diagnosis on the back of the patient's prescription. After the morning shift, the pharmacist visited the ED satellite pharmacy to record information from prescriptions containing antibiotics, including the patients' age, sex, diagnosis, and details of the prescribed antibiotics, such as their indication, dose, and duration, in a checklist.

The pharmacist then assessed the irrational prescribing of antibiotics based on reliable references, such as UpToDate® (UptoDate, Waltham, MA, USA, http://www.uptodate.com), and through consultation with an infectious disease specialist and a clinical pharmacist. The educational topics were determined based on the most common diagnoses associated with irrational antibiotic prescribing and were finalized in consultation with the clinical pharmacist and infectious disease specialist. The topics included antibiotic treatment for periodontitis, pharyngitis, urinary tract infection, sinusitis, animal bites, and wounds.

Subsequently, a 20-minute educational video with clear audio and visuals featuring the pharmacist was prepared as the educational tool and provided to the doctors. The content of the video was approved by the clinical pharmacist and the infectious disease specialist. The video covered key points regarding the appropriate indication, dose, and duration of antibiotics for the aforementioned infections, based on UpToDate®. The doctors were given one week to watch the video.

Two weeks after the educational intervention, the post-intervention (second) phase was conducted in the same manner as the first phase over one month. During this phase, the pharmacist again evaluated the patients' prescriptions for irrational antibiotic prescribing.

3.5. Statistical Analysis

The present study was conducted as a pilot study to assess the efficacy of the intervention, enhance the researchers' experience with the study method, and validate the feasibility of the study. Based on the results of this pilot study, a large-scale multicenter study will be planned. The irrational antibiotic prescription rate was assumed to be approximately 38% (4), and it was anticipated that this rate would decrease to 20% following the pharmacist-led educational intervention. Therefore, a sample size of 96 prescriptions containing antibiotics in each phase was required to detect the change between the two mentioned proportions with a 95% confidence level and 80% power.

All data were analyzed using SPSS 25 software. Descriptive statistics were applied to all variables. Independent samples *t*-test and chi-square test were used to compare quantitative and qualitative variables, respectively, between the pre- and post-intervention phases. A P-value < 0.05 was considered statistically significant.

4. Results

During the first phase of the present study, out of 314 prescriptions, 100 (31.85%) contained antibiotics. Similarly, in the second phase, among a total of 235 prescriptions, 100 (42.55%) contained antibiotics. It is noteworthy that 112 antibiotics were prescribed for the 100 patients in the first phase, while 110 antibiotics were prescribed for the 100 patients in the second phase. Some prescriptions included more than one antibiotic.

Among the 100 patients prescribed antibiotics during the first phase, 52 (52.00%) were male, and 48 (48.00%) were female. In the second phase, among the 100 patients, 47 (47.00%) were male, and 53 (53.00%) were female. The mean age of the patients was 36.65 ± 15.73 years in the first phase and 37.30 ± 15.71 years in the second phase. There was no significant difference in the patients' age (P = 0.758) and gender (P = 0.887) between the two phases of the study.

Antibiotics with inappropriate indications (21 in the first phase and 3 in the second phase) were excluded from the evaluation of proper dose and duration. The analyses demonstrated that the educational intervention had a statistically significant effect on reducing irrational antibiotic prescribing with respect to indication (P = 0.0001), dose (P = 0.005), and duration (P = 0.0001) (Table 1).

In Table 2, the prescribed antibiotics during the pre- and post-intervention phases are presented. The educational intervention did not have a statistically significant effect on the types of prescribed antibiotics (P = 0.143). The most frequently prescribed antibiotics were cephalexin (28.57%), azithromycin (15.18%), and ciprofloxacin (15.18%) in the pre-intervention phase, and amoxicillin/clavulanic acid (20.91%), cephalexin (20.91%), and azithromycin (17.27%) in the post-intervention phase.

The infectious diseases diagnosed by the doctors during the pre- and post-intervention phases are presented in Table 3. The most common infectious diseases in the first phase were wounds and urinary tract infections, while wounds and animal bites were the most common in the second phase.

Examples of irrational antibiotic prescribing are summarized in Table 4.

5. Discussion

The present study demonstrated that the pharmacists' educational intervention effectively reduced irrational antibiotic prescribing with respect to indication, dose, and duration in the outpatient ED. The strength and novelty of this study lie in the approach where the pharmacist first identified the specific diseases for which physicians lacked knowledge regarding rational antibiotic prescribing, and then designed the educational intervention based on these findings. In essence, a targeted educational intervention was implemented in this study.

It is worth noting that a targeted educational intervention addressing specific knowledge gaps is more effective than interventions based on generic information (12). As previously suggested in a study, assisting physicians in decision-making related to antibiotic prescribing can be an effective strategy to reduce irrational antibiotic use (2). Additionally, involving pharmacists in antibiotic decision-making can lead to more appropriate antibiotic choices and regimens (13). Moreover, educational interventions have been shown to enhance physicians' knowledge and behaviors concerning the appropriate use of antibiotics (14).

Table 1. The Effect of Education on the Rational Prescription of Antibiotics [a]

Variables	Pre- intervention	Post- intervention	P-Value [b]
Indication of antibiotics	N = 112	N = 110	0.0001
Appropriate	91 (81.25)	107 (97.27)	
Inappropriate	21 (18.75)	3 (2.73)	
Dose of antibiotics	N = 91	N = 107	0.005
Appropriate	68 (74.73)	96 (89.72)	
Inappropriate	23 (25.27)	11 (10.28)	
Duration of antibiotics treatment	N = 91	N = 107	0.0001
Appropriate	36 (39.56)	92 (85.98)	
Inappropriate	55 (60.44)	15 (14.02)	

[a] Values are expressed as No. (%).
[b] Based on chi-square test.

Table 2. The Prescribed Antibiotics in the Pre and Post-intervention Phases [a]

Prescribed antibiotics	Pre-intervention (n = 112)	Post-intervention (n = 110)	P-Value [b]
Amoxicillin	3 (2.68)	1 (0.91)	0.143
Amoxicillin/clavulanic acid	14 (12.50)	23 (20.91)	
Azithromycin	17 (15.18)	19 (17.27)	
Cephalexin	32 (28.57)	23 (20.91)	
Cefixime	12 (10.71)	12 (10.91)	
Ciprofloxacin	17 (15.18)	12 (10.91)	
Levofloxacin	1 (0.89)	3 (2.73)	
Metronidazole	13 (11.61)	7 (6.36)	
Penicillin	3 (2.68)	10 (9/09)	

[a] Values are expressed as No. (%).
[b] Based on chi-square test.

Several studies have demonstrated that decision-support strategies based on pharmacists' interventions can promote rational antibiotic prescribing. Pharmacists' interventions, such as attending ward rounds, training physicians, reviewing medical orders, and providing feedback to physicians, have been shown to positively influence physicians' prescribing behaviors and their knowledge of antibiotic use (15).

In a study conducted in an ED, a pharmacist's intervention, including participation in ward rounds, review of medical records, and communication with physicians, resulted in identifying 78 (43.33%) inappropriate antibiotic prescriptions out of 180 and correcting 51 (52.56%) of them within one month (4).

In another study conducted in Iran, it was demonstrated that a pharmacist's educational programs, particularly when delivered interactively over nine sessions, had a significant impact on improving the rational use of surgical antibiotic prophylaxis. The improvements were observed in terms of indication, timing of administration, dose, duration of prophylaxis, and cost-effectiveness (16).

Similarly, a study in Pakistan evaluated the impact of a pharmacist's educational intervention (10 - 15 days of training) on post-surgical antibiotic prophylaxis based on clinical practice guidelines for antimicrobial prophylaxis in surgery. The study found that the pharmacist's intervention significantly improved the rational prescribing of prophylactic antibiotics, particularly regarding dose, frequency, and duration in post-surgical procedures. Moreover, the intervention notably reduced antibiotic use and hospitalization costs (17).

Additionally, Fesus et al. reported that a pharmacist-led intervention increased rational antibiotic use in surgical antibacterial prophylaxis in Hungary,

Table 3. The Infectious Diseases Diagnosed by the Doctors in the Pre and Post-intervention Phases [a]

Infectious Diseases	Pre-intervention (n = 100)	Post-intervention (n = 100)	P-Value [b]
Acute otitis media	0	3 (3.00)	0.0001
Animal bites	11 (11.00)	23 (23.00)	
Cellulite	1 (1.00)	0	
Diabetic foot	(1.00)	0	
Gastrointestinal infection	2 (2.00)	3 (3.00)	
Mastitis	1 (1.00)	0	
Pelvic inflammatory disease	0	1 (1.00)	
Periodontitis	3 (3.00)	1 (1.00)	
Pharyngitis	8 (8.00)	17 (17.00)	
Respiratory tract infection	7 (7.00)	13 (13.00)	
Scorpion sting	1 (1.00)	0	
Sinusitis	9 (9.00)	5 (5.00)	
Urinary tract infection	24 (24.00)	8 (8.00)	
Vaginal infection	0	1 (1.00)	
Wounds	32 (32.00)	25 (25.00)	

[a] Values are expressed as No. (%).
[b] Based on chi-square test.

Table 4. Some Examples of Irrational Antibiotics Prescribing

Clinical Cases	Irrational Prescription Type	Appropriate Prescription
For a patient diagnosed with periodontitis, metronidazole 250 mg every 8 hours, 30 tablets, and amoxicillin 500 mg every 8 hours, 30 tablets, were prescribed.	Inappropriate dose	The correct dose of metronidazole for periodontitis is 500 mg three times a day.
For a patient, who suffered from wounds and lacerations, cephalexin 500 mg every 6 hours, 30 tablets, was prescribed.	Inappropriate duration of treatment	The correct treatment duration for wounds and lacerations is 3 to 5 days. Twenty tablets were enough for the recommended duration.
For a patient with pharyngitis, cefixime 400 mg every 12 hours, 10 tablets, was prescribed.	Inappropriate duration of treatment and dose	For pharyngitis, cefixime 400 mg once daily for ten days should be prescribed.
Metronidazole and cefixime were prescribed for treatment of uncomplicated urinary tract infection in a patient.	Inappropriate indication	Metronidazole should not be used for treatment of uncomplicated urinary tract infection.
Azithromycin was prescribed for a patient with sinusitis	Inappropriate indication	Azithromycin is not recommended for treatment of sinusitis because of high rates of *Streptococcus pneumonia* resistance.

emphasizing the critical role of clinical pharmacists in antibiotic stewardship teams (18). Furthermore, Radhakrishnan et al. found that video-based consultations provided by a clinical pharmacist increased public knowledge about appropriate antibiotic use. They concluded that video-based consultation is an effective educational tool for raising awareness about antibiotic use (19).

Thus, it is evident that a pharmacist's educational interventions can effectively enhance rational antibiotic prescribing.

It should be noted that the majority of antibiotic prescriptions in medicine occur in outpatient settings (14), where 30% to 50% of them may be irrational (20). Moreover, previous studies have demonstrated that educational interventions can significantly reduce inappropriate antibiotic prescribing in outpatient departments (14). Craddock et al. reported that an educational intervention involving guideline development resulted in a nearly 24% reduction in irrational outpatient antibiotic prescriptions for acute upper respiratory tract infections (21). Similarly, Yadav et al. found that educational interventions could reduce inappropriate antibiotic prescribing by 33% for acute respiratory infections in outpatient EDs (22).

The current study showed a relative decrease of 15% in inappropriate dose and indication of antibiotics and a 45% reduction in inappropriate antibiotic duration following the implementation of the pharmacist's educational intervention in the outpatient ED.

Furthermore, long-term monitoring of the effectiveness of educational interventions is recommended. It has been reported that educational interventions aimed at improving the rational use of antibiotics are often difficult to sustain; therefore, they should be continuous, flexible, and evolving. Additionally, the continuous availability of guidelines and standard antibiotics has been identified as essential for the sustainability of educational interventions (23).

The limitations of the present study include its implementation in a single medical center and one outpatient department over a short period of time, which may limit the generalizability of the findings to other centers or settings. As this was a small-scale study, it is suggested that similar, larger multicenter studies be conducted in both outpatient and inpatient settings to definitively establish the effectiveness of pharmacist-led educational interventions. Moreover, it is recommended that future studies assess the long-term impact of such educational interventions.

Seniority and specialty of antibiotic prescribers have also been associated with rational antibiotic prescribing in EDs (24). Additionally, a seasonal pattern in antibiotic use has been reported previously (25). As these factors could influence the results of similar studies, they should be considered in future research.

In conclusion, the pharmacists' educational intervention was shown to improve rational antibiotic prescribing in the outpatient ED.

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Footnotes

Authors' Contribution: All authors have substantial contributions to the design of the study, acquisition of data, analysis and interpretation of data, preparation and revision of the draft of article, and final approval of the manuscript.

Conflict of Interests Statement: The authors declare that there is no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: This study (99000168) was approved by the ethical committee of Kerman University of Medical Sciences bearing the number IR.KMU.REC.1399.384 .

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Informed Consent: In the present study, all patients provided written informed consent.

References

1. Kose A, Colak C. Knowledge and Awareness of Physicians About Rational Antibiotic Use and Antimicrobial Resistance Before and After Graduation: A Cross-Sectional Study Conducted in Malatya Province in Turkey. *Infect Drug Resist*. 2021;**14**:2557-68. [PubMed ID: 34262300]. [PubMed Central ID: PMC8275012]. https://doi.org/10.2147/IDR.S317665.
2. Limato R, Nelwan EJ, Mudia M, Alamanda M, Manurung ER, Mauleti IY, et al. Perceptions, views and practices regarding antibiotic prescribing and stewardship among hospital physicians in Jakarta, Indonesia: a questionnaire-based survey. *BMJ Open*. 2022;**12**(5). e054768. [PubMed ID: 35589350]. [PubMed Central ID: PMC9121411]. https://doi.org/10.1136/bmjopen-2021-054768.
3. Nabovati E, TaherZadeh Z, Eslami S, Abu-Hanna A, Abbasi R. Antibiotic prescribing in inpatient and outpatient settings in Iran: a systematic review and meta-analysis study. *Antimicrob Resist Infect Control*. 2021;**10**(1):15. [PubMed ID: 33446279]. [PubMed Central ID: PMC7809737]. https://doi.org/10.1186/s13756-021-00887-x.
4. Amiri Jabalbarez F, Dabaghzadeh F, Oghabian Z. Role of pharmacists in reducing antibiotic prescribing errors in an emergency department. *J Pharmacy Practice Res*. 2020;**50**(1):42-7. https://doi.org/10.1002/jppr.1586.
5. Taxifulati Y, Wushouer H, Fu M, Zhou Y, Du K, Zhang X, et al. Antibiotic use and irrational antibiotic prescriptions in 66 primary healthcare institutions in Beijing City, China, 2015-2018. *BMC Health Serv Res*. 2021;**21**(1):832. [PubMed ID: 34404405]. [PubMed Central ID: PMC8371863]. https://doi.org/10.1186/s12913-021-06856-9.
6. Yi S, Ramachandran A, Epps L, Mayah A, Burkholder TW, Jaung MS, et al. Emergency department antimicrobial use in a low-resource setting: results from a retrospective observational study at a referral hospital in Liberia. *BMJ Open*. 2022;**12**(4). e056709. [PubMed ID: 35437249]. [PubMed Central ID: PMC9016394]. https://doi.org/10.1136/bmjopen-2021-056709.
7. Sharif Z, Peiravian F, Salamzadeh J, Mohammadi NK, Jalalimanesh A. Irrational use of antibiotics in Iran from the perspective of complex adaptive systems: redefining the challenge. *BMC Public Health*. 2021;**21**(1):778. [PubMed ID: 33892681]. [PubMed Central ID: PMC8063475]. https://doi.org/10.1186/s12889-021-10619-w.
8. Guan X, Tian Y, Song J, Zhu D, Shi L. Effect of physicians' knowledge on antibiotics rational use in China's county hospitals. *Soc Sci Med*. 2019;**224**:149-55. [PubMed ID: 30784853]. https://doi.org/10.1016/j.socscimed.2019.01.049.

9. Mahmood RK, Gillani SW, Alzaabi MJ, Gulam SM. Evaluation of inappropriate antibiotic prescribing and management through pharmacist-led antimicrobial stewardship programmes: a meta-analysis of evidence. *Eur J Hosp Pharm*. 2022;**29**(1):2-7. [PubMed ID: 34848531]. [PubMed Central ID: PMC8717790]. https://doi.org/10.1136/ejhpharm-2021-002914.

10. Wang H, Wang H, Yu X, Zhou H, Li B, Chen G, et al. Impact of antimicrobial stewardship managed by clinical pharmacists on antibiotic use and drug resistance in a Chinese hospital, 2010-2016: a retrospective observational study. *BMJ Open*. 2019;**9**(8). e026072. [PubMed ID: 31377693]. [PubMed Central ID: PMC6687004]. https://doi.org/10.1136/bmjopen-2018-026072.

11. Abubakar U, Tangiisuran B. Nationwide survey of pharmacists' involvement in antimicrobial stewardship programs in Nigerian tertiary hospitals. *J Glob Antimicrob Resist*. 2020;**21**:148-53. [PubMed ID: 31628999]. https://doi.org/10.1016/j.jgar.2019.10.007.

12. Thong KS, Chang CT, Lee M, Lee JCY, Tan HS, Shafie AA. Impact of targeted educational intervention towards public knowledge and perception of antibiotic use and resistance in the state of Perak, Malaysia. *Antimicrob Resist Infect Control*. 2021;**10**(1):29. [PubMed ID: 33541440]. [PubMed Central ID: PMC7860508]. https://doi.org/10.1186/s13756-021-00892-0.

13. Wong LH, Tay E, Heng ST, Guo H, Kwa ALH, Ng TM, et al. Hospital Pharmacists and Antimicrobial Stewardship: A Qualitative Analysis. *Antibiotics (Basel)*. 2021;**10**(12). [PubMed ID: 34943655]. [PubMed Central ID: PMC8698014]. https://doi.org/10.3390/antibiotics10121441.

14. Zheng K, Xie Y, Dan L, Mao M, Chen J, Li R, et al. Effectiveness of Educational Interventions for Health Workers on Antibiotic Prescribing in Outpatient Settings in China: A Systematic Review and Meta-Analysis. *Antibiotics (Basel)*. 2022;**11**(6). [PubMed ID: 35740197]. [PubMed Central ID: PMC9220158]. https://doi.org/10.3390/antibiotics11060791.

15. Shen L, Wei X, Yin J, Haley DR, Sun Q, Lundborg CS. Interventions to optimize the use of antibiotics in China: A scoping review of evidence from humans, animals, and the environment from a One Health perspective. *One Health*. 2022;**14**:100388. [PubMed ID: 35686150]. [PubMed Central ID: PMC9171522]. https://doi.org/10.1016/j.onehlt.2022.100388.

16. Rangchian M, Shah-Ebrahimi T, Mehrpooya M. The Sustainability of the Impact of Pharmacists' Educational Programs on the Adherence to the Recommendations of Preoperative Antibiotic Prophylaxis Guidelines. *Curr Drug Saf*. 2023;**18**(1):39-50. [PubMed ID: 35382725]. https://doi.org/10.2174/1574886317999220405113744.

17. Butt SZ, Ahmad M, Saeed H, Saleem Z, Javaid Z. Post-surgical antibiotic prophylaxis: Impact of pharmacist's educational intervention on appropriate use of antibiotics. *J Infect Public Health*. 2019;**12**(6):854-60. [PubMed ID: 31196776]. https://doi.org/10.1016/j.jiph.2019.05.015.

18. Fesus A, Benko R, Matuz M, Kungler-Goracz O, Fesus MA, Bazso T, et al. The Effect of Pharmacist-Led Intervention on Surgical Antibacterial Prophylaxis (SAP) at an Orthopedic Unit. *Antibiotics (Basel)*. 2021;**10**(12). [PubMed ID: 34943721]. [PubMed Central ID: PMC8698705]. https://doi.org/10.3390/antibiotics10121509.

19. Radhakrishnan R, Maheswary D, Leela KV, Damodharan N. Impact of clinical pharmacist's educational intervention tools in enhancing public awareness and perception of antibiotic use: A randomized control trial. *Clin Epidemiol Global Health*. 2023;**19**. https://doi.org/10.1016/j.cegh.2022.101191.

20. Rowe TA, Linder JA. Novel approaches to decrease inappropriate ambulatory antibiotic use. *Expert Rev Anti Infect Ther*. 2019;**17**(7):511-21. [PubMed ID: 31232615]. https://doi.org/10.1080/14787210.2019.1635455.

21. Craddock K, Molino S, Stranges PM, Suda KJ, Bleasdale SC, Radosta J, et al. The impact of educational interventions on antibiotic prescribing for acute upper respiratory tract infections in the ambulatory care setting: A quasi-experimental study. *J Am College Clin Pharmacy*. 2020;**3**(3):609-14. https://doi.org/10.1002/jac5.1205.

22. Yadav K, Meeker D, Mistry RD, Doctor JN, Fleming-Dutra KE, Fleischman RJ, et al. A Multifaceted Intervention Improves Prescribing for Acute Respiratory Infection for Adults and Children in Emergency Department and Urgent Care Settings. *Acad Emerg Med*. 2019;**26**(7):719-31. [PubMed ID: 31215721]. [PubMed Central ID: PMC8146207]. https://doi.org/10.1111/acem.13690.

23. Murni IK, Duke T, Kinney S, Daley AJ, Laksanawati IS; Nurnaningsih, et al. Multifaceted interventions for healthcare-associated infections and rational use of antibiotics in a low-to-middle-income country: Can they be sustained? *PLoS One*. 2020;**15**(6). e0234233. [PubMed ID: 32544154]. [PubMed Central ID: PMC7297356]. https://doi.org/10.1371/journal.pone.0234233.

24. Hamill LM, Bonnett J, Baxter MF, Kreutz M, Denny KJ, Keijzers G. Antimicrobial Prescribing in the Emergency Department; Who Is Calling the Shots? *Antibiotics (Basel)*. 2021;**10**(7). [PubMed ID: 34356764]. [PubMed Central ID: PMC8300735]. https://doi.org/10.3390/antibiotics10070843.

25. Guisado-Gil AB, Mejias-Trueba M, Penalva G, Aguilar-Guisado M, Molina J, Gimeno A, et al. Antimicrobial Stewardship in the Emergency Department Observation Unit: Definition of a New Indicator and Evaluation of Antimicrobial Use and Clinical Outcomes. *Antibiotics (Basel)*. 2024;**13**(4). [PubMed ID: 38667032]. [PubMed Central ID: PMC11047618]. https://doi.org/10.3390/antibiotics13040356.