Chapter 10. Unit-Dose Drug Distribution Systems

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Background

Medication errors are especially likely when health professionals engage in multiple tasks within a short time span. This situation occurs repeatedly in hospitals when pharmacists and technicians load unit-dose carts, and when nurses administer medications. Unit-dose carts are prepared daily, often manually, by technicians and then checked by pharmacists. These carts, containing thousands of patient-specific dosages of drugs, are sent to the wards daily, for nurses to administer medications to patients. Dosing frequencies vary widely, ranging from regular intervals around the clock to "stat" doses given to control acute pain or other symptoms. Medication administration alone is an enormous task for nurses, and one in which they are repeatedly interrupted. It is not surprising that the administration phase of medication use is particularly vulnerable to error.[1]

Unit-dose dispensing of medication was developed in the 1960s to support nurses in medication administration and reduce the waste of increasingly expensive medications. Most of the investigations of medication errors and unit-dose dispensing took place from 1970 to 1976. Now, unit-dose dispensing of medications is a standard of practice at hospitals in the United States. This chapter reviews the evidence supporting this practice.

Practice Description

In unit-dose dispensing, medication is dispensed in a package that is ready to administer to the patient.[2] It can be used for medications administered by any route, but oral, parenteral, and respiratory routes are especially common. When unit-dose dispensing first began, hospital pharmacies equipped themselves with machines that packaged and labeled tablets and capsules, one pill per package. They also purchased equipment for packaging liquids in unit-doses. As the popularity of this packaging increased, the pharmaceutical industry began prepackaging pills in unit-of-use form. Many hospitals now purchase prepackaged unit-dose medications. However, it is still common for hospital pharmacies to purchase bulk supplies of tablets and capsules from manufacturers and repackage them in the central pharmacy into unit-dose packages.[2] It is important to note that hospitals vary in the proportion of their wards covered by a unit-dose system.

There are many variations of unit-dose dispensing. As just one example, when physicians write orders for inpatients, these orders are sent to the central pharmacy (by pharmacists, nurses, other personnel, or computer). Pharmacists verify these orders and technicians place drugs in unit-dose carts. The carts have drawers in which each patient's medications are placed by pharmacy technicians—one drawer for each patient. The drawers are labeled with the patient's name, ward, room, and bed number. Before the carts are transported to the wards, pharmacists check each drawer's medications for accuracy. Sections of each cart containing all medication drawers for an entire nursing unit often slide out and can be inserted into wheeled medication carts used by nurses during their medication administration cycles. A medication administration recording form sits on top of the cart and is used by the nurse to check-off and initial the time of each administration of each medication. The next day, the carts are retrieved from the wards and

replaced by a fresh and updated medication supply. Medications that have been returned to the central pharmacy are credited to the patient's account.

A 1999 national survey of drug dispensing and administration practices indicated that three-fourths of responding hospitals had centralized pharmacies, 77% of which were not automated.[2] Larger hospitals and those affiliated with medical schools were more likely to have some component of decentralized pharmacy services. About half of the surveyed hospitals reported drug distribution "systems" that bypassed the pharmacy, including hospitals that reported using floor stocks, borrowing other patients' medications, and hidden drug supplies.

Studies often compare unit-dose dispensing to a *ward stock system*. In this system, nurses order drugs in bulk supplies from the pharmacy; the drugs are stored in a medication room on the ward. Nurses prepare medication cups for each patient during medication administration cycles. The correct number of pills must be taken out of the correct medication container for each cycle and taken to the patient for administration. Liquids must be poured by the nurse from the appropriate bottle and each dose carefully measured. Nurses are responsible for any necessary labeling. Any medications taken from stock bottles and not administered to patients are generally disposed of.

Prevalence and Severity of the Target Safety Problem

The targets of the safety problem for unit-dosing are drug dispensing[3] and administration.[4,5] Improving these stages probably carries the greatest opportunity to reduce medication errors.

Bates et al[6] identified 530 medical errors in 10,070 written orders for drugs (5.3 errors/100 orders) on 3 medical units observed for 51 days. Of the 530 errors, 5 (0.9%) resulted in an adverse drug event. The most common reason for an error was a missing dose of medication, which occurred in 53% of orders. In a systems analysis of 334 errors causing 264 adverse drug events over 6 months in 2 tertiary care hospitals, 130 errors (39%) resulted from physician ordering, 40 (12%) involved transcription and verification, 38 (11%) reflected problems with pharmacy dispensing, and 126 (38%) were from nursing administration.[4] In other words, 164 (49%) of the errors in the above-cited study[4] were in the dispensing and administration stages. In further research, the investigators found that errors resulting in preventable adverse drug events were more than likely to be those in the administration stage (34%) than those in the dispensing stage (4%) of the medication use process.[1]

Opportunities for Impact

Because unit-dose dispensing now constitutes a standard for approval by the Joint Commission for Accreditation of Healthcare Organizations (JCAHO)[7,8] and is closely linked to the increasingly common use of automated dispensing devices (see Chapter 11), there is likely little opportunity for further implementation of this practice in US hospitals. In a 1994 survey of pharmacy directors, 92% of acute care hospitals reported using unit-dose dispensing.[7] Use of unit-dose dispensing is extremely common on general medical and surgical wards, but less so in other locations such as intensive care units, operating rooms, and emergency departments. In these areas, bulk medication stock systems are still found. In a 1999 survey of pharmacy directors, 80% reported that unit-dose dispensing was used for 75% or more of oral doses, and 52% of injectable medications dispensed in their hospitals.[9]

Study Designs

The 5 studies meeting inclusion criteria for this review (Table 10.1) included 4 Level 3 studies, and one prospectively designed before-after observation (Level 2 design). We excluded the following studies for the reasons outlined:

- Read[10] conducted a study of a unit-dose system applied to respiratory therapy solutions that was focused primarily on measures of efficiency. Volume/concentration errors in preparing respiratory solutions were also discussed, but the method of detection was not stated nor were specific error data provided for the study period.
- Reitberg et al[11] conducted a prospective before-after study with a concurrent comparison floor as a control (Level 2 design) in which medication errors represented the main outcomes (Level 2). During period 1 when both wards used the ward stock system, total errors were 4.7% on the ward that remained on ward stock and 34.2% on the ward that used the modified dispensing system. During period 2, the ward stock system had 5.1% error, while the intervention ward (unit-dose) exhibited a significantly *increased* 18% error rate. Excluding administration-time errors resulted in error rates of 5.1% (conventional system) and 4.8% (unit-dose), which are not significantly different. The greater number of errors on the modified dispensing ward before and after the intervention were attributed by the authors to factors other than the dispensing systems. Because of this problem, and the fact that this study took place in a skilled nursing facility rather than an acute care hospital, we excluded this study.
- Shultz et al[12] conducted a prospective before-after study (Level 2) involving a somewhat complicated comparison. In the baseline period, approximately 50% of wards used a unit-dose system. During the study period, some wards switched to a unit-dose system in which nurses still administered the medications, while other wards adopted an experimental system, in which pharmacists and pharmacy technicians handled all aspects of the mediation dispensing and administration process. The authors report an error rate of 0.64% for complete unit-dose plus pharmacy technician medication system compared to 5.3% in the more conventional unit-dose system in which nurses continue to administer medications ($p<0.001$ for this comparison). The authors repeated their observations 2 years later, and show a persistent marked reduction in the "complete unit-dose system" compared to the nurse-administered unit-dose system. Unfortunately, nowhere do the authors report the error rate in the baseline period in the wards without a unit-dose system. Thus, none of the results reported by the authors relate specifically to the conversion from a multi-dose to a unit-dose system.

In addition, 2 of the relevant references identified[13,14] almost certainly reported the same data. The 2 papers have only one author in common, but they come from the same institution, involve study wards of the same size and observation periods of the same duration, and report identical error rates for the main comparison. The data from these 2 papers were combined to produce a single entry in Table 10.1.

Lastly, we were unable to obtain one of the original studies of the unit-dose system within the timeline of the project. The data from this study appears to have been published only as a technical report.[15] Other publications related to this study and which we were able to obtain[16-18] did not provide sufficient detail on the aspects of the study relating to medication errors to permit abstraction or inclusion in this chapter. The published reports of a study conducted in a private hospital similarly did not contain sufficient detail about the study methods or results to permit abstraction and inclusion.[19,20]

Study Outcomes

Studies reported errors measured by direct observation using a methodology that was first described by Barker.[21] All of these studies involved Level 2 outcomes.

Evidence for Effectiveness of the Practice

Though the practice of unit-dose dispensing is generally well accepted and has been widely implemented, the evidence for its effectiveness is modest. Most of the published studies reported reductions in medication errors of omission and commission with unit-dose dispensing compared with alternative dispensing systems such as ward stock systems. One exception was the international study by Dean,[22] which compared a United States hospital using unit-dose and transcription of medication orders with a United Kingdom hospital using ward stock and no transcription of orders. The results of this study indicated that the United Kingdom hospital had less than half the errors of the United States hospital. The study groups were often difficult to compare because of differing cultures, hospitals, or nursing care units. Moreover, co-interventions undoubtedly confounded the results. Each study is summarized in Table 10.1.

Potential for Harm

Unit-dosing shifts the effort and distraction of medication processing, with its potential for harm, from the nursing ward to central pharmacy. It increases the amount of time nurses have to do other tasks but increases the volume of work within the pharmacy. Like the nursing units, central pharmacies have their own distractions that are often heightened by the unit-dose dispensing process itself, and errors do occur.[3]

Overall, unit-dose appears to have little potential for harm. The results of most of the Level 2 observational studies seem to indicate that it is safer than other forms of institutional dispensing. However, the definitive study to determine the extent of harm has not yet been conducted.

A major advantage of unit-dose dispensing is that it brings pharmacists into the medication use process at another point to reduce error.[3] Yet, as pointed out in the Practice Description above, about half of the hospitals in a national survey bypass pharmacy involvement by using floor stock, borrowing patients' medications, and hiding medication supplies.[2]

Costs and Implementation

The cost considerations of unit-dose dispensing are mainly a trade-off between pharmacy and nursing personnel. The pharmacy personnel involved are mainly technicians who load unit-dose ward carts for the pharmacists to check and may package some medications that are commercially unavailable in unit-dose form. The pharmacist must verify that the correct medication and dosage of each medication is sent to the ward for the nurse to administer. Nursing time to maintain a drug inventory is reduced, allowing more time for other nursing activities. A variable cost of unit-dose dispensing is the cost of equipment and supplies to those

hospitals that wish to do much of the packaging themselves instead of purchasing medications pre-packaged as unit-doses.

Comment

The studies evaluating the practice of unit-dosing contain important methodologic problems and, although yielding somewhat heterogeneous results, are overall relatively consistent in showing a positive impact on error reduction. In contrast to other practices related to medication use, none of the studies evaluated Level 1 outcomes, such as actual adverse drug events. Nonetheless, unit-dose dispensing or some form of automated dispensing of unit-doses (see Chapter 11) has become ubiquitous in American hospitals and a standard of care in the delivery of pharmacy services. Consequently, it is unlikely that more rigorous studies could now be conducted.

Table 10.1. Studies evaluating the impact of unit-dose dispensing on medication errors*

Study	Study Design, Outcomes†	Results: Error Rates (95% CI)
Hynniman, 1970[23]	Cross-sectional comparison between study hospital and non-randomly selected "comparison" hospitals (Level 3) Errors of commission and omission (Level 2) among doses ordered	Unit-dose system: 3.5% (3.1-4.0%) Conventional distribution systems at 4 hospitals: 8.3% (7.1-9.7%) 9.9% (8.0-12.2%) 11.4% (9.9-13.2%) 20.6% (18.4-22.9%)
Means, 1975[13] Simborg, 1975[14]‡	Cross-sectional comparison of 2 wards within a single hospital over a 60-day period (Level 3) Errors of commission (Level 2) among doses administered during randomly chosen observation periods	Unit-dose ward: 1.6% (1.0-2.5%) Multi-dose ward: 7.4% (6.1-8.9%)§
Schnell, 1976[24]	Prospective before-after study (Level 2) at four Canadian hospitals Errors observed during medication preparation and administration (Level 2)	Before vs. after implementation of unit-dose system: 37.2 vs. 38.5%; 42.9 vs. 23.3%; 20.1% vs. 7.8%; 38.5% vs. 23.1%¶
Dean, 1995[22]	Cross-sectional comparison (Level 3) of US and UK hospitals with different pharmacy distribution systems Errors observed during medication administration (Level 2)	84 errors among 2756 observations in UK hospital using traditional ward stock system: 3.0% (2.4-3.7%) 63 errors among 919 observations in US hospital using unit-doses and automated dispensing: 6.9% (5.2-8.5%) Absolute difference: 3.9% (2.1-5.7%)
Taxis, 1998[25]	Cross-sectional comparison (Level 3) of 2 hospitals in Germany and one hospital in the UK Errors observed during medication administration	UK hospital using traditional ward stock system: 8.0% (6.2-9.8%) German hospital using traditional ward stock system: 5.1% (4.4-5.8) German hospital using unit-dose system: 2.4% (2.0-2.8%) Omission was the most common type of error

* CI indicates confidence interval.
† Errors of commission include administration of wrong dose or wrong or unordered drug, whereas errors of omission include missed doses for inclusion in a patient's unit-dose drawer or a dose not administered.
‡ As outlined in the text, the similarities in study setting, time, design and results suggest that these 2 references contain data from the same study; information from these references was therefore combined and treated as a single study.
§ The 95% CIs shown in the table were calculated using the reported data: 20 errors in 1234 observed doses on the unit-dose ward vs. 105 errors in 1428 observed doses on the multidose ward.

¶ When wrong time errors were omitted, the above results changed so that the change to a unit-dose was associated with a significant increase in errors at the first hospital, a non-significant decrease in errors at the second hospital, and significant decreases in errors at the other two hospitals.

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