UTILIZATION OF ANALYTICS FOR INTEGRATION OF CLINICAL INFORMATION SYSTEMS (CISs) INTO AN EMR

William T Schmeling MD¹, PhD and Gerard M Ozanne MD²

¹ Division Manager, Anesthesia and Critical Care, The Zablocki VA Medical Center, Milwaukee Wisconsin, Professor of Anesthesiology, Pharmacology and Toxicology, The Medical College of Wisconsin, Milwaukee, Wisconsin
² Anesthesiology Service, The San Francisco VA Medical Center, Professor Emeritus, Department of Anesthesiology and Perioperative Care, UCSF, San Francisco, California

Author Bios:

William T Schmeling MD, PhD is currently the Division Manager for Anesthesiology, Pain and Critical Care at the Milwaukee VA Medical Center, and a Professor in the Departments of Anesthesiology, Pharmacology and Toxicology at the Medical College of Wisconsin. Prior education includes: undergraduate study at Princeton University and Graduate and Postgraduate (MS, PhD, Postdoctoral Fellow) and Medical (MD and Residency), all at the Medical College of Wisconsin. Past and present research interests include the actions of anesthetics and pharmacological agents on the cardiovascular and central nervous systems, the physiology and pharmacology of thermoregulation and the integration and utilization of informatics in the clinical delivery of care. Authorship includes 200+ peer reviewed Publications and Abstracts. For the past several years, he has co-directed the acquisition, integration and implementation of Clinical Information Systems for all Critical care and Perioperative areas within the Department of Veterans Affairs Medical centers.

Gerard M Ozanne MD currently is Anesthesiologist, Anesthesiology Service, San Francisco VA Medical Center and Professor Emeritus, Department of Anesthesiology and Perioperative Care, University of California, San Francisco. Previous education: BS, MS Theoretical and Applied Mechanics, University of Illinois; MD University of Michigan; Residency and Fellowship, Department of Anesthesia, University of California, San Francisco. Since 2007, he has co-directed the acquisition, integration and implementation of Clinical Information Systems for all Critical care and Perioperative areas within the Department of Veterans Affairs Medical centers.
Abstract

INTRODUCTION: CISs are designed specifically to create EMRs capable of capturing the complex, rapidly-changing clinical course of patients in Intensive Care Units (ICUs) and undergoing Anesthesia and Surgery. When CISs are implemented, in conjunction with an existent enterprise EMR, successful integration is very challenging in a multi-hospital National health care system such as the Department of Veterans Affairs (VA), already using one of the most advanced EMR (VISTA/CPRS). The VA utilized multiple vendors to foster competition for product improvement and provides identical requirements, including 1) standardization of terminology (ST), 2) defined CIS integration, 3) certified CIS interfacing with the existent EMR, and 4) extraction of all CIS elements into an analytical environment (ANA). Placing all clinical elements into a true ANA, including data from the existent EMR, can significantly improve installation process by providing for close examination of the CIS build and of the CIS interfacing by allowing the production of ANA reports, specifically addressing all functional requirements, prior to go live. Such a process, crossing multiple VAs and vendors, has been implemented.

METHODS: The VA utilized subject matter experts (SMEs) to develop complete ST elements (> 30,000 terms) and construct standard vendor specific builds for CISs. Testing of the interfaces between VISTA and the newly built CIS was accomplished. Prior to go live, data extraction of all terms in these builds was accomplished to the VA’s ANA. The ANA was then utilized to run reports to ensure that the interface transmitted all data correctly and that only ST were utilized in the new CIS builds.

RESULTS: Utilizing the ANA reports, which examined the conformance of a vendor test initial build, to the established ST, of 1948 terms, 248 had CIS display terms different from ST and after correcting for upper and lower case, punctuation and a specific term usage, while only 34 represented coding errors. Subsequent reports (14,658, ICU; PACU, 3852; Anesthesia, 4669), after CIS ST correction iteratively decreased errors until they reached zero. Similarly, reports to examine the data elements in the VISTA EMR and the transfer of data elements in the CIS, revealed a significantly decreasing error rate during implementation.

CONCLUSIONS: The utilization of customized reports in an independent ANA environment including all data extracted from a new CIS can before and during implementation verify the correct linkage and data transfer from an existent EHR; assure that compliance with pre-defined ST is attained; and provide for continued significant improvement in performance metrics within an enterprise as large as the VA. These lessons can be applied at a hospital, regional or National health care system level.

INTRODUCTION

The delivery of the highest quality of health care is significantly compromised by the multiple limitations inherent in the current systems utilized to collect, collate and analyze inter- and intrapatient medical data. [Kohn et al, 2000, Institute of Medicine (IOM), 2001] Virtually every other modern industry has already adopted comprehensive digital data storage and analytical technologies. However, the delivery of medical care continues to employ centuries old data management methodologies. The vast majority of medical data, accumulated on paper records during routine clinical care, is simply inaccessible to health policy decision makers, clinicians or researchers. Consequently, much of our medical knowledge, healthcare policies and clinical practice patterns are derived from incomplete, non-standardized data sets, frequently collected primarily for single-purpose, clinical studies. This lack of comprehensive, longitudinal data limits the universality of the results, reducing the applicability both to general and individual patient populations. Hence, essential medical information will always remain inaccessible for fundamental analysis until comprehensive medical data from entire patient populations are routinely standardized, collected electronically, analyzed and made accessible for clinical care. Such a comprehensive compilation of health care information mandates the universal employment of electronic technologies for medical data management (Stead, 2009; Thompson, 2007).

Electronic medical records (EMR) systems have been recognized repeatedly as essential for the improvement of patient safety, quality of care, research, and efficiencies of care. [Kohn et al, 2000; IOM 2001; Aspden et al, 2004; Stead, 2009] The implementation of full electronic medical record systems is now rapidly becoming a true national mandate with recent federal laws providing the impetus (CMS-Meaningful Use). Most EMRs store patient data in a transactional database that performs predominantly basic medical record functions and are designed to care for individual patients. Such comprehensive data collections typically are ineffective for epidemiological analysis of clinical patterns, comprehensive outcome analysis, determination of quality assurance measures, or management decision analysis (O’Malley, 2011; http://www.hhs.gov/recovery/programs/cer/execsummary.html). Because of limitations inherent in most/all Clinical Information Systems (CISs) employed in Critical Care Areas (CCAs),
including ICUs, ORs (including Anesthesia Record Keepers (ARKs)) and Perioperative areas, full-featured, analytic systems must be employed to provide essential healthcare analyses. Comprehensive medical and administrative data, stored in electronic formats readily accessible analytically, almost certainly could facilitate substantial improvements in the future practice of medicine. Such analyses would comprise an invaluable international resource, impacting all aspects of medical care in the 21st Century.

The Department of Veterans Affairs (VA) is the largest single medical system in America and one of the few systems that have achieved the qualifications for HIMSS stage 7, the highest level of electronic health record integration. However, the VA’s existent EMR, VistA/CPRS, was not designed for dense data environments and is unable to meet the clinical requirements of the data intensive CCAs (~50% of daytime in-patient beds). Prior to adoption of the processes design, the majority of CCAs used paper records, subsequently scanned into the EMR, precluding practical clinical analyses of CCA patients. With no enterprise-wide or unified strategy for acquisition, implementation and sustainment, many VA hospitals attempted but failed to implement/purchase CISs. We coordinated an enterprise-wide program (Schmeling and Ozanne, HIMSS 2011) which included: 1) the clinical requirements, 2) a vendor-independent, uniform interface between CISs and the VA EMR 3) uniform contracts throughout VA, 4) a single, standard Analytical system for VA, 5) all clinical and administrative vendor data extracted into the Analytics system (Gray, 2004; Sittig, 2010), 6) standardized data nomenclature utilized by each vendor, 7) change process management system for vendors and 8) comprehensive system sustainment. The 2004 IOM report discussed the complexity of achieving data standardization and addressed what it termed “…the three primary areas in which standards for health care data need to be developed: data interchange, terminologies, and knowledge representation…”. The integration of human factors, which might include documentation processes utilizing data standardization and related information technology may be important in maximizing clinical care delivery (Reid, et al, 2005). Previously (Ozanne and Schmeling, HIMSS 2011), we described the methodology for complete CCA Data Standardization utilized across all CIS vendors. This investigation now describes a novel process, utilizing the analytics database, for assuring that such standardization is utilized in all CIS builds and is maintained through all change management data terminology processes.

METHODS

Complete data standardization was first obtained through multiple meetings and review teleconferences utilizing hundreds of subject matter experts (SMEs), utilizing a consensus validation process (Weir-Hughes, 2012). The standardization included terminology sets for ICU (which covers nursing assessments, procedures, lab results, medication orders, and other clinical content) and ARK (which includes anesthesia delivery in all locations, PACU and Preop Patient Assessments). These clinical concepts were first determined by these SMEs and harmonized with existent ontological coding and existent medical terminology such as SNOMED (http://htsdo.org/), International Organization for Terminology in Anesthesia (http://www.apsf.org/initiatives_systems.php), and prior VA standards. The clinical concepts were also mindmapped in structural, ontological coding. Further standardization included a process for standardizing all electronic patient care devices by initiating a process requiring eventual full compliance by all CIS vendors with the evolving CEN ISO/IEEE 11073 Health informatics - Medical / health device communication standards (CEN ISO/IEEE 11073 Standards). These standards address streaming and periodic data communication from the electronic patient care devices employed in critical care locations to the CISs. Parameters such as vital signs, monitored parameters, device specific operational data, etc. (Sims, 2000), will be transmitted in a standardized format for inclusion in the CIS environment and subsequently extracted to the Analytics system, completely neutral to any CIS of medical device vendor.

After the extensive task of creating these instruments VA Enterprise Concepts were created. VA then assigned VA unique specific identification numbers (including versioning and structural relationships) and assigned vendor-specific identification numbers. Each individual vendor’s display terminology (i.e., the GUI display of data elements actually viewed by clinicians documenting within the CIS), in each of the CIS builds is correlated with all of the other corresponding data standardization elements, permitting vendor-neutral analyses.
A specific custom software database has been integrated with a graphical-user-interface mindmap to permit creation of new or modified terms and standardization management for the thousands of necessary terms for the CCAs. This database and GUI viewing software allows for simple, concise and complete change management, inclusive of historical precedent. The VA National Terminology Process for CIS ICU/ARK Analytics provides a systematic change management as needed for ICU/ARK Analytics systems which includes: receipt and review of requests for terminology changes management of review and approval with subject matter experts and other participants in terminology management, from Nursing, Field-based experts, VA Central Offices, and other organizations. Subsequently there is a coordinated management of releases of terminology sets, coordination in implementation of terminology into vendor builds, coordination of terminology among the ICU and ARK vendors, with each vendor representing the standard data in its data base and implementation of terminology as part of all CIS ICU/ARK implementation.

SMEs then met in large, vendor-specific meetings to “build” the CIS or ARK applications, utilizing this standard terminology. The builds were allowed to vary among ICU CIS and ARK vendors to the extent that the SMEs determined necessary and sufficient individual data elements were required for correct documentation in each vendor’s build. Vendors are required to include only standardized terminology within their CIS build database to assure enterprise-wide compliance.

As noted above, a critical component of the VA’s CIS/ARK/ANALYTICS program is the inclusion of an analytical database which contains ALL administrative and clinical data from every CIS from each vendor. This requirement creates the capacity for an iterative analysis of the data standardization within the entire database utilized by each vendor employed by the VA. Additionally, the precise elements utilized by each vendor within every individual hospital build can also be examined. In order to accomplish this complete terminology compliance analysis, a sophisticated report from CIS elements extracted and contained within the analytics, was specifically created. This report examines ALL data elements within each vendor build, comparing the structure of the nomenclature of the vendor display terminology and the corresponding vendor standardized ID number to both the corresponding VA enterprise concept and the VA unique specific identification numbers. The resultant report also examined the vendor’s CIS build and complete database dictionary for matching to the VA standard regarding punctuation, upper/lower case, and numerical errors.

RESULTS

The standardization effort was first completed utilizing large spreadsheets, dividing the VA enterprise concepts into point of care sites (i.e. ICU, PACU, ARK, etc.) and within each of these, by broad categorical usage (such as gastrointestinal, cardiovascular, integumentary, nursing admission, invasive lines, PACU events, etc). Over 30,000 terms have now been standardized and included. As an example of the standardization, below, is a very select portion of the Gastrointestinal terms, for bowel sounds, the VA enterprise concept terms and VA unique specific identification numbers, one vendors display terminology (in this case they match the VA terms), and the vendor standardized ID number (read left to right; single numeric values (i.e. 05, 01, 01 etc.) correspond to the” nesting “within mindmaps):

<table>
<thead>
<tr>
<th>Bowel Sounds</th>
<th>05 Bowel Sounds</th>
<th>Normal present all quads</th>
<th>01 Active</th>
<th>IC.GA.010501</th>
<th>01 Normal present all quads</th>
<th>PI.IC.GA.010501.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>Hypoactive all quads</td>
<td>02 Hypoact</td>
<td>IC.GA.010502</td>
<td>01 Hypoactive all quads</td>
<td>PI.IC.GA.010502.01</td>
</tr>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>Hyperactive all quads</td>
<td>03 Hyperact</td>
<td>IC.GA.010503</td>
<td>01 Hyperactive all quads</td>
<td>PI.IC.GA.010503.01</td>
</tr>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>HF ventilation all quads</td>
<td>04 UTA</td>
<td>IC.GA.010504</td>
<td>01 HF ventilation all quads</td>
<td>PI.IC.GA.010504.01</td>
</tr>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>Absent all quads</td>
<td>05 Absent</td>
<td>IC.GA.010505</td>
<td>01 Absent all quads</td>
<td>PI.IC.GA.010505.01</td>
</tr>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>Abnormal: add protocol</td>
<td>06 Abnormal</td>
<td>IC.GA.010506</td>
<td>01 Abnormal: add protocol</td>
<td>PI.IC.GA.010506.01</td>
</tr>
<tr>
<td>Bowel Sounds</td>
<td>05 Bowel Sounds</td>
<td>IABP all quads</td>
<td>07 IABP all Quads</td>
<td>IC.GA.010507</td>
<td>01 IABP all quads</td>
<td>PI.IC.GA.010507.01</td>
</tr>
</tbody>
</table>

The reports, obtained from the Analytics, examining the compliance of each vendor’s database data dictionary and comparing the entire termset to the VA standards, were run for each vendor. These reports resulted in a tabulation of discordant/non-compliant elements from the VA standards. As an example of the first running of the reports, for two vendors (vendor A and vendor B):
VENDOR A:
Example#1—first standards report for ICU CIS Vendor A:
Of 14,846 VA standardized terms, 7528 had vendor ID codes and 7318 did not (Note: many standard terms were unused in the CIS build). 496 of the 7528 (~5%) terms were where the vendor display term from the VA standard spreadsheet did not match the term displayed. Additionally, 75 / of the 496 terms mismatched by more than punctuation or upper/lower case (1%). Some of the 75 differed in meaning; some differed in wording/spacing but not meaning. Therefore, 75 of the total 7528 in the vendor CIS 1st Build required vendor alteration of build for compliance with the established VA data standards.

Sample from Vendor A Analytics Standardization Compliance report

<table>
<thead>
<tr>
<th>VAGENERICNAME</th>
<th>VAVALUEDESC</th>
<th>VENDORID</th>
<th>VADISPLAY</th>
<th>VENDORGENERICNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema #3 Characteristics Dependent PI.IC.CV.130105.01</td>
<td>Nondependent Edema #3 Characteristics</td>
<td>PI.IC.CV.130106.01</td>
<td>Anasarca</td>
<td>Edema #3 Characteristics</td>
</tr>
<tr>
<td>IABP Head Of Bed Head of bed lower than 30 degrees PI.IC.CV.161701.01</td>
<td>Auto flush and filling IABP Flush/Fill</td>
<td>PI.IC.CV.161702.01</td>
<td>Manual fill IABP Flush/Fill</td>
<td></td>
</tr>
<tr>
<td>IABP Head Of Bed Head of bed higher than 30 degrees PI.IC.CV.161703.01</td>
<td>Manual flush IABP Flush/Fill</td>
<td>PI.IC.CV.161903.01</td>
<td>IABP site: other specify IABP Location</td>
<td></td>
</tr>
<tr>
<td>Jugular Vein Condition Normal with HOB @ 30 degrees PI.IC.CV.080701.01</td>
<td>Normal when HOB @ 30 degrees Jugular Vein Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jugular Vein Condition Distended with HOB @ 30 degrees PI.IC.CV.080702.01</td>
<td>Distended when HOB @ 30 degrees Jugular Vein Condition</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VENDOR B:
Example#2—first standards report for ICU CIS B vendor B:
Of the 13,986 VA standardized terms in the CIS build, only 1,136 vendor applied names "names" which matched the VA names. Most of the mismatches were based on shortening the vendor build version. 11,113 of the vendor "values" matched the corresponding VA values. Almost all of the mismatches were not mismatches in meaning, and many of the mismatches were due to the presence of a "":" and other punctuation or line feeds. Of the 13, 986 terms, the name match number of terms was 1136 and the value match number was 11,113. Therefore the VA and the vendor worked to resolve the name/value/vendor ID mismatches.

Sample from Vendor B Analytics Standardization Compliance report

<table>
<thead>
<tr>
<th>GenericIDPrefix</th>
<th>VName</th>
<th>Vendorname</th>
<th>VValue</th>
<th>VendorValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC.CV.160303</td>
<td>IABP Balloon Pressure Waveform</td>
<td>Pressure Waveform</td>
<td>Damped</td>
<td>Dampened</td>
</tr>
<tr>
<td>IC.CV.160802</td>
<td>IABP Discharge-Exudate Color/Characteristics/Amount/Odor</td>
<td>IABP Discharge Status</td>
<td>Drainage decreasing Drainage decreasing</td>
<td></td>
</tr>
<tr>
<td>IC.CV.161602</td>
<td>IABP Duration Tracking/Stabilization IABP Stabilization</td>
<td>Sutured Securement device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC.CV.020109</td>
<td>Ace Wrap#2 Location Ace Wrap 2 Location Other specify Not Applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC.IT.213301</td>
<td>Wound #3 Wound Bed Characteristics</td>
<td>Wnd3 Healing</td>
<td>Epithelialization (shades of Pink): specify % Epithelialization (shades of pink)</td>
<td></td>
</tr>
</tbody>
</table>

The above sample is from the first runs of the data standardization compliance reports, from the analytic database’s extraction of all CIS terms, for two of the vendors. As noted, when non-standardization of terminology was identified, the CIS database was subsequently corrected. Subsequent running of these reports, for all individual vendor builds was iterative, until full compliance with the data standards was accomplished. By running these for each subsequent CIS vendor, as acquired by the VA, assurance is provided that full data standardization, independent of hospital or vendor selected, is achieved. These reports, along with similar structured reports regarding the precise CIS builds, and not described in the present investigation, are run upon the installation of new CISs, or during sustainment changes in terminology across all hospitals in the VA. The use of the analytical database, containing the extracts of each vendor’s entire nomenclature after standardization, with the established capacity to create compliance reports, as demonstrated in the present investigation, is essential in assuring that only standardized terminology is utilized for all clinical documentation for CISs in CCAs, within the VA.

DISCUSSION

Complex medical care in CCAs, such as ICUs, PACUs and ORs, requires rapid interventions based on medical decisions dependent on the accurate collection, analysis, delivery and integration of complex medical information.
(Glaser, 2008; Bates, 2003). This complex care involves frequent critical incidents, adverse events and medical errors, especially for intensive care unit (ICU) patients. This can be minimized by CIS implementation (Were, 2011, Shekelle, 2006). The VA has previously implemented many computerized process instruments, including bar-coding of all medications, clinical reminders, computerized order entry, extensive monitoring of clinical processes, the application of extensive metrics evaluating clinical care (AHRQ, etc), VistA/CPRS itself, etc. In most clinical care settings, new EMR implementation requires planned integration with any existing EMR (in the case of the VA, the VISTA/CPRS EMR). Clinical care delivery entities often expend significant resources on this integration. However, often the importance of data standardization and the capacity for application of true integrated analytics for decision support processes receives no or far less attention. Often, vendors simply hand the clinical entity implementing the EMR “starter sets” of clinical terminology and then allow site specific addition of terms without consideration of interoperability or universal standardization. Additionally, as new terms for care become required by care sites or enterprise systems, there is an ever increasing drift from data universality and standardization. The present investigation demonstrates the importance of first completely standardizing comprehensive data elements describing complex, clinical environments, for subsequent use across many hospitals and vendors. Standardizing data elements is important in the application of the core functionality of decision support (IOM, 2003; Sittig, 2010) in the utilization of EMRs. Previously, the extreme need for enhanced integrated decision support processes in combination with enterprise wide tools to maintain and standardize clinical terminology, in conjunction with enhanced outcomes analysis has been repeatedly reiterated (Sittig, 2010; Osheroff, 2005; Bates, 2003; Glaser, 2008; HHS Report, 2009).

In the present investigation, the utilization of a custom database and the mind mapping of all standardized terminology for ICUS, ORs, Preop, PACUs, etc., in conjunction with the analytics database environment, produce a simplified data element change control management process that retains full involvement of the essential SME’s. Such standardization, across vendors and hundreds of VA hospitals, will vastly improve the capacity to perform meaningful QA, QI, research and meaningful clinically assisted decision making. Additionally, the integration of a the unique Analytics environment into the CIS EMR, independent of any specific EMR CIS vendor, as demonstrated in the present investigation, allows and supports a standardization process implementation and the continued sustainment of standardized clinically meaningful terminology (O’Malley, 2011). The use of the Analytics as a compliance tool, as reported in this investigation, and the developing very large VA Analytical standardized database, which may be utilized first to verify that standardization of documentation terminology is present (and then use the same analytical reporting instruments to sustain the data standards during change control over time) may be a very important piece for clinical enterprise systems to drive individual vendors towards true data standardization.

For the VA, the newly accruing, meaningful clinically assisted decision making processes in all critical care environs (Balas, 2000; Bates, 2003; Shekelle, 2006), is a unique endeavor. The process reported here also represents a new application of analytics to EMR implementation, maintenance and utilization. The analytics database with nomenclature extracts from CIS databases, when utilized as a tool for assessing and assuring that the initial structure of a CIS EMR is correct and as a sustainment tool for data standardization and clinical documentation evolution could be an important piece during new EMR implementations, particularly in data rich and documentation intense environs such as Critical care areas.

In conclusion, the present investigation demonstrates the ability of an analytic database, coupled with CIS EMR installs for critical care sites, to assure both initial complete data standardization and then subsequent utilized to assure continued compliance. Ultimately, the CIS/ARK/Analytics effort within VA will develop an unparalleled clinical database, with a tightly integrated and sophisticated analytics system. This process should result in an unparalleled and fundamental tool in the evolution of health care delivery. The Standardized Terminology, which underlies all of the above initiatives, may allow greater VA/DOD EMR integration improving Veteran health care and could serve as a national Data Dictionary Standard, in any critical care areas for any health care enterprise. The VA has established a very extensive SharePoint site, information rich in the process details. Unfortunately, it resides within the VA firewall. However, since the VA is a public enterprise, any health care organization wishing to utilize
the standardized terminology can simply request the data dictionary, associated mindmaps, or information regarding the individual vendors utilized. Finally, further details regarding the precise processes employed in the entire endeavor, may be obtained by contacting the authors for any specifics.

Acknowledgements: The authors wish to acknowledge the helpful support in the preparation of the current manuscript of Robert Riera, Robert Stults, Christina Jette, Pat Linehan, and Nadine Malcolm.

References


Crossing the Quality Chasm-A New Health System for the 21st Century; Committee on Quality of Health Care in America. INSTITUTE OF MEDICINE NATIONAL ACADEMY PRESS, Washington, D.C., 2001


Kohn, LT, Corrigan JM, Donaldson MS, eds.: To Err Is Human-Building a Safer Health System, Editors Committee on Quality of Health Care in America. INSTITUTE OF MEDICINE NATIONAL ACADEMY PRESS, Washington, D.C., 2000


Ozanne and Schmeling, Veterans Health Administration: Standardized Terminology for Critical Care Areas, HIMSS 2011


Schmeling and Ozanne, Uniform Integration of Clinical Information Systems (CISs) and Analytics in the VA, HIMSS 2011


