Drug Safety - How to Optimally Organise the Storage of Medications in a Ward Setting

[Läkemedelssäkerhet – hur skall läkemedelsförråd på en slutenvårdsavdelning organiseras på ett optimalt sätt?]
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Abstract

Background
Many patients cared for by the Swedish healthcare system are harmed due to drug mix-ups. It is thus pivotal to identify methods that can reduce the risks. One significant contributing factor to drug mix-ups is the way in which medications are stored in the clinical wards.

Aim
The aim of the present study was to identify published methods that reduce the risks for medication errors in a clinical ward setting. Special emphasis was set on human factors associated with how prescribed drugs are picked from the shelf, handled, and dispensed.

Method
The literature searches were performed in the Embase, PubMed, Cochrane Library, and CINAHL databases as well as in a number of other HTA databases. Two librarians conducted the primary literature searches and independently read and sorted the articles before sending selected articles to the project group for assessment. A third information specialist completed the literature searches in the HTA databases and in the biomedical database Embase. The members of the project group read articles independently and consensus was used to decide which articles should be included in the report.

Results
Two studies were identified which reported on the effect of organization of medication storages on rates and types of medication errors. Both studies found medication errors to be common. They also concluded that when drugs where issued and administered at the patient’s bedside they were less likely to be omitted and more likely to be given on time.

Conclusion
There is at present insufficient evidence to recommend methods of storage that might decrease medication errors in a ward setting. This calls for further research in the field.
Health Technology Assessment (HTA)

HTA is a systematic evaluation of the available scientific literature concerning the properties, effects, and impacts of health-care technologies. The purpose is to evaluate technologies and methods by focusing on

- the effects in terms of patient benefits and risks
- ethical aspects
- organisational aspects
- costs and cost-effectiveness

To evaluate the level of evidence, the HTA Unit in Region Skåne is using the GRADE system.

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>GRADE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High level of evidence</td>
<td>(★★★★)</td>
<td>Further research is very unlikely to change our confidence in the estimate of effect.</td>
</tr>
<tr>
<td>Moderate level of evidence</td>
<td>(★★★)</td>
<td>Further research is likely to have an important impact on our confidence in the estimate of effect and might change the estimate.</td>
</tr>
<tr>
<td>Low level of evidence</td>
<td>(★★)</td>
<td>Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.</td>
</tr>
<tr>
<td>Very low level of evidence</td>
<td>(★)</td>
<td>Any estimate of effect is very uncertain.</td>
</tr>
</tbody>
</table>

An HTA offers guidance to decision makers in the health-care system. If the level of evidence for a positive effect of a technology is of high or moderate quality, then the technology most probably qualifies for use in routine medical care. If the level of evidence is of low quality, the use of the technology might be motivated provided there is an acceptable balance between benefits and risks, cost-effectiveness, and ethical considerations. Promising technologies with a very low level of evidence motivate further research but should not be used in routine clinical work.
Conclusion

Two studies were identified that examined the effect of medication storage systems on the rate of medication errors and on the type of medication errors. Both studies were of low methodological quality and concluded that:

- Medication errors are common
- Medications are less likely to be omitted and are more likely to be given on time when they are issued and administered at the patient's bedside

No studies were found that examined the effects of drug storage in ATC (Anatomic Therapeutic Chemical classification) order versus alphabetical order. There were neither any studies on the use of high-alert medication lists nor separate storage for look-alike medications.

Currently there are no national Swedish recommendations concerning which drugs are considered to be high-alert medications. There are neither any consensus lists of look-alike nor sound-alike medications.

These shortcomings and knowledge gaps thus highlight the need for further research studies in this field.

Quality of evidence: GRADE (⊕⊕○○) - very low level of evidence.
Background

Medication errors have been identified as the most common single preventable cause of adverse drug events (1). Errors are the result of complex interactions between human and system factors that go wrong (2). Negligence or failure to follow manuals and protocols and lack of knowledge are commonly identified individual factors preceding such errors. Other known factors are work overload, unclear communication, inadequate access to guidelines, bad routines, inappropriate location, and look-alike medications.

Medication errors can occur at any stage of the medication process, including physician ordering, nurse administration, transcription or dispensing (3). Studies have shown that many errors occur during administration (4-6). Other important error-contributing factors are related to organisation of the medication storage or the presence of sound-alike and look-alike drugs (7-8). The latter include drugs that are quite different but are delivered in similar packaging which thus causes a potential for confusion errors. The Swedish network Collaboration for Safe Health Care has estimated that nearly 6,000 patients are injured in the Swedish health-care system due to drug mix-ups every year (9). Of these, 750 events are considered to be serious or disastrous. It is thus of pivotal importance to find methods that could reduce medication errors through safe systems of organising and storing drugs.

Project organisation

Inquirer
The Department of Medicine Management and Informatics, Regional Office, Region Skåne (Enheten för läkemedelsstyrning, Koncernkontoret, Region Skåne)

Project members from the profession
Åsa Bondesson, Pharmacist, PhD Pharm, The Department of Medicine Management and Informatics, Regional Head Office, Region Skåne asa.bondesson@skane.se
Ingrid Wallström, Pharmacist, The Hospital of Ystad ingrid.wallstrom@skane.se
Kerstin Roos, Nurse, Skåne University Hospital kerstin.roos@skane.se
Anna Bergkvist-Christensen, Pharmacist, PhD Pharm, The Department of Medicine Management and Informatics, Regional Head Office, Region Skåne anna.bergkvistchristensen@skane.se

Project members from the HTA unit
Matthias Bank, Medical Librarian, Medicinal faculty, Lund University
Kristina Ellingjord Johansson, Librarian, Skåne University Hospital Library, Lund
Göran Hollenby, Informatician, Regional HTA Unit, Region Skåne
Martin Laurell, MD, PhD, SC. Head of Regional HTA Unit, Region Skåne

External reviewer
Karin A. Henricson, Pharmacist, Dr Med Sci. Pharmaceutical unit, Staff for Operational Development, Skåne University Healthcare Office

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Clinical question

What can be done to reduce the risk of medication errors in a ward setting when the prescribed medications are picked from the shelf, handled, and dispensed?

Limitations: The clinical question concerns medication errors occurring when nurses pick, handle, and dispense medications to adult patients in a ward excluding direct delivery to the patient.

<table>
<thead>
<tr>
<th>P</th>
<th>Patients</th>
<th>Adult patients in a ward setting. ICUs (Intensive Care Units) not included</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Intervention</td>
<td>Medication errors due to human factors associated with mistakes when the prescribed medications are picked from the shelf, handled, and dispensed</td>
</tr>
<tr>
<td>C</td>
<td>Control/Comparison</td>
<td>Not applicable</td>
</tr>
<tr>
<td>O</td>
<td>Outcome</td>
<td>Eligible outcome parameters: patient mortality, morbidity, or any reported harm or quality deviation report</td>
</tr>
</tbody>
</table>

Magnitude of the problem

Although the true incidence of medication errors in wards is unknown, a previous review reports a median error rate of 19.6% (IQR/Interquartil Range 8.6-28.3%), (10).

The Swedish network Collaboration for Safe Health Care has estimated that nearly 6,000 patients are injured in the Swedish health-care system due to drug mix-ups every year (9). Of these, 750 events are considered to be serious or disastrous. Almost 200,000 patient ward episodes are yearly recorded at hospitals in Skåne county, which potentially equals 600 medical errors every year.

Medication errors lead to potentially serious adverse effects among patients, lengthen of hospital stay, reduction of patient quality of life all of which increases health-care costs. Errors can also cause psychological trauma for the staff involved.

Literature search and selection

Systematic literature searches were conducted in January and February of 2012 in the Embase, PubMed, Cochrane Library, and CINAHL databases as well as in a number of HTA databases.

On 7 Oct. 2015, four updated literature searches were conducted in Embase (including Medline), and one search in Cochrane Library. Key words and search terms were chosen with the PICO as a starting point. After the removal of duplicates altogether 556 articles were identified eligible for assessment.

Two librarians conducted the primary searches and independently read and selected 249 articles which were sent to the project group for assessment. Another informatics specialist made subsequent literature searches in the HTA databases in May 2012 and in June 2012 in the Embase database. If in doubt as to whether an article should be included, the article was sent to the project group.
The search strategies, limitations, and selection process are reviewed in Appendix 1 and in the flow chart. The number of references and the selection are shown in Appendix 2. The two primary articles are presented in Appendix 3, and the excluded articles are presented in Appendix 4.

Members of the project group read the articles independently and decided in consensus which articles should be included in the analysis.
Results

Two studies reporting on a total of 710 medication error events fulfilled the P and I of the PICO criteria. The publications were observational studies without controls and of poor methodological quality. The primary outcome in both studies was the occurrence of medication error rates and type of errors as an effect of the medication storage system. Both studies concluded that when medications are issued at the patient’s bedside they are more likely to be well-timed and less likely to be omitted. No outcome data for mortality, morbidity or other specified adverse events were reported. As a consequence, the study results are presented in a narrative manner omitting statistics. For study details, see Appendix 3.

Conclusion

Medication errors are common and are less likely to occur when using medication trolleys/bedside systems compared to a ward bay. 
Quality of evidence: GRADE (+○○○) - very low level of evidence

Recommendations from experts and professional organisations

Institute for Safe Medication Practices (ISMP)
1. Establish guidelines for safe storage and handling
   - limit access (eliminate)
   - reduce options (avoid stocking different strengths of the same drug)
   - reduce “look-alike” potential (Tall Man lettering, storage at different locations, bold face lettering)
   - require redundancies (independent double check)
   - educate staff
   - employ technology (bar coding, automated dispensing technology)
   - educate patients
   - monitor patients (implement policies)

2. Focus on high-alert medications (drugs that bear a heightened risk of causing significant patient harm when errors occur), including: insulin, heparin, opioids, concentrated injectable potassium chloride/phosphate, neuromuscular blocking agents, and chemotherapy drugs. [http://www.ismp.org/](http://www.ismp.org/)


The Joint Commission on Accreditation of Healthcare Organizations (JCAHO)
- Maintain awareness of problematic product names and error prevention recommendations provided by the ISMP (Institute for Safe Medication Practices), FDA (Food and Drug Administration), and USP (US Pharmacopeial Convention).
- Develop processes for managing high-alert drugs.
- Identify and, at a minimum, annually review a list of look-alike/sound-alike drugs used in the organisation, and take action to prevent errors involving the interchange of these drugs.

The World Health Organization (WHO)
- Drugs are arranged in alphabetical order of generic names.
- Each dosage form of a drug is arranged in separate and distinct areas.
• Sufficient empty space should demarcate one drug or dosage form from another. 

Vårdhandboken
Storage is done according to the manufacturer and may be divided into four groups:
• drugs for injection
• other drugs for internal use
• drugs for external use
• drugs requiring refrigeration
Within the groups, the drugs are stored in alphabetical order or in the order of the pharmacological ATC system. 
  [http://www.vardhandboken.se/Texter/Lakemedelshantering/Oversikt/](http://www.vardhandboken.se/Texter/Lakemedelshantering/Oversikt/)

Statens beredning för medicinsk och social utvärdering (SBU)
No support to suggest that storing drugs in the order of the pharmacological ATC system reduces the risk of medication errors. 

Ongoing research, knowledge gaps and unanswered questions

The Swedish network Collaboration for Safe Health Care
The Swedish network Collaboration for Safe Health Care, in 2010, initiated a project to reduce the risk of medication mix-ups by using safer medication packages. The project is still on-going (July 2015), and a standardised medication packaging has been proposed with the following features:
• a standardised allocation of the information label
• a prominent generic name
• a particular marking for solutions that are to be diluted
• a non-standardised colour for different medicine strengths
• Tall Man lettering\(^1\) for selected medications
• a particular colour for specific “high-alert” drugs
• non-transparent labels
For more information, see [http://www.patientforsakring.se/Lakemedelsforvaxlingar.html](http://www.patientforsakring.se/Lakemedelsforvaxlingar.html).

As mentioned, no studies were found that addressed the effect of storage in the ATC order versus alphabetic order, the use of Tall Man Lettering, the use of high-alert medication lists, or the use of separate storage on the medication error rate.

There is currently no Swedish national definition of which drugs are considered to be high-alert medications. There is neither any consensus of look-alike nor sound-alike medications that are candidates for likely being mixed-up. However one Swedish study based on nurses’ views on the likelihood and consequences of mix-up drugs have been published (11).

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\(^1\) Tall Man lettering is the practice of writing part of a drug’s name in capital letters to help distinguish sound-alike and look-alike drug names from one another in order to avoid medication errors. In the US, the Food and Drug Administration (FDA) Centre for Drug Evaluation and Research and the Institute for Safe Medication Practice (ISMP) have published a list of look-alike drug names with the recommended Tall Man letters. For more information, see [https://www.ismp.org/tools/tallmanletters.pdf](https://www.ismp.org/tools/tallmanletters.pdf).
References


**Literature searches**

Kristina Ellingjord Johansson, Librarian, Skåne University Hospital Library, Region Skåne, Matthias Bank, Medical librarian, Library & ICT, Faculty of Medicine, Lund University and Göran Hollenby, Informatician, HTA unit, Region Skåne conducted the literature searches.

Duplicates were sorted out on 6 Feb. 2012 by KEJ, MB, and GH. No publication date limits were used for the searches below, apart from search 4 which was limited to 2009–2012. The updated literature searches were conducted on 7 Oct. 2015.
Appendix 1 – Search strategies

1. **Search strategy in Embase** (including Medline) - Medication errors and drug storage/storerooms
   Result: 60 hits, 2012-01-05
   
   `"drug storage'/exp AND 'medication error'/exp/mj`

2. **Search strategy in Embase** (incl. Medline) - Medication errors and high-alert medications, Reviews
   Result: 7 hits, 2012-01-05
   
   `('high-alert medications' OR 'high-alert medication' OR 'high-risk medications' OR 'high-risk medication') AND ('medication error'/exp OR 'medication error' OR 'drug administration error' OR 'drug administration errors')`

   Limited to literature reviews.

3. **Search strategy in Embase** (incl. Medline) - Medication errors and the ‘human factor’
   Result: 107 hits, 2012-01-05. Limited to references in English, Danish and Swedish.
   
   `"nurse'/exp/mj OR 'hospital personnel'/exp/mj AND 'medication error'/exp/mj`

   Result: 15 hits, 2012-02-01
   (BCMA=Bar Code Medication Administration.)
   
   `"medication error'/exp AND ("bar code assisted medication administration" OR bcma OR "automated dispensing systems")`

5. **Search strategy in PubMed** - Medication errors and bar code-assisted medication
   Result: 25 hits, 2012-02-02
   
   `("medication errors"[MeSH Terms] OR ("medication"[All Fields] AND "errors"[All Fields])) OR "medication errors"[All Fields] AND ("automatic data processing"[MeSH Terms] OR ("automatic"[All Fields] AND "data"[All Fields] AND "processing"[All Fields])) OR "automatic data processing"[All Fields] OR ("bar"[All Fields] AND "code"[All Fields] OR "bar code"[All Fields]) AND assisted[All Fields] AND ("pharmaceutical preparations"[MeSH Terms] OR ("pharmaceutical"[All Fields] AND "preparations"[All Fields])) OR "pharmaceutical preparations"[All Fields] OR "medication"[All Fields])`

6. **Search strategy in PubMed** - Medication errors and drug storage
   Result: 102 hits, 2012-02-02
   
   `("medication errors"[MeSH Terms] OR ("medication"[All Fields] AND "errors"[All Fields])) OR "medication errors"[All Fields] AND ("drug storage"[MeSH Terms] OR ("drug"[All Fields] AND "storage"[All Fields])) OR "drug storage"[All Fields])`

7. **Search strategy in PubMed** - Medication errors and high-alert medications
   Result: 38 hits, 2012-02-02
8. Search strategy in PubMed - Medication errors and human factors
Result: 161 hits, 2012-02-02

9. Search strategy in the Cochrane Library - Medication errors and storage
Result: 4 hits, 2012-01-16
Kristina Ellingjord Johansson searched for 'medication errors storage' and this resulted in 4 articles but no reviews.

Result: 5 hits, 2015-10-07. The last reference below (Irwin et al.) is new compared with the search 2012-01-16.


10. Search in CINAHL – ‘Medication errors’ AND ‘high-alert medications’ in the text fields
Result: 30 hits, 2012-02-15

Kristina Ellingjord Johansson searched in the text fields for ‘medication errors AND high-alert medications’. This resulted in 30 references to articles, but no relevant hits were retrieved that had not been found in the other databases.

11. Additional searches in Embase (including Medline) – The ATC code order

<table>
<thead>
<tr>
<th>#</th>
<th>Searches</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>'atc':ab,ti OR 'anatomical therapeutic chemical':ab,ti</td>
<td>2,656</td>
</tr>
<tr>
<td>2</td>
<td>'drug storage'/exp OR store*:ab,ti OR storage*:ab,ti OR room*:ab,ti OR reservoir*:ab,ti OR depositor*:ab,ti</td>
<td>370,261</td>
</tr>
<tr>
<td>3</td>
<td>#1 AND #2</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>#3 AND hospital*</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>'drug storage'/exp OR 'drug storage'</td>
<td>8,601</td>
</tr>
<tr>
<td>6</td>
<td>hospital NEAR/3 storage</td>
<td>207</td>
</tr>
<tr>
<td>7</td>
<td>hospital NEAR/3 'store room'</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>hospital NEAR/3 reservoir*</td>
<td>852</td>
</tr>
<tr>
<td>9</td>
<td>hospital NEAR/3 depositor*</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>hospital NEAR/3 depositor*</td>
<td>2</td>
</tr>
</tbody>
</table>
No relevant references were found among the new hits.

12. Searches in HTA databases
Searches were also carried out during May 2012 in a number of HTA databases and on HTA sites, but no relevant hits were found.

13. Number of articles before removal of duplicates

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</tr>
<tr>
<td>13</td>
<td>#6 OR #7 OR #8 OR #9 OR #10</td>
<td>1,086</td>
<td></td>
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<tr>
<td>15</td>
<td>#1 AND #5</td>
<td>0</td>
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<tr>
<td>16</td>
<td>#6 OR #7 OR #8 OR #9 OR #10 AND ('drug storage'/exp OR store*:ab,ti OR storage*:ab,ti OR room*:ab,ti OR reservoir*:ab,ti OR repositor*:ab,ti OR depositor*:ab,ti)</td>
<td>288</td>
<td></td>
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<tr>
<td>17</td>
<td>#1 AND #16</td>
<td>0</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>18</td>
<td>'atc':ab,ti OR 'anatomical therapeutic chemical':ab,ti AND (storage* OR 'store room' OR storeroom)</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

14. Number of articles after removal of duplicates and screening by KEJ, MB, and GH

556 (285 from PubMed, 185 from Embase and 86 from Embase including Medline)

15. Number of articles sent to and screened by the project group

249 (77 from PubMed, 86 from Embase and 86 from Embase including Medline)

16. Number of articles assessed for eligibility by the project group

139

17. Number of articles evaluated by the project group

22

18. Number of articles nominated for inclusion in the final report

2
Appendix 2 – Selection process – flow chart

Drug safety – how to optimally organise the storage of medications in a ward setting

Records identified through database searching (n = 661)

Records after duplicates removed (n = 556)

Records screened by library (n = 556)

Abstract in full-text articles assessed for eligibility by library (n = 249)

Full-text articles assessed for eligibility by project group (n = 139)

Articles evaluated by project group. See Appendix 4 (n = 22)

Full-text articles included in synthesis. See Appendix 3 (n = 2)

Records excluded by library because they did not fulfil PICO or other eligibility criteria (n = 307)

Abstracts excluded by library because they did not fulfil PICO or other eligibility criteria (n = 110)

Full-text articles excluded by project group (n = 117)
### Appendix 3 – Summary of included studies

<table>
<thead>
<tr>
<th>Author, (year) country</th>
<th>Study type</th>
<th>Methods</th>
<th>Characteristics of samples</th>
<th>Data analysis</th>
<th>Major findings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher, M., et al (2001) Australia</td>
<td>Prospective observational</td>
<td>Observation of errors occurring during preparation and administration of medications Storage and issued of medications in a ward bay vs. a medication trolley at the patient’s bedside</td>
<td>340 observations for errors in a surgical ward</td>
<td>Descriptive statistics and Chi-square statistics</td>
<td>Observed errors 20 (5.8%) When medication trolley 4 (2.6%) When ward bay 15 (9.2%) Significant more errors when medication from ward bay ($X^2 = 4.47; p = 0.034$)</td>
<td>Inter observer reliability was 1.0 Observational bias risk Presence of the observer might have positively or negatively influenced the drug administration process Single site study Small sample</td>
</tr>
<tr>
<td>Camac, KJ., et al (1996) Australia</td>
<td>Prospective observational</td>
<td>Observation of errors occurring during preparation and administration of medications Storage and issued in a ward bay vs a locked drawer at the patient’s bedside</td>
<td>370 observations for errors were observed during five eight-hour shifts in a surgical ward</td>
<td>Descriptive statistics and Chi-square statistics</td>
<td>Observed errors 47 (12.7%). Using bedside system 7 (6.8%), Using the ward bay 39 (16 %).</td>
<td>Inter observer reliability was consistent Observational bias risk Presence of the observer might have positively or negatively influenced the drug administration process Single site study Small sample Injections excluded from analysis</td>
</tr>
</tbody>
</table>
## Appendix 4 – Excluded studies

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Motivation for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribe International, 2004</td>
<td>Not relevant, only about the French medication error-reporting program, type of errors, main causes, and contributing factors.</td>
</tr>
<tr>
<td>Joint Commission of Accreditation of Healthcare Organization, 2005</td>
<td>Not relevant, only provided requirements for programs to minimize risks for errors.</td>
</tr>
<tr>
<td>Benjamin MN, 2003</td>
<td>Not relevant, only patient case studies.</td>
</tr>
<tr>
<td>Bergqvist M, 2009</td>
<td>Not relevant, too general of an article.</td>
</tr>
<tr>
<td>Bergqvist M, 2010</td>
<td>Not relevant, only a description of medication errors reported to the National Board of Health and Welfare.</td>
</tr>
<tr>
<td>Alvarez Diaz AM, 2009</td>
<td>Not relevant, deals only with types of errors, main causes, and contributing factors when introducing new technologies.</td>
</tr>
<tr>
<td>Bertsche T, 2008</td>
<td>Not relevant, deals only with strategies for preventing medication handling.</td>
</tr>
<tr>
<td>Brady A-M, 2009</td>
<td>Not relevant, deals with individual and system factors that contribute to medication errors in nursing practice, but not storage.</td>
</tr>
<tr>
<td>Cohen MR, 1994</td>
<td>Not relevant, only about look-alike names.</td>
</tr>
<tr>
<td>Hakonsen H, 2010</td>
<td>Not relevant, only deals with generic substitutions.</td>
</tr>
<tr>
<td>Hellman R, 2004</td>
<td>Not relevant, only deals with analysis and redesign of systems to develop a “culture of safety”.</td>
</tr>
<tr>
<td>Lisby M, 2005</td>
<td>Not relevant, deals only with the prevalence of errors, stages of errors, and type of errors.</td>
</tr>
<tr>
<td>Nair, 2010</td>
<td>Not relevant, only about dispensing errors from a pharmacy point of view.</td>
</tr>
<tr>
<td>Reeve JF, 2005</td>
<td>Not relevant, only two case reports.</td>
</tr>
<tr>
<td>Runy LA, 2004</td>
<td>Not relevant, only considers high-alert medications and case studies.</td>
</tr>
<tr>
<td>Schulmeister L, 2006</td>
<td>Not relevant, only considers look-alike and sound-alike oncology medications.</td>
</tr>
<tr>
<td>Simmons D, 2009</td>
<td>Not relevant, deals with the environment.</td>
</tr>
<tr>
<td>Sundhagen R, 2006</td>
<td>Not relevant, deals only with barcoding.</td>
</tr>
<tr>
<td>Arinal MF, 2014</td>
<td>Not relevant, deals with reported medication errors.</td>
</tr>
</tbody>
</table>