Automated Drug Dispensing Systems:

Literature Review

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Prepared by:

Ellen Balka   **Kelsey Nutland**
Principal Investigator, ACTION for Health   **Undergraduate Student**
Simon Fraser University   **Simon Fraser University**

Document Contact:

Ellen Balka
School of Communication
Simon Fraser University
8888 University Drive
Burnaby, BC, Canada V5A 1S6

tel: +1.604.725.2756
email: ellenb@sfu.ca
website: www.sfu.ca/act4hlth/

SFU Institutional Repository: http://ir.lib.sfu.ca/handle/1892/3701

Introduction

The automated drug distribution systems (ADDS) in use today – such as those manufactured by Omnicell, Inc. and Pyxis, Inc. – are predicated on a transformation in drug distribution originating in the United States in the early 1960's known as unit-of-use packages, or unit-dose systems. These systems replaced a previous approach to drug distribution known as multiple-dose drug distribution systems (multidose systems). Multidose systems meant nurses had full responsibility for the entire medication system, which involved administering hundreds of doses of medicine along with paper-work, inventory control and dose preparation. Unit-dose systems on the other hand, provide nurses with individually packaged and labeled doses at eight or more hour intervals and are ready to administer according to the administration schedule determined by the nurse (Simborg & Derewicz, 1975).

Gaining widespread popularity, unit-dose systems substantially reduced the dramatic occurrence of errors, medication waste and the inappropriate use of nursing time (Hynniman, Conrad, Urch, Rudnick, & Parker, 1970; Riley, Derewicz, & Lamy, 1973; Shultz, White, & Latiolais, 1973). Building on this success, Johns Hopkins Hospital introduced an automated feature into the unit-dose system making the entire process, from physician prescription entry to hourly dose administration, computer-assisted (Simborg & Derewicz 1975, p. 342). As technology has evolved, the pharmacy automation trend that began in the late 1960s has continued, and been marked by the proliferation of automated drug dispensing systems into hospitals and healthcare systems such as the Vancouver Coastal Health Authority's Vancouver General Hospital.

Today automation in drug dispensing includes solutions that range from computer-assisted physician order entry, to robotic handling, packaging and sorting of drugs in the

pharmacy, to stand-alone nursing-unit based cabinets and the automated generation of customizable reports and forms.[1] The nursing-unit based automated drug dispensing cabinets are the centerpiece of most automation solutions opted for by healthcare facilities and sit at the apex of most of the discussion found in the available literature. Each system and each cabinet is configured slightly different, but all operate on the same basic principle: typically installed in nursing wards, and often in the emergency departments and operating rooms of hospitals and other healthcare facilities, the cabinets look and function much like an automated teller machine.   The user inputs their confidential ID, selects a patient profile from a list of options and chooses the appropriate medication to be administered. The dispensing cabinet then unlocks a specified drawer or carousel containing the medication allowing the user access for a limited amount of time. Different institutions have different protocol around who has access to the machines, for how long and at what times, as well as what is to be done with returned medications, and how to handle medication errors.

Medication error is a fundamental issue addressed in the literature evaluating the successes and failures of automation in pharmacy, along with cost-savings and the efficient use of nursing and pharmacy time. Section II of this literature review focuses on these specific issues and how they have been treated in both academic and industry material; Section I provides a broad characterization of the entire body of work that comprises the up-to-date coverage of automated drug dispensing.

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[1] Omnicell and Pyxis are industry leaders in providing healthcare facilities with automation solutions for drug dispensing. See http://www.omnicell.com and http://www.pyxis.com for detailed descriptions of their products and services.

Section I: Overview

The literature on automated drug dispensing systems can be categorized as originating in either academic or trade publications and as theoretical, empirical or editorial in nature – many articles are a combination of the above. The academic literature is constituted largely by articles published in the *American Journal of Health-System Pharmacy* (formerly the *American Journal of Hospital Pharmacy*) (Barker, Pearson, Hepler, Smith, & Pappas, 1984; Borel & Rascati, 1995; Guerrero, Nickman, & Jorgenson, 1996; Lee, Wellman, Birdwell, & Sherrin, 1992; Perini & Vermeulen, Jr., 1994; Schwarz & Brodowy, 1995; Tribble, 1996; Wong, Rancourt, & Clark, 1999) and those published by Canadian scholar Joel Novek (Novek, 1998; Novek & Rudnick, 2000a; Novek, 2000; Novek, 2002; Novek, Bettess, Burke, & Johnston, 2000b). Other academic publications include the *Journal of Medical Systems* (Chung, Choi, & Moon, 2003; Schumock, Nair, Finley, & Lewis, 2003a), *Hospital Pharmacy* (Ray, Aldrich, & Lew, 1995) and *Nursing Economic$* (Wise, Bostrom, Crosier, White, & Caldwell, 1996).

The explicitly theoretical material is insubstantial and limited to a handful of articles written by Joel Novek (Novek, 2000; Novek, 2002), each of which include an empirical element to support the conclusions. A number of the academic articles are editorial in nature and draw on secondary and/or anecdotal evidence, often offering detailed descriptions of the systems and various institutions' experiences with implementation (Barker, 1995; Chung et al., 2003; Darby, 1996; Garrelts, Koehn, Snyder, Snyder, & Rich, 2001; Perini et al., 1994; Ray et al., 1995; Tribble, 1996; Wellman, Hammond, & Talmage, 2001; Wong et al., 1999). Otherwise, the bulk of the academic material is largely empirical in nature providing primary evidence for findings using a combination of interviews (Novek, 1998; Novek et al., 2000a; Novek, 2000; Novek, 2002; Novek et al., 2000b), observations (Barker et al., 1984; Borel et al.,

1995; Lee et al., 1992; Novek, 1998; Novek, 2000; Simborg et al., 1975; Sutter, Wellman, Mott, Schommer, & Sherrin, 1998; Wise et al., 1996), surveys (Lee et al., 1992; Novek et al., 2000a; Novek, 2002; Novek et al., 2000b; Pedersen, Schneider, & Scheckelhoff, 2003; Ringold, Santell, & Schneider, 2000; Schumock et al., 2003a; Schumock, Walton, Sarawate, & Crawford, 2003b), time and motion studies (Klein, Santora, Pascale, & Kitrenos, 1994; Lee et al., 1992; Schwarz et al., 1995; Wise et al., 1996) and self-reported work sampling studies (Guerrero et al., 1996).

The trade literature is less substantial and found mainly in healthcare management publications such as *HD: The Journal for Healthcare Design & Development* (Cork, 1998), *Modern Healthcare* (Scott, 1996), *Hospital Material Management* (Anonymous, 1998; Hofer, 2001), *Drug Topics* (Lee, 2002; Vecchione, 2002), *Nursing Management* (Miller, 1999; Tallon, 1996), *Managed Healthcare Executive* (Shaha, 2001), and *Health Industry Today* (Werner, 1995). Automated drug dispensing is also addressed in newsletters, such as the one published for the American Hospital Association – *AHA News* (Levenson, 2000). This literature is all editorial in nature with some references to secondary sources (Cork, 1998; Levenson, 2000; Miller, 1999; Scott, 1996; Tallon, 1996) and a strong focus on detailed descriptions of automated dispensing systems (Hofer, 2001; Tallon, 1996; Vecchione, 2002), institutions' experiences with implementation (Anonymous, 1998; Hofer, 2001; Miller, 1999; Scott, 1996) and suggestions for successful implementation (Cork, 1998; Tallon, 1996; Werner, 1995).

Section II: Issues in Automated Drug Dispensing

There are a number of common issues addressed in both the academic and trade literature. Those most regularly focused on are cost-savings (Garrelts et al., 2001; Klein et al., 1994; Lee et al., 1992; Miller, 1999; Perini et al., 1994; Ray et al., 1995; Schwarz et al., 1995;

Simborg et al., 1975; Wise et al., 1996), medical errors (Barker, 1995; Barker et al., 1984; Borel et al., 1995; Chung et al., 2003; Schumock et al., 2003a; Simborg et al., 1975; Sutter et al., 1998; Vecchione, 2002) and the efficiency of both pharmacy (Chung et al., 2003; Darby, 1996; Guerrero et al., 1996; Klein et al., 1994; Lee et al., 1992; Miller, 1999; Ray et al., 1995; Schwarz et al., 1995; Tallon, 1996) and nursing (Barker et al., 1984; Guerrero et al., 1996; Lee et al., 1992; Miller, 1999; Novek et al., 2000a; Schwarz et al., 1995; Simborg et al., 1975; Tallon, 1996).

Other topics include: relations between pharmacy and nursing (Novek et al., 2000a; Novek, 2002); the demarcation of professional boundaries (Barker, 1995; Guerrero et al., 1996; Lee, 2002; Novek, 2000; Novek, 2002); specific suggestions and criteria for successful implementation of ADDS (Barker, 1995; Cork, 1998; Darby, 1996); and the attitudes toward ADDS and automation in drug dispensing in general of both pharmacy (Lee et al., 1992; Lee, 2002; Novek, 2002) and nursing (Lee et al., 1992; Novek et al., 2000a; Novek, 2002; Novek et al., 2000b; Schwarz et al., 1995). There are a handful of articles that are less specific and therefore have been categorized as generic, in that they cover a range of issues, such as far-reaching surveys (Pedersen et al., 2003; Ringold et al., 2000; Schumock et al., 2003b), or that they address a very specific topic particular to that article and that publication, such as system failures (Tribble, 1996) or secondary data-analysis systems (Wellman et al., 2001).

Cost-savings is by far the issue dealt with most in both the academic and trade material and is the most common reason given for implementation. Overwhelmingly, the trade journals advocate for the implementation of ADDS based on the promise of a significant decrease in drug and personnel expenditures (Anonymous, 1998; Cork, 1998; Hofer, 2001; Miller, 1999), though a few articles do caution against the assumption that substantial savings are guaranteed

upon installation (Scott, 1996; Tallon, 1996). For example, in *Modern Healthcare* Scott (1996)

claims – rather facetiously – that the benefits of ADDS are turning out "to be like the health

value of oat bran – exaggerated" (p. 84). She notes the disappointment of Jon Hubble, director

of management engineering at U.S. hospital Scott & White Memorial Hospital in Temple,

Texas, who justifies the continued use of the systems at the hospital because the machines can

provide valuable information about inventory and supply use, despite the unsatisfactory

increase in cost-savings (p. 84). Hubble suggests that if a hospital is trying to rectify a history

of financial trouble and save a lot of money, these systems are not the answer (p. 84). In

Nursing Management Tallon (1996) states:

> Direct cost-savings arising from implementing automated dispensing
> systems can no longer be naively assumed. Some clinical investigators
> have failed to demonstrate substantial FTE savings with system use,
> while others reveal measurable nurse productivity increases
> counterbalanced by decreased pharmacy productivity and increased
> medication costs." (p. 46).

The academic material looking at cost-savings also comes out in favour of ADDS, but

of the nine considering the issue, only four provide a definitive cost-savings conclusion using

primary evidence to support their findings (Klein et al., 1994; Lee et al., 1992; Schwarz et al.,

1995; Simborg et al., 1975). Klein, et al. (1994) report a total savings of personnel time and

drug costs of $7044 annually (estimated), though the authors do state that the overall savings in

personnel time was not great enough to substantially affect pharmacy operations, and drug costs

were higher with the automated system" (p. 1196). Lee, et al. (1992) claim that although the

decision to implement automated drug dispensing is a costly one, "they can be justified by the

many financial benefits resulting from reduction or reallocation of personnel time, improved

revenue and billing efficiency, and service improvement" (p. 854). Schwarz and Brodowy

(1995) make clear where cost-savings for institutions using ADDS is likely to come from: "The potential savings associated with Medstation Rx [manufactured by Pyxis, Inc.] would stem primarily from reductions in personnel. […] Thus, Medstation Rx could save the institution approximately $1 million over five years […]" (p. 827). Simborg and Derwicz (1975) discuss cost-savings related to computer-assisted unit-dose dispensing – the precursor to modern ADDS discussed in the introduction – suggesting that larger institutions will reap a greater benefit with a 14% increase for a 450 bed hospital, but a 7% decrease for a 250 bed hospital (p. 342).

Otherwise, the remaining academic articles suggest the *potential* for savings based on primary evidence (Wise et al., 1996) or based on secondary evidence and/or personal experience (Darby, 1996; Garrelts et al., 2001; Perini et al., 1994; Ray et al., 1995). For example, although Wise, et al. conducted an empirical study looking at costs before and after the implementation of ADDS – and did find an increase once saved personnel time was translated into a dollar amount (p. 229) – in their discussion the authors caution that this is only one aspect of a cost-benefit analysis that should include other nonquantitative elements if such a capital expenditure is to me made (p. 229). In their description of one institution's experience with implementing ADDS Ray, et al. conclude that of many benefits realized by the new automated system, substantial cost-savings in labour costs is one of the most important (p. 30).

Reducing medical error has also warranted significant attention in both trade and academic publications and provides another incentive for adopting automated drug dispensing, but to a lesser extent than cost-savings. The trade literature is limited to one article presenting news briefs on healthcare, including one about automation reducing medical errors at a certain hospital (Levenson, 2000) and another discussing vendors at an American Society for Health-System Pharmacy meeting and the reduction of medical errors as the driving force behind

automated technology trends (Vecchione, 2002). At first glance the academic literature seems to suggest that automated drug dispensing significantly reduces medical errors, but upon further investigation a different picture is revealed. To demonstrate, of the twelve articles published five are editorial – one discusses the peripheral infrastructure needed to ensure the most efficient and effective use of ADDS (Chung et al., 2003), two describe experiences with implementing ADDS, suggesting the *potential* for reducing medical errors (Garrelts et al., 2001; Ray et al., 1995), another describes in detail the options healthcare organizations have when it comes to choosing a system right for their institution (Perini et al., 1994), and lastly, one article argues that ADDS need to be evaluated based on patient safety standards, otherwise it will not reduce medical errors (Barker, 1995).

The empirical evidence supporting the error reduction claim constitutes five articles on this topic (Barker et al., 1984; Borel et al., 1995; Klein et al., 1994; Schwarz et al., 1995; Simborg et al., 1975), while two make ambiguous conclusions leaving the reader with an unclear impression of the impact this technology had on medical errors (Schumock et al., 2003a; Sutter et al., 1998). For example, Sutter, et al. categorize medical errors as "discrepancies" (p. 1925) and fail to conclude one way or another whether medical errors were positively or negatively affected. The authors do state that changes in the delivery of drugs (i.e. automated dispensing) "come with potential for access discrepancies" (p. 1926). Of the five declaring ADDS as the major cause of the reduction of medical errors found after implementation of various systems, one deals specifically with slightly improved accuracy rates in cart-filling in the pharmacy (Klein et al., 1994), another shows dramatically improved error rates, but to do with the implementation of a computer-assisted unit-dose system rather than full automation of drug dispensing (Simborg et al., 1975), and the remaining three demonstrate the

significant reduction of a specific kind of medical error that can happen at the administration

phase of drug dispensing – wrong-time errors and to a lesser extent dose omissions (Barker et

al., 1984; Borel et al., 1995; Schwarz et al., 1995).

It can be argued that both wrong-time errors and dose omissions – the most common

kinds of medical error – do not have an impact on patient outcomes (Borel et al, 1995, p. 1878);

unordered-drug and wrong-dose errors on the other hand do affect patient outcomes and in two

of the studies remained unaffected by the implementation of ADDS (Barker et al., 1984; Borel

et al., 1995). Therefore, in order to determine the real clinical effect automated drug dispensing

systems have in terms of reducing medical errors and improving patient safety, more research

needs to be conducted that focuses on the error rates of unordered-drugs and wrong-doses

before and after the implementation of an ADDS.

Related to both cost-savings and the reduction of medical errors is the efficient use of

pharmacy and nursing time. This is dealt with to a lesser extent than the former, but has

received significant enough attention in the literature to warrant considering in this literature

review. The trade material addressing pharmacy efficiency with respect to automation is

limited and makes no definitive claims one way or another. Of three articles, one reports the

results from an informal survey of pharmacists on how the nursing shortage has impacted

pharmacy operation (Lee, 2002), one describes an institution's experience with implementation

(Miller, 1999), and another discusses the pressures and strategies of implementing ADDS

(Tallon, 1996).

The academic treatment of the issue is more focused on establishing a clear

understanding of how ADDS impacts the time pharmacy and pharmacy technicians spend on

dealing with drugs, rather than clinical activities for example. Largely, the academic material

suggests that ADDS will free up pharmacy time, which often translates into personnel

reductions and to a lesser extent transferring pharmacists to patient care activities, but those

studies supporting this claim with empirical evidence are limited to only one (Guerrero et al.,

1996) with two other empirical studies challenging this claim with evidence of both *decreased*

pharmacy efficiency (Lee et al., 1992) and no impact on pharmacy efficiency (Klein et al.,

1994). Otherwise, support for an increase in efficiency is found in editorial articles that suggest

increased pharmacy efficiency is a likely outcome of automation (Chung et al., 2003; Darby,

1996; Ray et al., 1995). One study avoided making any claims about pharmacy efficiency but

did include the idea in the discussion (Schwarz et al., 1995).

Efficiency in nursing also received notable attention in the literature, with only the trade

journal *Nursing Management* giving this issue any consideration from the industry perspective

— both editorial articles in this publication addressing nursing efficiency use secondary

evidence to suggest a probable positive impact but stop short of explicitly making this claim

(Miller, 1999; Tallon, 1996). Six academic articles offer primary empirical evidence to support

their findings, only one of which claiming that automation in drug distribution increases nursing

efficiency (Lee et al., 1992). One article suggests ADDS may decrease efficiency (Simborg et

al., 1975), and two declare that there is no impact on the efficient use of nursing time (Barker et

al., 1984; Guerrero et al., 1996). There are two articles that examined nursing efficiency,

among other topics, but refrained from claiming an absolute substantial increase in efficiency

that could be generalizable to other institutions (Novek et al., 2000a; Schwarz et al., 1995). For

example, Schwarz et al. write: "There was a definite time savings for nurses associated with

Medstation Rx, but measuring the entire effect on nursing time would require extensive

observational studies […]" (p. 827), the scope of which wasn't undertaken in this study.

Relations between pharmacy and nursing is another topic dealt with in the literature,

primarily by Joel Novek (Novek et al., 2000a; Novek, 2002). In "IT, Gender, and Professional

Practice: Or, Why an Automated Drug Distribution System Was Sent Back to the

Manufacturer" Novek (2002) "examines the relationship between technological change and the

occupational identities and practices of nurses, pharmacists, and patient care managers through

a case study of the highly problematic deployment of an automated drug-dispensing system" (p.

381). Novek addresses what is termed the interplay between control and contingency, which is

a consideration of the move toward standardization as work routines become incorporated into

networks versus the need for technology to be sensitive to the specific needs of particular

professional roles (p. 380).

Novek discusses the ADDS as a boundary object between nursing and pharmacy and

explores the difficulties associated with this idea. He writes:

> A second point involves the negotiation of occupational boundary
> crossings as computer networks crosscut the traditional lines of
> cleavage between health care occupations. Hospital work is highly
> cooperative yet also specialized and fragmented. Hardware devices or
> packets of information are often shared as boundary objects
> representing common ground between occupations. (p. 380)

Novek claims that computerization and automation of drug dispensing involves distribution of

tasks that are shared by both pharmacists and nurses meaning that the dispenser becomes the

boundary object between the two professions with the machine itself becoming a boundary

object and other technical artifacts and the patient information databases being shared between

the departments (p. 383). But, both nurses and pharmacists have resisted the ADDS as a

boundary object because of the difficulty both departments have with the system. Nurses are

distrustful, there are often conflicts and a need to "go around the system" (p. 394) to access

medication when there are glitches, both mechanical and human. The nurses don't see the

system as reliable enough to get them the medication and the information they need (p. 395).

These difficulties and the conflicts between nursing and pharmacy over medication errors

undermined the ADDS's value as a boundary object between the two professions (p. 397) and

because of this neither department saw the system as a boundary object that demonstrated

interdepartmental cooperation (p. 400).

Novek also writes about the demarcation of professional boundaries in the pharmacy

profession (Novek, 1998; Novek, 2000; Novek, 2002), a topic that has also received attention

from other authors writing about automated drug dispensing (Barker, 1995; Guerrero et al.,

1996; Lee, 2002). In *Social Science & Medicine* Novek (2000) examines the relationship

between new technology – in particular automation technology – and the changing role of

pharmacy in the division of labour in healthcare (p. 491). He asks whether automation enables

pharmacists' collective control over their labour process or if it challenges their authority over

dispensing medication. He also investigates whether automation contributes to collective

mobility whereby pharmacists move to clinical activities once their time is freed up by ADDS.

Using qualitative case studies Novek concludes that pharmacists have exercised collective

control – refusing to concede dispensing responsibilities – at least as much as they have asserted

collective mobility (p. 500). He suggests that automation has "reinforced rather than

transformed the lines of demarcation between pharmacy and other health care occupations" (p.

500).

Using less rigorous methods, in *Drug Topics* Shirley Lee (2002) reports on an informal

survey of pharmacists that asks them how the nursing shortage affects pharmacy operations.

Quoting pharmacist Farena Salek, Lee writes:

> The nursing shortage has hindered the ability of pharmacy to grow more
> as a profession. For example, because of the lack of nurses at the

> patients' bedside, nurses are not as flexible using automated dispensing
> units for the majority of their patients' drugs. But the nursing shortage
> has also caused our pharmacists to grow, as a profession, in some areas,
> because pharmacists can now become more involved in direct patient
> care activities. (n.p.)

In the *American Journal of Health-System Pharmacy* Barker (1995) and Guerrero et al. (1996)

each address the demarcation of professional boundaries from a slightly different perspective

than both Novek and Lee. In an opinion piece about automated systems and their function in

patient safety Barker (1995) considers how pharmacists have often seen automation as a means

to free them up for clinical duties – what Novek refers to as collective mobility. He uses this as

a platform from which he goes on to detail the various challenges to this scenario, and the

implementation of ADDS in general, vis-à-vis patient safety (p. 2445). Using a self-reported

work sampling Guerrero et al. (1996) look at the work activities of pharmacists and nurses

before and after the implementation of ADDS at a hospital with a specific concern for how

much time is made available for pharmacists to do clinical activities (p. 548). They concluded

that while the time nurses spent dealing with drugs remained steady, the ADDS "seemed to give

pharmacists more time for clinical work" (p. 553).

Emerging from the body of work empirically studying the implementation of ADDS,

many articles make suggestions and offer criteria for the successful implementation of ADDS

(Barker, 1995; Cork, 1998; Darby, 1996; Wong et al., 1999). Barker (1995) situates the would-

be success of ADDS in the adherence to patient safety standards. He recommends certain

features of automation that would be desirable for reducing medication errors. For example,

Barker advocates for, among other ADDS attributes, *comprehensiveness* where automation

would extend from order entry to dose administration. Also, an automation system should

dispense unit-doses and provide for *access control* to ensure that the right dose is given at the

right time to the right patient and only by approved personnel (p. 2447). Cork (1998) makes

recommendations on what kinds of systems to install such as modular automated units and

Darby (1996) counsels the reader on their choice between a centralized, decentralized or hybrid

system. Wong (1999) discusses a series of criteria for choosing to implement one ADDS over

another that involves identifying the unique issues faced by individual healthcare organizations

(p. 1398), determining the system requirements needed to address those issues (p. 1399) and

finally comparing those needs to existing automated systems (p. 1399).

There is also some concern for the attitudes expressed by both pharmacy (Lee et al.,

1992; Lee, 2002; Novek, 2002) and nursing (Lee et al., 1992; Novek et al., 2000a; Novek,

2002; Novek et al., 2000b; Schwarz et al., 1995) toward the use of ADDS in healthcare. Lee et

al. studied various effects of a recently implemented ADDS in a hospital, including the attitudes

of pharmacy toward the system. Using a questionnaire the authors found that due to an

increased amount of time needed by technicians to fill stock items and the inconvenient location

of the cabinets, the attitudes of pharmacy toward the system were poor (p. 853). Novek (2002)

doesn't quantify the impact of ADDS on pharmacy, but in his discussion includes a number of

comments that suggest that both pharmacists and pharmacy technicians were dissatisfied with

the system and in general had a poor attitude toward it. For example, Novek writes:

"Confirming the fears of some voices within the pharmacy profession, technology originally

developed as an adjunct to pharmacists had been translated into a management tool to control

their practice" (p. 399).

The attitudes of nurses drew particular attention from researchers, above all Joel Novek.

For example, in "Nurses' Perceptions of the Reliability of an Automated Medication

Dispensing System" Novek et. al. (2000) emphasize that if an ADDS is to be successfully

implemented the perceptions of the system by hospital staff and in particular nurses need to be

taken into account before, during and after the implementation process is complete (p. 2). Their

research showed that almost half (49%) of the 102 full-time and part-time nurses that responded

to the questionnaire thought ADDS actually *increased* the risk of medical errors, while 30%

saw no change and only 20% believed ADDS reduced the chance of error (p. 4). The authors

found pervasive distrust of the system not only among nurses, but also among all health care

personnel (p. 5). This distrust propagates institutional practices that in turn threatened the

potential success of ADDS at the institution under study and in all likelihood other institutions

experiencing similar difficulties. These practices included: avoidance of the machine

altogether, refusing to document floor stock through the ADDS machine (p. 7); resistance to

computer control of work practice, overriding controls to obtain medications on the nurses' own

schedule rather than during predetermined administration times (p. 8); and miscommunication,

especially between pharmacy and nursing over discrepancies (p. 8).

Lee et al. (1992) simply state that "the results of the nurse questionnaire indicated

positive perceptions" (p. 853) and that overall the system received a positive evaluation by

nursing personnel – a population of forty for this study (p. 854). Schwarz et al. (1995) offer

their results from a questionnaire responded to by twenty nurses, saying that all respondents

liked the system for the acquisition of controlled substances while most liked the system for the

acquisition of all medication (65%) (p. 825). Most (80%) indicated they would like to keep the

system on their unit (p. 826). Some of the disparity in the findings of Novek, Lee et al. and

Schwarz et al. may be explainable by the significantly different sizes in study populations and

the particular exigencies experienced by individual institutions in implementing ADDS.

The remaining literature is broader in character and has therefore been categorized as generic. These few articles are far-reaching but warrant some attention in this literature review because they are of considerable interest to those researching this topic. The annual surveys of pharmacists in the United States conducted by the American Society for Health-System Pharmacy are revealing of how pharmacy professionals see their trade and how the profession is evolving. As well, these surveys provide a snapshot of the state of pharmacy in the U.S. up to a certain point and offer multiple starting points for further research. For example, the national survey of hospital-based pharmaceutical services and pharmacy practice attempts to discern the state of hospital pharmacy today and to stay abreast of future developments. Focusing on the role of pharmacists in managing and improving the medication-use process (Ringold et al., 2000), the survey is divided into three parts, each part undertaken in consecutive years establishing a cycle that repeats tri-annually. The first year of the cycle looks at prescribing and transcribing behavior, the second dispensing and administration, and the third monitoring and patient education and wellness. In 1999 the survey focused on the second phase of the cycle – pharmacy practice with respect to dispensing and administration, and is intended to:

> describe the methods by which the integrity of medications is ensured, to characterize drug preparation and dispensing activities, to describe the use of technology in drug preparation and dispensing, to characterize drug administration activities, to report on the design and implementation of quality improvement programs, and to characterize activities associated with identifying and reporting medication errors. (n.p.)

The authors conclude that through automation, centralization and the use of technicians, pharmacists are working to improve the efficiency of the dispensing component of the use of medicines. They recognize the potential for technology to allow pharmacists to improve drug safety but estimate that less than one-quarter of centralized pharmacy activity is automated highlighting the underutilization of the technology. The authors conclude that: "hospitals and

health systems need to capitalize on the advances of dispensing technologies if pharmacists'

potential to provide clinical services that improve patient care and medication safety is to be

fully realized" (n.p.).

In the 2002 survey (Pedersen et al., 2003) much of the same issues were presented but

the de-centralization of pharmacy services was seen as significantly increasing in response to

acutely-ill patients with shorter hospital stays and a rapidly changing approach to drug-therapy

that necessitates quick turnover of drugs available to nurses for dispensing (p. 67). An

increased reliance on technology was again recognized as being necessary to free up

pharmacists' time for clinical work and the underutilization of ADDS was further emphasized

(p. 67).

An increased reliance on technology is also recognized as a liability when it comes to

automation and improved patient safety. Writing for the *American Journal of Health-System*

Pharmacy Tribble (1996) provides on overview of the kinds of failures that can occur when

using ADDS. He claims there are three kinds of failures: hardware, software, and users.

Because hardware contains physical moving parts, Tribble says it is the most prone to failure (p.

2623) and although it is more often than not reliable, that very reliability can make failures all

the more disastrous and unexpected. The hardware in automated dispensing machines must

therefore regularly check itself and report on its condition (p. 2624). Software failures are more

complicated and can originate in a number of different places. Tribble writes:

> An algorithmic-procedure failure is caused by logic (i.e. nonarithmetic
> operations) built into the program itself. These failures can result from
> a typographical error in the program, a failure by the programmer to
> anticipate and with a given situation, or the creation of multiple
> contradictory conditions that prevent the software from functioning
> properly. (p. 2623)

He suggests the focus on a consistent user interface and error trapping as critical elements in software design that can contribute to the safety of an automated system (p. 2626).

User failures result from underutilized instructions and an insistence on using experience as a means to understand how to use a system (p. 2623). Tribble suggests proper training of users and the creation of policies and procedures that give users a clear understanding of what their role is with respect to the use, maintenance and modification of the technology. He also suggests putting in place policies and procedures that help identify the competency of those designated to use the automated system relative to their system privileges (p. 2627).

<u>**Conclusion**</u>

This literature review – and indeed the conclusions of many of the authors cited in this paper – points to the need for more research to be conducted into the impact of automated drug dispensing. There is a considerable gap in knowledge about how these systems affect patient outcomes and although it seems there is strong potential for cost-savings and an increase in efficiency for both pharmacy and nursing, the evidence is divided and therefore inconclusive. Studies looking at these systems that have a specific concern for a measurable effect on patient safety and improved patient outcomes need to be prioritized by governments, organizations and independent researchers if the enormous costs of implementing ADDS are to be justified. There needs to be more empirical evidence to support manufacturers' claims of substantial cost-savings, reduction of medical error and increased efficiency – currently, there is a dearth of information available to institutions considering this technology to make informed and effective decisions that will address the particular issues they face as an organization.

Automated Drug Dispensing Systems: Literature Review
Kelsey Nutland

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