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# Physicians' and pharmacists' perceptions on real-time drug utilization review system: a nationwide survey

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## Abstract

**Objective:** To identify healthcare providers' experience and satisfaction for the drug utilization review (DUR) system, their impact on prescription changes following alerts, and difficulties experienced in the system by surveying primary healthcare centers and pharmacies.
**Design:** A cross-sectional nationwide survey.
**Setting and participants:** Approximately 2000 institutions were selected for the survey by a simple random sampling of nationwide primary healthcare centers and community pharmacy approximately practices, and 358 replied.
**Main outcomes measures:** The questionnaire included questions on experience and recognition of DUR alerts, personal attitude and respondents' biographical information. Space was included for respondents to suggest improvements of the DUR system.
**Results:** The DUR system scored 71.5 out of 100 points for satisfaction by physicians and pharmacists, who reported that the alerts prevent medication-related errors; most respondents (96.6%) received the alerts. Several respondents (10.9%) replied that they prescribe or dispense prescriptions as they are without following the alerts. Physicians (adjusted odds ratio, 8.334; 95% confidence interval, 3.449–20.139) are more likely to change the prescription than pharmacists and persons with alert experience (4.605; 1.080–19.638). However, current practice in metropolitan areas (0.478; 0.228–1.000) and frequent alerts regarding co-administration incompatibilities within prescriptions (0.135; 0.031–0.589) negatively influence adherence to DUR alerts.
**Conclusions:** Although most surveyed physicians and pharmacists receive the alerts, some do not or reported that they would not follow the alerts. To increase adherence, the DUR system should be improved to ensure a preferential and intensive approach to detecting potentially high-risk drug combinations.

**Key words:** drug utilization review, pharmacist, physician, medication-related errors

## Introduction

The drug utilization review (DUR) system is a valuable tool for improving patient safety and quality of care by diminishing medication-related errors and adverse events [1, 2]. In Korea, the DUR system, which was implemented in April 2008, monitors drug prescriptions from healthcare institutions for co-administration incompatibilities and is concerned with drug–drug interactions (DDIs), drug-pregnancy warnings and drug-age conflicts [3, 4]. Furthermore, pilot programs for a real-time DUR system were instituted at Goyang-si and Jeju-do in May and November 2009 to prevent potential adverse events from medication-related errors or inappropriate drug use [5]. From December 2010, real-time DUR

projects were implemented nationwide to detect co-administration incompatibilities between prescriptions issued by departments in the same and other healthcare institutions and examine ingredient overlap. This process involves sending prescriptions from hospitals and primary healthcare centers, or preparations from community pharmacies to the internet web server of the Health Insurance Review and Assessment (HIRA) Service for real-time checks. Additionally, HIRA sends drug names and dates to the electronic monitoring systems of corresponding healthcare institutions for co-administered incompatible drugs or overlapping components. Although the DUR system was used by 98.6% of all healthcare institutions as of March 2011 [3], problems exist, such as institutions skipping real-time checks and dispensing prescriptions/preparations while ignoring DUR alerts [6]. Similar challenges are encountered with DUR systems in other countries including the United States, where alerts are easily ignored by pressing a key, which increases alert overriding [7, 8]. Numerous prospective DUR messages, including low-importance alerts, increase 'alert fatigue,' which can cause pharmacists and physicians to ignore and miss clinically significant alerts [9–14].

Therefore, this study aimed to identify healthcare providers' experience and satisfaction for the DUR system, their impact on prescription changes following DUR alerts, and difficulties experienced during DUR processes related to practical settings by surveying primary healthcare centers and pharmacies.

## Methods

### Questionnaire development

We used a cross-sectional design with a questionnaire based on a systematic review of DUR policy-related literature and survey items the questionnaire was pre-tested and reviewed by three physicians and two pharmacists with extensive prescribing and drug preparation experience. It included questions on experience with and recognition of DUR alerts, attitudes, satisfaction with the DUR system and respondent's biographical information; space was included for respondent suggestions for improving the DUR system. Satisfaction was scored on a 100-point scale using a visual analog scale, and other recognition-related questions were asked based on a 4-point Likert scale. The final survey form contained 21 structured items and could be completed in 20 minutes.

### Study subjects

Primary healthcare centers and community pharmacies are important parties in the DUR system in South Korea and are involved in outpatients prescriptions medications in primary healthcare settings; therefore, they were included in this survey. Simple random sampling was conducted to simultaneously select 2000 healthcare institutions of the total (114 092) nationwide institutions as of October 2014, including primary healthcare centers and community pharmacies. Only names of selected institutions and addresses were used for mailing questionnaires. The selected institutions included 1149 primary healthcare centers and 851 community pharmacies corresponding to 57.5% and 42.5% of the total, respectively. We requested that one healthcare professional, by institution, respond to the questionnaire. Of the responders from 1149 primary healthcare centers, primary care physicians constituted the highest proportion (27.9%), followed by internists (14.5%), otolaryngologists (9.1%) and pediatricians (7.0%), which reflected the distribution seen in the parent population.

### Data collection

DUR recognition was surveyed from October- through December 2014 using a mail survey method. Self-addressed envelopes were sent with the questionnaires to encourage respondents to return completed questionnaires anonymously. The questionnaire was mailed twice in October and November 2014 to increase response, and collection ended in mid-December. This study was reviewed and approved by the Institutional Review Board of HIRA.

### Statistical analysis

The results were summarized using descriptive statistics to calculate the means ± standard deviations for continuous variables, and frequencies and proportions for categorical variables. Physicians and pharmacists were compared using *t*-tests and chi-square tests. Factors affecting changes in prescriptions following a DUR alert were analyzed with multivariable models constructed using logistic regression analysis; variables were selected with $P < 0.2$ by the forward selection method. All statistical analyses were performed using statistical analysis software (SAS, version 9.4), and a $P < 0.05$ was considered significant.

## Results

The respondent and healthcare institution survey responses were reviewed based on their characteristics to determine DUR recognition. Of the 2000 institutions that were mailed questionnaires, 358 replied, corresponding to an 18% response rate. There were more male respondents (73.5%), with a mean age and duration of service of 50.2 and 17 years, respectively; metropolitan area (including Seoul, Gyeonggy-do and Incheon) constituted 45.3% of the service area. Furthermore, 90.4% of respondents from primary healthcare centers were specialists, and the highest rate (50.7%) was noted for residents in private university hospitals (Table 1). The distribution of respondents was similar to the whole population in terms of practice area and specialty class.

Of the 358 respondents, 356 (99.4%) used DUR systems while two did not. Furthermore, 96.4% of respondents received DUR pop-up alerts from the system, which was higher than that received by those who had no experience with alerts (3.1%); no significant differences were observed between physicians and pharmacists. Mean satisfaction with the DUR system was found to be 71.5 out of 100 points, showing satisfaction overall; no significant differences in satisfaction were observed between physicians and pharmacists (Table 2).

When questioned whether DUR alerts reduce damage associated with inappropriate medications or drug misuse, 96.6% of respondents replied 'yes' (absolutely or somewhat), showing that most respondents opined that DUR alerts are helpful for preventing medication-related errors; no significant differences were observed between physicians and pharmacists. Furthermore, 39.1% of respondents (140) thought that the frequency of DUR alerts is high, with alerts regarding ingredient overlap representing the highest number of alerts received by respondents (27.4% of the total respondents), followed by co-administration incompatibilities between prescriptions (16.8%), duplication within the same efficacy group (14.5%), drug-pregnancy warnings (7.3%), drug-age conflicts (4.2%) and co-administration incompatibilities within prescriptions (3.1%). More pharmacists experienced ingredient overlapping and duplications within the same efficacy group than physicians ($P < 0.001$). When questioned whether physicians and pharmacists received alerts on co-administrations resulting in severe or light

**Table 1** Respondents' general characteristics

| Variables | Physician ($n = 209$) | | Pharmacist ($n = 149$) | | Total ($N = 358$) | | $P$-value[a] |
|---|---|---|---|---|---|---|---|
| | $n$ | (%) | $n$ | (%) | $N$ | (%) | |
| Sex | | | | | | | |
| Male | 184 | (88.0) | 77 | (51.7) | 261 | (72.9) | <0.001 |
| Female | 25 | (12.0) | 72 | (48.3) | 97 | (27.1) | |
| Age | | | | | | | |
| Mean ± SD (years) | 51.6 | ±7.6 | 48 | ±11.6 | 50.1 | ±9.6 | 0.001 |
| <40 | 11 | (5.3) | 38 | (25.5) | 49 | (13.7) | <0.001 |
| 40–59 | 168 | (80.4) | 88 | (59.1) | 256 | (71.5) | |
| ≥60 | 30 | (14.4) | 23 | (15.4) | 53 | (14.8) | |
| Practice period | | | | | | | |
| Mean ± SD (years) | 16.2 | ±7.8 | 17.3 | ±11.2 | 16.6 | ±9.4 | 0.279 |
| <10 | 37 | (17.7) | 41 | (27.5) | 78 | (21.8) | 0.006 |
| 10–19 | 98 | (46.9) | 46 | (30.9) | 144 | (40.2) | |
| ≥20 | 74 | (35.4) | 62 | (41.6) | 136 | (38.0) | |
| Practice area | | | | | | | |
| Metropolitan area | 91 | (43.5) | 71 | (47.7) | 162 | (45.3) | 0.441 |
| Other areas | 118 | (56.5) | 78 | (52.3) | 196 | (54.7) | |
| Specialty certification | | | | | | | |
| Specialist | 189 | (90.4) | | | | | |
| General practitioner | 20 | (9.6) | | | | | |
| Class of training institute | | | | | | | |
| Public University Hospital | 37 | (17.7) | | | | | |
| Private University Hospital | 106 | (50.7) | | | | | |
| Public Non-university Hospital | 18 | (8.6) | | | | | |
| Private Non-university Hospital | 39 | (18.7) | | | | | |
| None | 9 | (4.3) | | | | | |
| Class of specialty | | | | | | | |
| Surgical | 68 | (32.5) | | | | | |
| Internal | 121 | (57.9) | | | | | |
| General practice | 20 | (9.6) | | | | | |

[a]*P*-values were calculated using *t*-test or chi-square test.

symptoms, 66.2% answered 'yes,' with no significant differences observed between physicians and pharmacists. Further, when questioned whether valuable alerts were ignored because alerts appeared too frequently, 29.3% of the respondents answered 'yes,' including 26.3 and 33.6% of the total physicians and pharmacists, respectively; significantly more pharmacists than physicians answered positively ($P = 0.004$). When questioned whether they thought DUR alerts enable the identification of rare adverse drug reactions, 52.8% responded 'yes,' representing 59.3 and 43.6% of physicians and pharmacists, respectively; a significant difference in responses between physicians and pharmacists was observed ($P = 0.043$). Respondents (24.3%) reported that DUR alerts often give recommendations contrary to clinical practice guidelines, which 30.2 and 16.1% of physicians and pharmacists agreed upon, respectively, showing a significant difference ($P = 0.024$). Furthermore, 18.7% of all respondents thought that DUR alert pop-ups are difficult to understand, and 17.3 and 20.8% of physicians and pharmacists, respectively, reported experiencing difficulties.

Respondent opinions regarding risky combinations were obtained by questioning their response to co-administration of selegiline/moclobemide and amitriptyline/nortriptyline/imipramine. The results revealed that 10.9% of total respondents would prescribe (or had prescribed) these combinations, unchanged, without following the alerts. In contrast, 85.5% would change (or had changed) the prescriptions, showing that more respondents chose to change prescriptions involving co-administration incompatibilities than to dispense them unchanged. Physicians and pharmacists (93.8% and 73.8%, respectively) reported that they would change prescriptions, showing a significant difference from those that would not change prescriptions ($P < 0.001$). Furthermore, a significant proportion of respondents answered that they provided medication counseling to discourage patients from using old prescribed medications (36.3%) or encouraged patients to use medications in intervals (20.4%) instead of changing prescriptions when alerted about co-administration incompatibilities. Some respondents (10.1%) reported keeping co-administration incompatible drugs based on previous experiences that those co-administrations had no significant adverse drug reactions; 4.7% thought that the benefits of co-administering incompatible drugs outweighed the adverse drug reactions and maintained the prescriptions. Some physicians ignored the alerts regarding co-administering incompatible drugs because the prescriptions were low-dose, and responded that they often treated patients based on their opinions. Some pharmacists responded that procedures for changing prescriptions include calling the hospitals and are very complicated (Table 3).

Logistic regression analyses were used to determine the factors affecting changes in prescriptions following a DUR alert; physicians were more likely to change the prescription (adjusted odds ratio [AOR], 8.334; 95% confidence interval [CI], 3.449–20.139) than pharmacists and healthcare professionals with DUR alert experience (AOR, 4.605; 95% CI, 1.080–19.638). However, current practices in metropolitan area (AOR, 0.478; 95% CI, 0.228–1.000) and frequent DUR alerts on co-administration incompatibilities within prescriptions (AOR, 0.135; 95% CI, 0.031–0.589) have negative effects on whether DUR alerts are followed (Table 4).

**Table 2** Experience of DUR alerts and satisfaction

| Variables | Physicians | | Pharmacists | | Total | | *P*-value[a] |
|---|---|---|---|---|---|---|---|
| | (*n* = 209) | | (*n* = 149) | | (*N* = 358) | | |
| | *n* | (%) | *n* | (%) | *N* | (%) | |
| Experience with DUR pop-up alerts | | | | | | | |
| Any experience | 203 | (97.1) | 142 | (95.3) | 345 | (96.4) | 0.656 |
| No experience of alerts despite use of DUR system | 5 | (2.4) | 6 | (4.0) | 11 | (3.1) | |
| Did not use DUR system | 1 | (0.5) | 1 | (0.7) | 2 | (0.6) | |
| Satisfaction with DUR alerts (mean ± SD) | 72.1 | ±19.8 | 70.6 | ±17.9 | 71.5 | ±19.0 | 0.447 |
| 80% or more | 111 | (53.1) | 68 | (45.6) | 179 | (50.0) | 0.163 |
| Less than 80% | 98 | (46.9) | 81 | (54.4) | 179 | (50.0) | |
| DUR alerts are helpful for preventing medication-related errors | | | | | | | |
| Strongly agree | 87 | (41.6) | 69 | (46.3) | 156 | (43.6) | 0.112 |
| Agree | 119 | (56.9) | 71 | (47.7) | 190 | (53.1) | |
| Disagree | 2 | (1.0) | 5 | (3.4) | 7 | (2.0) | |
| Strongly disagree | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | |
| Do not know | 1 | (0.5) | 4 | (2.7) | 5 | (1.4) | |
| Frequency of DUR alerts | | | | | | | |
| High | 70 | (33.5) | 70 | (47.0) | 140 | (39.1) | 0.009 |
| Low | 139 | (66.5) | 78 | (52.3) | 217 | (60.6) | |
| Frequent DUR alerts | | | | | | | |
| Co-administration incompatibilities within prescriptions | 5 | (2.4) | 6 | (4.0) | 11 | (3.1) | 0.377 |
| Co-administration incompatibilities between prescriptions | 29 | (13.9) | 31 | (20.8) | 60 | (16.8) | 0.084 |
| Drug-age conflicts | 9 | (4.3) | 6 | (4.0) | 15 | (4.2) | 0.897 |
| Drug-pregnancy warnings | 18 | (8.6) | 8 | (5.4) | 26 | (7.3) | 0.244 |
| Ingredient duplication | 42 | (20.1) | 56 | (37.6) | 98 | (27.4) | <0.001 |
| Therapeutic duplication | 18 | (8.6) | 34 | (22.8) | 52 | (14.5) | <0.001 |
| Alerts for co-administrations resulting in severe symptoms were similar to those resulting in light symptoms | | | | | | | |
| Strongly agree | 42 | (20.1) | 33 | (22.1) | 75 | (20.9) | 0.181 |
| Agree | 94 | (45.0) | 69 | (46.3) | 163 | (45.5) | |
| Disagree | 42 | (20.1) | 21 | (14.1) | 63 | (17.6) | |
| Strongly disagree | 12 | (5.7) | 4 | (2.7) | 16 | (4.5) | |
| Do not know | 19 | (9.1) | 22 | (14.8) | 41 | (11.5) | |
| Valuable alerts are ignored because alerts appeared too frequently | | | | | | | |
| Strongly agree | 15 | (7.2) | 6 | (4.0) | 21 | (5.9) | 0.004 |
| Agree | 40 | (19.1) | 44 | (29.5) | 84 | (23.5) | |
| Disagree | 94 | (45.0) | 43 | (28.9) | 137 | (38.3) | |
| Strongly disagree | 44 | (21.1) | 34 | (22.8) | 78 | (21.8) | |
| Do not know | 16 | (7.7) | 22 | (14.8) | 38 | (10.6) | |
| DUR alerts enable identification of rare adverse drug reactions | | | | | | | |
| Strongly agree | 37 | (17.7) | 19 | (12.8) | 56 | (15.6) | 0.043 |
| Agree | 87 | (41.6) | 46 | (30.9) | 133 | (37.2) | |
| Disagree | 49 | (23.4) | 49 | (32.9) | 98 | (27.4) | |
| Strongly disagree | 18 | (8.6) | 13 | (8.7) | 31 | (8.7) | |
| Do not know | 18 | (8.6) | 22 | (14.8) | 40 | (11.2) | |
| DUR alerts often give recommendations opposite to clinical practice guidelines | | | | | | | |
| Strongly agree | 11 | (5.3) | 4 | (2.7) | 15 | (4.2) | 0.024 |
| Agree | 52 | (24.9) | 20 | (13.4) | 72 | (20.1) | |
| Disagree | 91 | (43.5) | 69 | (46.3) | 160 | (44.7) | |
| Strongly disagree | 36 | (17.2) | 33 | (22.1) | 69 | (19.3) | |
| Do not know | 19 | (9.1) | 23 | (15.4) | 42 | (11.7) | |
| DUR alert pop-ups are difficult to understand | | | | | | | |
| Strongly agree | 11 | (5.3) | 8 | (5.4) | 19 | (5.3) | 0.144 |
| Agree | 25 | (12.0) | 23 | (15.4) | 48 | (13.4) | |
| Disagree | 91 | (43.5) | 49 | (32.9) | 140 | (39.1) | |
| Strongly disagree | 64 | (30.6) | 46 | (30.9) | 110 | (30.7) | |
| Do not know | 18 | (8.6) | 23 | (15.4) | 41 | (11.5) | |

[a]*P*-values were calculated using *t*-test or chi-square test.

Of the total respondents, 109 answered questions regarding improvements that should be made to the DUR system. Of those who were satisfied with the current system, some reported that it enables avoidance of even small adverse drug reactions, as well as being convenient and effective. Others proposed strategies to expand the system's coverage, including addressing overlap of efficacy

**Table 3** Opinions of respondents regarding alerts for monoamine oxidase inhibitor (MAOI)/serotonin modulator (high-risk drug combinations)

| Variables | Physician | | Pharmacist | | Total | | *P*-value[a] |
|---|---|---|---|---|---|---|---|
| | (*n* = 209) | | (*n* = 149) | | (*N* = 358) | | |
| | *n* | (%) | *n* | (%) | *N* | (%) | |
| Response to alerts for MAOI/serotonin modulator | | | | | | | |
| I will prescribe (or have prescribed) as is without following alerts | 7 | (3.3) | 32 | (21.5) | 39 | (10.9) | <0.001 |
| I will change (or have changed) prescriptions based on alerts | 196 | (93.8) | 110 | (73.8) | 306 | (85.5) | |
| I do not know | 6 | (2.9) | 7 | (4.7) | 13 | (3.6) | |
| Reasons why prescriptions were not changed | | | | | | | |
| Patients stopped taking previously prescribed medications | 70 | (33.5) | 60 | (40.3) | 130 | (36.3) | 0.189 |
| Patients take medications with intervals | 41 | (19.6) | 32 | (21.5) | 73 | (20.4) | 0.667 |
| Experience that specific co-administrations do not cause significant adverse drug reactions | 23 | (11.0) | 13 | (8.7) | 36 | (10.1) | 0.480 |
| There is no alternative drug available | 19 | (9.1) | 10 | (6.7) | 29 | (8.1) | 0.416 |
| Considered co-administration beneficial over adverse drug reactions and maintained prescriptions | 12 | (5.7) | 5 | (3.4) | 17 | (4.7) | 0.295 |

[a]*P*-values were calculated using *t*-test or chi-square test.

**Table 4** Factors affecting prescription changes following DUR alerts

| Variable | Univariable model | | | Multivariable model | | |
|---|---|---|---|---|---|---|
| | Unadjusted odds ratio | 95% CI | *P*-value[a] | Adjusted OR | 95% CI | *P*-value[a] |
| Physicians (reference: pharmacists) | 8.145 | 3.480–19.067 | <0.001 | 8.334 | 3.449–20.139 | <0.001 |
| Female respondents | 0.292 | 0.148–0.578 | <0.001 | | | |
| Aged ≥ 50 years | 1.046 | 0.534–2.049 | 0.895 | | | |
| Practice period ≥ 5 years | 2.465 | 1.037–5.862 | 0.041 | 2.050 | 0.787–5.343 | 0.142 |
| Current practice in metropolitan area | 0.500 | 0.254–0.985 | 0.045 | 0.478 | 0.228–1.000 | 0.050 |
| Experienced DUR alerts | 4.258 | 1.219–14.864 | 0.023 | 4.605 | 1.080–19.638 | 0.039 |
| ≥80% satisfaction with the DUR alerts | 1.906 | 0.955–3.807 | 0.068 | | | |
| Agree that DUR alerts are helpful in preventing medication-related errors | 2.014 | 0.412–9.841 | 0.387 | | | |
| Agree that alerts for co-administrations resulting in severe symptoms are similar to those resulting in light symptoms | 1.137 | 0.567–2.280 | 0.719 | | | |
| Agree that valuable alerts are ignored because alerts appear too frequently | 0.952 | 0.462–1.962 | 0.895 | | | |
| Agree that DUR alerts enable identification of rare adverse drug reactions | 1.682 | 0.855–3.309 | 0.132 | | | |
| Agree that DUR alerts often give recommendations that are opposite to clinical practice guidelines | 1.258 | 0.554–2.856 | 0.583 | | | |
| Agree that DUR alert pop-ups are difficult to understand | 0.621 | 0.286–1.351 | 0.230 | | | |
| Frequent DUR alerts on co-administration incompatibilities within prescriptions | 0.175 | 0.047–0.650 | 0.009 | 0.135 | 0.031–0.589 | 0.008 |
| Frequent DUR alerts on co-administration incompatibilities between prescriptions | 0.620 | 0.277–1.389 | 0.245 | | | |
| Frequent DUR alerts on drug-age conflicts | 0.821 | 0.178–3.781 | 0.800 | | | |
| Frequent DUR alerts on drug-pregnancy warnings | 1.504 | 0.341–6.638 | 0.590 | | | |
| Frequent DUR alerts on ingredient duplication | 0.547 | 0.273–1.096 | 0.089 | | | |
| Frequent DUR alerts on therapeutic duplication | 0.516 | 0.228–1.164 | 0.111 | | | |

[a]*P*-values were calculated using logistic regression analysis.

groups and including non-prescription drugs in the DUR. For items requiring detailed improvements, 5.0% of respondents answered that alert fatigue is a problem, while numerous opined that the certificate confirmation window appeared frequently and alerts regarding allowed capacities are unnecessary. Some respondents were concerned that alert fatigue causes missed alerts regarding critical adverse drug reactions and suggested an alternative method to rank alerts, including the risk level of co-administering incompatible drugs and whether the prescription would be hazardous. Some opined that prepared measures and back-ups for server breakdown would improve errors in DUR alerts. Furthermore, it was pointed out that DUR management of uncovered drugs is difficult and should be improved to facilitate administration. Numerous respondents suggested that more information needs to be provided when using the DUR while some physicians hope to reduce overlapping prescriptions, including re-prescription because of rejection by patients or loss by elderly patients. Furthermore, some respondents suggested the DUR could provide more details regarding overlapping prescription contents including overlaps in efficacy groups and disease. Additionally, there was an opinion that DUR should

provide information about patients with chronic diseases who need to take medications continuously and co-administration of incompatible drugs should be provided as components rather than product names. Finally, numerous respondents believe that healthcare institutions and people need to be educated on DUR, which should be introduced and publicized possibly using the media (Table 5).

## Discussion

In the nationwide survey to evaluate recognition of DUR systems by physicians and pharmacists, a satisfaction rating of 71.5 out of 100 points indicated that most respondents are satisfied with the DUR system. Furthermore, respondents reported that DUR alerts prevent medication-related errors; most respondents (96.6%) received DUR alerts. According to physicians' prescriptions and pharmacists' preparations data from 2011 through 2012, the rates of prescription change for co-administration of incompatible drugs was 37.9% after alerts were received [6]. Additionally, our recognition survey revealed that a high proportion of respondents (67.5%) maintained the prescriptions, but counseled patients them to stop taking previous medications or take them in intervals. We discovered that 9.8% of respondents maintained prescriptions because alternatives were unavailable; therefore, providing a list of alternative drugs with alerts may raise future DUR acceptance by healthcare institutions.

Prescription change rates can be regarded as alert acceptance, which is also used as an indicator of adherence to DUR systems [15–17]. Isaac *et al.* analyzed 233 537 alert cases with 2872 physicians in Massachusetts, New Jersey and Pennsylvania from January to September 2006. They found that 6.6% of total electronic prescriptions resulted in alerts, of which physicians accepted 9.2 and 23% DDI and allergy alerts, respectively [10]. Alerts regarding combinations with severe adverse drug reactions accounted for 61.6% of all alerts; those alerting to more severe adverse drug reactions were accepted at a higher rate (7.3%, 7.1% and 10.4%). Alternatively, physicians who had received alerts previously were less likely to accept them again. Useful alerts and adverse drug reactions could be ignored based on clinical decisions of low specificity or risk level [18]. Weingart *et al.* investigated physician opinions on satisfaction, safety, efficacy and treatment cost of a commercial Computerized Physician Order Entry System (CPOE) used in Massachusetts [19]. Of the 300 physicians surveyed, 184 (61%) responded to the survey; results suggested that numerous outpatient electronic prescribers in Massachusetts prevented severe medication errors by using the alerts for drug allergies and DDIs, despite low satisfaction (47%). Furthermore, 57% of respondents opined that alerts prevented errors at least once a month, regardless of severity, and 22% said drug alerts had prevented potentially severe errors or deleterious effects. Various measures have been proposed to increase physician adherence to DDI alerts, and Paterno *et al.* suggested a strategy to differentiate DDI alerts depending on severity level in the CPOE [20].

Paterno *et al.* retrospectively analyzed alert log data from inpatients in two hospitals in 2004; both hospitals used a service to check DDIs in the CPOE. They compared adherence based on DDI alerts between the two hospitals, with the experimental group receiving alerts that classified drugs and the control group receiving alerts that did not classify drugs; results suggest that adherence in the experimental group was dependent on severity [20]. The most severe alerts were accepted in the experimental group (hospital with alert classification) 100% of the time and in the control group (hospital without alert classification) 34% of the time. Based on these results, the research team proposed an alert-tiering method for DDI-related information. In this method, tier 1 contains the most severe life-threatening alerts where physicians are requested to cancel the current prescription or stop existing prescriptions called a 'hard stop.' Tier 2 contains less severe alerts, but still requests physicians to act by stopping the prescription or choosing a reason for alert rejection. Tier 3 alerts use available screen real estate and need no response; the physician is not required to click the 'OK' button. According to DUR criteria and standards used by the Pharmacy Benefit Managers

**Table 5** Opinions on improvements for DUR system

| Answers | Physician ($n$ = 209) | | Pharmacist ($n$ = 149) | | Total ($N$ = 358) | |
|---|---|---|---|---|---|---|
| | $n$ | (%) | $n$ | (%) | $N$ | (%) |
| Alert fatigue needs to be improved by less frequent alerts | 23 | (11.0) | 8 | (5.4) | 31 | (8.7) |
| Medical institutions need education on DUR | 1 | (0.5) | 12 | (8.1) | 13 | (3.6) |
| Expand the coverage of DUR system | 3 | (1.4) | 9 | (6.0) | 12 | (3.4) |
| Satisfied with the current system | 8 | (3.8) | 2 | (1.3) | 10 | (2.8) |
| More detailed information about content of overlapping prescriptions | 4 | (1.9) | 6 | (4.0) | 10 | (2.8) |
| Diversify causes of overlapping prescriptions, including re-prescription attributable to rejection by patients or loss by elderly patients | 9 | (4.3) | 0 | 0.0 | 9 | (2.5) |
| Back-ups for breakdown of server | 4 | (1.9) | 4 | (2.7) | 8 | (2.2) |
| Information on risk level of alerts | 5 | (2.4) | 0 | 0.0 | 5 | (1.4) |
| Information about potential adverse reactions attributable to co-administration | 1 | (0.5) | 4 | (2.7) | 5 | (1.4) |
| DUR should provide information about patients with chronic diseases who need to take medications continuously | 3 | (1.4) | 1 | (0.7) | 4 | (1.1) |
| People need to be educated about DUR, which should be publicized | 1 | (0.5) | 1 | (0.7) | 2 | (0.6) |

in the United States, DDIs are divided into three categories, with the first corresponding to the highest severity, classified as a refusal of payment where requests are not accepted at community pharmacies; this is another example of a referral [20].

The present study focused on declining rates of prescription drug changes to rank criteria used to determine conflicting drug events, such as co-administration of incompatible drugs and drug-age conflicts. Further, we outline a strategy to increase the rate of prescription drug changes for incompatible combinations that can cause relatively severe adverse drug reactions using selection and concentration methods. Discrimination of more important alerts from those that are less important will be required to improve the current system; these changes would likely increase cancellation of prescriptions and preparations after the appearance of pop-up alerts intended to inform the physician or pharmacist that the combination could cause severe adverse drug reactions,. Overall, this would increase physician and pharmacist sensitivity to alerts regarding clinically important DDI combinations.

It is necessary to improve the DUR system to prevent physicians and pharmacists from ignoring risky or conflicting criteria outlining severe adverse drug reactions during real-time checks. Alert-tiering methods have been proposed by other researchers to address alert fatigue and reduce co-administration of incompatible drugs and drug-age conflict combinations. Survey respondents also included suggestions for areas they felt should be preferentially improved. The alert-tiering method proposed by Paterno *et al.* provides a benchmark, as it has already been used in Korea and provides drug-pregnancy alerts that are checked per the classification levels [20].

Therefore, we propose a new alert-tiering method as follows: (i) Tier 1 would be limited to very severe cases that are extremely hazardous and should not be used. (ii) Tier 2 or 3 would require justification from the physician or pharmacist if the alert cannot be followed. (iii) An additional tier would be provided that includes only information that is needed and may not specify that there are conflicting drugs; this would be the level that includes information regarding DDI risks.

This study has some limitations. Non-response bias is likely attributable to healthcare providers who are not interested in the DUR. Therefore, it is necessary to exercise caution when attempting to generalize these findings, as professionals interested in the DUR may have been the primary respondents. However, the studied institutions were sampled from all healthcare facilities nationwide and the responders had similar characteristics to those of the sampled population; their experience rate with the DUR system reflected that in the nationwide data [3]. Furthermore, it may be difficult to extrapolate our findings to other specific clinical and societal situations related to DUR systems. For example, pharmacists had a significantly lower acceptance rate for changing medications following DUR alerts than that of physicians, which may be attributable to their lack of authority to change prescriptions in Korea. Separation of drug prescribing and dispensing has been implemented in Korea since 2000; therefore, physicians in medical institutions cannot dispense any medicines other than injectable drugs for outpatient treatment and can only issue prescriptions. Further, pharmacists can dispense prescription medications only by a physician's prescription and permission is required from the physician to change the prescription [21]. Information presented in this study is less objective than other studies because we directly surveyed participants and requested opinions. Previously, a study of the Korean DUR system was conducted to explore providers' responses to DUR alerts and identify institutional characteristics, providers and drug components associated with providers' acceptance of the system using an electronic database [6]. Therefore, the purpose of this study was to directly collect essential data from healthcare professionals with the intention of improving the system. We focused on the perceptions of healthcare professionals regarding the DUR and the difficulties they are having with the DUR process related to practical settings.

Numerous healthcare institutions do not change prescriptions and preparations even after implementing a DUR system; therefore, a strategy to address this situation is necessary. To enhance adherence to the DUR system, a modified and improved system should be implemented to ensure a preferential and intensive approach targeting potentially high-risk combinations of drugs when performing safety checks in real time or when information is provided retrospectively.

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