Pharmacy Practices and Technologies: Evidence for Effectiveness and Adoption into Canadian Hospital Pharmacy Practice

Aurélie Guérin, Kevin Hall, and Jean-François Bussières

INTRODUCTION

Significant progress has been made in the adoption of evidence-based decision-making by clinical pharmacy practitioners. However, in other areas of pharmacy practice, such as drug distribution, evidence-based decision-making appears to be more limited. Eriksson[1] recently reinforced the need for pharmacists to identify and use trusted sources of information for decision-making in all areas of pharmacy practice, in order to optimize patient health outcomes. One important area where evidence-based decisions are needed relates to the use of certain practices and technologies in the drug-use process. In particular, it is of interest to know how long it takes the pharmacy profession to implement evidence-based practices and technologies.[2]

We hypothesized that the adoption of innovations in pharmacy practice has been as slow as the reported adoption of health care innovation more generally,[2] in terms of rate of uptake of evidence-based practices, such as unit-dose drug distribution systems, centralized IV admixture systems, and decentralization of pharmacists working in patient care programs. The aim of this exploratory study was to examine the adoption of new pharmacy practices and technologies in Canadian hospitals and the relationship between actual adoption and published evidence supporting adoption.

DESCRIPTION OF THE PRACTICE

Four pharmacy practices and technologies were chosen for this study: obtaining a medication history or performing medication reconciliation, use of smart pumps, bar code medication administration, and computerized prescriber order entry (CPOE). The selection was based on the level of interest and discussion that these practices and technologies have generated, as well as the availability of data to facilitate studying them. For each of the 4 practices and technologies, the literature was searched for published evidence, and an index year was identified, i.e., when the evidence was deemed sufficient to justify widespread adoption by Canadian hospitals.

To capture the published evidence supporting adoption of these practices and technologies, a research assistant (A.G.) performed a literature search using PubMed, Google Scholar, and Google. Studies eligible for consideration were meta-analyses, systematic reviews, and literature reviews covering one or more of the specified pharmacy practices and technologies, published between 1990 and 2014. For each publication, the number of positive outcomes and the total number of outcomes measured were documented. The outcome indicators were based on the lists proposed by Bond and Raehl,[3] Chisholm-Burns and others,[4] and Pitterle and others[5] (i.e., mortality, morbidity, adverse drug reactions, medication errors, health care costs, length of stay, and adherence with guidelines). The index year was defined as the year when there was sufficient published evidence to support the practice or technology as being effective. The year of proven effectiveness was defined as the median year of meta-analyses, systematic reviews, and literature reviews showing positive outcomes for at least 3 of the 7 indicators.

To determine the extent of adoption of the 4 selected pharmacy practices and technologies, the 19 editions of the *Hospital Pharmacy in Canada Report* (*HPC Report*) published between 1985/1986 and 2011/2012 were reviewed.[6] The *HPC Reports* are based on biennial surveys that have collected information on the adoption of practice innovations and technologies in Canadian hospitals since 1985/1986. For each of the 4 specified pharmacy practices and technologies, the extent of adoption was determined at the time the item was first included in the HPC Survey and at the time of the 2011/2012 HPC Survey. We also identified the year when at least 50% of the hospitals that responded to the HPC Survey reported implementation of the pharmacy practice or technology. Then, the time between the index year and the year when 50% of respondents had adopted the practice or technology was calculated.

Both the literature review and the extraction of relevant data were audited by a pharmacist member of the research team (J-F.B). No inferential statistical analysis was conducted.

EVALUATION OF THE PRACTICE

Table 1 summarizes the published evidence[7-45] and the extent of adoption of the 4 pharmacy practices and technologies in the drug-use process in Canada. Three meta-analyses and 15 system-

Table 1. Published Evidence for and Extent of Adoption of 4 Pharmacy Practices and Technologies in the Drug-Use Process in Canada

Characteristic	Medication History/ Medication Reconciliation	Smart Pumps	Bedside Bar Code Medication Administration	Computerized Prescriber Order Entry
Publication type	No. of publications, reference numbers, median year of publication (range of years)			
Meta-analyses	*n* = 0	*n* = 0	*n* = 0	*n* = 3 References 7–9 2009 (2008–2013)
Systematic reviews	*n* = 11 References 10–20 2012 (2009–2014)	*n* = 2 References 21, 22 2010 (2007–2014)	*n* = 2 References 23, 24 2012 (2010–2014)	*n* = 15 References 21, 24–37 2008 (2003–2014)
Literature reviews	*n* = 1 Reference 38 2005	*n* = 3 References 39–41 2009 (2008–2011)	*n* = 3 References 41–43 2009 (2003–2011)	*n* = 4 References 41, 42, 44, 45 2009 (2003–2011)
Index year*	2012	NA	NA	2008
Proportion of positive outcomes	No. of studies with positive outcome / no. of studies† (and their references)			
Mortality	0/1 Reference 17	No data	No data	0/1 Reference 9
Morbidity	1/3 References 10, 19, 20	No data	No data	0/3 References 8, 31, 32
Adverse drug events	1/1 Reference 13	1/1 Reference 22	0/1 Reference 42	2/8 References 9, 25, 27–30, 36, 42
Medication errors	3/6 References 10, 13, 15, 17, 18, 38	1/5 References 21, 22, 39–41	1/4 References 23, 24, 41, 42	12/16 References 7–9, 21, 24–26, 28–30, 33, 36, 37, 41, 42, 44
Costs	1/1 Reference 14	1/1 Reference 22	No data	1/4 References 26, 29, 30, 37
Length of stay	0/5 References 11, 13, 17, 18, 20	No data	No data	1/1 Reference 26
Guideline adherence	No data	1/1 Reference 22	No data	4/4 Reference 26, 29, 30, 32
Adoption by Canadian hospitals‡				
Extent of adoption when first reported (year of report)	6% (1985/1986)	61% (2007/2008)	3% (2003/2004)	7% (2001/2002)
Most recent extent of adoption (year of report)	85% (2011/2012)	75% (2011/2012)	8% (2005/2006)	8% (2011/2012)
Year with extent of adoption ≥ 50%	1999/2000 (53% adoption)	2007/2008 (61% adoption)	NA	NA
Time between index year and adoption by 50% hospitals	12 years	NA	NA	NA

NA = not applicable.
*The index year corresponds to the median year of publication for meta-analyses, systematic reviews, and literature reviews showing positive outcomes for at least 3 indicators (i.e., sufficient evidence to support the practice or technology as being effective, thus justifying widespread adoption by Canadian hospitals). A positive outcome was defined as a primary or secondary issue under evaluation with a statistically significant result (e.g., improvement associated with the technology or the practice).
†Denominator for each proportion is the number for studies for the particular practice or technology that reported data for the specified outcome.
‡As reported in the *Hospital Pharmacy in Canada Reports* (1985/1986 to 2011/2012).[6]

atic reviews about CPOE were found. No meta-analyses were found for the 3 other practices. There were 11 systematic reviews of medication history/reconciliation, 2 related to smart pumps, and 2 related to bedside bar code medication administration. The proportion of studies with positive results on the specified outcome measures was variable. According to the *HPC Report*, medication history/reconciliation and use of smart pumps were the most widely adopted practices in 2011/2012.

IMPLICATIONS AND SIGNIFICANCE FOR PRATICE

On the basis of this review, there was sufficient evidence for adoption of 2 of the 4 pharmacy practices and technologies (medication history/reconciliation and CPOE), but evidence for the positive impacts of the other technologies (smart pumps and bar code medication administration) was more limited. Interestingly, more than 50% of hospitals had adopted the practice of carrying out medication history/reconciliation before clear evidence of its effectiveness had been established (1999/2000 v. 2012). We believe that adoption of this practice was driven by the Accreditation Canada process, which has included medication reconciliation as a Required Organizational Practice since 2008.[46] At the other end of the spectrum, CPOE has not been widely implemented in Canada, and as of 2011/2012 its adoption by Canadian hospitals was still below 10%, despite a substantial amount of positive evidence. Although the count of positive outcomes measured by our approach favours the CPOE technology, we recognize the challenges associated with electronic prescribing in hospitals, including financial costs of the technologies themselves and the extensive training required to support transition to the use of CPOE.

For 2 technologies—smart pumps and bar code medication administration—sufficient evidence to support the practice or technology is still lacking. In the case of smart pumps, adoption of the technology has been driven by the companies supplying the technology. For example, it is no longer possible to buy replacement infusion pumps that do not have “smart” technology. The extent of adoption of smart technology infusion pumps by Canadian hospitals was already above the 50% threshold when data on smart pumps were first captured in the *HPC Report* (in 2007/2008). Smart pump manufacturers have been able to charge a substantial premium for these devices, even though there is a paucity of evidence demonstrating a positive impact. In the case of bar code medication administration, the limited adoption of this technology appears to be in line with the lack of evidence for its effectiveness.

This study had some limitations. The quality of the meta-analyses, systematic reviews, and literature reviews identified in the literature search was not evaluated. Other methods could be used to establish the “index year”, including more detailed analysis of the included evidence. The data presented in the *HPC Reports* also have limitations (e.g., based on a self-reported survey with voluntary participation, limited to hospitals with at least 50 acute care beds).

CONCLUSION

On the basis of these data, it is difficult to conclude that pharmacy practice decisions are based on formal evidence. The adoption of these 4 pharmacy practices and technologies appears to be driven, in large part, by factors other than evidence, including the accreditation process and the marketing practices of technology vendors. If the implementation of a particular practice or technology takes time, its adoption will also depend on costs and implementation difficulties. This exploratory study puts into perspective the need for a “dashboard” of evidence about pharmacy practices and technologies. Updated on a regular basis, such a tool would contribute to a more coherent approach to the adoption of new technologies and practices. Our pharmacy practice research unit aims to develop such a dashboard and test its usefulness in the years to come.

References

1. Eriksson T. Practicing evidence-based pharmacy. *Eur J Hosp Pharm.* 2013;20(6):323.
2. Balas EA, Boren SA. Managing clinical knowledge for health care improvement. In: Bemmel J, McCray AT, editors. *Yearbook of medical informatics 2000: patient-centered systems.* Stuttgart (Germany): Schattauer Verlagsgesellschaft mbH; 2000. p. 65-70.
3. Bond CA, Raehl CL. Clinical pharmacy services, pharmacy staffing, and hospital mortality rates. *Pharmacotherapy.* 2007;27(4):481-9.
4. Chisholm-Burns MA, Kim Lee J, Spivey CA, Slack M, Herrier RN, Hall-Lipsey E, et al. US pharmacists’ effect as team members on patient care: systematic review and meta-analyses. *Med Care*. 2010;48(10):923-33.
5. Pitterle ME, Bond CA, Raehl CL, Franke T. Hospital and pharmacy characteristics associated with mortality rates in United States hospitals. *Pharmacotherapy.* 1994;14(5):620-30.
6. Hospital Pharmacy in Canada Editorial Board. *Hospital pharmacy in Canada report.* Eli Lilly Canada; [multiple years; cited 2014 Sep 30]. Available from: www.lillyhospitalsurvey.ca/hpc2/content/Reports3.asp
7. Shamliyan TA, Duval S, Du J, Kane RL. Just what the doctor ordered. Review of the evidence of the impact of computerized physician order entry system on medication errors. *Health Serv Res*. 2008;43(1 Pt 1):32-53.
8. Radley DC, Wasserman MR, Olsho LE, Shoemaker SJ, Spranca MD, Bradshaw B. Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems. *J Am Med Inform Assoc.* 2013;20(3):470-6.
9. van Rosse F, Maat B, Rademaker CM, van Vught AJ, Egberts AC, Bollen CW. The effect of computerized physician order entry on medication prescription errors and clinical outcome in pediatric and intensive care: a systematic review. *Pediatrics*. 2009;123(4):1184-90.
10. Bayoumi I, Howard M, Holbrook AM, Schabort I. Interventions to improve medication reconciliation in primary care. *Ann Pharmacother.* 2009;43(10): 1667-75.
11. Hansen LO, Young RS, Hinami K, Leung A, Williams MV. Interventions to reduce 30-day rehospitalization: a systematic review. *Ann Intern Med.* 2011; 155(8):520-8.
12. Hesselink G, Schoonhoven L, Barach P, Spijker A, Gademan P, Kalkman C, et al. Improving patient handovers from hospital to primary care: a systematic review. *Ann Intern Med.* 2012;157(6):417-28.
13. Mueller SK, Sponsler KC, Kripalani S, Schnipper JL. Hospital-based medication reconciliation practices: a systematic review. *Arch Intern Med.* 2012;172(14):1057-69.

14. Etchells E, Koo M, Daneman N, McDonald A, Baker M, Matlow A, et al. Comparative economic analyses of patient safety improvement strategies in acute care: a systematic review. *BMJ Qual Saf.* 2012;21(6):448-56.
15. Manias E, Williams A, Liew D. Interventions to reduce medication errors in adult intensive care: a systematic review. *Br J Clin Pharmacol*. 2012; 74(3): 411-23.
16. Laugaland K, Aase K, Barach P. Interventions to improve patient safety in transitional care—a review of the evidence. *Work*. 2012;41 Suppl 1:2915-24.
17. Chhabra PT, Rattinger GB, Dutcher SK, Hare ME, Parsons KL, Zuckerman IH. Medication reconciliation during the transition to and from long-term care settings: a systematic review. *Res Social Adm Pharm.* 2012; 8(1):60-75.
18. Kwan JL, Lo L, Sampson M, Shojania KG. Medication reconciliation during transitions of care as a patient safety strategy: a systematic review. *Ann Intern Med*. 2013;158(5 Pt 2):397-403.
19. Vigod SN, Kurdyak PA, Dennis CL, Leszcz T, Taylor VH, Blumberger DM, et al. Transitional interventions to reduce early psychiatric readmissions in adults: systematic review. *Br J Psychiatry*. 2013;202(3):187-94.
20. Lehnbom EC, Stewart MJ, Manias E, Westbrook JI. Impact of medication reconciliation and review on clinical outcomes. *Ann Pharmacother.* 2014;48(10):1298-312.
21. Conroy S, Sweis D, Planner C, Yeung V, Collier J, Haines L, et al. Interventions to reduce dosing errors in children: a systematic review of the literature. *Drug Saf.* 2007;30(12):1111-25.
22. Ohashi K, Dalleur O, Dykes PC, Bates DW. Benefits and risks of using smart pumps to reduce medication error rates: a systematic review. *Drug Saf.* 2014; 37(12):1011-20.
23. Young J, Slebodnik M, Sands L. Bar code technology and medication administration error. *J Patient Saf*. 2010;6(2):115-20.
24. Keers RN, Williams SD, Cooke J, Walsh T, Ashcroft DM. Impact of interventions designed to reduce medication administration errors in hospitals: a systematic review. *Drug Saf.* 2014;37(5):317-32.
25. Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med*. 2003;163(12):1409-16.
26. Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*. 2006;144(10):742–52.
27. Wolfstadt JI, Gurwitz JH, Field TS, Lee M, Kalkar S, Wu W, et al. The effect of computerized physician order entry with clinical decision support on the rates of adverse drug events: a systematic review. *J Gen Intern Med.* 2008;23(4):451-8.
28. Ammenwerth E, Schnell-Inderst P, Machan C, Siebert U. The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc*. 2008;15(5):585-600.
29. Eslami S, de Keizer NF, Abu-Hanna A. The impact of computerized physician medication order entry in hospitalized patients—a systematic review. *Int J Med Inform*. 2008;77(6):365-76.
30. Eslami S, Abu-Hanna A, de Keizer NF. Evaluation of outpatient computerized physician medication order entry systems: a systematic review. *J Am Med Inform Assoc*. 2007;14(4):400-6.
31. Georgiou A, Williamson M, Westbrook JI, Ray S. The impact of computerised physician order entry systems on pathology services: a systematic review. *Int J Med Inform*. 2007;76(7):514-29.
32. Jamal A, McKenzie K, Clark M. The impact of health information technology on the quality of medical and health care: a systematic review. *HIM J.* 2009;38(3):26-37.
33. Reckmann MH, Westbrook JI, Koh Y, Lo C, Day RO. Does computerized provider order entry reduce prescribing errors for hospital inpatients? A systematic review. *J Am Med Inform Assoc.* 2009;16(5):613-23.
34. Weir CR, Staggers N, Phansalkar S. The state of the evidence for computerized provider order entry: a systematic review and analysis of the quality of the literature. *Int J Med Inform.* 2009;78(6):365-74.
35. Weir CR, Staggers N, Laukert T. Reviewing the impact of computerized provider order entry on clinical outcomes: the quality of systematic reviews. *Int J Med Inform.* 2012;81(4):219-31.
36. Georgiou A, Prgomet M, Paoloni R, Creswick N, Hordern A, Walter S, et al. The effect of computerized provider order entry systems on clinical care and work processes in emergency departments: a systematic review of the quantitative literature. *Ann Emerg Med.* 2013;61(6):644-653.e16.
37. Rinke ML, Bundy DG, Velasquez CA, Rao S, Zerhouni Y, Lobner K, et al. Interventions to reduce pediatric medication eerors: a systematic review. *Pediatrics.* 2014;134(2):338-60.
38. Barnsteiner JH. Medication reconciliation: transfer of medication information across settings—keeping it free from error. *J Infus Nur*s. 2005;28(2 Suppl): 31-6.
39. Murdoch LJ, Cameron VL. Smart infusion technology: a minimum safety standard for intensive care? *Br J Nurs*. 2008;17(10):630-6.
40. Hertzel C, Sousa VD. The use of smart pumps for preventing medication errors. *J Infus Nurs.* 2009;32(5):257-67.
41. Benoit E, Beney J. [Can new technologies reduce the rate of medications errors in adult intensive care?]. *J Pharm Belg*. 2011;(3):82-91. Article in French.
42. Oren E, Shaffer ER, Guglielmo BJ. Impact of emerging technologies on medication errors and adverse drug events. *Am J Health Syst Pharm.* 2003; 60(14):1447-58.
43. Shane R. Current status of administration of medicines. *Am J Health Syst Pharm*. 2009;66(5 Suppl 3):S42-8.
44. Woodward HI, Mytton OT, Lemer C, Yardley IE, Ellis BM, Rutter PD, et al. What have we learned about interventions to reduce medical errors? *Annu Rev Public Health*. 2010;31:479-97.
45. Niazkhani Z, Pirnejad H, Berg M, Aarts J. The impact of computerized provider order entry systems on inpatient clinical workflow: a literature review. *J Am Med Inform Assoc*. 2009;16(4):539-49.
46. *Required Organizational Practices handbook 2016.* Ottawa (ON): Accreditation Canada; 2015 [cited 2015 Nov 16]. Available from: www.accreditation.ca/ sites/default/files/rop-handbook-2016-en.pdf

Aurélie Guérin is a Research Assistant with the Pharmacy Practice Research Unit and the Pharmacy Department, Centre hospitalier universitaire Sainte-Justine, Montréal, Quebec. She is also a DPharm candidate in the Faculté de pharmacie de Paris, Université Paris Descartes, Paris, France.

Kevin Hall, PharmD, was, at the time this study was conducted, a Clinical Associate Professor in Social and Administrative Pharmacy, Faculty of Pharmacy and Pharmaceutical Sciences, University of Alberta, Edmonton, Alberta. He is now retired.

Jean-François Bussières, BPharm, MSc, MBA, FCSHP, is Director of the Pharmacy Practice Research Unit and the Pharmacy Department, Centre hospitalier universitaire Sainte-Justine, and Clinical Professor, Faculty of Pharmacy, Université de Montréal, Montréal, Quebec.

Competing interests: Kevin Hall was (until June 2015) one of the Managing Editors and Jean-François Bussières is a continuing member of the Editorial Board for the Hospital Pharmacy in Canada Survey and Report, funded by Eli Lilly Inc. The company had no role in the design, analysis, interpretation, or reporting of the study presented here. Kevin Hall occasionally gives invited presentations at conferences and other educational venues, including a recent presentation at the Banff Seminar on the future of hospital pharmacy practice, sponsored by Pharmaceutical Partners of Canada (now Fresenius Kabi). No other competing interests declared.

Address correspondence to:
Jean-François Bussières
Pharmacy Department
Centre hospitalier universitaire Sainte-Justine
3175, chemin de la Côte Sainte-Catherine
Montréal QC H3T 1C5

e-mail: jf.bussieres@ssss.gouv.qc.ca

Funding: None received.