Original Article

Factors Associated Prescribing Errors in Ophthalmic Medication and Effect of Prescription Error Notification System: An Observational Study

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Objective: To study the characteristics of ophthalmic prescribing error (OPE), associated factors and the effect of direct personal notification using the Prescription Error Notification System (PENS).

Materials and Methods: A retrospective review was done in the outpatient Ophthalmology department of King Chulalongkorn Memorial Hospital (KCMH) of the written prescriptions of the ophthalmic drugs given between June 2012 and May 2017. The incidence and types of OPE were analyzed and stratified by types of practitioners. After April 2015, PENS was applied to reduce OPE. Odds ratios (ORs) of associated factors that affected OPE and adjusted ORs (AORs) for PENS were calculated.

Results: The five-year incidence of OPE was 0.27% (1781/662382). The three most common types of OPE were unspecified dosage form (25.1%), incorrect abbreviation (15.1%), and incorrect instruction (12.6%). The associated factors of OPE were prescription by residents (AOR 1.753; p<0.001), especially for the first-year residents (AOR 1.884; p<0.001). The preventive factors of OPE included prescription by faculty members (AOR 0.378; p<0.001) and prescription in second half of the year (AOR 0.651; p=0.001). PENS reduced OPE, especially in fellow and staff group.

Conclusion: Ophthalmic trainees trend to have more OPEs than faculty members. Active personal notification using PENS reduces OPE. However, its effectiveness does not sustain more than a year. Continuous surveillance of OPEs and repeated PENS is only effective in the first year. Other strategies are needed to reduce OPE.

Keywords: Ophthalmic prescription error, Outpatient, Ophthalmology, Notification system, Training center, Health quality

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Prescribing error (PE) is one of the preventable processes of medical error that can occur at several stages including prescribing, transcription, dispensing, and administration[1]. PE cause a financial impact on both individuals and government health services[1]. PEs are caused by many factors and stages of prescription. A previous study showed that the stage of writing the prescription was one of the most common PE[2]. Lacking of experience, absence of reference materials, and absence of self-awareness of error were demonstrated to be associated with PE[3].

Patient safety is an important goal for the health care system. Irrational drug use includes inappropriateness of the drug, dose, frequency, and route of administration, real or potential drug-drug interactions (DDIs), allergies, therapeutic duplications, and variation from organization criteria for use[4]. PE is one of the Joint Commission International (JCI) standard for patient safety and in risk management of Hospital Accreditation (HA) that was implemented in King Chulalongkorn Memorial Hospital (KCMH).

The prescription error notification system (PENS) was implemented as a feedback system to facilitate learning and formulate the best solution to reduce PE[5]. In the outpatient section of the Department of

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Table 1. Definition of types of prescribing error

Type of prescribing error	Description
Drug in the same group	Prescribing the another drug in the same class which is considered unnecessary and can cause a potential harm
Ambiguous prescription	Writing an ambiguous medication order
Incorrect abbreviation	Writing a drug's name using abbreviations or other non-standard nomenclature
Unspecified number	Prescribing a drug without specified number of drug
Unspecified dosage form	Prescribing a drug without specified form of drug
Unspecified strength	Prescribing a drug without specified drug strength
Wrong number	Prescribing a drug with incorrect quantity of drug
Incomplete number	Prescribing a drug that do not enough quantity for next visit
Incorrect instruction	Prescribing a drug with missing, wrong and incomplete instruction
Dosage form error	Prescribing a wrong dosage form of drug e.g. Eye drop or gel
Frequency error	Prescribing a wrong frequency of drug
Dose error	Prescribing a wrong total dose of drug
Strength error	Prescribing a wrong strength of drug
Drug allergy	Prescribing a drug that patient have allergy
Incorrect drug	Prescribing a wrong drug

Ophthalmology, KCMH, ophthalmic prescribing error (OPE) report system has been implemented in 2012. Therefore, the aim of the present study was to identify types of OPE, the risk factors that can help formulate the PE solution and to report the effect of PENS.

Materials and Methods

The present research was a retrospective observational study on OPE conducted in the outpatient department of Ophthalmology in KCMH, a tertiary care university hospital in Bangkok, Thailand. As a training center in ophthalmology, 3 year-residency programs and 1- or 2-year-fellowship programs are conducted. The educational year is between June and May of the following year. All written prescriptions by Ophthalmology residents, fellows, and faculty members were checked by pharmacists during drug dispensing. Details of prescription errors were recorded in electronic medical record (EMR) and reported to the prescribers for revising of the prescriptions. The record was sent to Head of Ophthalmology Department every month.

Data collection

All prescription errors between June 2012 and May 2017 were analyzed. The types of OPE were determined by reviewing the error description text based on a predetermined list as defined in Table 1. Missing and incomplete reports as well as prescription of non-ophthalmic medication were excluded.

Prescription error notification system

Since March 2015, the Department of Ophthalmology, KCMH has applied the PENS to report prescription errors directly to related physicians every month to increase awareness in drug prescription and decrease OPEs. Three components of PENS were implemented as the following:

1. Overall OPEs were reviewed by the Department of Ophthalmology committee to check the current outpatient prescription situation and find out methods to decrease the incidence of OPEs.

2. Each error was reported to the related physician individually with the details of OPE and example of the correct prescription via personal or e-mail discussion.

3. Interactive feedback was personally discussed.

Ethical considerations

The present study was exempted by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand (COA No.019/2017). The reports did not contain any identification information of the patient or the health personnel.

Data analysis

Overall incidence of OPE and types of OPE

Table 2. Number of prescribing errors for ophthalmic drug reviewed from educational year of 2012-2016 (June 2012 to May 2017)

Educational year	OPEs			Incidence of OPEs (%)	Total prescription
	Number of OPEs	Incomplete data of provider types	Total OPEs		
2012	322	16	338	0.27	123,337
2013	406	5	411	0.32	125,309
2014	310	4	314	0.23	132,061
2015	250	4	254	0.18	138,073
2016	449	15	464	0.32	143,602
Total	1,737	44	1781	0.27	662,382

OPEs=ophthalmic prescribing errors

were calculated and analyzed according to types of prescribers and educational years. To assess the factors associated with OPE, odds ratios (OR) concerning educational half year (first and second 6-month period), provider types, implementation of PENS were calculated. To assess the effect of duration on feedback system, incidence and OR of OPEs at the time close to the initial implementation of PENS (one year before and after) was calculated. A test of proportions (chi-square test) was used to compare the incidence of PEs and frequency of error types. Odds ratios were calculated. Adjusted ORs (AORs) for PENS was performed for other factors. Statistical analysis was performed using SPSS statistical package version 22.0 (SPSS Inc, Chicago, IL). The p-values less than 0.05 were considered statistically significant.

Results

Two thousand three hundred seventeen OPEs from 769,434 prescriptions were reported between June 2012 and May 2017 (educational year 2012 to 2016). One hundred seven thousand fifty-two prescriptions (13.9%) and 526 PEs (22.7%) were excluded due to non-ophthalmic drug prescription. Overall incidence of OPE was 0.27%. Of the 1,781 OPEs, 44 OPEs were excluded due to missing data as shown in Table 2.

Types of prescribing error

One thousand seven hundred eighty-one OPEs were reviewed and classified by 15 error types as shown in Figure 1. Among the OPEs, the three most common types of error were unspecified dosage form (25.1%), incorrect abbreviation (15.1%), and incorrect instruction (12.6%), respectively. The most common type of incorrect instruction was incorrect administration eye side (92.9%).

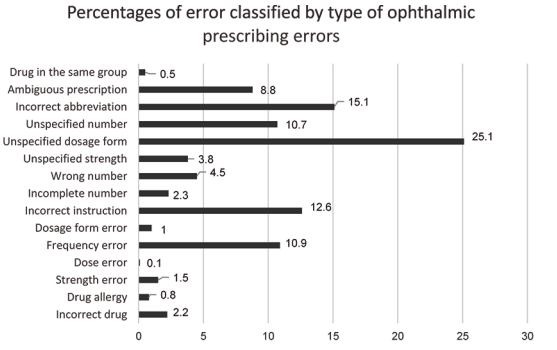

Figure 1. The percentages of error classified by type of OPEs.

OPEs, ophthalmic prescribing errors

The PE was classified by type of providers including residents (n=630), fellows (n=426) and staff (n=681) as shown in Table 3. In the resident group, the three most common OPE were unspecified dosage form (22.1%), incorrect abbreviation (15.1%), and frequency error (12.9%). From sub-group analysis by resident year, unspecified dosage form was the most common OPE for the first- and the second-year resident (29.3% and 21.2%, respectively). For the third-year resident, both instruction error and unspecified number of drugs were the most common OPE (16.5%, both). In the fellow group, the three most common OPE were unspecified dosage form (40.4%), incorrect abbreviation (14.3%), and instruction error (8.9%). In the staff group, the three most common OPE were unspecified dosage form (19.5%), incorrect abbreviation (16.2%), and instruction error (15.6%).

Effect of PENS on the incidence of OPE

After applying PENS at the end of educational year 2014 (April 2015), OPEs decreased in the

Table 3. Classification of errors by type of providers (total=1737, missing data was excluded)

Taxonomy of errors	Resident, n (%)				Fellow	Staff	p-value#
	Year 1	Year 2	Year 3	Total	n (%)	n (%)	
Drug in the same group	0 (0.0)	2 (1.0)	0 (0.0)	2 (0.3)	2 (0.5)	5 (0.7)	0.569
Ambiguous prescription	14 (5.9)	26 (12.8)	22 (11.7)	62 (9.8)	23 (5.4)	70 (10.3)	0.013
Incorrect abbreviation	49 (20.5)	18 (8.9)	28 (14.9)	95 (15.1)	61 (14.3)	110 (16.2)	0.697
Unspecified number	24 (10.0)	19 (9.4)	31 (16.5)†	74 (11.7)	30 (7.0)	80 (11.7)	0.023
Unspecified dosage form	70 (29.3)†	43 (21.2)†	26 (13.8)	139 (22.1)†	172 (40.4)†	133 (19.5)†	<0.001*
Unspecified strength	11 (4.6)	13 (6.4)	8 (4.3)	32 (5.1)	19 (4.5)	14 (2.1)	0.010
Wrong number	14 (5.9)	12 (5.9)	10 (5.3)	36 (5.7)	18 (4.2)	26 (3.8)	0.239
Incomplete number	1 (0.4)	4 (2.0)	4 (2.1)	9 (1.4)	5 (1.2)	25 (3.7)	0.005
Incorrect instruction	18 (7.5)	18 (8.9)	31 (16.5)†	67 (10.6)	38 (8.9)	106 (15.6)	0.002
Dosage form error	0 (0.0)	3 (1.5)	3 (1.6)	6 (1.0)	3 (0.7)	8 (1.2)	0.739
Frequency error	33 (13.8)	32 (15.8)	16 (8.5)	81 (12.9)	33 (7.7)	72 (10.6)	0.031
Dose error	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	1 (0.1)	0.518
Strength error	1 (0.4)	6 (3.0)	4 (2.1)	11 (1.7)	9 (2.1)	5 (0.7)	0.125
Drug allergy	1 (0.4)	3 (1.5)	2 (1.1)	6 (1.0)	2 (0.5)	6 (0.9)	0.664
Incorrect drug	3 (1.3)	4 (2.0)	3 (1.6)	10 (1.6)	10 (2.3)	20 (2.9)	0.265
Total OPEs	239	203	188	630	426	681	
Total prescription	50,345	60,065	52,724	163,134	80,913	418,335	
Incidence of OPEs (%)	0.47	0.34	0.36	0.39	0.53	0.16	

OPEs=ophthalmic prescribing errors

p-value by chi-square or Fisher's exact test, * Statistical significance, † Most common error in each type of providers

following year, 2015. However, the number of OPEs increased to the same level as earlier in 2016. The analysis of the 1-year effect of PENS was done by comparing the OPE incidence with one year before (April 2014 to March 2015) and one year after (April 2015 to March 2016) applying the system shown in Table 4.

Within one year of PENS, the type of OPEs that decreased in incidence (compared to all type of OPE) included unspecified dosage form (26.9% versus 14.7%, p<0.001), unspecified number (12.8% versus 7.7%, p=0.044), strength error (1.7% versus 0.8%, p=0.316), unspecified strength (4.2% versus 1.9%, p=0.121), dosage form error (0.6% versus 0.4%, p=0.762), and prescribing drug in the same group (0.3% versus 0.0%, p=0.298).

Risk and protective factors for the incidence of OPE

The ORs of half educational year and PENS by each type of provider are shown in Table 4. To assess the effect of duration after implementation of PENS, OR for PENS around one year (April 2014 to March 2015 versus April 2015 to March 2016) duration were 0.680 (95% CI 0.580 to 0.798, p<0.001). OR for overall resident was 1.735 (95% CI 1.573 to 1.913; p<0.001). Meanwhile OR for staff was 0.378 (0.343 to 0.417; p<0.001).

Discussion

There was an overall of 0.27% (1781/662382) of OPEs that occurred over five years and varied around 0.18% to 0.32% per year. Of total OPEs, 2.5% (44/1781) were incomplete for the type of provider, which may be due to incomplete data of prescriber code during writing the prescription. Previous studies in Ophthalmology Department reported the incidence of PEs at 4.7% to 32.9%[6,7]. This large difference between studies might be because of differences in definition of drug errors, differences of clinical setting, and an under-reporting problem[8]. As the prescribing records were encoded from written prescription in KCMH, incomplete or missing data of PEs might explain the lower-than-actual rate of OPE.

The unspecified dosage form (25.1%), incorrect abbreviation (15.1%), and incorrect instruction (12.6%, of which, more than 90% was caused by

Table 4. Odds ratio (OR) and adjusted OR of specific factors for OPEs

Factors	OR (95% CI); p-value	Adjusted OR (95% CI); p-value
Half educational year by types of provider (adjusted for PENS)		
1-year Resident	0.647 (0.501 to 0.834); 0.001	0.651 (0.503 to 0.841); 0.001
2-year Resident	0.877 (0.665 to 1.157); 0.354	0.875 (0.663 to 1.154); 0.343
3-year Resident	1.092 (0.820 to 1.455); 0.546	1.083 (0.812 to 1.444); 0.588
Fellow	0.726 (0.598 to 0.882); 0.001	0.730 (0.601 to 0.886); 0.001
Staff	0.921 (0.805 to 1.054); 0.231	0.927 (0.810 to 1.062); 0.276
Prescription error notifying system (PENS)		
1 year duration around implementation of PENS (April 2014 to March 2015 vs. April 2015 to March 2016)		
• 1-year Resident	0.983 (0.641 to 1.507); 0.936	
• 2-year Resident	0.933 (0.608 to 1.432); 0.751	
• 3-year Resident	0.812 (0.502 to 1.316); 0.398	
• Fellow	0.455 (0.313 to 0.663); <0.001	
• Staff	0.644 (0.501 to 0.829); 0.001	
• Total	0.680 (0.580 to 0.798); p<0.001	
Provider types (adjusted for PENS)		
• Overall Resident	1.742 (1.579 to 1.921); <0.001	1.735 (1.573 to 1.913); <0.001
• Staff	0.376 (0.342 to 0.414); <0.001	0.378 (0.343 to 0.417); <0.001

OPEs=ophthalmic prescribing errors; CI=confidence interval

incorrect eye side) accounted for the three most common types of OPE. This can be the result of wide forms and administration routes of differing ophthalmic medications such as eye drop, ointment, gel, tablet, capsule, and injection including local injection into the eye or systemic route. Moreover, due to bilaterality of the eye, confusing between right and left side may potentially occur especially in the busy clinic. Although abbreviation is time saving, the non-standard abbreviation can cause misunderstanding and harm, which approximately 5% of the medication are associated with the use of unsafe abbreviations[9].

The OR of OPEs by provider types was higher in resident (AOR 1.735), especially in first year residents (AOR 1.884). Prescription from staff was considered as a protective factor from PE (AOR 0.378). These might be from less experience in ophthalmic drug of junior resident and would lead to produce PE. Previous study showed the association between PE and prescribers' working experience[10]. Compared to the first half of educational year (June to November), the order prescribed during the second half of the year (December to May) was considered to be a protective factor (AOR 0.884). However, this was significant only in the first-year resident group (AOR 0.651) and fellow group (AOR 0.730). This may reflect a lack of knowledge of ophthalmic drug causing higher rate of PEs in the early training of the new residents and unfamiliarity of prescription system of the new fellow. However, after getting more knowledge and experience, incidence of OPEs were reduced in the last six months of training year course. Teaching and giving the information of ophthalmic drugs before the start of the work might improve their PE[11].

The Ophthalmology Department authors developed PENS to increase awareness of writing prescription. Although overall OPE rate decreased, not all types of OPE were reduced. Only types of OPE associated with dosage, drug strength, and dispensing drug number responded well by the measure. The OPE rate of incorrect abbreviation and incorrect instruction, which was the majority of OPE, did not decrease. Many doctors in the Ophthalmology Department of KCMH still continue using the non-universal abbreviation probably due to familiarity and unawareness of potentially harm. Other measures might have to be applied to increase awareness such as pharmacist-led educational interventions, which could result in the reduction of improper abbreviation[12].

The PE incidence transiently reduced in educational year 2015 after PENS, but the rate increased again in 2016. This result may be explained

by the Hawthorne effect, which is a type of reactivity in which individuals modify an aspect of their behavior in response to their awareness of being observed[13]. This might be inferred that the awareness of prescription was decreased with the time after implementation of PENS. The incidence of OPEs at one-year duration was decreased in all provider types. However, the decreasing of OPE at one-year duration was significant only in the fellow and staff groups.

As for prevention, besides active notification feedbacks, many methods have been shown to decrease the OPE rates. The EMR has a potential to reduce incidence of medication errors and improve communication between pharmacists and prescribers. Obviously, EMR can prevent pharmacists' misinterpretation caused by poor handwriting. EMR have the largest impact on reducing medication errors, with reported error reductions of 55% to 83%[14]. EMR has been demonstrated to decrease dose, frequency, and incorrect drug error, compared to paper-based prescription[15]. Abbreviation error was reduced by the application of EMR in a previous study[16]. Another solution was Preprinted prescription based on the hospital formulary[7]. Despite effective methods for reducing OPE, incidence of PEs can increase long after initial implementation of those methods. A previous report also showed the gradual increase in the incidence of OPE in many years after initial success of reducing PEs after applying EMR[17]. The event was similar to what happened in the present study. Therefore, repeated surveillance of PEs and assessment of adherence to planned strategies are crucial.

As a retrospective study at a single center, the conclusions may be limited and cannot be generalized. First, the number of OPEs of the present study may not be the actual rate due to the potential of data loss as pharmacologists at outpatient department had high workload per day. Further PE notification system will improve data completeness and accuracy to provide all related data by giving an encouragement and emphasis on the importance of PE reporting system. Second, other factors that may affect the occurrence of OPE such as the amount of workload, working environment, and working under supervision were not assessed. Further study may be needed to consider these factors so that the risk factors can be identified and OPE may be prevented.

Conclusion

Prescription errors are preventable. Identification of PE can reduce adverse event to the patient. The number of studies about PE was limited in Thailand. PE notification system generates more information about OPEs, which the current study reflects the real situation of only one teaching hospital in Thailand. Although active notification feedback showed the decrement of the OPE incidence, adherence to planned strategies is essential to keep the rate of OPEs in the low level. Repeated surveillance of OPEs and audits of prescription should be performed periodically to update the current situation and detect any unidentified error.

What is already known on this topic?

Prescription errors are common especially in outpatient unit. Many tools are used to reduce the errors.

What this study adds?

Ophthalmic PEs were specific and have more details. Most are preventable. Prescription Error Notification System was one effective tools for reducing the errors, but it is not sustainable. Another dynamic tools should be found and implemented.

Conflicts of interest

The authors declare no conflict of interest.

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