
Assessing the Value of the Department of Veterans Affairs' Investments in Health Information Technology" (ID # 2010-0119)

Technical Appendix:

Bar Code Medication Administration Value Modeling Analyses

Approach to Analysis

This is a description of the modeling process employed by the Center for IT Leadership (CITL) to estimate the financial costs and quantifiable benefits of health information technologies. This process was used for the analyses of several Veterans Health Information Systems and Technology Architecture (VistA) applications, including the Department of Veterans’ Affairs (VA) bar code medication administration system, which is described in detail below.

The benefits are estimated each year from the start of the system development in 1998 to 2007, on savings from having the system as opposed to not having the system, and thus this analytic approach assumes a constant impact of bar code medication administration on administration adverse drug events over time. It does not model how changes in practice, VA policy, or quality improvement programs related to the system might have impacted adverse drug events rates.

The basic bar code medication administration modeling process involves:

1. Conducting a literature review for strong evidence of quantitative impacts of bar code medication administration;
2. Identifying the quantitative sources of value to be modeled;
3. Vetting these value sources with both VA and non-VA experts;
4. Estimating the costs and benefits of bar code medication administration implementation and maintenance through gathering information on system implementation and functionality.
Background on Bar Code Medication Administration Benefits

CITL’s literature review of bar code medication administration systems’ benefits indicated that the only quantifiable and significant evidence of benefit was a reduction in adverse drug events. Adverse drug events are medication errors that result in injuries to the patient.(1) Adverse drug events can be caused by errors at any of the four stages of the medication administration process, as defined by Dr. David Bates — prescribing, transcribing, dispensing and administration.(1) Some adverse drug events are not preventable, such as those resulting from a previously unknown drug allergy. Therefore, this analysis only considered “preventable adverse drug events”(2)—those adverse drug events that could have been anticipated and avoided, such as those resulting from misidentifying patients or medications.

By definition, bar-coding systems can only prevent medication errors that occur during the dispensing and administration stages since they neither affect the prescribing patterns of clinicians, nor the transcription process of nursing and pharmacy staffs. VA’s system is further limited to the prevention of administration errors, since bar code medication administration is not in use at the hospital pharmacy’s dispensing process. Thus, this analysis focused on the impact of bar code medication administration on avoiding adverse drug events due to administration of medications within inpatient settings.

Modeling

Model context and parameters

a. Timeframe

CITL analyzed the benefits and costs of bar code medication administration in VA hospitals from 1998 to 2007. The start date of 1998 was chosen because bar code medication administration software development began in August 1998. The end date reflected the last year of complete usage data that were available at the time of this analysis.

b. VA bar code medication administration versions

Three different versions of bar code medication administration software were used during the period of analysis:
• Version 1 of bar code medication administration software was developed between August 1998 and August 1999, and implemented between August 1999 and June 2000. This version covered oral, intramuscular, and subcutaneous medications.

• Version 2 of bar code medication administration software was implemented between June and November 2002. This version replaced version 1 and included complete coverage of all common medication routes, including intravenous medications.

• Version 3 of bar code medication administration software was implemented between April and August 2004. This version was primarily an effort in customization, user interface changes, and enhanced coverage of medication administration routes such as subcutaneous and intramuscular. As these changes are important for workflow and user acceptance but only have indirect impacts on medication safety, CITL did not quantify additional patient safety improvement to the software upgrade from version 2 to version 3.

c. Adoption

CITL extracted bar code medication administration adoption data from a survey performed by Spetz et al.(3) Each of the VA facilities surveyed had reported the year when bar code medication administration adoption started in acute care settings and the year in which the system implementation was completed (Exhibit 1). However, benefits were not captured until after the system was fully implemented. As Exhibit 1 illustrates, adoption was not completed until 2004. The adoption estimates used in CITL’s projections are consistent with the implementation schedule provided by the VA Bar Code Resource Office.(4) The differential coverage of different administration routes (i.e., oral vs. intravenous) is incorporated separately in the benefit section.
Bar Code Medication Administration benefits

CITL modeled the bar code medication administration benefits due to avoiding the costs associated with preventable adverse drug events, which include reduced length of hospital stays and associated costs. The key variables in this analysis are described below:

a. Annual inpatient preventable adverse drug events affected by bar code medication administration

The CITL estimate of preventable adverse drug events rates in VA was based on non-VA research since there was no reported national rate of preventable adverse drug events in VA facilities. For this study, CITL used an average preventable adverse drug events rate of 11.5 events per 100 admissions, which was the combination of 8.8 events per 100 admissions, adjusted by 130 percent to reflect the uniqueness of the VA age distribution. The age-adjustment factor for preventable adverse drug events rate for the VA was calculated using the 2007 Healthcare Cost and Utilization Project inpatient adverse drug events study and the average VA inpatient age distribution from 1997 to 2008. The Healthcare Cost and Utilization Project report provided adverse drug events rates by age group, which increases with age.

The 11.5 preventable adverse drug events per 100 admissions were then applied to VA admissions from the Patient Treatment File to project the annual VA preventable adverse drug event volume. The total VA preventable adverse drug event volume was then multiplied by the rate of preventable adverse drug events at the administration stage, estimated at 38 percent.

b. Bar code medication administration coverage

Bar code medication administration impacts patient care at the point of medication administration. Therefore, CITL needed to estimate the percentage of medications administered using bar code medication administration during each year of analysis based on information on implementation of versions 1 and 2 (when intravenous medications were
added) by all of the hospitals. CITL primarily used adoption statistics reported by Spetz et al.(3)

In the absence of VA inpatient medication usage data, inpatient pharmacy data from a VA facility(9) was combined with data from a large non-VA academic medical center(10) to estimate that oral medication accounts for 85-90 percent and intravenous medication accounts for 10-15 percent of all medication usage by dose. These estimates were incorporated into the bar code medication administration coverage estimates since IV medications were not included in bar code medication administration until 2002.

c. Impact of bar code medication administration on preventable adverse drug event

Studies on the effectiveness of bar code medication administration have reported error prevention rates of 50 percent to 85 percent.(8, 11, 12) For this analysis, CITL used the midpoint of the range, 67.5 percent as the estimated effectiveness of bar code medication administration in preventing inpatient preventable adverse drug events in the medication administration process.

d. Cost per preventable adverse drug event

CITL estimated the costs saved per preventable adverse drug event as $5,226, which is the inflation-adjusted average of evidence from two studies. The first was the 1997 paper by Bates et al., where each preventable adverse drug event was estimated to cost $4,685 of additional inpatient services in 1993 dollars, inflation-adjusted to $6,337 in 2007 dollars.(13) The second is the recent 2008 Massachusetts Technology Collaborative and New English Healthcare Institute inpatient CPOE study, where a very similar marginal cost of $4,195 per preventable adverse drug event was found.(5) After adjusting for inflation, the Massachusetts Technology Collaborative and New English Healthcare Institute cost amounted to $4,115 in 2007 dollars.
Bar Code Medication Administration costs

Distinct from bar code medication administration benefits, CITL estimated the costs of bar code medication administration software development, implementation, maintenance, training, and hardware. The cost for version 1, 2, and 3 of bar code medication administration was incorporated, each with its own development, training, and implementation schedule. The development, implementation, maintenance, and training costs were extracted from internal VA cost analysis with the details reported below in the results section. The following assumptions and extrapolations were confirmed and validated by VA domain experts:

- Development on new versions started as soon as the old version is released.
- Maintenance on old versions ceased as soon as the new version is implemented.
- Both development cost and maintenance costs were evenly distributed during their respective time periods, as reflected in the original VA internal bar code medication administration cost study. (4)

The national Bar Code Resource Office, based on a detailed cost analysis at the Veterans Integrated Service Network 3, reported that the average hardware cost for each facility was $376,839, prior to adjustment for inflation. (4) Since the national Bar Code Resource Office (BCRO) was not formed until 2003, significantly after the initial implementation, actual national expenditure on hardware across all facilities was never collected. CITL estimated the operating and maintenance costs at 20 percent of original purchase cost per year, consistent with the standard healthcare industry operating and maintenance rates.

Modeling the Value of Bar Code Medication Administration

CITL has provided details on how all cost and benefit model estimates are derived using evidence-based research on the impact of bar code medication administration systems, and to the extent possible, VA-specific information to estimate costs and quantifiable benefits. These inputs
are then used to model annual and cumulative benefits, costs, and net value. Readers are advised to refer to the modeling approach described in the companion Health Affairs article “Assessing the Value of the Department of Veterans Affairs’ Investments in Health Information Technology” (ID # 2010-0119)
Exhibit 1. Bar Code Medication Administration Adoption By VA Hospitals, 1998 To 2007
Notes


Supplemental Exhibit 5

Descriptions Of Vista Applications And Sources Of Value Included In Cost-Benefit Modeling Analysis

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<tr>
<td>- Reduced workload</td>
<td>$74.2</td>
<td>$34.7</td>
<td>$42.4</td>
<td>$49.5</td>
<td>$57.6</td>
<td>$66.5</td>
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<td>- Freed space</td>
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<td>$0</td>
<td>$2.26</td>
<td>$4.33</td>
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<td>- Eliminated redundancy</td>
<td>$357</td>
<td>$176</td>
<td>$208</td>
<td>$217</td>
<td>$230</td>
<td>$237</td>
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<tr>
<td>- Avoided utilization</td>
<td>$1,000</td>
<td>$458</td>
<td>$482</td>
<td>$511</td>
<td>$534</td>
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<td>- Decreased expenses</td>
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<td>$2.55</td>
<td>$4.88</td>
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<td>Total benefits</td>
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<td>Total costs</td>
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<td>$210</td>
<td>$220</td>
<td>$220</td>
<td>$220</td>
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- Annual Net              | -$1,080  | $450   | $520   | $570   | $620   | $660   | $660   | $690   |
- Cumulative Net           | -$1,080  | -$650  | -$100  | $470   | $1,080 | $1,740 | $2,400 | $3,090 |

**SOURCE:** The information in this exhibit is derived from the authors’ analyses.

**NOTES:**
- Reduced workload: Reduced labor costs due to improved or eliminated tasks (e.g., reduced need for radiology film clerks due to PACS)
- Freed space: Reduced overhead costs due to space being made available for other purposes (e.g., due to eliminated film storage)
- Eliminated redundancy: Utilization savings due to avoiding a redundant activity (e.g., due to reduced duplicate laboratory tests)
- Avoided utilization: Utilization savings due to avoiding health care usage attributable to quality improvement (e.g., avoided hospital admissions due to prevented medication errors)
- Decreased expenses: Reduced overhead costs for the supplies to run day to day activities (e.g., reduced use of supplies such as film and paper)
## Appendix Exhibit 6

**Selected Health-IT Related Quality Measures, VA And Private Sector, 2004-2007**

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<td>Breast cancer screening +</td>
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<td>Beta blocker after AMI</td>
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**OUTPATIENT QUALITY MEASURES**

- **Colorectal cancer screening**: The percent of adults 50 to 80 years of age who had appropriate screening for colorectal cancer.
- **Cervical cancer screening**: The percent of women 21 to 64 years of age who received one or more Pap tests during the measurement year or the two years prior to the measurement year.
- **Breast cancer screening**: The percentage of women 50 to 69 years of age who had one or more mammograms during the measurement year or the year prior to the measurement year.
- **Influenza immunization**: The percent of patients age 65 and over who had received an influenza vaccination in the last year.
- **Pneumococcal immunization**: The percent of patients age 65 and over who have ever received a pneumococcal vaccination.
- **Beta Blocker after AMI**: The percent of patients who are prescribed a beta blocker at discharge during a hospital stay for Acute Myocardial Infarction (AMI).

**SOURCE**: Notes 20 and 21 in text

**NOTES**:
- Colorectal cancer screening is the percent of adults 50 to 80 years of age who had appropriate screening for colorectal cancer.
- Cervical cancer screening the percent of women 21 to 64 years of age who received one or more Pap tests during the measurement year or the two years prior to the measurement year.
- Breast cancer screening is the percentage of women 50 to 69 years of age who had one or more mammograms during the measurement year or the year prior to the measurement year.
- + Age criteria and sampling method changed around 2001.
- Influenza immunization is the percent of patients age 65 and over who had received an influenza vaccination in the last year.
- Pneumococcal immunization is the percent of patients age 65 and over who have ever received a pneumococcal vaccination.
- Beta Blocker after AMI is the percent of patients who are prescribed a beta blocker at discharge during a hospital stay for Acute Myocardial Infarction (AMI).