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Brief Report

OPEN

The Digital Drag and Drop Pillbox

Design and Feasibility of a Skill-based Education Model to Improve Medication Management

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Objective: We present the design and feasibility testing for the ''Digital Drag and Drop Pillbox'' (D-3 Pillbox), a skill-based educational approach that engages patients and providers, measures performance, and generates reports of medication management skills. **Methods:** A single-cohort convenience sample of patients hospitalized with heart failure was taught pill management skills using a tablet-based D-3 Pillbox. Medication reconciliation was conducted, and aptitude, performance (% completed), accuracy (% correct), and feasibility were measured. **Results:** The mean age of the sample (n = 25) was 59 (36–89) years, 50% were women, 62% were black, 46% were uninsured, 46% had seventh-grade education or lower, and 31% scored very low for health literacy. However, most reported that the D-3 Pillbox was easy to read (78%), easy to repeat-demonstrate (78%), and comfortable to use (tablet weight) (75%). Accurate medication recognition was achieved by discharge in 98%, but only 25% reported having a ''good understanding of my responsibilities.'' **Conclusions:** The D-3 Pillbox is a feasible approach for teaching medication management skills and can be used across clinical settings to reinforce skills and medication list accuracy.

KEY WORDS: health technology, mHealth, patient centered, patient education, skill-based learning, teach-back

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Studies have shown that patients with chronic conditions such as heart failure adhere to only 50% to 60% of medications as prescribed,[1,2] despite evidence that medical therapy prevents death and improves quality of life. Improving medication management and adherence is dependent on redesigning the traditional educational approach.

Current medication education focuses on unidirectional information delivery—telling patients what to do in a written format. An ongoing, bidirectional exchange of information between patients and providers is more consistent with adult learning theory,[3,4] and person-centered principles of shared decision making,[5,6] and may be more effective. Active listening, planning, and documentation of patients' medication goals regarding why, what, how, and when to take prescribed medications and providing feedback on patient performance and progress toward established goals may also improve medication management.[3,5] Technology-based approaches for facilitating medication management are available[7]; however, current designs are predominantly reminder systems or 1-way communications that lack a skill-based approach, a patient goal, and a feedback mechanism.[8,9] Without assessment of learning or consistent documentation via a common portal or electronic health record (EHR) link, lack of connectivity across settings poses a barrier to long-term medication management.

The purpose of the "Digital Drag and Drop Pillbox" (D-3 Pillbox) innovation project was to design and develop a pedagogically appropriate instrument for use across clinical settings. The specific aims of this study were to (1) obtain patient input into the design of the new skill-based educational model for teaching medication management, (2) assess the feasibility of using an electronic tablet (e-tablet) as a mode of delivery for skill-based education in the inpatient and ambulatory clinical settings, and (3) evaluate the performance of the e-tablet for assessing a core set of medication management skills (baseline aptitude [health literacy score], accuracy [medication reconciliation], competence [performance score], and knowledge [learning check score]).

Methods

Patient Input in the Digital Drag and Drop Pillbox Design

Patients were involved in designing the Digital Drag and Drop Pillbox in 3 phases. First, patients participated in small group sessions in which the teach-back method was used for medication education using an actual pillbox. Next, feedback was obtained from patients regarding how the content would be perceived and used if it were available in an e-tablet format. Finally, patients used and evaluated the digital application of the pillbox on e-tablets using a Web-based application platform. Actual pill images were integrated in the program in a pick list so that patients could identify the correct pill and dose and then "drag and drop" the pill image into the correct time and frequency. Using the focus group feedback, the educational content about each pill was combined in this skill-based exercise. "Challenge questions" were added at the conclusion of the exercise to assess learning about the medications themselves and the appropriate management of the medications.

The approach to soliciting and integrating the patient perspective in the exercise was planned using applied principles of simulation and adult learning theory (Figure). We incorporated the 6 categories most applicable for medication education: (1) the content of written materials to be at fifth grade level or lower; (2) inclusion of patient-oriented outcome measures; (3) inclusion of pictures and drawings; (4) use of patients' native language, in particular, the recommendation for use of first language; (5) use of comprehension-enhancing instruments, such as participatory, manipulative exercises; and (6) patient participation in the development process.[11]

Feasibility Pilot Study

A feasibility pilot study was conducted to evaluate the new educational model and describe the patients' response to the change from text-based information delivery to interactive skill-based learning using the patients' own medications. We evaluated a cohort of 25 patients admitted to a university-based hospital with acute decompensated heart failure. The institutional review board approved the protocol, and all participants provided written informed consent.

Measures

Patient-reported outcome (PRO) surveys were used to determine baseline health literacy (Rapid Evaluation of Adult Literacy in Medicine)[12] and medication adherence (Morisky Medication Adherence Scale) (Table 1).[13] Patients' knowledge (understanding of the content) (Table 2), perceived feasibility and usability of the e-tablet (Table 3), and satisfaction with the application (Table 3) were evaluated using 2 medication-related items from the Hospitalized Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey. Skill performance (% accuracy) and skill completion (% competency) were scored as 3-level categories.

Analysis Plan

Patient demographics, feasibility, usability, and performance were analyzed for the single group using descriptive statistics. A Kruskal-Wallis test was used to determine the difference in performance by 3 levels of health literacy.

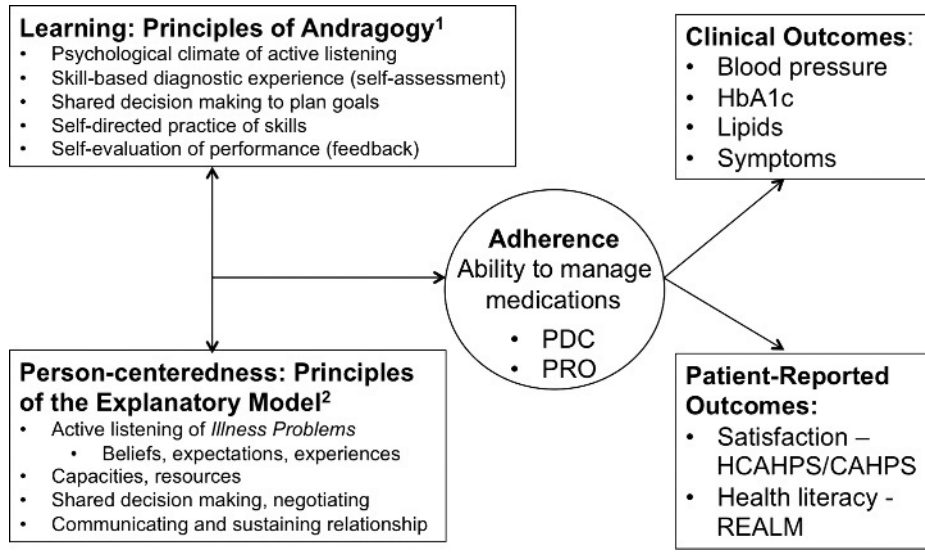

FIGURE. *Theoretical measurement model for skill-based patient education. Abbreviations: PDC, proportion of days covered; PRO, patient-reported outcome. PDC is a metric for patient persistence and adherence to medications based on refill rates. Calculation of PDC = total days all drug(s) available / number of days in follow-up period.*[10]

Procedures

All nurses on the heart failure progressive care unit and selected nurses in the outpatient cardiology clinic were trained to use the Digital Drag and Drop Pillbox according to the standardized protocol in Table 4. Nurses invited each patient to participate in education about their medications using the e-tablets. After obtaining informed consent, nurses logged into the e-tablets to obtain access to patients' protected health information, including prescribed medications. Patients registered and logged into the e-tablet to ensure a secure environment for protected health information. The nurse completed medication reconciliation by verifying the patients' active medication list in the EHR with the list appearing in the e-tablet D-3 Pillbox application. Next, the nurse correctly "filled" the pillbox by "dragging and dropping" tablet images for the correct drug, dose, and dosing frequency and clicked "set." Then, the correct pill and dosing regimen on the e-tablet was "cleared," removing medication images from view, and the e-tablet was given to the patient. The patient then completed PRO surveys, the pill management "drag and drop" exercise, and the feasibility and usability questions.

Patients practiced the exercise as many times as they liked during the hospital stay. Before patient discharge, a copy of the D-3 Pillbox summary report was printed for the patient and included in the patient's medical record for postdischarge follow-up. Nurses in the clinic were also trained on the D-3 Pillbox application and repeated the exercise with patients at the follow-up visit.[15]

Results

Among the patients who agreed to participate (n = 25), one had incomplete data and could not be used for analysis. The mean age was 59 (range, 39–89) years, 50% of the participants were men, 62% were black, and 54% were insured by Medicare or Medicaid. All

TABLE 1 Psychometric Properties for Patient-Reported Outcome Measures

Instrument/Description	Validity, Reliability, Responsiveness, and Meaning
Morisky Medication Adherence Score (MMAS-8): an 8-item structured Likert response, patient-reported medication adherence measure	MMAS is reliable (α = .83), with good concurrent and predictive validity; sensitivity and specificity were 93% and 53%, respectively.[13] Item example: ''Do you sometimes forget to take your medicine?'' Score interpretation: higher scores correlate with higher adherence (range, 0–8)
Rapid Estimate of Adult Literacy in Medicine–Short Form (REALM-SF): a 7-item visual recognition and verbal response, patient-reported literacy assessment instrument	REALM-SF is a single-factor visual and verbal assessment instrument with stable model coefficients and high correlation (r = 0.95, P < .001) and validity (r = 0.94, P < .001) when tested with the longer REALM and also when tested with the Wide Range Achievement Test (r = 0.83, P < .001).[14] Instruction example: ''Read as many words as you can from this list. Begin with the first work and read aloud (read the seven words).'' Score interpretation: higher scores correlate with higher grade level (range, 0–7)

TABLE 2 Learning Checks for Medication Management Competency

Learning checks:
1. I should always bring my list of medications with me to clinic visits and always carry the correct list in my wallet at all times – (T/F) TRUE
2. If I feel that I should stop a medication for any reason, I should:
   a. Stop the medication and let my provider know at the next visit
   b. Not stop without discussing with my healthcare provider
   c. Stop the medication and let my pharmacist know because he/she will probably tell my provider
   CORRECT – not stop without discussing with provider
3. If a dose is missed, I should do which of the following:
   a. if more than halfway between the next dose, take it on the next dose.
   b. if less than halfway until time to take the next dose, take it right away.
   c. if the medication is once a day, take it as soon as I realize I missed it.
   d. all of the above
   CORRECT = all of the above
4. I should not take herbal supplements/cold meds without discussing with my provider – (T/F) TRUE

patients had 3 or more chronic conditions, requiring 8 or more medications, on average. In addition, 46% had attained a seventh-grade education or lower, and 31% scored "very low literacy" on the Rapid Evaluation of Adult Literacy in Medicine health literacy questionnaire (Table 5). Most patients were able to complete the e-tablet–based educational program in the course of 1 hour, with a completion rate varying at baseline across all levels of health literacy. However, by discharge, 98% of all patients accurately completed the medication management skills, regardless of health literacy level.

Patient scores on learning outcomes, accuracy (medication list verification), competence (skill completion/performance), and knowledge (learning checks) are shown in Table 5. Adherence scores were relatively evenly split into high (31%), medium (38%), and low (31%). Few patients correctly answered 4 of 4 posttest medication questions correctly on the first try (25%). When baseline accuracy was evaluated according to the level of health literacy, patients with higher levels of health literacy performed better (Kruskal-Wallis $\chi^2(2) = 10.968$, $P = .004$).

Patient-reported feasibility and usability were acceptable across all domains (Table 3). Medication goals and patient engagement were captured on a final report that was provided to patients and providers to give feedback on strengths and gaps in learning in the postdischarge follow-up phone call and clinic visit. Change over time in learning outcome was not assessed; however, nurses observed a trend of improved accuracy with practice.

Discussion

Our findings suggest that a skill-based approach using an e-tablet and the patient's own medication list is a feasible solution for teaching medication self-management for patients with chronic illness. This approach has 2 unique capabilities. First, it overcomes health literacy barriers through the use of pill images; second, it assesses and evaluates learning outcomes longitudinally. These advantages surpass traditional text-based print materials that do not easily accommodate frequent regimen changes and do not present patients with individualized feedback on learning and improved skill performance over time.

TABLE 3 Usability and Satisfaction With Electronic Medical Education System (N = 24)

Usability	Response Items' Acceptability	Respondents, n (%)
1. How easy was it to read the e-tablet learning check questions?	Very easy or somewhat easy	19 (78)
2. How easy was it to use the e-tablet to respond to the questions?	Very easy or somewhat easy	19 (78)
3. How easy was it to navigate the survey with the e-tablet?	Very easy or somewhat easy	16 (68)
4. Was the weight of the e-tablet comfortable for your use?	Very comfortable	18 (75)
5. Did you notice the temperature of the e-tablet on your lap?	Did not notice or warm but not uncomfortable	24 (100)
6. How was the length of time required?	About right or could have done more	21 (86)
Satisfaction	**Response Items' Acceptability**	**Respondents (N = 24), n (%)**
1. Explained things in a way that I could understand.	Totally agree	24 (100)
	Somewhat agree	0 (0)
2. Good understanding of my responsibilities.	Totally agree	18 (75)
	Somewhat agree	6 (25)

TABLE 4 Procedure for Use of the Digital Drag and Drop Pillbox

1. In the inpatient and clinic setting, all patients receive help to establish a D-3 Pillbox app account and log into the EHR health portal.
2. The EHR education tab is used to ensure continuity of D-3 Pillbox learning progression and to indicate patient-designed medication goals to be addressed at the follow-up call and visit.
3. During a medication education interaction (in any setting), the healthcare provider initiates the exercise using the following steps:
   a. Enter user log-in, use the search feature to enter the patient's name or medical record number (MRN).
   b. Click the pillbox icon and open the patient record (or create a new patient record)
   c. ''FILL'' the pillbox accurately, conducting medication reconciliation by matching the medication list in the EHR with the patient-reported list.
   d. Verify accuracy of the med list and ''clear'' the pillbox.
   e. Turn the e-Tablet or computer screen to the patient and assess patient teaching needs and medication adherence risk using the REALM and MMAS, respectively, on the e-tablet.
   f. Allow the patient to fill the pillbox by dragging and dropping medications by name and dose into the correct day, time, and frequency (using repeat-demonstration, as would occur in an actual pillbox teach-back scenario).
4. AFTER the patient completes placement of the medications, complete the ''medication goal'' screen.
5. Develop and implement a teaching plan using the patient goal, the teach-back program learning score, and the health literacy aptitude score via the e-tablet.
6. Ensure that the patient should be offered multiple opportunities to complete patient education modules and assessments.
7. Assess patient caregiver knowledge through teach-back assessments as well, if possible.
8. With educator assistance, patients should continue working with Pillbox demonstration until skill mastery is complete.

Tips:

9. If you make a mistake, move the medication to trash can and try again.
10. If you touch hint, you must touch it again to clear medications.
11. Patients should complete discharge questionnaires before discharge, and the educator should document the medication goal on the discharge readiness form.
12. Print a copy of the final report and include a copy with the patient's discharge materials.
13. Remind patients that they will be called by the QI coordinator every 2–4 weeks for 3 months while using the pillbox and will be asked to redemonstrate the updates to their pillbox if medications change.

In this study, the population was characterized by the complexity of the typical medication regimen. The pedagogical basis for integrating skill development is to address the fundamental need for patients themselves to recognize, understand, and account for the dynamic nature of a medication regimen. Particularly in the case of chronic illness with multiple comorbidities in which changes in both symptom experience and medications are often poorly communicated between patients and providers, the patient's ability to self-manage and self-advocate is critically important.[5,16]

The Digital Drag and Drop Pillbox uses skill-based learning to advance medication education by not only addressing what to take but also eliciting the patients' input and participation in why, how, and when to take a medication. In addition, the instrument promotes active listening to patient preferences and negotiating for safe and acceptable instances when not to take it.[17] As symptoms, concomitant illnesses, or severity of illnesses change, the regimen must also change. Patients inevitably face frequent changes between generic and brand medications from potentially multiple prescribing providers and many pharmaceutical sources. It is imperative that they obtain the skills necessary to manage changes in their medication regimen.

Evaluating these skills before discharge allows the care team to evaluate the patient's aptitude and ability to organize and take medications accurately. Perhaps more important, the timing of the assessment also stimulates discussion about medication-specific barriers, cost considerations, intolerance or adverse effects, and scheduling conflicts encountered as part of fitting medications into everyday life. As reported in similar studies,[18] in 30% of cases in this pilot cohort, health literacy was lower than a third grade level, and at the

TABLE 5 Characteristics of the Feasibility Cohort (N = 24)

Characteristic	Participants (N = 24)[a]
Age, mean (min–max), y	59 (36–89)
Sex	
Male	12 (50)
Female	12 (50)
Race	
Black	15 (62)
White	9 (38)
Payer status	
Medicare/Medicaid	13 (54)
Self-pay/uninsured	11 (46)
Health literacy score (REALM)	
Third grade or less	4 (17)
Fourth to seventh grade	7 (29)
Eighth or greater	13 (54)
Morisky Medication Adherence Score	20[a]
High adherence	6 (31)
Moderate adherence	8 (38)
Low adherence	6 (31)
Skill performance at baseline	
Accuracy (completely achieves)	13 (54)
Competency (completely achieves)	7 (29)

Data presented as n (%), unless otherwise indicated.
[a]24 participants completed the questionnaire. One failed to complete all 8 items, and the survey could not be reliably scored.

time of discharge, information about medications was not learned.[19] In our baseline needs assessments of patient experience, care team workflow, and the medication education processes, the prevalence of health illiteracy and low rates of actual learning achieved by the time of discharge were undiscoverable data. The data were not captured in the EHR. In preliminary work with patients to develop the intervention, patients reported that conversations with providers about learning achievement or confidence to self-manage the regimen were not taking place.

Electronic Health Record Integration

Although teach-back is a common approach used with both patients and healthcare providers for teaching medication management skills,[20–22] the Digital Drag and Drop Pillbox is unique in that it integrates with the EHR. Integration enables data capture on the ultimate health education "trifecta": (1) healthcare system support, measured by educational processes (content delivery, timeliness, responsiveness); (2) PROs (knowledge and skill acquisition, behavioral outcomes such as self-reported adherence, and learning satisfaction outcomes such as "understanding of medication information at discharge" and "satisfaction with the information received"); and (3) clinical outcomes (medication adherence surrogates such as blood pressure, lipid levels, or hemoglobin A1c). Generalizability of the findings is limited by the small number of patients with heart failure who participated in this feasibility pilot study and the specific configuration of the EHR used.

Patient Input Into Design

Patient input into the design of technology to support health and healthcare is increasingly important. Adoption is dependent on the acceptability of the user interface, and we recognize the value and weight of the patient perspective. Evidence for patient-oriented outcome measures in educational initiatives was notably missing in the review conducted by Bunge and colleagues,[11] and methods and educational approaches designed by patients remain sparse. In designing the Digital Drag and Drop Pillbox, we solicited input from patients using in-depth interviews, observed e-tablet use patterns, and transcribed field notes of patient narrative on how technology could best meet their learning needs.

Conclusions

The Digital Drag and Drop Pillbox model was designed with the help of patients to improve the skills required to manage medications and to improve patient-provider communication around medication changes. By using a Web-based platform, the Digital Drag and Drop Pillbox model makes the "practice setting" accessible to patients and providers at any time, from hospital to clinic to home. Finally, the Digital Drag and Drop Pillbox successfully implements a pedagogically appropriate feedback loop, using baseline aptitude, patient-specific medications, and real-time feedback on skill competency reports for both patients and providers.

What's New and Important

- Traditional medication education fails to assess aptitude or evaluate learning.
- Skill-based methods improve patient-provider engagement and learning outcomes.
- The ''Digital Drag and Drop'' Pillbox is a skill-based solution for the assessment and evaluation of learning outcomes, and electronic health record integration facilitates longitudinal evaluation of learning outcomes.

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