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Integrating Evidence into Clinical Information Systems for Nursing Decision Support

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Abstract

Purpose—To illustrate approaches for providing decision support for evidence-based nursing practice through integration of evidence into clinical information systems (CISs) with examples from our experience at Columbia University Medical Center.

Organizing Construct—Examples are organized according to three types of decision support functions: information management, focusing attention, and patient-specific consultation.

Methods—Three decision support tools that are integrated into three types of CISs are discussed: 1) infobuttons that provide context-specific access to digital sources of evidence; 2) automated Fall-Injury Risk Assessment; and 3) personal digital assistant-based screening reminders, screening assessments, and tailored documentation templates for the identification and management of obesity, depression, and tobacco cessation. The informatics infrastructure for implementing these decision support tools is described from the perspective of components identified in the published literature.

Conclusions—Efforts to facilitate application of evidence into nursing practice are unlikely to be successful unless the approaches used are integrated into the clinical workflow. Our approaches use a variety of informatics methods to integrate evidence into CISs as a mechanism for providing decision support for evidence-based practice in a manner consistent with nursing workflow.

In recent years, there has been increased attention to evidence-based nursing practice. The number of systematic reviews and resources for evidence-based practice has also risen. Despite these factors, application of evidence to practice remains challenging for nurses as well as for other clinicians. The findings of Tanner, Pierce, and Pravikoff's [1] national survey indicate

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that although the majority (64.5%) of nurses had information needs on a regular basis, less than half of the respondents ever searched electronic databases. Moreover, two-thirds reported "never" as the frequency of evaluating research reports and 52% reported "never" as the frequency of using research in practice. In a related study, Pravikoff, Tanner, and Pierce [2] reported that the nurses felt more confident asking colleagues or peers and searching the Internet and World Wide Web than using bibliographic databases such as PubMed or CINAHL to find specific information. The findings of these studies suggest that standalone approaches for accessing evidence for practice are inadequate and highlight the need for meeting information needs for evidence-based practice through tools that are integrated into the nurse's workflow.

A number of authors have stressed the importance of an informatics infrastructure for evidence-based practice and patient safety and identified the components of such an infrastructure: data acquisition methods and user interfaces, health care data standards, data repositories and clinical event monitors, data mining techniques, digital sources of evidence or knowledge, communication technologies, clinical information systems (CISs), and informatics competencies [3,4]. Studies in nursing have addressed particular aspects of this infrastructure such as health care data standards [5-8], data mining [9,10], and informatics competencies [11-13]. However, there are few reports of approaches for integrating evidence into the nursing workflow through CISs to enable decision support for evidence-based practice.

In this paper, we illustrate approaches for providing decision support for evidence-based nursing practice through integration of evidence into CISs with examples from Columbia University Medical Center (CUMC). We also describe the components of the informatics infrastructure for evidence-based practice and patient safety used to implement each decision support tool. The goal is to share our experience so that it may inform development by others.

Decision Support Examples

Clinical decision support systems are computer programs designed to help health care professionals make clinical decisions and can be characterized according to one of three functions provided: information management, focusing attention, and patient-specific consultation [14]. Tools for information management enable access to information needed by the clinician, but do not help apply that information to the task. Information management tools include electronic resources such as bibliographic databases, Cochrane Collaboration, and pharmacy knowledge bases. Tools for focusing attention remind the user of problems that might otherwise be overlooked (e.g., abnormal lab values, potential drug interactions) or relevant care protocols. Tools for patient-specific consultation provide custom-tailored assessments or advice based on sets of patient-specific data (e.g., decision analysis, diagnostic decision support, protocol eligibility, treatment recommendations). Each type of decision support tool has relevance for evidence-based nursing practice as illustrated through the following examples from our work at CUMC.

Information Management

Many information management tools are standalone systems. For example, typically in order to meet an information need, the nurse must exit the CIS and use another type of information system such as an intranet to access a pharmacy knowledge base, search for patient education materials, or retrieve an institution-specific practice guideline. In contrast, at CUMC, context-specific links called infobuttons are integrated into two CISs: the web-based CIS, WebCIS, and the order entry module of the Eclipsys XA commercial product [15,16]. The links are considered context-specific because the information retrieved is tailored to the location in the CIS (e.g., sodium result or particular drug in the medication list) as well as to selected patient data such as age and gender. Screen shots from two types of infobuttons are shown in Figure

1. The first infobutton is accessed through the laboratory results section of WebCIS and the second from the patient medication list.

The information needs that form the basis of the questions addressed in the infobuttons were derived from observational studies during CIS use, focus groups, and interviews with nursing quality assurance leaders [17]. Research team members selected the internal or external resources they felt best met each information need [18]. The linkage between the clinician's information needs that occur as she uses a CIS for tasks such results review, order entry, or documentation and the resources to resolve the information needs is managed through the Infobutton Manager application [19].

Infobuttons have been in use for several years. Extracts of log file records of infobutton usage from January 2006 until February 2007 indicate that 4,397 users accessed the infobutton at CUMC for a total of 26,527 accesses. [20] The average monthly infobutton use during this same time period was 1,863. The primary advantage of the infobutton approach from the clinician perspective is that the information provided is context-specific. From the developer perspective, a major feature of the approach is that the task of keeping the evidence up to date resides with the content providers. Infobuttons as implemented at CUMC and elsewhere (e.g., KnowledgeLink at Partners HealthCare System) [21] and other context-specific methods [22] illustrate a decision support approach that is suitable for broader application to enable access to information for evidence-based nursing practice from within an existing CIS.

Focusing Attention

Computer-based alerts for focusing clinicians' attention have been implemented in some institutions for more than 30 years [23,24]. Common areas of application include drug-drug and drug-laboratory interactions [25]. Such alerts are frequently integrated into computer-based provider order entry and e-prescribing systems [26-28]. There have been few reports of strategies for focusing attention that are specific to evidence-based nursing care.

A strategy for focusing attention on patient fall and injury risk was developed at the CUMC campus of NewYork-Presbyterian Hospital. A seven-item Fall-Injury Risk Assessment instrument was created based upon a review of the literature and a retrospective case-control study, with five items deriving fall risk and two items deriving injury risk [29]. The fall risk items include: 1) Fall(s) in the past seven days, 2) Use of sedatives or hypnotics; 3) Male gender; 4) Impaired cognition; and 5) Unsteady gait while not using an assistive device, an interaction variable. The injury risk items include risk for bleeding and risk for fracture. Following usability testing of an initial prototype, an automated Fall-Injury Risk Assessment with tailored safety measures based upon risk scores was deployed in WebCIS [29]. This CIS-based strategy was developed to improve identification of patients at risk for falling while hospitalized, focus clinicians' attention on fall and injury risk scores, and facilitate selection of appropriate evidence-based safety measures. The initial implementation of the Fall-Injury Risk Assessment in WebCIS, was followed by deployment in a second CIS at Weill-Cornell Medical Center, Eclipsys Sunrise Clinical Care. Screen shots of the two implementations are shown in Figure 2. The Fall-Injury Risk Assessment is in routine use within the CIS and studies evaluating its impact on fall and injury rates are ongoing. The approaches that we have implemented to focus attention on the risks of falling and sustaining falls-related injuries are applicable to other aspects of nursing care that include identification of patients at risk based upon a standardized assessment and implementation of evidence-based interventions based upon level of risk.

Patient-specific Consultation

For more than two decades computers have helped clinicians to provide care consistent with standardized protocols or clinical practice guidelines (CPGs) [24,30]. A number of randomized

controlled trials have demonstrated that computer-based reminders increase compliance with preventive care CPGs [31-32]. Several systematic reviews suggest that such systems impact clinician adherence to CPGs [33-35], but most studies have focused exclusively on physicians.

The literature indicates that the impact of these systems is best realized through an integrated set of applications with access to a broad array of patient data and well-specified decision rules [24,35]. However, many clinicians see patients in settings without an integrated set of applications. Recently, the potential for the use of personal digital assistants (PDAs) to support CPG-based care has been recognized, [36-37] but no large-scale trials have been conducted. The conclusion of the AHRQ-funded report, Making Health Care Safer: A Critical Analysis of Patient Safety Practices, notes that "...well-constructed guidelines could play a significant role in ensuring patient safety and reducing medical errors. The effectiveness of guidelines, however, is dependent on many factors outside of their content. In particular, specific attention must be focused on utilizing appropriate implementation strategies if the full potential of guidelines is to be realized" [38].

The implementation strategy for CPG-based care at the Columbia University School of Nursing, one of four schools comprising CUMC, is based upon PDAs because many of the advanced practice nursing (APN) students deliver care in community-based environments that lack CISs. For the last five years, APN students have documented clinical encounters using a PDA-based clinical log and accessed other resources on their PDAs (e.g., Micromedex) within the context of promoting evidence-based nursing practice [39-40]. Although the PDA-based clinical log is not an enterprise CIS such as the WebCIS and Eclipsys systems described in the previous examples, it shares many features of the documentation modules contained within CISs such as the ability to enter patient demographic data, diagnoses, and a plan of care. In addition, CPG-based decision support for depression screening, obesity management, and tobacco cessation has been added recently to the clinical log application as an integrated strategy for improving evidence-based care [41-45] .

The screening and treatment recommendations for each area were based on national CPGs. For obesity management in adults, a single CPG provided the primary evidence [46]. However, because we wished to support a shared decision making process, plans of care were tailored according to one of three patient goals: lose weight, maintain weight, or no desire to lose or maintain weight. The CPG chosen for tobacco cessation was *Treating tobacco use and dependence* from the U.S. Department of Health and Human Services [47]. No single guideline existed for adult or pediatric depression screening and management. Consequently, multiple sources of evidence were used [48-53].

Patient-specific consultation is provided through tailoring of screening assessments based upon age and additional tailoring of plans of care based upon the results of the screening (e.g., body mass index, depression score, lactation/pregnancy status), and in the instance of obesity, patient goal. CPGs were decomposed into screening elements and treatment recommendations according to the five parts of the APN Plan of Care as implemented in the clinical log: Diagnostics, Procedures, Medications, Teaching and Counseling, and Referrals. The resulting CPG-based documentation templates were modeled using a variety of techniques including use case analysis [54] and guideline interchange format [55] and were iteratively refined based upon domain expert review. [41] In our approach (Figure 3), the nurse completes her documentation by selecting from among the tailored CPG recommendations displayed in the plan of care template.

The CPG-based decision support system has been in use for more than a year and the reminder to screen has been deployed in more than 11,000 clinical encounters. A randomized controlled trial testing the impact of the system on screening rates and adherence to CPG-based care is in

progress. The three-pronged approach illustrated in our example: 1) reminder to screen, 2) generation of diagnosis based upon standardized screening assessment, and 3) CPG-based tailored plan of care may be applied to other aspects of nursing care that are evidence-based and possess a similar workflow.

Informatics Infrastructure Components Used in the Decision Support Tools

The three approaches for decision support for evidence-based nursing practice are built upon the informatics infrastructure for evidence-based practice and patient safety as described in the introduction to this paper. [3,4] Four particularly relevant aspects of the infrastructure are described in the following paragraphs: data acquisition and user interface, health care standards, data repositories, and digital sources of evidence. The manner in which each approach is integrated into a CIS, another key component of the infrastructure for evidence-based practice and patient safety, was addressed in the previous section.

Data Acquisition and User interface

Data acquisition methods and user interface approaches are similar for infobuttons and the automated Fall-Injury Risk Assessment. In both instances, some data is pre-populated from other systems in the CIS and the applications can be accessed through a web-based user interface (i.e.,WebCIS) or Eclipsys. One difference between the two decision support tools in terms of data acquisition is that the automated Fall-Injury Risk Assessment requires some data input from the clinician completing the assessment. For the PDA decision support system for CPG-based care, selected data elements such as age, gender, height, and weight are fed to the decision support module from the clinical log patient data module, but nurses must also enter additional CPG-related data (e.g., screening items, patient goal) using a variety of techniques including radio buttons, picklists, keyboard, and graffiti. The decision support module does not acquire data from systems external to the clinical log.

Health Care Standards

Health care standards are essential to the three decision support tools. For instance, all integrate multiple standardized terminologies. The Infobutton Manager uses a concept-oriented data dictionary that integrates Medical Subject Heading terms [57] to implement a variety of methods for linking resources to context-specific information needs. These methods have been described in detail elsewhere [16]. The Fall-Injury Risk Assessment instrument items are represented in the same concept-oriented data dictionary that supports infobuttons using names and codes from the Unified Medical Language System and the Logical Observation, Identifiers, Names, and Codes database [29]. The student clinical log and decision support system for CPG-based care for depression screening, obesity management, and smoking cessation incorporates a variety of standardized terminologies including International Classification of Diseases-Clinical Modification, Current Procedural Terminology Codes, Clinical Care Classification, and SNOMED Clinical Terms [43].

Other health care standards relevant to the implementation of the decision support tools that we described include Health Level 7 messaging [58] for pre-population of selected data for infobuttons and the automated Fall-Injury Risk Assessment from other information systems and an evolving guideline representation format standard [55] for representation of the CPG algorithms for the PDA-based decision support system [41]. In addition, the CPG documentation templates, while not technically compliant with the Health Level 7 Clinical Document Architecture standard, are informed by the standard [59].

Data Repositories

Data repositories are an essential component in the applications described. In the instance of infobuttons and the automated Fall-Injury Risk Assessment, data are retrieved from and stored in the clinical data repository during interactions with the decision support tools. The PDA decision support system interacts with its associated data repository through an explicit synchronization process in which the user initiates the synchronization through the use of Ethernet cradles, WiFi, or cellular telephone technology [60]. At the time of synchronization, data are transferred from the user's PDA to the data repository and application updates are transferred from the data repository to the PDA.

Digital Sources of Evidence

Digital sources of evidence or knowledge are integral to all three decision support approaches. Infobuttons support context-specific access to a broad variety of internal and external sources of evidence and are premised on the separation of sources of evidence from the actual CIS from which the evidence is accessed, i.e., the evidence is referential rather integrated into the CIS. Consequently, updating the evidence is the task of the evidence provider rather than the CIS developer. In contrast, for the automated Fall-Injury Risk Assessment and PDA-based decision support system, the sources of evidence are integrated into the applications themselves. For the Fall-Injury Risk Assessment, this includes institution-specific weights for the risk variables and evidence-based interventions for the level of Fall-Injury Risk. In the latter, national CPG recommendations were decomposed into templates against which the APN plan of care is documented.

Conclusions

Efforts to facilitate application of evidence into nursing practice are unlikely to be successful unless the approaches used are integrated into the clinical workflow. The approaches that we have described use components of an informatics infrastructure to integrate evidence into CISs to provide decision support for evidence-based practice in a manner consistent with the nursing workflow. It is the responsibility of the tool developer to ensure the safety, usability, and usefulness of such tools. In order to gain maximum benefit from such tools, nurses also must possess basic competencies in the areas of evidence-based practice and informatics.

Toward the goal of informing development by others, our CUMC examples illustrated implementation of three types of decision support functions (information management, focusing attention, and patient-specific consultation) to evidence-based nursing practice. We are currently evaluating the impact of the applications used in our examples. Additional research is needed to implement and test integrated decision support functions for evidence-based nursing practice in other CISs and to further develop the necessary information infrastructure.[61]

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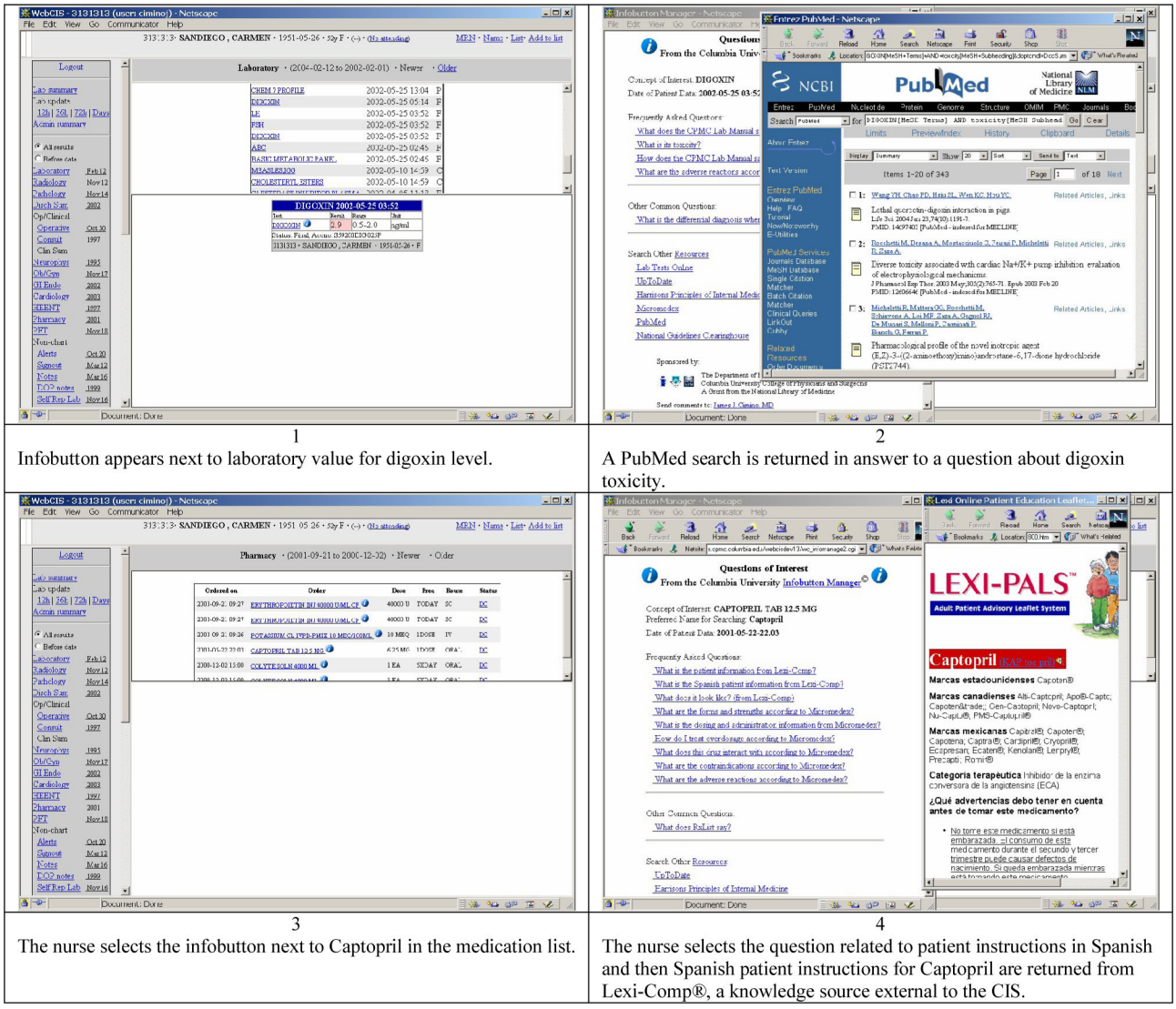
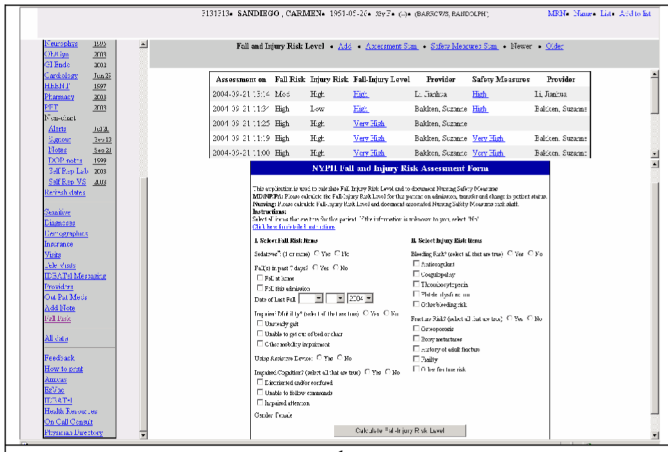
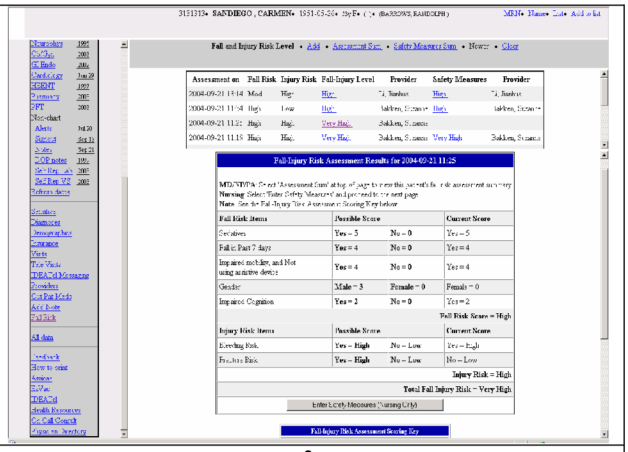


Figure 1.
Infobuttons in the laboratory results and medication list in WebCIS.



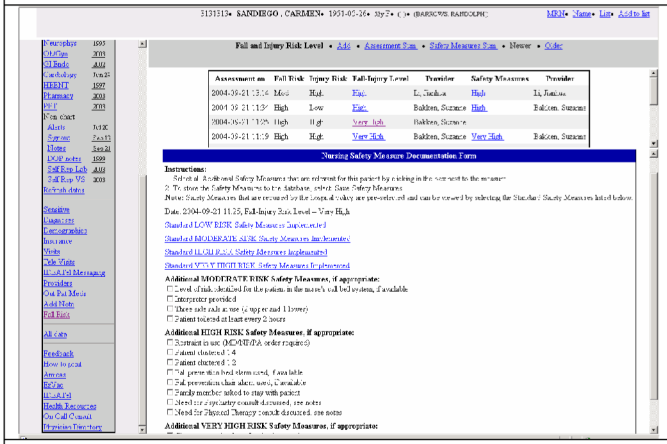
1

Falls Risk, Injury Risk, and Fall-Injury level are displayed in order to focus the clinician's attention.



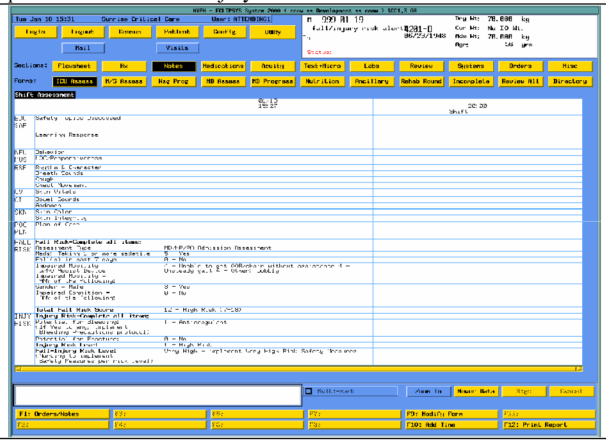
2

The evidence-based scoring algorithm is displayed along with the patient's falls risk and injury risk scores.



3

Institution-specific standard measures that are required by hospital policy are pre-selected. The nurse can select additional safety measures by checking relevant boxes.



4

The computer screen displays score and reminds to nurse to implement safety measures appropriate to risk level.

Figure 2.
Fall-Injury Risk Assessment instrument as implemented in WebCIS (Screens 1-3) and Eclipsys Sunrise Clinical Care (Screen 4).

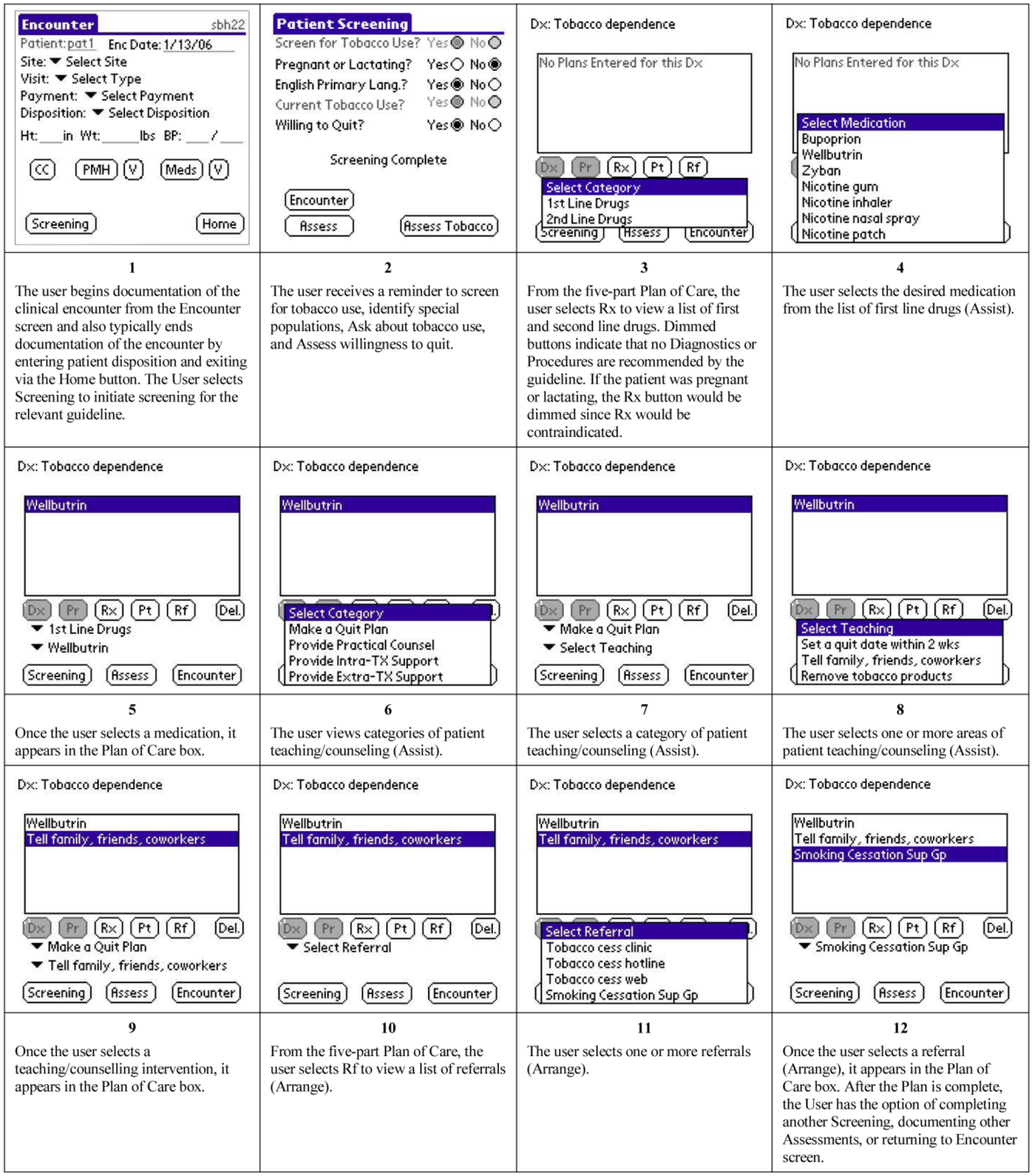


Figure 3.

Screen shots from PDA-based decision support system for tobacco cessation. Ask, Assess, Assist, and Arrange are components of the 5 A's of smoking cessation. The fifth A, Advise, in which the smoker is advised of the importance of quitting prior to Assessing willingness to quit is not explicitly documented in the application.