IMPACT OF TELEPHARMACY SERVICES ON THE IDENTIFICATION OF MEDICATION DISCREPANCIES, HIGH-ALERT MEDICATIONS, AND COST AVOIDANCE AT RURAL HEALTHCARE INSTITUTIONS

Ross J Bindler DPharm

College of Nursing, Washington State University, Spokane, Washington, USA

Abstract

Telepharmacy, remote reviewing and profiling of medication orders by an offsite pharmacist, has been shown to be an effective method for reducing medication order inaccuracy rates, but there is a lack in studies examining harm reduction and potential cost avoidance by such services. **Methods:** Retrospective data, collected over a one-year period, were examined for medication order deficiencies; a deficiency was defined as the telepharmacist being required to advocate for clinical action. Based on published rates of adverse drug reactions and expenses related to their treatment, a potential cost avoidance was calculated. **Results:** Over the course of the one-year study period over 218,000 orders were reviewed by a telepharmacist with 2,292 orders flagged as deficient which included 16,224 individual medication deficiencies. The most common deficiencies included patient allergy to medication, or class of medications, (31.2% of deficiencies) and medication dose adjustment via renal and/or hepatic guidelines (24.1% of deficiencies). There were also a number of deficiencies for specific medications found on the Institute for Safe Medication Practices' high-alert medication list for ambulatory/community healthcare settings such as insulins and heparinoids. Based on adverse drug reaction incidence rates and treatment expenses, potential cost avoidance was calculated to be as high as over $1.4 million US dollars. Telepharmacists aided in enhancement of pharmacy services by continuing to review medication orders and provide clinical interventions even when an onsite pharmacist was unavailable. **Conclusions**: Use of the telepharmacist service provided a large cost avoidance by the prevention of potential adverse drug reactions.

Keywords: adverse drug reaction; pharmacist; medication error; rural health; telemedicine
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Introduction

Telepharmacy is considered to be the reviewing and profiling of prescriber medication orders by a pharmacist from a remote site.[1] Hospital error event monitoring programmes and multiple studies have shown that the use of telepharmacy has led to a reduction in the rates of prescribing inaccuracies.[2-5] Despite the noted benefits of telepharmacy, it is not yet extensively used within rural institutions, which typically require additional support due to a limited supply of pharmacists.[2,6] Telepharmacy based systems have the ability to enhance pharmacy services in smaller rural institutions by actively reducing prescribing errors, countering the severe shortage of pharmacists, and improving patient safety in these clinics and hospitals.[1,2,7]

Many states have not yet adopted regulations regarding the use of telepharmacy within institutions, especially rural hospitals, as many are not Joint Commission, an independent, non-profit endorser of healthcare organisations and programmes, accredited.[2] Joint Commission certification is a major reason why larger hospitals have adopted telepharmacy for afterhours medication order review.[2] The time required to process an order significantly decreased at multiple hospitals after the implementation of telepharmacy services while the number of documented clinical interventions performed by pharmacy services, staff and telepharmacists, increased.[1,8] There were large increases in chart reviews, medication clarifications, dosing adjustments, medication based teaching, discharge education and warfarin follow-up by the staff pharmacists; there was also a significant increase in nurses' global satisfaction.[1]

Although there has been one study that indicated cost savings after initiation of telepharmacy services, studies evaluating the potential cost avoidance in conjunction with prescriber deficiency rates, adverse drug reactions (ADRs) and high-alert medications are lacking.[9-11] Current gaps in the literature exist in regard to cost avoidance by using telepharmacy services. The aims of this study were to i) review a sample set of medication order deficiencies (prescribing errors and pharmacist clinical activities)

identified by a telepharmacist over a one-year period, ii) illustrate the frequencies of deficiencies in relation to high-alert medications, and iii) extrapolate potential cost avoidances based upon the deficient orders after initiation of telepharmacy services.

Methods

The study used a retrospective design in which de-identified patient information, collected from June 2013 to May 2014, was reviewed for multiple types of deficiencies and subsequent telepharmacist initiated interventions. All prescriber orders from 27 rural institutions verified by telepharmacists employed in Eastern Washington over a one-year period were acquired via an unsolicited data request. The complete order sets were reviewed and verified in DocuScripts for any possible deficiency; orders with confirmed deficiencies were then exported into Microsoft Excel 2013. Multiple data elements were extracted from deficient orders including non-identifying demographic information, the medication(s) ordered, information regarding the prescribed medication(s), and the pharmacist's recommendation, and whether the recommendation was accepted or declined and if declined by the prescriber as well as their clinical justification.

For the purposes of the study, deficiencies consisted of multiple endpoints in which the telepharmacists were required to advocate for specific clinical action. A comprehensive list of all of the deficiencies being examined during the one-year study period were:

- a documented allergy to the medication (or a similar medication) that the prescriber ordered
- any telepharmacist initiated dose adjustment for renal and/or hepatic dysfunction
- any medication dose adjustment for geriatric patients
- any medication dose adjustment for paediatric patients
- therapeutic duplications were also monitored
- orders for a medication that was contraindicated in a particular patient
- use of an inappropriate form, dose, frequency, or route of a medication
- situations in which additional laboratory assessments were required in order to receive a medication
- any medication-medication interaction
- any telepharmacist directed medication dosing.

The high-alert medications described in the manuscript are from the Institute for Safe Medication Practices (ISMP) list for the community and ambulatory healthcare setting.[12] All of the classes/categories of medications that were listed, as well as the specific medications, were researched by using Microsoft SQL Server 2014 and SPSS version 23. The results were then documented and basic statistics were completed using Microsoft SQL Server 2014 and SPSS version 23.

The incidence rates of ADRs that were used came from references indicating ADRs occur at a frequency ranging from two to seven events per 100 admissions.[13-16] Cost information identified indicated US dollar amounts of the treatment of an individual ADR can range anywhere from $677 for pruritus to $9,022 for drug-induced fever; however other sources described varying cost information.[13] Another source cited $4,685 for the treatment of an average ADR which was consistent with the previously mentioned figures.[17] Potential costs could reach $38,007 in patients with more severe ADRs such as arrhythmias, bone marrow depression, seizures, or bleeding.[18] A range of the values cited for potential cost avoidance information and rounding were used as the calculated values are solely estimates, and the majority of ADRs (eg, nausea, constipation, headache, etc.) are not as expensive as the most severe events.[19,20] Microsoft Excel 2013 was used to calculate all cost information in the current study.

As previously described, after deficiencies were documented they were transferred to Microsoft Excel 2013 for further evaluation; all data were stored in a password-protected and encrypted Microsoft Excel 2013 spreadsheet. Microsoft SQL Server 2014 was used for non-aggregate data evaluation and analysis as well as basic aggregate data such as counts while SPSS version 23 was used for descriptive statistics such as frequencies.

All procedures followed throughout the course of the present study were in accordance with the ethical standards of the Helsinki Declaration and its later amendments as well as other location-specific comparable ethical standards. The study was ruled exempt by the Washington State University Institutional Review Board due to the use of completely de-identified data in a retrospective manner.

Results

Deficiencies

Over the one-year study period, 381,275 total prescriptions and 218,568 total orders were reviewed by telepharmacists located in Eastern Washington. There were 16,224 deficiencies in prescriptions (4.3% of all prescriptions) and 2,292 deficiencies in the orders (1.1% of the orders) noted by a telepharmacist during the study period (Table 1). The most common deficiency throughout the study was a medication prescribed to a patient with an allergy to the agent or another similar medication (n=714; 31.2%). Second on the list was the need for a telepharmacist to dose the medication per renal or hepatic dysfunction guidelines (n=553; 24.1%). Therapeutic duplications (n=305; 13.3%) and an inappropriate form, dose frequency and/or route (n=289; 12.6%) were the next most common deficiencies. Telepharmacists were also often requested to dose patients' medications (n=120; 5.2%) or needed to ask for additional laboratory data in order to safely approve the use of the

Table 1. Description of documented deficiencies.

Type of Deficiencies	Frequency (N=2,292)	% of Total Deficiencies
Allergy and/or adverse reaction to the medication (or a similar medication)	714	31.2%
Renal and/or Hepatic Dosage Adjustment Required	553	24.1%
Therapeutic duplication	305	13.3%
Inappropriate form, dose, frequency, or route judged by the order-entry pharmacist	289	12.6%
Pharmacy to dose prescribed medication (pharmacy consultation)	120	5.2%
Laboratory data recommended or requested	98	4.3%
Geriatric dosage adjustment	59	2.6%
Contraindication to prescribed medication	56	2.4%
Medication-medication interaction	52	2.3%
Paediatric dosage adjustment	46	2.0%

Table 2. Classes/categories of high-alert medications in community and ambulatory healthcare.

Class/Category	Number of Deficiencies	Reasons for Deficiencies
Antiretroviral Agents	Total: 1 • Darunavir: 1	• Inappropriate dose
Oral Chemotherapeutic Agents	Total: 1 • Raloxifene :1	• Inappropriate frequency
Hypoglycaemic Agents	Total: 5 • Glimepiride: 1 • Glipizide: 3 • Glipizide/metformin: 1	• Drug allergy • Therapeutic duplication • Inappropriate frequency • Pharmacy to dose
Immunosuppressant agents	No immunosuppressants ordered	N/A
All Formulations of Insulin	Total: 18 • Insulin detemir: 6 • Insulin glargine: 4 • Insulin lispro: 4 • NPH insulin: 1 • Regular insulin: 1 • Unspecified insulin: 2	• Therapeutic duplication • Inappropriate dose • Inappropriate frequency • Inappropriate route
Opioids	Total: 317 • Hydrocodone/acetaminophen: 86 • Morphine sulphate: 70 • Hydromorphone: 65 • Oxycodone: 29 • Oxycodone/acetaminophen: 23 • Acetaminophen/codeine: 13 • Hydrocodone: 12 • Meperidine: 8 • Tramadol: 6 • Promethazine/codeine: 2 • Diphenoxylate/atropine: 1 • Methadone: 1 • Pentazocine/naloxone: 1	• Drug allergy • Paediatric dosing adjustment • Inappropriate dose • Inappropriate frequency • Therapeutic duplication • Contraindication • Inappropriate frequency • Adverse event • Inappropriate route • Geriatric dosage adjustment • Renal dosing required • Inappropriate form • Medication intolerance • Contraindication
Paediatric Liquid Medications that Require Measurement	Total: 32 • Acetaminophen/codeine: 1 • Acetaminophen: 1 • Acyclovir: 2 • Azithromycin: 4 • Epinephrine: 1 • Esomeprazole: 1 • Famotidine: 1 • Gentamicin: 3 • Ibuprofen: 5 • Ketorolac: 2 • Magnesium gluconate: 1 • Methylprednisolone: 5 • Oseltamivir:3 • Promethazine/dextromethorphan: 1 • Piperacillin/tazobactam: 1	• Paediatric dosing adjustment
Pregnancy Category X Medications	No contraindicated medications ordered.	N/A

prescribed medication (n=98; 4.3%). Geriatric dosage adjustments (n=59; 2.6%), rejection of the order due to a noted contraindication (n=56; 2.4%), medication-medication interactions (n=52; 2.3%) and paediatric dosage adjustments (n=46; 2%) completed the list.

Multiple orders for high-alert classes and/or categories of medications throughout the study period were found to have deficiencies (Table 2).

One order for an antiretroviral agent, darunavir, was found to be deficient due to an inappropriate dose. Raloxifene, the only oral antineoplastic agent noted during the study period, was found to have a deficient order due to being prescribed at an inappropriate frequency. Sulfonylureas were the only oral hypoglycaemic agents ordered that were found to have deficiencies and the group included glimepiride (n=1), glipizide plus metformin in a fixed dose combination product (n=1) and glipizide alone (n=3). Insulin detemir (n=6) was the most common insulin product with a documented deficiency followed by insulin glargine and insulin lispro (both n=4), then orders for an unspecified insulin (n=2), followed by NPH insulin and regular insulin (both n=1). There was a total of 317 deficiencies noted during the ordering of opioids with the hydrocodone/acetaminophen combinations having the most (n=86), followed by morphine sulphate (n=70), hydromorphone (n=65), oxycodone alone (n=29) or in combination with acetaminophen (n=23), acetaminophen with codeine (n=13), hydrocodone alone (n=12), meperidine (n=8), tramadol (n=6), promethazine with codeine (n=2) diphenoxylate and atropine (n=1), methadone (n=1) and pentazocine in combination with naloxone (n=1). Finally, there were 32 deficiencies noted in medications which require measurements in paediatric patients with ibuprofen and methylprednisolone (both n=5) being the most common. There were no deficiencies noted in orders for immunosuppressant medications or those agents that are considered a pregnancy category X prescribed to a pregnant patient.

For specific medications (Table 3) there were two orders for carbamazepine that were deficient due to an inappropriate dose and the prescriber requesting the telepharmacist to dose the medication. Heparinoids had the most deficiencies of any medication, consisting of five deficient orders for unfractionated heparin and 170 orders of enoxaparin; there were no orders for daltaparin that were considered deficient. The reasons for deficiency in the orders for heparinoids included: the patient required renal dosing; additional laboratory values were needed; the telepharmacist was being requested to dose the medication; therapeutic duplication, the medication was being ordered at an inappropriate frequency or dose; the patient had previously experienced an adverse event with the medication; or a geriatric dosage adjustment was needed.

Another high-alert medication, metformin, had 18 total deficiencies including 17 as a stand-alone medication and once in a combination product. The reasons identified for deficiencies included inappropriate frequency, a contraindication was noted, and renal dosing was needed. One order of methotrexate for non-oncologic therapy was found to have a noted deficiency which was due to a potential medication-medication interaction. Finally, there were 25 deficiencies noted when prescribers were ordering warfarin with additional laboratory data needed, presence of a therapeutic duplication, the telepharmacist was requested to dose the medication, or the patient had previously experienced an adverse event with a coumarin. Chloral

Table 3: Specific medications of high-alert in community and ambulatory healthcare.

Medication	Number of deficiencies	Reasons for Deficiency
Carbamazepine	Total: 2	• Inappropriate route • Pharmacy to dose
Chloral hydrate liquid for the sedation of children	Total: 0	N/A
Heparin (both unfractionated and low molecular weight heparin)	Total: 175 • Unfractionated heparin: 5 • Enoxaparin: 170	• Renal dosing required • Laboratory values needed • Pharmacy to dose • Therapeutic duplication • Inappropriate frequency • Inappropriate dose • Adverse event • Geriatric dosing adjustment
Metformin	Total: 18 • Metformin: 17 • Glipizide/metformin: 1	• Inappropriate frequency • Contraindication • Renal dosing required • Contraindicated
Methotrexate for non-oncologic therapy	Total: 1	• Drug Interaction
Midazolam liquid for the sedation of children	Total: 0*	N/A
Propylthiouracil	Total: 0	N/A
Warfarin	Total: 25	• Laboratory data requested • Therapeutic duplication • Pharmacy to dose • Adverse event
*There were deficiencies related to the prescribing of midazolam found in the current study, but none of the issues were related to the prescribing of the medication for the sedation of children.		

hydrate for the sedation of children was not used during the study period; similarly, midazolam liquid for the sedation of a child was not ordered within the study period. Finally, there were no orders for propylthiouracil.

Cost avoidance

Based on the quantified deficiencies cost avoidance information was then extrapolated (Table 4). Using a 2% adverse event rate there were roughly 46 events avoided secondary to having a telepharmacist review the order set and identifying the documented deficiencies. This calculated to be an avoidance of roughly $27,504 to $412,506 US dollars. Using the 7% adverse event rate there was a potential of about 161 ADRs avoided which reflects a $96,264 to $1,443,960 cost savings by using telepharmacy services.

Table 4. Potential adverse events and cost avoidance.

	2% adverse event rate	7% adverse event rate
Number of potential events	45.8	160.4
Potential cost of events at $600.00 per event	$27,504	$96,264
Potential cost of events at $9,000.00 per event	$412,506	$1,443,960

Discussion

This study included a retrospective review of 381,275 total prescriptions and 218,568 total orders. There were 16,224 deficiencies in prescriptions (4.3% of all prescriptions) and 2,292 deficiencies in the orders (1.1% of the orders) identified over the course of the one-year data collection period. Telepharmacists in this study helped to enhance pharmacy services by continuing to check orders and perform clinical interventions when staff pharmacists were not available. Multiple clinical services were provided including examining patients' profiles, ordering laboratory assessments as well as dosing and dose adjusting medications. There was also potential cost avoidance estimated by avoiding preventable ADRs in the patient population monitored.

This was the first study to examine the rate of order set deficiencies in relation to the ISMP's list of high-alert medications. Data indicated that there were many deficiencies noted when these medications were prescribed. The class of medication with the most deficiencies was the heparinoids with enoxaparin having the highest number of deficiencies. This finding demonstrated that even though these medications are listed as high-alert they still need extra monitoring as prescribing errors do occur.

No other study has examined rates of potential harm prevention in orders that had documented deficiencies. Incidence rates of ADRs used were based on published data that indicated there are still multiple preventable errors that can lead to ADRs.[13-16] Based on published ADR treatment cost data, the present study showed that with telepharmacy services there is a potential cost avoidance.[13,17-20]

Limitations of this study included a relatively small sample size from rural healthcare institutes, it was retrospective and not an RCT, there was no comparison group, and there was not a direct cost-analysis (estimates were extrapolated from formulas suggested in the literature), the charts did not contain pregnancy data, and there was lack of demographic data for the patients whose charts were reviewed. Data could only be provided after all insurance billing was completed and the data de-identified. Due to the listed limitations, the results of this study would not apply to larger healthcare centres in densely populated areas that include 24-hour onsite pharmacy staff and needs to be confirmed with long-term, prospective RCTs that includes comparator group(s). At this time further research is needed to evaluate the impact that the current study's limitations have on the calculated cost avoidance.

However, this study corroborates previous findings and suggests that use of telepharmacists to review all orders in rural facilities would help promote safety and provide clinical services which potentially results in substantial cost avoidance. Ways to provide these services in the rapidly evolving times of the electronic health record and mandatory prescribing alerts should be explored further. Future research could focus on determining the number and types of discrepancies for a period before and after telepharmacy services were available, and calculating the required telepharmacist workload and cost. Alternative approaches to reduce medication discrepancies could be examined including use of patient demographics to highlight those most at risk, or provision of educational information to identified prescribers or groups of prescribers.

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Corresponding author:
Ross J Bindler
Washington State University College of Nursing
PO Box 1495
Spokane, WA 99210-1495
eMail: rossb4@wsu.edu

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