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*Original Article*

# Antibiotic prescribing errors generated by the use of an electronic prescribing system in the emergency department: A mixed-method study

[Errores de prescripción de antibióticos generados por el uso de un sistema de prescripción electrónica en el servicio de urgencias: un estudio de método mixto]

**Ahmad Z. Al Meslamani[1], Derar H. Abdel-Qader[2], Noura Ziad[3], Nadia Al Mazrouei[4], Asma A. El-Shara[5], Husam El Sharu[6], Eman Merghani Ali[7], Rand Haider Al Zahawi[8], Samah Bahy Mohammed Ebaed[9], Osama Mohamed Ibrahim[4,10]**

[1]College of Pharmacy, Al Ain University of Science and Technology, Abu Dhabi, United Arab Emirates.
[2]Faculty of Pharmacy and Medical Sciences, University of Petra, Amman, Jordan.
[3]Allied Medical Sciences, Zarqa University, Zarqa, Jordan.
[4]Department of Pharmacy Practice and Pharmacotherapeutics, College of Pharmacy, University of Sharjah, United Arab Emirates.
[5]Faculty of Pharmacy, Philadelphia University, Amman, Jordan.
[6]Indiana University Center for Health Innovation and Implementation Science, Indianapolis, Indiana, USA.
[7]College of Pharmacy, Jazan University, Jazan, Saudi Arabia.
[8]Dubai Pharmacy College for Girls, Dubai, United Arab Emirates.
[9]Clinical Pharmacology Department, Benha Faculty of Medicine, Benha University, Benha, Egypt.
[10]Department of Clinical Pharmacy, Faculty of Pharmacy, Cairo University, Egypt.
*E-mail: amaslamanie1095@gmail.com, ahmad.almeslamani@aau.ac.ae

**Abstract**

*Context*: Inappropriate prescribing of antibiotics can result in serious patient harm.

*Aims*: To investigate the incidence, nature, clinical severity, and causes of antibiotic prescribing errors (APEs) in the emergency department (ED) of a large hospital in Jordan.

*Methods*: A mixed-method approach was used to explore the incidence and types of APEs by direct observation of electronic prescriptions (EPS) of antibiotics over four weeks, and to identify causes of errors by semi-structured interviews with ED physicians. The clinical severity of APEs was rated by a committee of experts. SPSS V26 and NVivo 10 were used for the analysis of quantitative and qualitative data, respectively.

*Results*: The incidence of APEs caused by the use of EPS was 4.3%. Wrong quantity (32.62%), wrong dose (15.25%), and duplicate drugs (13.55%) were identified as the most common types of APEs. More than one-third of APEs identified were deemed clinically significant, seven were serious, and one was lethal. Minor and significant antibiotic APEs across physicians who attended workshops on EPS and those who did not were 75.00% *versus* 46.77% (p = 0.001) and 18.75% *versus* 52.41% (p = 0.013), respectively. Three major causes of errors were identified: 1) System-related (system crash, drop-down menu), 2) user-related (lack of computer skills), and 3) workplace-related (overcrowding, inadequate staffing).

*Conclusions*: APEs generated by the use of EPS were common in EDs in Jordan, clinically significant, and multifactorial. Further research is required to cover pharmacists' perspectives of this kind of errors.

*Keywords*: antibiotics; emergency departments; prescribing errors.

**Resumen**

*Contexto*: La prescripción inadecuada de antibióticos puede provocar daños graves al paciente.

*Objetivos*: Investigar la incidencia, naturaleza, gravedad clínica y causas de los errores en la prescripción de antibióticos (APE) en el departamento de emergencias (DE) de un gran hospital en Jordania.

*Métodos:* Se utilizó un enfoque de método mixto para explorar la incidencia y los tipos de APE mediante la observación directa de prescripciones electrónicas de antibióticos (EPS) durante cuatro semanas, y para identificar las causas de los errores mediante entrevistas semiestructuradas con los médicos del servicio de urgencias. Un comité de expertos calificó la gravedad clínica de los APE.

*Resultados*: La incidencia de APE causada por el uso de EPS fue del 4,3%. La cantidad incorrecta (32,62%), la dosis incorrecta (15,25%) y los fármacos duplicados (13,55%) se identificaron como los tipos más comunes de APE. Más de un tercio de los APE identificados se consideraron clínicamente significativos, siete fueron graves y uno fue letal. Los APE antibióticos menores y significativos entre los médicos que asistieron a talleres sobre EPS y los que no asistieron fueron 75,00% *versus* 46,77% (p = 0,001) y 18,75% *versus* 52,41% (p = 0,013), respectivamente. Se identificaron tres causas principales de errores: 1) relacionadas con el sistema (caída del sistema, menú desplegable), 2) relacionadas con el usuario (falta de conocimientos informáticos) y 3) relacionadas con el lugar de trabajo (hacinamiento, personal inadecuado).

*Conclusiones*: Los APE generados por el uso de EPS fueron comunes en los DE en Jordania, clínicamente significativos y multifactoriales. Se requiere más investigación para cubrir las perspectivas de los farmacéuticos sobre este tipo de errores.

*Palabras Clave*: antibióticos; departamentos de emergencia; prescribir errores.

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## INTRODUCTION

Antibiotics given to treat bacterial infections are heavily misused, and this practice is one of the major health issues globally (Cebotarenco and Bush, 2008; Al-Niemat and Aljbouri, 2014; Sartelli et al., 2017; Jordanian Ministry of Health, 2018; Alanazi et al., 2019). Emergency Department (ED) offers frontline health care services to vulnerable patients in different age groups (Alanazi et al., 2015). As cases admitted to the ED are progressive, it is necessary to interfere with indiscriminate empirical treatment despite the absence of a precise aetiology (Huai et al., 2019). Moreover, the appropriateness of prescribing is questioned as antibiotics are misused in viral infections cases (Alumran et al., 2012). In the United States, at least one antibiotic is prescribed to around 7% to 8% of cases admitted to the ED on a daily basis (Harrison and Ouyang, 2013). Phungoen et al. (2019) studied patients who were admitted to the ED having sepsis. It was found that almost a fifth (17%) of the ED admitted patients received inappropriate antibiotics and resulted in a longer stay in the hospital and an increased mortality rate. This malpractice was consistent with a study conducted in a tertiary hospital in Saudi Arabia (Alanazi et al., 2019). Unfortunately, such practices globally resulted in adverse drug events, multi-drug resistant bacterial strains, increased costs as well as higher numbers of morbidity and mortality (Jordanian Ministry of Health, 2018; Alanazi et al., 2015; 2019).

In Jordan, the literature on medication safety is rare (Abdel-Qader et al., 2020; 2021; Al Meslamani et al., 2021). A study found that antibiotics consumption had a market-share of 23% in Jordanian Dinars (Al-Niemat and Aljbouri, 2014).

Recently, an EPS was implemented in EDs in Jordan and all prescriptions have been processed electronically. Nevertheless, there were no studies in the Middle East focused on antibiotic prescribing errors (APEs) due to inappropriate use of EPS. Therefore, this pilot study aimed to investigate the frequency, types, and clinical severity of errors in APEs generated from using an EPS in the ED and explore the causes these errors.

## MATERIAL AND METHODS

### Study design

This was a mixed-method pilot study conducted over two months in the ED of an 1150-bed hospital in Jordan. Firstly, electronic prescribing of antibiotics in the ED was prospectively observed. Secondly, physicians who committed the APEs were interviewed using semi-structured interviews. The study setting was a 45-bed ED, which included 77 physicians and 8 pharmacists who provided healthcare services to more than half a million patients per year. Physicians in the ED were from different specialties, while pharmacists were pharmacy degree holders and had 3 to five years of experience in a hospital setting. Patients were included if they were prescribed at least one antibiotic during their visit to the ED. Prescriptions from other departments were excluded. The Ethics Approval for this study was given by the Institutional Review Board at the University of Petra and the Ethics Committee of the Ministry of Health in Jordan (MOH-REC-180092).

### Electronic prescribing system (EPS)

The EPS used in the ED was developed by a local health technology company and implemented by all public healthcare facilities in Jordan (Al Meslamani et al., 2021). Although clinical decision support systems (CDSS) were not included, this EPS provided physicians with information about each patient's past medical history, allergies, laboratory results, surgeries, and other clinical data. The process was simple; once the patient was diagnosed, his medication orders were entered into the system, which was directly connected with hospital pharmacists, who were able to review the prescription along with the patient's electronic record.

### Definitions

To address APEs in the ED, clinical pharmacist interventions, and pharmacist-physician interactions, the main investigator reviewed the literature and adopted the most common definitions of relevant topics, adjusted them to fulfill the study purposes, and updated them based on the guidance issued by healthcare organizations and based on published papers. These definitions include:

- ***Clinical Decision Support Systems (CDSS)*** were defined as "*Health information technology applications that relate individual patient health data to established knowledge bases and thereby assist in clinical decision making and health management*" (Yu, 2015).
- ***Pharmacist intervention*** was defined as "*any pharmacist-induced alteration in patient therapy or management*" (Dooley et al., 2004).
- ***Taxonomy of prescribing errors*** was adopted from Odukoya et al. (2014).

- ***Polymorbidity (Multimorbidity)*** was defined as "*co-occurrence of at least two chronic health conditions in one patient*" (Gomes et al., 2018).
- ***High-risk patient groups*** were considered as "Children, older people, pregnant women, immunocompromised individuals, and those suffering from underlying chronic condition (World Health Organization., 2010)".
- ***An electronic prescribing error*** was defined as "prescribing errors that wouldn't have occurred if the physician had prescribed manually (Kenawy and Kett, 2019)".

**The study procedures**

Following a deep look into the literature, the principal investigator developed two research tools. The first instrument was a standardised data reporting from, which included the following sections: First, the occurrence of an error, at which the researchers relied on valid operational definitions adopted and tailored for this study to decide if what he observed was an error or not. Second, the nature of the error was classified into: wrong drug, wrong drug dose, omission error, electronic selection error, wrong dosage form, wrong dose, and duplicates drug. Third, the outcome of the error, at which the researchers were asked to report if the error reached the patient or not. In this case, the researchers were asked to record if the regular hospital pharmacist intervened in the error or not. Fourth, past medical history, concurrent medications, allergies, laboratory results, and demographic data of patients with errors were all reported. Three trained clinical pharmacists used the data reporting form to directly observe electronic prescriptions in the ED and spent 346 hours over a month reviewing all medication orders prescribed electronically on a shift basis (12 hours for each shift) over four weeks. Researchers were instructed to report how an APE was identified and originated. At the end of each research day, the principal investigator reviewed and validated APEs based on adopted criteria, and then transcribed them into a final database. APEs with incomplete information were excluded.

To assess causes of APEs, short semi-structured interviews were conducted with physicians in the ED. The preliminary findings from the observation were used to optimize the framework of the interviews. At the beginning of each interview, the principal investigator greeted the physician, briefly explained the purposes of the study, and then asked the physician to sign a consent form to record the interview. The principal investigator led the interviews with a second researcher, who used the probe technique to extract and clarify information from the interviewees. Verbatim transcription for each interview's recording was conducted by three independent data abstractors, of which two of them transcribed the recordings, and one verified their work. Interviews were conducted in physicians' offices, and due to the crowding nature of the setting, it was decided to reduce the time of the interview from 30 minutes to 15 minutes.

To our knowledge, this was one of the first studies in Jordan to examine the electronic prescribing practice of antibiotics in the ED. Hence, a small-scale study was needed to ensure a proper flow for the data collection. The purpose of this pilot was to ensure the feasibility of the study and to which extent the study aims could be fulfilled. Accordingly, three days of observation were followed by one interview. The amendments to the study procedure were increasing the number of observers to three. Also, we decided to start the interviews with a brief about each case to help physicians recall their past experiences with APEs, their causes, and potential consequences.

**Data management and statistical analysis**

This study had two data sources. First, data from direct observation of electronic prescribing of antibiotics, which were quantitative in nature. Data resulted from the observation process were analysed through the SPSS V26 (IBM Corp., Armonk, NY). Second, data from physicians' interviews, which were qualitative, and thus NVivo 10 was used for their content analysis. To determine causes and consequences of APEs, codes were built, categorised into themes, and then appraised by an expert. Stages of data analysis were vetted by the research team through a series of meetings and discussions that focused on eliminating inconsistencies, duplications, and biased sources.

## RESULTS

**Incidence, nature, and severity of antibiotic E-prescribing errors (EPEs)**

Of the 1203 patients included in the study, 720 (59.85%) were females, 322 (26.76%) had polymorbidity, and 341 (25.34%) were at high risk of getting an infection (Table 1). There were no statistically significant differences between the characteristics of patients with and without APEs.

A total of 5845 medication orders were included, of which 1922 were antibiotics. The overall incidence of prescribing errors, including all types of medication, was 15.86%; however, the APEs were 4.3%. The most common types of APEs identified during the study were wrong quantity (32.62%), wrong dose (15.25%), and duplicate drugs (13.55%) (Table 2). The

most common types of antibiotics related to electronic prescribing errors were amoxicillin (21.61%), ceftriaxone (15.67%), and gentamicin (11.86%) (Fig. 1).

Of the 236 APEs detected, 86 (36.44%) were deemed significant, seven were serious, and one was lethal. Minor and significant APEs across physicians who attended workshops on EPS and those who did not were 75.0% *versus* 46.77% (p = 0.001) and 18.75% *versus* 52.41% (p = 0.013), respectively. Duplicates drug and wrong dosage form errors across physicians who attended workshops on EPS and those who did not were 65.62% *versus* 34.37% (p = 0.02) and 37.83% *versus* 62.16% (p = 0.04), respectively. Examples of clinical scenarios of APEs are summarized in Table 3.

**Causes of APEs**

Of the 75 doctors approached by the research team, 17 accepted to participate, 2 withdrew before the interviews, and 15 were interviewed. Interviewees were either emergency department specialists (n = 6) or general practitioners (n = 9).

Causes of APEs described by physicians included computer-related, user-related, and workplace-related causes. Regarding the first category, many physicians attributed APEs to technical issues in the EPS, such as system crash, the discrepancy in the drop-down menu, and non-updated database. They commented that these issues could affect their communication with the pharmacy team. Interviewee 9 stated that "*The system was crashed when I was selecting the antibiotic dose, I tried to refresh the page, it seems that the order was already sent to the pharmacy with the wrong dose, it happens sometimes, not often that the system or the computer are crashed*". They also emphasised that errors caused by technical issues were not disturbing because physicians knew when something went wrong with the system, so they directly contacted the pharmacy to correct any errors, if any. Interviewee 7 said that "*Although technical problems could lead to errors, but I am not worried, because usually I contact the pharmacy after each problem in the system*".

APEs are associated with poor computer skills as some physicians expressed that they did not know how to do some tasks on the computer. Interviewee 2 stated "*I was aware that I selected the drug for the wrong patient, because I was opening the other patient's profile. The issue is that I did not know how to edit it or modify it so I called the pharmacy twice, but I got no response, 16 minutes later, they called about the error. I think the workshop that I attended for the purpose of learning how to deal with the electronic prescribing system was not enough*". APEs also arose due to the misinterpretation of prescribers' intention by the pharmacy team. One physician perceived that due to crowding, he entered medication orders quickly to the system, with some missing information about the duration of therapy or the dose frequency, expecting the pharmacy team to fill it from previous prescriptions.

Several workplace-related errors emerged when assessing interviewees' thoughts of events leading up to APEs. Crowding, heavy workload, and inadequate staffing were commonly cited reasons for APEs. Physicians seemed frustrated with the large volume of cases they deal with every day.

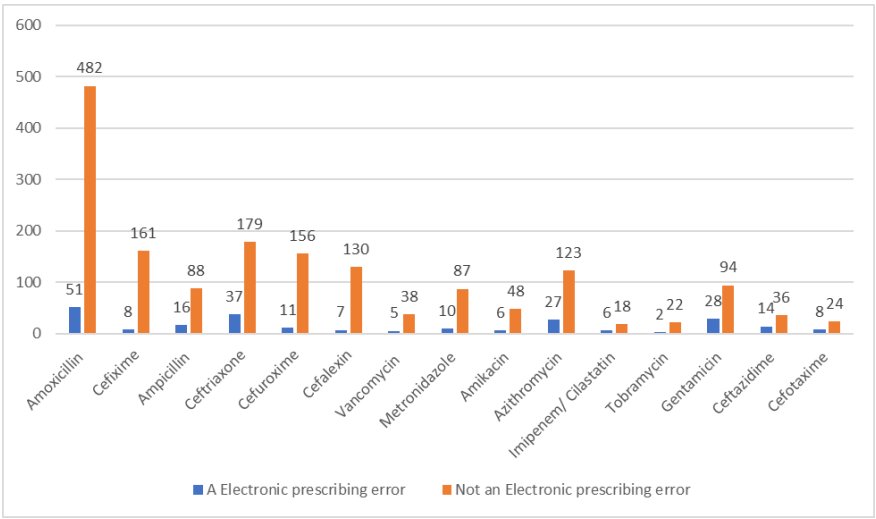


**Figure 1.** The proportion of antibiotic categories.

**Table 1.** Characteristics of patients enrolled in the study*β (n = 1203).

| Parameters | Total | Patients with at least one antibiotic E-prescribing error |
|---|---|---|
| Total No. of patients had at least one antibiotic in their electronic prescriptions, n | 1203 | 115 (9.55) |
| No. of patients with high-risk of infection | 341 (25.34) | 86 (74.78) |
| No. of patients discharged | 964 (80.13) | 103 (89.56) |
| No. of patients had bacterial culture | 69 (5.73) | 4 (3.47) |
| Age, (years), mean (SD) | 28.45 ± 16.69 | 30.12 ± 17.29 |
| Gender, female, | 720 (59.85) | 69 (60.00) |
| Marital status, married | 402 (33.41) | 36 (31.30) |
| Smoking status, yes | 468 (38.90) | 36 (31.30) |
| Polymorbidity, yes | 322 (26.76) | 29 (25.21) |
| **Comorbidities** | | |
| Diabetes | 201 (16.70) | 8 (6.95) |
| Hypertension | 186 (15.46) | 16 (13.91) |
| Hyperlipidemia | 179 (14.87) | 9 (7.82) |
| Heart failure | 69 (5.73) | 7 (6.08) |
| COPD | 87 (7.23) | 19 (16.52) |
| Atrial fibrillation | 36 (2.99) | 1 (0.86) |
| Renal disease | 22 (1.82) | 1 (0.86) |
| Liver disease | 17 (1.41) | 0 (0.00) |
| Coronary artery disease | 9 (0.74) | 1 (0.86) |
| Cancer | 2 (0.16) | 0 (0.00) |

*Parameters described as proportions [ n (%)] unless stated otherwise. SD: standard deviation, COPD: Chronic obstructive pulmonary disease, β: All differences were not statistically significant (p>0.05).

## DISCUSSION

While it is documented in the literature that implementation of electronic prescribing systems (EPS) in hospital settings reduces medication errors (Nuckols et al., 2014; Hitti et al., 2017), the evidence demonstrated that inappropriate use of EPS can introduce new types of prescribing errors (Klepser et al., 2016). Irrational prescribing and use of antibiotics, which are very common in EDs in developing countries, are serious threats to patient safety (Haddadin et al., 2019). Therefore, this mixed-method pilot study was the first in the region to comprehensively assess electronic antibiotic prescribing errors (APEs) in the ED. Besides reporting the incidence, types and potential clinical severity of APEs in emergency practice in Jordan, this study discovered the causes of errors by directly interviewing those responsible for them. Thus, it underscored the weaknesses of digital health services in Jordan and helped decision makers design and implement the proper corrective actions.

Nonetheless, it is important to mention that this research was not without limitations. Regarding the study's setting and sample, the research was conducted in one hospital. Though it was the largest in the country, we could not claim that our findings can be generalized to all hospitals in the region. In addition, pharmacists' perspectives of APEs were beyond the scope of the study. As a result, a piece of the puzzle was missing, and the information gathered might not reflect the whole picture. Regarding the study design, although data in the first stage of the study were collected by direct observation not self-reporting, the "*Hawthorne effect*" could influence the validity of our findings, because subjects could alter their prescribing behaviour if they knew they were watched, since it was extremely difficult to hide completely the purpose of the study from prescribers. Additionally, not all physicians who committed APEs were interviewed, since some of them refused to participate and others withdrew before the interview. Finally, we are concerned that the findings of the interviews with

**Table 2.** Incidence, nature, and clinical severity of EPEs.

| Parameters | Total | Prescribed by physicians attended workshops on EPS | Prescribed by physicians who did not attend workshops on EPS |
|---|---|---|---|
| Total number of medication orders, n | 5485 | 2962 (54.00) | 2523 (46.00) |
| No. of antibiotics prescribed | 1922 (35.04) | 1063 (55.30) | 859 (44.69) |
| ¥Total number of EPEs, n | 870 | 264 (30.34) | 606 (69.65) |
| Non-Antibiotic EPEs | 634 (72.87) | 152 (23.97) | 482 (76.02) |
| No. of antibiotic EPEs | 236 (27.12) | 112 (47.45) | 124 (52.54) |
| ¥Overall EPEs incidence (total EPEs/total No. of medication orders×100, %) | (870/5485×100, 15.86) | (264/2962×100, 8.91) | (606/2523×100, 24.01) |
| Antibiotic EPEs incidence (No. of antibiotic EPEs/total No. medication orders ×100, %) | (236/5485 ×100, 4.30) | (112/2962×100, 3.78) | (124/2523×100, 4.91) |
| **Types of antibiotic EPEs** | | | |
| Wrong quantity | 77 (32.62) | 33 (42.85) | 44 (57.14) |
| Wrong dose | 36 (15.25) | 17 (47.22) | 19 (52.78) |
| ¥Duplicate drugs | 32 (13.55) | 21 (65.62) | 11 (34.37) |
| ¥Wrong dosage form | 37 (11.44) | 14 (37.83) | 23 (62.16) |
| Omission error | 30 (12.71) | 16 (53.33) | 14 (46.66) |
| Wrong patient | 18 (7.62) | 9 (50.00) | 9 (50.00) |
| Wrong direction | 6 (2.54) | 2 (33.33) | 4 (66.66) |
| **Clinical severity of antibiotic EPEs** | | | |
| ¥Minor | 142 (60.16) | 84 (75.00) | 58 (46.77) |
| ¥Significant | 86 (36.44) | 21 (18.75) | 65 (52.41) |
| Serious | 7 (2.96) | 1 (0.89) | 6 (4.83) |
| Lethal | 1 (0.42) | 0 (0.00) | 1 (0.80) |

*Parameters described as proportions (n, %) unless stated otherwise. EPEs: e-prescribing errors, SD: standard deviation. ¥: differences are significant (p≤0.05).

**Table 3.** Clinical scenarios of antibiotic e-prescribing errors.

| Clinical Scenarios | Type of the error | Severity of the error | Cause of the error | Outcome of the error |
|---|---|---|---|---|
| A 4-year child diagnosed with bronchitis; the prescription contains amoxicillin as a tablet dosage form. | Wrong dosage form | Minor | Wrong selection from the dropdown menu | It was resolved based on the pharmacist intervention |
| An older female patient (69 years old) was diagnosed with pneumonia. The e-prescription contains cefuroxime 500 mg once daily, and diclofenac sodium 100 mg twice daily, without a stomach protection drug | Wrong dose and omission error | Significant | Wrong selection from the dropdown menu due to crowding | No stomach protection was added, the dose of the antibiotic was not modified the pharmacist did not intervene upon the error |
| A 36-year adult patient experienced severe headache; the prescription contains ampicillin 500 mg | Wrong patient | Serious | Computer crashing | The pharmacist contacted the physician and resolved the error |
| A prescription contains metronidazole syrup for an adult patient suffering from non-infectious gastroenteritis | Wrong dosage from | Minor | Wrong selection from the dropdown menu due to crowding | It was resolved based on the pharmacist intervention |
| Cefalexin and chlorpheniramine have been written for an adult patient suffering from chronic headaches | Wrong drug | Significant | Wrong selection from the dropdown menu due to crowding | The error reached the patient |
| A 27-year female patient with penicillin allergy, diagnosed with acute bronchitis. The prescription contains amoxicillin 1 g twice daily | Wrong drug | Lethal | Wrong selection from the dropdown menu due to crowding | It was resolved based on the pharmacist intervention |
| A prescription contains metronidazole 500 mg tablet for a 5-year patient | Wrong dosage from | Significant | Wrong selection from the dropdown menu due to crowding | It was resolved based on the pharmacist intervention |

physicians might be affected by attributional bias. Physicians might have blamed external factors, such as software and the crowd, rather than themselves for errors. Nevertheless, most interviewees were often keen to admit their mistakes during the interviews. Despite these limitations, the methods applied and operational definitions adopted were feasible to fulfil the purposes of this study since we were able to describe APEs in the ED of a large hospital in Jordan, and also were able to identify potential causes for these errors.

The findings of this study demonstrated that mistakes in antibiotic prescribing due to computer-related errors were occurring at a high rate in the ED in Jordan. Most of these errors were either duplicate drugs or omission of quantities or strengths. Additionally, more than one-third of the errors identified were deemed clinically significant. These findings indicated a serious issue that should be addressed comprehensively to prevent patient harm, because compelling evidence has emerged about the risks of misuse of antibiotics and how it stimulates antibiotic resistance (Ventola, 2015). Mistakes in antibiotic quantities or strengths could have serious outcomes as there is a risk that these erroneously selected strengths or quantities could be reached patients and harm them if they were less or more than the intended quantities or strengths. Although it was quite difficult to make a full comparison between our work and previous ones, because each author followed different methodologies and used different definitions, all studies agreed that EPS could contribute to errors different from those that occurred when physicians use handwritten prescriptions (Villamañán et al., 2013; Brown et al., 2017). More specifically and in line with our findings (Villamañán et al., 2013), found that EPS could contribute up to 77% of medication errors. According to our findings, there was one error related to penicillin allergy, though it was intercepted by pharmacists, it could easily have been administered by the patient and potentially triggered a life-threatening medical situation. The available EPS contained a warning tool that can be triggered when the prescriber entered a medication order, of which the patient was allergic to, but in this case, we believe that patient information regarding penicillin allergy was missing or wrongly registered.

In order to identify the causes of EPEs and potential circumstances that led to the appearance of these errors, qualitative-based interviews with physicians in the ED were conducted. Physicians identified three major causes of errors.

The first one was the system itself, particularly the drop-down menu, antibiotic database, and frequent crashing events. This explained the high rate of duplicate drugs as physicians clicked many times to select a drug while the system was not responding. Surprisingly and unlike several authors who found auto-filling of drugs' names one of the major causes of errors (Goldman et al., 2010; Westbrook et al., 2013), this tool was not mentioned by physicians in our study as one of the causes. Another cause that was not mentioned by our physicians was how easily the screen could move between different patients (Adelman et al., 2013). In crowding situations, this may explain the number of wrong patient errors associated with the system.

The second major cause identified by physicians was the user-related cause of errors, which included lack of computer skills among physicians and pharmacists' misinterpretation of prescriptions. The plausible explanation was that several physicians did not attend workshops or regular training on the system. Training and education about the functionality of the system is crucial to improve physicians' IT skills. Although the same system was operated in the outpatient pharmacy, some prescriptions were delivered to the pharmacy with incomplete information due to the busyness of the physician, and that may mislead the pharmacy team. Our findings indicated that workplace issues, such as overcrowding, heavy workload, and inadequate staffing could contribute to errors associated with electronic prescribing. It was reported that overcrowding in the ED was associated with an increased rate of prescribing errors (Kulstad et al., 2010). We believe that physicians who were distracted and tired under the stress of the workload were vulnerable to make errors. In addition, we believe that the absence of CDSS was a potential cause of errors, but surprisingly it was not brought up by physicians.

To sum up, the implementation of an EPS in EDs in Jordan is a step forward and a potential opportunity to improve healthcare services in the country. However, prescribing errors generated by the use of EPS were common in the ED and could significantly harm patients. Therefore, the workflow in the ED needed continual evaluation, and thus we recommend the following: First, system developers should consider implementation of CDSS, which would help physicians in their clinical assessment and thus reduce potential errors. In addition, the functionality of the system should be upgraded to suit the heavy workload of physicians. Second, educational interventions and training on EPS are important for physicans to avoid errors caused by poor computer skills. Third, we urge decision makers to increase medical staff and reduce crowding in EDs.

### Study limitations

The study was carried out in one hospital, and this limited the generalisability of the study findings. Additionally, the chance for subjective bias was inevitable. Also, some missing data were reported. However, this study can be considered as the groundwork for future research.

## CONCLUSION

Antibiotic prescribing errors associated with the use of an EPS were common and clinically significant in the EDs in Jordan. Three major categories were identified as causes of errors: system-related, user-related, and workplace-related causes of errors. Further research should be conducted to cover pharmacists' perspectives of these errors.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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**AUTHOR CONTRIBUTION:**

| Contribution | Al Meslamani AZ | Abdel-Qader DH | Ziad N | Al Mazrouei N | El-Shara AA | El Sharu H | Merghani Ali EM | Al Zahawi RH | Ebaed SBM | Ibrahim OM |
|---|---|---|---|---|---|---|---|---|---|---|
| Concepts or ideas | x | x | | x | | x | | x | x | x |
| Design | x | x | | x | x | x | | x | x | x |
| Definition of intellectual content | x | x | | x | x | | x | x | x | |
| Literature search | x | x | x | x | x | | x | | x | |
| Experimental studies | x | x | x | x | | x | | | | |
| Data acquisition | x | x | x | x | | | | x | | |
| Data analysis | x | x | | x | x | x | x | x | x | x |
| Statistical analysis | x | x | | x | x | x | x | x | x | x |
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