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Medtable™: An EMR-Based Tool to Support Collaborative Planning for Medication Use

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Medtable™ is an Electronic Medical Record (EMR)-integrated tool designed to address the significant problem of medication nonadherence, especially barriers related to patients' limited cognitive resources and ineffective patient-provider communication. Medtable™ supports the patient-provider collaboration needed to create effective medication schedules that are easy to implement by diverse patients. The tool builds on prior research and, through its integration with EMR systems, creates medication lists and schedules that are more easily updated, more accurate and more reliable. Used in clinical practice, it is expected to improve patient satisfaction, medication understanding and adherence, as well as health outcomes among patients struggling to manage multiple medications.

INTRODUCTION

Medication Nonadherence

Medication nonadherence, or the failure to take medications as prescribed, is a serious health care problem that threatens patient safety. According to an Institute of Medicine (IOM) report, more than one third of 1.5 million preventable adverse drug events occur in outpatient settings each year (Aspden et al., 2007). Older adults with chronic illness are at greatest risk for medication errors because they take more medications than younger and healthier adults (Budnitz & Layde, 2006) and because of age-related cognitive declines (Morrow & Wilson, 2010).

Two important factors contributing to medication nonadherence are patients' limited cognitive resources and ineffective patient-provider collaboration. First, managing multiple medications is cognitively challenging. Patients must integrate medication information and schedule constraints into a medication-taking plan (Park & Jones, 1997). These processes can be undermined by age-related declines in cognitive resources such as working memory and processing speed (Salthouse, 1991; Park & Jones, 1997). Older adults also tend to have lower levels of health literacy, or the capacity to obtain, understand and use health information to make health decisions (DHHS, Healthy People 2010), which can impair understanding of medication information (Davis et al., 2006).

Second, nonadherence is often traced to inadequate communication and collaboration between providers and patients (Aspden et al., 2007; Wolf & Parker, 2007). This may be especially true for lower-literacy patients. These patients report that physicians are their major source of health information, yet they are less likely to actively provide information, request information or ask for clarification during medical visits with their physicians (Makoul, Arntson, Scholfield, 1995; Rollins, 2003). On the other hand, physicians often present information that patients don't completely understand and fail to effectively educate or check patients' comprehension of presented information (Schillinger et al., 2003; Tarn et al., 2009). Inadequate patient-provider collaboration may result from insufficient physician training in communication strategies and limited time during encounters with patients (Castro et al., 2007).

To improve medication adherence and patient safety, the IOM has recommended that patient-provider collaboration be improved by use of up-to-date patient medication lists and patient-centered communication strategies, which can both support medication review and reconciliation. Patient-centered communication not only increases patients' satisfaction and engagement in decision-making, but also leads to better adherence among older adults with limited health literacy and cognitive abilities (Aspden et al., 2007; Schillinger et al., 2006). These communication strategies can be effectively supported by applying information technology to improve comprehension and assist decision-making (Paasche-Orlow et al., 2006).

External Artifacts (Tools)

Distributed cognition may provide a theoretical approach that assists in the development of IT-based tools to support patient-provider collaboration (Hutchins, 1995). An important insight from this approach is that the cognitive demands of complex tasks may be distributed among internal forms of cognition (e.g., working memory) and external forms (e.g., displays, tools). Performance can be improved by offloading cognitive load to external resources. Older adults may especially benefit from such environmental support (Morrow & Rogers, 2008). Given the complex information requirements involved in medication scheduling, both patients and providers can greatly benefit from external tools that serve as external representations in patient-provider communication. Effective visual external representations, such as diagrams and matrices, can assist patients in structuring situational models and improve comprehension of medication scheduling information. (Day, 1988; Larkin & Simon, 1987). These external physical media can also serve as memory aids that improve planning (Zhang & Norman, 1994), and support collaboration, helping both patients and providers initiate discussion, present information, and reach agreement (Clark & Brennan, 1991).

Several tools have been developed to support low-literacy patients' management of complex medication regimens and to improve adherence. However, these tools have either not been evaluated as collaborative tools (Kripalani et al., 2007), have shown limited effectiveness in improving adherence (Cordasco et al., 2009), or were developed to support adherence to individual medications but not complete regimens (Machtinger et al., 2007). Moreover, none of these previous tools is integrated with IT systems in clinical environments. Integration with IT systems would allow these tools to be more easily updated, thus increasing their accuracy and reliability, as well as their cost-effectiveness and ease of use. It would enable them to more effectively serve as successful external artifacts that support patient-provider communication in order to improve medication adherence (Paasche-Orlow, et al., 2006).

PRACTICE INNOVATION

The Medtable™ is an Electronic Medical Record (EMR)-based tool that was designed to support the patient-provider collaboration needed to create effective medication schedules that are easy to implement by diverse patients. We expected that use of the Medtable™ tool during primary care clinic visits would improve patients' knowledge of and adherence to their medications by: 1) supporting the process of medication scheduling by externalizing and integrating medication task constraints from multiple sources (e.g., medication lists from the EMR system, medication instructions, patients' daily activities); 2) serving as an external workspace that supports communication between patient and provider to address any concerns about taking the medications; 3) using simple language and visual-graphic formats, and highlighting key information to support comprehension among patients with low health literacy; 4) providing printed medication schedules that patients could easily understand and use at home to guide medication taking.

Paper-based Medtable™

We first developed a paper-based Medtable™ tool in the form of a medication matrix, in which medication information and instructions were written in the leftmost column, schedule information was written across the top row, and an "x" was made in the cell that matched the appropriate time and medication to indicate a scheduled "taking" (Morrow et al., 2008). The conceptual model of a matrix itself is both intuitive and efficient in supporting this kind of task (Day, 1988). Medication scheduling is essentially a problem-solving task defined by two major constraints: the patient's daily activities and the medication requirements (dosage, whether taken with food, etc.). Employing the matrix design helped patients visualize the scheduling and medication requirements and assisted patients in cognitively integrating these constraints. Patients on multiple medications, could easily refer to the paper-based tool for information about which medications they needed to take at which time.

A laboratory study using a simulated collaborative scheduling task showed that pairs of older adults worked together more accurately and efficiently when using the paper-based tool compared to a no-aid condition and an unstructured aid condition (blank paper), presumably by externalizing the relationship between medication and patients' routine constraints. Furthermore, the paper-based tool has been used at OSF Saint Francis Medical Center at Peoria, IL with real providers and patients to help them collaboratively organize the patients' medication regimens. This field study showed that both provider and patient considered the paper-based Medtable™ useful for organizing medication information (Conner-Garcia et al., 2008).

Computer-based Medtable™

Next we developed the paper-based Medtable™ into a computer-based tool. A computer-based tool is more likely to be implemented in primary care visits because of the rising popularity of information technology in clinical settings. We expected that an electronic artifact would provide more flexibility in terms of function and presentation in order to create tailored schedules for patients with differing routines. A computer-based tool would also allow providers to easily update medication schedules as patients' regimens change over time. Again we used the simulated collaborative scheduling task to test the electronic Medtable™, which preserved the basic functions of the paper-based tool. The results showed that it supported more accurate scheduling with lower workload and higher usability compared to a less structured aid, which was similar to patient medication lists used for medication reconciliation in many clinics. We also showed that the electronic Medtable™ was as effective as the paper-based version (Waicekauskas et al., 2010). We used older adults (aged 60 and above) as participants because they were expected to be frequent users of a Medtable™ given that many of them were on multiple medications and therefore likely to have trouble with medication scheduling. Although older adults are often thought to have trouble using technology (Charness & Boot, 2009), we did not find evidence that they had difficulties using the computer-based Medtable™ compared to the paper version.

The final step in developing the Medtable™ tool was to integrate the computer-based tool into an EMR environment, to build on the growing prevalence of healthcare information systems. Integration of the Medtable™ tool into EMR systems and routine clinical care would make it easier for providers to efficiently access patient medication lists and accurately update these lists, and would address multiple barriers to effective care raised by incomplete communication, especially for patients with low health literacy.

Medtable™ Intervention

As part of Medtable™ development, we conducted a survey of clinicians at Northwestern Medical Center (Chicago, IL) and OSF Saint Francis Medical Center (Peoria, IL) to un-

derstand how medication information is communicated between providers and patients during routine clinic visits. Important implications for Medtable™ development and use during clinic visits that emerged from the survey included: 1) Providers often use multiple media to present and review medication information with patients. In addition to verbal communication, they also use writing, typing and graphical presentations to reinforce important information. At the end of a visit, a printout sheet is often provided for patients to take home. This finding suggested that use of the Medtable™ may enhance current medication communication practice by utilizing both verbal and computer-based communication, presenting graphical information integrated with easy to understand text, and providing a printed Medtable™ that patients can use at home. 2) Providers and patients often work collaboratively to ensure patients' understanding of medication information by using strategies such as teach back, teach-to-goal and categorizing medications. This finding suggests that tools that support more structured use of these strategies can be expected to improve this process. Providers also indicated they would adapt their communication styles for individual patients, especially older adults and patients with low health literacy. 3) Providers indicated it is often hard to acquire an accurate and up-to-date medication list since some sub-specialists may not appropriately document prescriptions in the EMR system. This is an important issue for Medtable™ since we set up the table by loading data directly from the EMR system. To address this problem, it will be necessary to include a medication reconciliation stage in the Medtable™ process in order to ensure the accuracy and completion of each patient's medication lists.

Based on these findings, we proposed a standard Medtable™ intervention process: 1) Setup. Before the patient visit, the Research Nurse (RN) loads the patient-specific information from the EMR system into the tool and makes changes, if necessary. 2) Patient check-in. The patient receives and completes a Medication Reconciliation Form at check-in. This form asks the patient to review her/his medication list retrieved from the EMR system, add or delete any item, if necessary, report her/his adherence and any concern about taking the medications. 3) Medication reconciliation. After the patient consults with the physician, the Medtable™ RN goes through the Medication Reconciliation Form with the patient, addresses her/his concerns and makes change to the current medication list if necessary. All changes should be reported to the EMR system. The goal of medication reconciliation is a complete and up-to-date list of medications. It is an indispensable step given that patients may take medications from sources that are not documented in the EMR system. 4) Medication scheduling using Medtable™. In this step, the RN and patient work together to create an effective medication schedule using the Medtable™ tool. At the beginning of this step, the RN should make sure changes made during the reconciliation phase are reflected in the Medtable™ by including additional entries in the setup page. The tool is designed to support effective communication strategies during this stage, such as providing complete information about each medication, creating optimal schedules that fit the patient's routine, and making sure the patient understands the plan. The patient is given a printed copy of the medication schedule to take home to guide adherence. A special toll-free number is also provided for patients to call if they have questions about using or updating the Medtable™.

In next section, we focus on the design of this EMR-based Medtable™, which is achieved by contributions from all the previous stages, as well as iterative design and evaluations. We will introduce the design of the Medtable™ interface in its functional sequence.

Step 1: Set up

Before the patient visit, the RN will set up the Medtable™ by retrieving the patient's medication list from the EMR system. The setup page will show the medication dosage, form (tablet vs. capsule), indication, and special instructions, all of which were extracted from the EMR system. The RN will then go through the medication list, choose the indication for the particular patient and make necessary changes to the medication instruction using simple, customized language. This is a necessary step since it allows the RN to adapt the medication instruction for patients with low health literacy, translating from the technical information in the EMR. This step is done before the patient encounter in order to allow the nurse to focus on communication and collaborative planning with the patient.

Step 2: Collaborative scheduling

The bulk of patient-provider collaboration will be completed on this page (Figure 1) as the nurse and patient create an effective, patient-specific medication schedule.

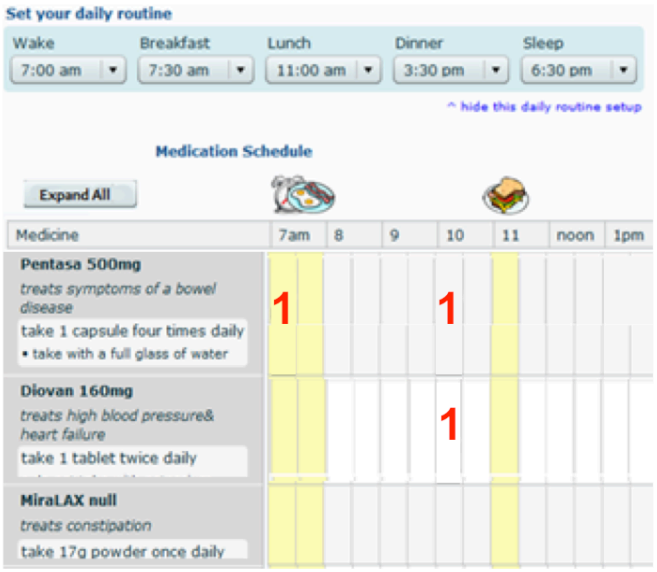

Figure 1. Collaborative scheduling page of Medtable™

Similar to the paper-based Medtable™, this part of the tool is a matrix with medication information in the leftmost column and schedule information across the top row. The patient sets

the time s/he wakes up, eats meals and sleeps. A pictorial icon will be added on top of those time slots and the corresponding columns will be highlighted. This will help the patient and the RN schedule the medication around these critical activities. Then, for each medication, the patient and RN could work together to schedule each taking by clicking on the cell corresponding to the medicine (row) and time slot (column). A numeral indicated the prescribed dose will be added into the cell.

The Medtable™ interface was designed to be used with patients with diverse abilities, especially those with low health literacy. Our goal is to build a user-friendly tool that is easy to operate, customizable for diverse user needs, and can reduce users' cognitive workload and improve patients' comprehension of medication information. We attempt to achieve this goal through the following design features:

*Organizing information according to patients' schemata***.** The EMR-based Medtable™ preserves the primary functionality of the paper-based Medtable™. Using the matrix conceptual model, it externalizes the relationship between medication-specific constraints and patients' schedule-related constraints and provides effective representation of medication schedules.

Providing key information for task completion. To minimize the need for recalling information, we included information critical for the scheduling task on the Medtable™ screen. First, the medication instructions and dosage information are listed under the medication name so the RN and patient can schedule the medication accordingly. Second, the medications are automatically ordered by three levels of constraints: insulin/non-insulin, taken with food/ taken without food, times taken per day. Color shading and icons indicate the level of each medication. This allows users, especially the RN who frequently uses the system, to capture these important constraints immediately without recalling or reading the medication instructions. Also, grouping medication with similar constraints together may make the scheduling task easier since patients would prefer to schedule them in similar ways in order to minimize the number of times they have to take medications in a day.

Using simple language and visual-graphic format to make Medtable™ easier to understand. When typing the customized instructions, the RN is encouraged to use language that helps patients mentally simulate the taking the medication (e.g. "take 1 tablet in the morning and 1 tablet in the evening" is better than " take 1 tablet twice daily"). This supports comprehension by low health literacy patients (Wolf & Parker, 2007) and may help them remember to actually take their medication once they are at home (Liu & Park, 2004).

Using a simple input method to support collaborative use. The electronic Medtable™ was implemented in a single workstation so it does not suffer from workspace sharing issues that sometimes arise with collaborative software. The RN will use the computer while the patient will be able to see the interface. To help patients easily track and understand the process, we tried to avoid complicated input methods. By a simple click a numeral will be added to the target cell. If a schedule is made by error, another click on the cell will delete the previous entry. By allowing continual changing and backtracking without pop-up windows asking users to verify the choice, we expect users will not be distracted from the ongoing task.

Step 3: Print out

One purpose of using the Medtable™ tool is to provide a print out that summarizes the key information that patients need to guide adherence at home. After completing the scheduling task, by clicking on the "print" button, the schedule and medication information sheet will be printed out. The printout is a simplified version of the Medtable™ used on the scheduling page. It excludes the medication instructions and dosage information that were used as scheduling task constraints. The dosage information is visualized by the numeral on the schedule table. If the patients want to refer to the detailed medication instruction, they can look on the medication information sheet, which includes the medication instructions customized by the RN.

EXPECTED FINDINGS

The primary goal of our current project is to test the EMR-integrated Medtable™ in a randomized clinical trial comparing the Medtable intervention to a usual care condition to determine its impact on medication knowledge, adherence and health outcomes among patients with type 2 diabetes at general internal medicine clinics in Chicago and Peoria, IL. We will select patients with 5 or more medications who are having difficulties managing their regimens (as reflected in blood glucose (glycosylated hemoglobin, HbA1c) levels outside of the target range. We expect to find that patients in the intervention arm are more satisfied with patient-provider communication, will have increased knowledge about their medications, will be more adherent to their regimens, and will have improved health outcomes compared to the patients in the control arm.

DISCUSSION

Medtable ™ has been designed to address the significant problem of medication nonadherence, which is driven largely by patients' limited cognitive resources and ineffective patient-provider communications during patient visits. This is a problem especially for older adults who take multiple medications and experience age-related cognitive declines, as well as patients with limited health literacy.

The EMR-integrated Medtable ™ serves as a tool to assist with patient-provider communication and medication scheduling. It has been designed to be consistent with and build on current provider practice, to improve communication between patients and providers during patient visits, and to assist with scheduling multiple medications given numerous constraints (high number of medications, medication constraints and varied patient schedules). Medtable ™ has been designed to be

especially beneficial for low health literacy patients and patients with cognitive difficulties.

We expect that, used in clinical practice, Medtable ™ will improve patient satisfaction, medication understanding and adherence, as well as health outcomes among patients struggling to manage multiple medications.

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