Resumen

Objetivo: Realizar un análisis cuantitativo de alertas asociadas a un sistema de prescripción electrónica asistida e identificar oportunidades de mejora de dicho sistema.

Método: Estudio observacional retrospectivo en un hospital general con 750 camas, de las cuales 500 disponen de prescripción electrónica asistida. Se analizó la frecuencia por tipo y medicamento de 525.691 alertas generadas durante un año en la prescripción de los tratamientos farmacológicos de 15.466 pacientes, transfiriéndose para ello a una base de datos. El sistema contempla tres categorías de alertas relacionadas con el medicamento, las características del paciente y la política de medicamentos del hospital. Mediante análisis de modos de fallos y efectos se identificaron oportunidades de mejora del sistema y se propusieron acciones correctoras.

Resultados: Se observó que 20 medicamentos del total de 1.084 generaron el 34% de las alertas, siendo los diez principios activos más frecuentemente implicados: cloruro potásico, acenocumarol, imipenem, lorazepam, diazepam, micofenolato, enoxaparina, tacrolimus, carbonato cálcico y ciclosporina. Las alertas más frecuentes generadas durante la prescripción electrónica se asociaron con duplicidad terapéutica (35.4%), insuficiencia renal (27.6%) y riesgo por geriatría (17.2%), constituyendo estos grupos el 80.2% del total. Se identificaron como puntos de mejora prioritarios la sobrecarga de alertas y la información facilitada por las alertas.

Conclusiones: El sistema genera excesivas alertas con el consiguiente riesgo de ser ignoradas y de disminuir su capacidad para la prevención de acontecimientos adversos a medicamentos. Se requieren modificaciones en el diseño del sistema de alertas, así como la actualización continua de las mismas.


Summary

Objective: To make a quantitative analysis of the alerts associated with a computerized physician order entry system and identify opportunities to improve the system.

Method: A retrospective observational study in a general hospital with 750 beds, 500 of which have a computerized physician order entry system installed. The frequency per type and medication of 525,691 alerts produced for a year in the prescription of drug treatments to 15,466 patients was analysed, entering these on a database. The system includes three categories of alert relating to the drug, the characteristics of the patient and the hospital medicine policy. By means of a failure mode and effects analysis, opportunities for improving the system were identified and corrective measures were suggested.

Results: It has been observed that from the total of 1,084 drugs, 20 of them produce 34% of alerts. The ten most frequently active ingredients involved are: potassium chloride, acenocumarol, imipenem, lorazepam, diazepam, mycophenolate, enoxaparin, tacrolimus, calcium carbonate and cyclosporine. The most frequent alerts generated during electronic prescription are associated with duplicated therapy (35.4%), renal failure (27.6%) and risk due to advanced age (17.2%), with these groups accounting for 80.2% of the total. The excess of alerts and information provided by the alerts were identified as priority improvement points.

Conclusions: The system produced excessive alerts which led to the risk of them being ignored and reducing the capacity to prevent adverse drug events. Modifications are required for the design of the alert system, which also needs to be continuously updated.

Key words: Computerized physician order entry. Alerts system. Medication errors. Adverse drug events. Prevention.
INTRODUCTION

The adverse drug events (ADEs) have considerable repercussions on morbidity and mortality in hospitalised patients\(^1\), also increasing the average cost of the hospital stay\(^2\), and even admissions to medical services\(^3\). It is worth mentioning that a significant proportion of these are preventable\(^4\). Medication errors (MEs) are the main cause of these events, and drug prescribing is one of the main processes where these errors originate\(^1\). Among the causes producing the prescription incidents are lack of specific information about the patient and the drug itself at the time of prescription\(^6\). This fact is also, dependent on the growing complexity of the drug treatment, the appearance of new drugs, new indications, dosage, adverse effects and interactions. The medical information available is subject to exponential growth and constant change. It has been calculated that scientific information doubles every five years, a period that will soon have decreased to every two years, creating information overload\(^7\), also known as infocytation\(^8\), hindering rapid access to appropriate, unbiased information.

Computerized physician order entry (CPOE) together with systems that support decision taking are tools with enormous potential for improving the safety of hospitalised patients, as well as the efficacy of the drug treatment process\(^9,10\). They facilitate the prevention of ME by making prescriptions legible, structured, avoiding ambiguity and transcription errors, among other factors. Additionally, as they integrate the clinical information and patient information and use a system of interactive alerts and recommendations, they notify the doctor about allergies, maximum doses, interactions, duplications, dosing schedule changes, therapeutic exchanges, etc.\(^11,12\) at the time of prescribing. They also allow adverse events that have already occurred to be identified, making it possible to respond more quickly to these\(^13\).

On the other hand, the CPOE is a tool for applying the policies and protocols that optimise the use of resources, increasing the efficiency of the drug treatment. In this manner, and in spite of the existence of a certain degree of controversy with regard to their level of acceptance because of the problems that arise if they are not used correctly, thanks to their media capturing potential and that when used appropriately they help to change behaviours, encouraging the creation of a culture of safety. It should therefore come as no surprise that CPOE is one of the safety strategies proposed by many bodies and healthcare societies, including the Institute for Safe Medication Practices (ISMP)\(^4\), the National Quality Forum (NQF)\(^15\), the Joint Commission on Accreditation of Health-Care Organizations (JCAHO)\(^16\) and the American Society of Health-System Pharmacists\(^17\), among others.

In spite of the important benefits of CPOE, it has been reported that it can lead to the appearance of ME, especially due to the design and management of the technology itself\(^18\). It therefore requires continuous evaluation as suggested in the recently published Quality Plan of the National Health System, as it include as strategy number six the evaluation of the technologies and clinical procedures to support clinical and management decisions\(^19\).

It is important for the pharmacist, as the person responsible of the drug, to play a leading role and to participate actively together with a multidisciplinary team in the design, implantation and follow up of the CPOE systems. In this framework, its strategic positioning on the side of these systems will help the Pharmacy Service achieve its mission and objectives.

The aims of this document are: to make a quantitative analysis of the alerts associated with a computerized physician order entry system and identify opportunities to improve the system.

METHOD

—Design: An observational, descriptive, retrospective study was made of the alerts issued in one year by the CPOE system during the prescription and validation of drug treatments. The alerts recorded on the history of the CPOE system were transferred to an Access\(^\circledast\) database and to an Excel\(^\circledast\) spreadsheet to facilitate their analysis and interpretation. The following fields were included in the database: type of alert, frequency of appearance (number of times), patient and drug product. By analysing the failures and effects, opportunities for improving the alerts associated with the CPOE were identified, with a proposed action plan.

—Scope: General Hospital belonging to a third level hospital complex that includes four care units (Rehabilitation, General, Maternity and Children’s Hospitals). This hospital covers the area of medical-surgical pathology of the adult, with a total of 750 beds, 550 of which have a unit dose medication dispensation system associated with CPOE.

—Size of sample and study variables: Of the total 525,691 alerts issued during one year in the corresponding drug prescriptions for 15,466 patients, the number of alerts, their type and frequency were analysed, as well as the drugs involved in the generation of these alerts. The failures modes identified in the mode analysis of failures and their effects were considered the points requiring improvement.

—Characteristics of the CPOE: It is used by approximately 500 prescribing doctors, who input the drug treatments directly into the computer system. The electronic prescription software is associated with a drug therapy database with 1,084 drugs and has an interactive alert and recommendation system, which helps the doctor to take decisions when prescribing (APD ATHOS Prisma\(^\circledast\), (Madrid). The Pharmacy Service has access to on line prescriptions, which must be validated before drugs are dispensed. Once the treatment has been validated it is used to help in the administration of drugs by the nursing
staff for the hospitalisation unit, by printing the administration sheets. The following categories are included in the alert system: a) alerts about problems due to the drug: exceeding the maximum amount per dose, exceeding maximum daily dose, days of treatment outside treatment interval, contraindications, incompatibilities, administration recommendations, route of administration not defined, time of administration outside interval, adverse effect, duplicated therapies; b) alerts regarding problems relating to patient characteristics: allergies, liver failure, renal failure, old age, pregnancy, breastfeeding; and c) alerts originating from the hospital drug policy: conditions of use (restricted antibiotics, medicines for compassionate use and problems with continuity of supply, among others). The CPOE contains a renal failure module (RF), where you can input the weight, age and level of plasma creatinine (CR), automatically calculating the clearance of creatinine and advising a change in dosing schedules when necessary. Furthermore, the pharmacist responsible for maintaining the database associated with the CPOE can select which alerts to activate and adapt it to a clinical situation. For example a dosing schedule alert because of RF will only be issued if the CR value has been specified in the patient characteristics. Furthermore, each user (doctor or pharmacist) can have an alert profile.

RESULTS

The percentage distribution by type of alert of a total of 525,691 analysed, corresponding to 15,466 patients is shown in table I. An average of 34 alerts per patient has been obtained. The frequency of the alerts related to drugs, the patient and the hospital drug policy was 45.6; 46 and 8.4%, respectively. With regard to the drugs involved in the generation of these alerts, a total of 14 active ingredients (20 drugs) were found, accounting for 34% of the total number of alerts (n = 178,735). Table II shows the percentage with which each drug contributes to the total of 34% accumulated.

With the aim of facilitating the identification of the opportunities to improve the system the frequency of the alerts, which made up almost 95% of the total was crossed with the type of medicine involved, the results of which are shown in table III. It was seen that four active ingredients (potassium chloride, acenocumarol, tacrolimus and cyclosporine) account for 43% of all alerts caused by duplicated therapy. These results led to an analysis of the causes of this excess of alerts and to generate a more advanced system in the development of the alerts. Table IV shows the weak points identified and the action plan for improving the CPOE system in our hospital.

DISCUSSION

The alert systems and associated recommendations for electronic prescription have been shown to reduce the occurrence of ME and SE\textsuperscript{[21,20,21].} However, false positives, with published figures of more than 36%, reduce the effectiveness of this type of systems as they damage the credibility and acceptability of these by medical personnel\textsuperscript{[22].} Too many alerts and irrelevant alerts lead to delays in prescriptions and “alert fatigue”, which are the main reasons why they are ignored\textsuperscript{[23,24].} This loss of acceptance has a risk, in fact, adverse effects have been observed in 6% of the alerts ignored in a study in which 80% of these were annulled\textsuperscript{[25].} In our study, the high number of alerts

<table>
<thead>
<tr>
<th>Description of the alert</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicated therapy</td>
<td>187,284</td>
<td>36</td>
</tr>
<tr>
<td>Patient: Renal failure</td>
<td>145,614</td>
<td>28</td>
</tr>
<tr>
<td>Patient: Geniatric risk</td>
<td>90,875</td>
<td>17</td>
</tr>
<tr>
<td>Specialising in:Conditions for use</td>
<td>44,240</td>
<td>8</td>
</tr>
<tr>
<td>Dosing schedule: Dose outside range</td>
<td>16,443</td>
<td>3</td>
</tr>
<tr>
<td>Dosing schedule: Maximum daily dose exceeded</td>
<td>8,200</td>
<td>2</td>
</tr>
<tr>
<td>Mixtures:Perfusion time outside range</td>
<td>6,367</td>
<td>1</td>
</tr>
<tr>
<td>Dosing schedule: Route of administration not specified</td>
<td>6,258</td>
<td>1</td>
</tr>
<tr>
<td>Dosing schedule: Maximum dose exceeded</td>
<td>4,978</td>
<td>1</td>
</tr>
<tr>
<td>Patient: Liver failure</td>
<td>4,744</td>
<td>1</td>
</tr>
<tr>
<td>Dosing schedule: Days of treatment outside range</td>
<td>3,472</td>
<td>1</td>
</tr>
<tr>
<td>Specialising in: Contraindications</td>
<td>2,379</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Parenteral: Volume outside range</td>
<td>2,097</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Parenteral: Pace of administration outside range</td>
<td>2,041</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Patient: Allergies to drugs</td>
<td>473</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Specialising in: Adverse effects</td>
<td>140</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Patient: Teratogenic risk</td>
<td>54</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Specialising in: Recommendations for administration</td>
<td>18</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Patient: Catheter recommendations</td>
<td>14</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Table II. Percentage distribution of alerts by medication. The 20 drugs giving rise to the most alerts are shown

<table>
<thead>
<tr>
<th>Drug</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium chloride amp 2M 5 ml</td>
<td>26,389</td>
<td>5.0</td>
</tr>
<tr>
<td>Acenocumarol tab 1 mg</td>
<td>16,822</td>
<td>3.2</td>
</tr>
<tr>
<td>Imipenem vial 500 mg</td>
<td>13,046</td>
<td>2.5</td>
</tr>
<tr>
<td>Lorazepam tab 1 mg</td>
<td>12,541</td>
<td>2.4</td>
</tr>
<tr>
<td>Diazepam tab 5 mg</td>
<td>11,693</td>
<td>2.2</td>
</tr>
<tr>
<td>Mycophenolate mofetil tab 500 mg</td>
<td>9,721</td>
<td>1.8</td>
</tr>
<tr>
<td>Enoxaparin syringe 40 mg</td>
<td>8,390</td>
<td>1.6</td>
</tr>
<tr>
<td>Tacrolimus caps 1 mg</td>
<td>7,918</td>
<td>1.5</td>
</tr>
<tr>
<td>Acenocumarol frac tab 0.5 mg</td>
<td>7,651</td>
<td>1.5</td>
</tr>
<tr>
<td>Calcium carbonate tab comp 1,260 mg</td>
<td>7,635</td>
<td>1.5</td>
</tr>
<tr>
<td>Tacrolimus caps 0.5 mg</td>
<td>6,377</td>
<td>1.2</td>
</tr>
<tr>
<td>Cyclosporin A caps 25 mg</td>
<td>6,302</td>
<td>1.2</td>
</tr>
<tr>
<td>Cyclosporin A caps 50 mg</td>
<td>6,238</td>
<td>1.2</td>
</tr>
<tr>
<td>Prednisone tab 5 mg</td>
<td>5,858</td>
<td>1.1</td>
</tr>
<tr>
<td>Cyclosporin A caps 100 mg</td>
<td>5,811</td>
<td>1.1</td>
</tr>
<tr>
<td>Human isophane insulin NPH vial 100 UI/ml</td>
<td>5,676</td>
<td>1.1</td>
</tr>
<tr>
<td>Human insulin vial 100 UI/ml</td>
<td>5,555</td>
<td>1.0</td>
</tr>
<tr>
<td>Enalapril tab 5 mg</td>
<td>5,493</td>
<td>1.0</td>
</tr>
<tr>
<td>Sulfametoxazol/trimetropin tab 400/80 mg</td>
<td>5,244</td>
<td>1.0</td>
</tr>
<tr>
<td>Diazepam tab 10 mg</td>
<td>5,085</td>
<td>1.0</td>
</tr>
</tbody>
</table>
was also shown, with an average of 34 alerts/patient, which justifies a quality programme for the CPOE system, even more given the complexity of treatments in the IU with CPOE (15 drugs per patient, 180 doses/patient, average stay of 10 days) according to an earlier analysis of our hospital.

The percentage distribution of alerts shows that only three types, duplicated therapy, renal failure and geriatric risk, account for 71% of the total. Many of the incidents of duplicated therapy are contaminants and lead to confusion, as they are not due to a genuine duplication of the therapy, rather the need to select two or more brand names of the same active ingredient to reach the necessary dose, as is the case for cyclosporin capsules of 100, 50 and 25 mg; or the need to prescribe a drug in more than one line, irregular dosing schedules, as is the case with acenocumarol. As an improvement, continuous training of healthcare professionals in the management of the CPOE is proposed, with automatic selection of the most appropriate brand. In the same context, the false duplications of potassium chloride have been resolved using a specific module for fluid therapy which designs a treatment schedule using total doses of fluids and potassium prescribed. This module is present in a new version of the CPOE computer application.

In the alert analysis it has been shown that the risk in geriatrics is also very common and requires assessment and improvement. Among the drugs involved, the benzodiazepine group is particularly outstanding. Although there are studies showing that an alert system optimises their

<table>
<thead>
<tr>
<th>Alert</th>
<th>n</th>
<th>Drug</th>
<th>n</th>
<th>(% accumulated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicated therapy</td>
<td>187,284</td>
<td>Potassium chloride 2M amp 5ml</td>
<td>23,148</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acenocumarol tab 1 mg</td>
<td>16,807</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tacrolimus caps 1 mg</td>
<td>7,870</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acenocumarol frac tab 0.5 mg</td>
<td>7,651</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tacrolimus caps 0.5 mg</td>
<td>6,371</td>
<td>33.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclosporin A caps 25 mg</td>
<td>6,265</td>
<td>36.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclosporin A caps 50 mg</td>
<td>6,061</td>
<td>39.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclosporin A caps 100 mg</td>
<td>5,661</td>
<td>42.6</td>
</tr>
<tr>
<td>Dose outside range</td>
<td>16,443</td>
<td>Potassium acetate caps 500 mg</td>
<td>991</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prednisone tab 5 mg</td>
<td>969</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prednisone tab 10 mg</td>
<td>881</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lactulose sachets 10 g</td>
<td>804</td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enalapril tab 5 mg</td>
<td>695</td>
<td>26.4</td>
</tr>
<tr>
<td>Maximum daily dose exceeded</td>
<td>8,200</td>
<td>Doxazosine tab 4 mg</td>
<td>1,536</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amiodipine tab 5 mg</td>
<td>1,306</td>
<td>34.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acetylcysteine tab 600 mg</td>
<td>605</td>
<td>44.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pancrease caps</td>
<td>566</td>
<td>50.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calcium carbonate tab 1,260 mg</td>
<td>397</td>
<td>55.8</td>
</tr>
<tr>
<td>Maximum dose exceeded</td>
<td>4,978</td>
<td>Pancrease sachet 10,000 UI</td>
<td>1,473</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pancrease caps</td>
<td>699</td>
<td>43.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calcium carbonate tab 1,260 mg</td>
<td>368</td>
<td>51.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulbuthanol inh 100 mcg/dose</td>
<td>338</td>
<td>57.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sodium bicarbonate tab 500 mg</td>
<td>307</td>
<td>64.0</td>
</tr>
<tr>
<td>Renal failure</td>
<td>145,614</td>
<td>Mycophenolate mofetil tab 500 mg</td>
<td>7,954</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enoxaparin syringe 40 mg</td>
<td>7,687</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calcium carbonate tab 1,260 mg</td>
<td>6,380</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sul tamethox-trimet tab 400/80 mg</td>
<td>5,208</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aspirin tab 100 mg</td>
<td>4,176</td>
<td>21.6</td>
</tr>
<tr>
<td>Liver failure</td>
<td>4,744</td>
<td>Pantoprazole tab 40 mg</td>
<td>1,178</td>
<td>24.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pantoprazole vial 40 mg</td>
<td>590</td>
<td>37.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Espironolactone tab 100 mg</td>
<td>415</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nifedipine oros tab 30 mg</td>
<td>260</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Morphine amp 1% 1 ml</td>
<td>222</td>
<td>56.2</td>
</tr>
<tr>
<td>Geriatric risk</td>
<td>90,875</td>
<td>Lorazepam tab 1 mg</td>
<td>12,271</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diazepam tab 5 mg</td>
<td>9,399</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diltaizem tab retard 120 mg</td>
<td>3,990</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enalapril tab 5 mg</td>
<td>3,931</td>
<td>32.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ramipril tab 5 mg</td>
<td>3,813</td>
<td>36.7</td>
</tr>
<tr>
<td>Conditions for use</td>
<td>44,240</td>
<td>Imipenem i.v. 500 mg</td>
<td>10,350</td>
<td>23.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Colistin mesilate vial 1 MU</td>
<td>3,917</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meropenem vial 1 g</td>
<td>3,215</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meropenem vial 1 g</td>
<td>2,823</td>
<td>45.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceftazidim vial 1 g</td>
<td>2,450</td>
<td>51.4</td>
</tr>
</tbody>
</table>
prescription in elderly outpatients, in our field the figure of 90,000 is considered excessive. As a result, to make the system more efficient, it is proposed that this be updated in accordance with the most recent scientific evidence, as well as establishing pre-defined schedules for geriatric patients, even extending the geriatric age segment.

Discarding the alerts with low predictive value and those with fewer clinical repercussions must be performed with great care so as not to cause an increase in the number of false negatives, i.e. so as not to omit necessary alerts. The alerts related to the patient characteristics, such as renal failure, liver failure and allergies, are only generated when the doctor includes these characteristics in the database. In a study carried out earlier to evaluate the use of the RI module of the CPOE system, it became clear that the system was being underused, finding that in 35.1% of cases the doctor had not put in CR values of the patient suffering from RF at the time of prescription, meaning the system could not issue an alert with the necessary dose adjustment. Furthermore, if the doctor does not update the return to normality of the changed parameter, the system produces a false positive that leads to underdosing. As a result, one of the actions for optimising this group of alerts is the automatic input of

### Table IV. Points for improvement, types of alert involved and corrective actions

<table>
<thead>
<tr>
<th>Improvement point (fault)</th>
<th>Alert involved</th>
<th>Origin (cause)</th>
<th>Effect (*)</th>
<th>Corrective action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess of alerts (false positives)</td>
<td>Duplicated therapy: potassium chloride, tacrolimus, cyclosporin, acenocumarol</td>
<td>Design: need to prescribe the same active ingredient in more than one line of treatment</td>
<td>Prescription delay</td>
<td>Automatic selection of brands</td>
</tr>
<tr>
<td></td>
<td>Geriatric risk: Lorazepam, diazepam, diltiazem, enalapril, ramipril</td>
<td>Design: absence of connection with laboratories. Still appears although the dose has been changed. Handling: not updated renal function</td>
<td>Prescription delay</td>
<td>Design fluidotherapy module</td>
</tr>
<tr>
<td></td>
<td>Adjust dosing schedule for RF</td>
<td>Design: glucose intolerance</td>
<td>Underdosing, reduced efficacy</td>
<td>Review geriatric schedules (clinical practice guide evidence). Review geriatric age segments. Establish predetermined dose schedules for geriatrics</td>
</tr>
<tr>
<td>Maximum dose: doxazosin, amiodipine</td>
<td>Update database</td>
<td>Underdosing, reduced efficacy</td>
<td>Integrate database with manufacturers, clinical history. Disappearance of alerts after recommending. Training to healthcare worker</td>
<td></td>
</tr>
<tr>
<td>Conditions for use: imipenem, colistin meropenem, ertapenem, ceftazidime</td>
<td>Design: Always appears when prescribing the medication. Update rational use policy</td>
<td>Prescription delay</td>
<td>Review maximum dose (clinical practices guides and scientific evidence). Issue informative notes</td>
<td></td>
</tr>
<tr>
<td>Excess of alerts (redundancy)</td>
<td>Geriatric risk, maximum dose, RF Conditions for use</td>
<td>Design: Continues to appear although the healthcare worker rejects after assessing the benefit/risk or having modified any value because of the alert.</td>
<td>Prescription delay</td>
<td>Change parameters for the alert: Adapt it to the need for justification, etc. Update Pharmacy Commission agreements</td>
</tr>
<tr>
<td>Omits alerts (redundancy)</td>
<td>Adjust dosing schedule for RF Liver failure Allergies</td>
<td>Design: Absence connection with manufacturer or clinical history. Handling: dose not updated. Clinical situation</td>
<td>Overdose Intoxication Hypersensitivity reaction</td>
<td>Integrated database with manufacturers, clinical history. Training healthcare staff</td>
</tr>
<tr>
<td>Drug interactions</td>
<td>Design: Absence drug interaction module</td>
<td>Overdosing, Underdosing Potential or real adverse effect</td>
<td>Introduce interaction module</td>
<td></td>
</tr>
<tr>
<td>Contextual information</td>
<td>Adjust dosing schedule for RF Contraindications</td>
<td>Design: recommend percentage reduction of usual dose without specifying it. Does not suggest alternatives</td>
<td>Ignored Potential or real error</td>
<td>Review dose (clinical practice guides and scientific evidence). Redesign RF module. Suggest alternatives</td>
</tr>
<tr>
<td>Alert format (monotony)</td>
<td>All the alerts</td>
<td>Design: they are the same colour and format</td>
<td>Delays identification</td>
<td>Differentiate the alerts via colours of formats according to category, seriousness or clinical importance</td>
</tr>
</tbody>
</table>

*AA PP: Sequence of affects: Alert fatigue > Alert ignored > Potential or Real Medication error > Potential or real side effect.
laboratory data by the CPOE system. With regard to the content, the system must provide a more precise, individualised recommendation for the patient, as it only proposed percentage reductions to the usual doses of drugs based on creatinine clearance of the patient, without considering the dosing schedule prescribed or whether or not the physician has corrected the dose. This aspect makes an enormous contribution to the excess number of alerts for their reiteration, meaning the RF module needs to be updated.

In this study there was an absence of alerts regarding risks to breastfeeding children, and a low incidence of alerts for teratogenic risk. This is because the hospital where the CPOE system is working does not look after paediatric or gestating patients, who are admitted to the children’s and maternity hospitals. Furthermore, the absence of alerts regarding interactions between drugs is attributed to the fact that the drug interaction module has still not been introduced into the CPOE system.

The CPOE is a very useful tool for spreading drug policy through the hospital and for managing supply problems. In our CPOE system this type of alert is found under the heading conditions for use, where more than 50% (n = 44,240) are generated by only five drugs, specifically imipenem i.v. reaching the figure of 10,350 as it is considered a restricted use antibiotic. In an earlier, unpublished study, in this type of alert it was found that 64% of them were unnecessary, as they were generated to ask for the reason for the prescription of the medication, when the pharmacotherapeutic history was evident.

With regard to the limitations of the study it must be pointed out that this is a preliminary quantitative analysis with regard to the alerts associated with the CPOE system with identification of improvement points, with no intention to analyse clinical repercussions, the study of which will be interesting and will be dealt with in a later work. User satisfaction with the CPOE has not been assessed, as we prefer to wait until the improvements have been introduced.

In spite of the drawbacks referred to by the healthcare workers such as the inappropriateness of the alerts, the difficulty interpreting these and the excess and redundancy of the alerts, which have also been found on our system, and which obviously cause delays in prescription, the alerts are useful and it is unadvisable to avoid them, an opinion shared by more than half of all prescribers interviewed in the alert evaluation study on the CPOE system. Professional computer system experts propose a series of general strategies for developing alert systems, which are suppressing irrelevant or inapplicable alerts, the use of clear, concise language, and the design of alerts with alternative suggestions to contraindications and precautions, continuous training of healthcare workers, the activating of alerts according to clinical importance or seriousness. It has also been suggested that regular reviews be carried out per user, notifying the prescribers with a list of the most frequent alerts seen in their prescriptions. Our experience as users supports these recommendations, as is set out in table IV, which also highlights the importance of improving the computer design which is responsible for useless duplications and redundancies, as well as the automatic gathering of laboratory data by the CPOE. We understand that the tools configuring the systems supporting the clinical decision must be configured as open systems and permanently updating their practical review involves the need for a programme to improve quality, guarantee an appropriate management of the knowledge and the information systems, with the maximum strictness and always based on scientific evidence.

To conclude, the CPOE system produce an excess of alerts which led to the risk of these being ignored and reducing the capacity to prevent adverse drug-related events. Modifications are required to the design of the alert system, which also needs to be updated continuously. New studies evaluating the results are required to determine the positive and negative predictive values of the alerts, rationalising their design and application according to criteria of patient safety and the efficiency of the pharmacotherapeutic process.

ACKNOWLEDGEMENTS

To all the users of the electronic prescription system for their help in improving it. To Javier García Pellicer for his help in the computerised management of the data.

References