Linking Technology to Address the Social and Medical Determinants of Health for Safer Use of Medicines

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Abstract

**Background:** Both medical and social issues can negatively affect health outcomes, especially for vulnerable populations. Assessing risk from these two perspectives independently, two non-profit organizations each developed a decision support program to identify medication-risk that could negatively impact health outcomes. This raises the question, could a combined program have greater potential for improved outcomes.

**Methods:** HomeMeds℠ (HM), a social health program in which trained social services staff make home visits to vulnerable clients, was combined with MedSafety Scan (MSS), a medical health, clinical decision support tool. Data captured in the home visit were entered into the HM and MSS programs to analyze each patient’s drug risk profile and their list of medicines to detect those patients at greatest risk of adverse health outcomes caused by medications.

**Results:** One hundred and eight patients (mean age 77 with multiple co-morbidities and LACE+ score >29) received a post-discharge home visit by trained social services staff. The number of drugs reported as being taken was 10.4 ± 5.1 (range 1-26) which was less than prescribed at discharge in 62% of patients (range 1-8). Both programs detected serious risk of medication-induced harm, mostly from different causes. HomeMeds detected medically relevant events such as unreported falls (24), dizziness (37), confusion (27) and uncontrolled pain (37). MedSafety Scan identified 22 patients with moderate to very high risk of cardiac arrhythmia due to their medicines. In 65% of patients, an average of 6.2 ± 5.6 potentially serious drug interactions were detected by MedSafety Scan but not HomeMeds.

**Conclusions:** Combined analyses of data from these two decision support programs that approach health issues and patient needs from different perspectives yielded complementary findings that address both medical and social determinants of health after hospital discharge. These have the potential to reduce medication-induced harm, costly re-hospitalization and/or emergency room visits. The results of this quality improvement project are encouraging and support the further evaluation of this combined approach in other vulnerable populations such as the seriously mentally ill, frail, those confined to home, opiate-dependent or otherwise impaired.

**Background**

Beginning in the 1990's, reports of medication-induced deaths\(^1\) were the focus of several books\(^2,3\) and white papers including two series of publications from the Institute of Medicine, “To Err is Human”\(^4\) and the “Quality Chasm Series”\(^5,6\). After a series of hearings, Congress authorized the federal Agency for Healthcare Research and Quality (AHRQ) in 1997 to fund a network of centers\(^7\) that grew to include fourteen Centers for Education and Research on Therapeutics (CERTs). The CERTs independently conducted research and education programs to reduce the growing number of patients being harmed by medications and their misuse.\(^8\) One of these centers, now the non-profit Arizona CERT (AZCERT), focused on prevention of drug-drug interactions, especially those that can result in arrhythmias and sudden
death.\textsuperscript{9} In 2017, with funding from the FDA’s Safe Use of Medicines program, AZCERT developed clinical decision support technology to identify hospitalized patients who are at high risk of harm from their medications.\textsuperscript{9,10} In 2020, in response to a growing concern for the safety of drugs being used to treat COVID-19, AZCERT released this decision support technology as an open-source web-based program, MedSafety Scan\textsuperscript{®}.\textsuperscript{11}

In 1998, separately from AZCERT’s work, the non-profit Partners in Care Foundation (Partners) developed a home-based medication safety program, HomeMeds\textsuperscript{℠}, that focuses on the social determinants of health and the improved use of medications in the home.\textsuperscript{12} This program captures a record of the medications actually being taken by patients and detects the medical and social factors influencing the patients’ health. HomeMeds then communicates the information to social service agencies responsible for collecting the information and they arrange for a pharmacist to contact prescribers and reconcile potential problem medications.\textsuperscript{12} A randomized clinical trial of 259 Medicare patients demonstrated the ability of the HomeMeds program to improve medication use and dramatically reduce therapeutic duplication.\textsuperscript{13} In 2004, AHRQ selected the HomeMeds program for its Health Care Innovations Exchange and rated the quality of evidence for its impact on health outcomes as “strong.”\textsuperscript{14}

Seeking to improve the performance of each decision support program, these two non-profit organizations have agreed to combine their separately developed program (HomeMeds and MedSafety Scan) to analyze data obtained during home visits conducted by Partners. The question posed in this quality improvement project is: Will the combined application of these two programs identify opportunities to improve patient well-being and health outcomes more effectively than either program alone?

**Methods**

For this study, patients being discharged from a network of four hospitals in California were referred to the Partners’ HomeMeds program when they met any of the following criteria: a LACE+ score >29\textsuperscript{15}, recent (within 3 months) hospitalization for acute myocardial infarction, coronary artery bypass graft, heart failure, pneumonia, sepsis, total hip/knee replacement, cognitive challenge or elderly living alone. The HomeMeds program includes a home visit by a Partners’ health coach, who is, by training, either a community health worker or social worker with additional training to apply observational skills that are critical to the process. Home visits were to be scheduled to occur within 72 hours after discharge from hospital or post-acute skilled nursing facility (or as agreed upon by the patient) using the evidence-based Coleman Care Transitions Intervention (Coaching Model).\textsuperscript{16} Data were analyzed for consecutive patients who enrolled in the HomeMeds program over a sixty-day period.

HomeMeds is an evidence-based, in-home, medication review and multi-level intervention program that includes a computerized risk assessment and advisory process and, when deemed necessary, referral to a pharmacist for review and recommendations to address potential therapeutic problems.\textsuperscript{12} HomeMeds
includes psychosocial, functional needs, and home safety assessments. The program is performed by highly trained health coaches who are competent in cultural and linguistic diversity, adept at patient engagement and knowledgeable about community resources. Not requiring licensure, this workforce is an alternative with unique value in the rapidly changing health and social environments. The coaches' evaluations are carried out in the home and include creation of an individualized plan of care, patient education and social services. HomeMeds also includes home safety evaluation, home modifications for fall prevention, screening for propensity to suicide, nutrition and dietary deficits. The program can refer patients to evidence-based health self-management programs available in community settings and online. When the HomeMeds computer analysis detects medication risk signals, a summary report is sent to a consulting pharmacist for analysis and possibly recommendations for medical risk mitigation.

In this study, four bilingual (Spanish/English) health coaches from Partners made the home visits and captured data for subsequent computer entry and analysis. All have at least a bachelor’s degree and a minimum of two weeks training by Partners in how to conduct the visits, how to execute the HomeMeds questionnaire, what environmental cues to observe, how to enter data into the HomeMeds software, HIPAA compliance, and how to communicate with consulting pharmacists using an encrypted secure email system.

MedSafety Scan\textsuperscript{11} (MSS), developed by the non-profit AZCERT, is a platform for therapeutic decision support that is based on the QTdrugs drug safety database from the CredibleMeds website.\textsuperscript{17} It includes risk factor analysis for cardiac safety and drug-drug interaction predictions to identify patients at greatest risk of adverse drug events.\textsuperscript{11} MSS captures medical history information to identify patients with a high risk profile, and then generates a report that includes a notification when medications and/or combinations of medicines have the potential to cause adverse events including a prolonged QT interval on the electrocardiogram, torsades de pointes (TdP) arrhythmia and/or sudden cardiac death.\textsuperscript{18} MSS also reports serious potential drug-drug interactions focusing on those recommended by the Center for Medicare/Medicaid Services as quality of care metrics\textsuperscript{19} and serious interactions listed in the official drug label. Potential drug-drug interactions are classified by severity (1-10) with severity $\geq 7$ considered “Major” if the interaction could result in death, permanent injury, hospitalization, impairment or disability.

**Results**

Data from one hundred and eight consecutive post-acute home visits performed by Partners’ health coaches (December 16, 2019 to February 15, 2020) were analyzed. The demographics of these patients referred for HomeMeds visits are summarized in Table 1. They ranged in age from 32 to 101 with a mean age of 77 and ninety-one were age 65 or older. Fifty-nine were female and forty-nine were male. Sixty-four were Hispanic, sixteen were Asian and twenty-eight were Caucasian. All patients had at least one chronic illness diagnosed: hypertension (65%), diabetes (36%, with 17% requiring insulin), atrial fibrillation (18%), hypothyroidism (13%), prior myocardial infarction (12%), congestive heart failure (7%), renal failure on dialysis (7%) or hepatic failure (3%). The number of medications per patient prescribed at the time of
hospital discharge ranged from 6 to 24 (mean = 11.7 ± 5.1). At the time of the home visit, the patients reported taking an average of 10.4 ± 5.1 medications. For some, the course of medicines such as antibiotics that had been prescribed at discharge had been completed and discontinued or were no longer taken. Sixty-two percent of patients and were taking from 1-11 fewer medicines than had been prescribed at discharge. Eight percent were taking from 2-7 more medications than at the time of discharge.

The findings and recommendations from the HomeMeds and MedSafety Scan analyses were analyzed separately and are summarized in Tables 2 and 3, respectively. Review of the 108 HomeMeds reports found twenty-four (22%) patients had experienced recent falls. The following new symptoms were reported as having developed since hospital discharge: Dizziness or vertigo 37 (34%), dizziness on standing 11 (10%), confusion 27 (25%), uncontrolled pain 37 (34%). In 78% of HomeMeds visits, computer analysis identified the following medication concerns that prompted referral to a consulting pharmacist for evaluation: drug-induced bleeding risk 25 (23%), improper adherence to instructions 4 (4%), Beer's criterion met for inappropriate drug for the elderly 22 (20%), duplicate therapies 12 (11%), potentially serious drug-drug interactions 25 (23%). After review of HomeMeds alerts, the consulting pharmacists recommended medical reconsideration of 1-3 prescriptions each for 75 patients. They recommended patient education on 1-3 specific topics each for 59 patients. Psychotropic medications were identified as a potential cause of confusion for 11 patients and reconsideration of opiate therapy was recommended for twenty patients.

MedSafety Scan analysis of the data collected during the home visits is summarized in Table 3. Three patients (3%) were taking two drugs contraindicated in the drugs’ labels. Therapeutic duplications were detected in the medications being taken by 15 patients (14%). Twenty-two (20%) patients had a QT risk score ≥ 9 which generated warnings for a risk of excessive QT prolongation, TdP and cardiac arrhythmias. One of these had a QT risk score of 16, the threshold for a warning of Very High Risk of arrhythmia. Figure 1 shows the MSS report listing the elements of the QT risk score for this patient. Three patients (3%) had a QT risk score from 12 to 15 resulting in a warning of High Risk and eighteen (17%) had a score from 9 to 12 resulting in a warning of Moderate Risk of arrhythmia. For these patients, MedSafety Scan recommended monitoring the ECG and QT in 15 patients (15%), checking the serum electrolytes for eight (7%) and considering an alternative drug for eight (7%). MedSafety Scan also identified an average of 6.2 ± 5.6 potential drug interactions per patient in eighty-eight patients and, of these, 4.2 ± 3.9 combinations per patient were considered major.

**Discussion**

In this mostly elderly, high risk population of patients recently discharged from hospital or rehabilitation, home visits made by trained health coaches identified serious medical conditions such as falls, dizziness, presyncope, uncontrolled pain and confusion that had not been previously reported to the patients’ healthcare providers. HomeMeds computerized analysis identified serious medication risk that was referred to consulting pharmacists who made recommendations for re-evaluation or change in therapy for 69 percent of patients. By combining the HomeMeds program with MedSafety Scan analysis of the
drugs lists, twenty-two additional patients were identified who were at high risk of harm from medications that are inappropriate for the elderly or specifically dangerous because of the patients diagnoses and overall risk profile.

Substantial differences were found between the lists of drugs in the hospital discharge orders and the medications that the patients reported taking. The MSS and HM analyses of the lists of medications that were being taking by the patient, supplemented by information directly reported by patients in their home environment, were incorporated in the evaluations made by consulting pharmacists and more fully informed their discussions and recommendations to the patients’ primary care providers.

The results of this quality improvement project support the potential value of community-based models that utilize trained workers\textsuperscript{21} who visit the home and serve as advocates, communicators and linkages for those who, for one reason or another, cannot access the level of healthcare they need. The scope of work for these programs includes gathering data and making connections, referrals and linkages that address both the medical and the social determinants of health. In addition to the assessment of conventional medical needs such as helping capture the results from patient-monitored glucose or blood pressure, they can assess the person’s need for food, their ability to travel to doctors’ offices or rehab services, their need for smoking cessation programs, opiate remediation, risk assessment for suicidality, falling or threats of violence in the home, etc.

The health coaches who perform home visits require specific training to recognize those patients who need either health maintenance or healthcare interventions and must know how to connect that person with the appropriate social or healthcare programs. As with any health worker, they must be carefully screened and they must be trained in a new curriculum that should require for entry only a high school or bachelor’s level of education, taking far less time and expense than the usual training of nurses or pharmacists. The training should include the use of checklists, pre-programmed electronic devices and decision support tools such as HomeMeds and MedSafety Scan to capture and manage the complex data that they must convey to healthcare providers. As in this project, the visitors can collect accurate medication lists and forward their computer-generated reports to pharmacists and physicians who, here-to-fore, had to perform medication reconciliation based on incomplete office records or administrative data that is out of date and incomplete.

We acknowledge some weaknesses in this quality improvement study. For this analysis, we lack outcome data on readmissions, emergency room visits, or records of actions taken by care providers after consultant pharmacists received the HM and MSS reports. However, previous randomized trials have demonstrated the value of surveillance of post-discharge medication lists\textsuperscript{22} and the proven ability of HomeMeds to improve medication use and reduce rehospitalizations.\textsuperscript{13} We believe the results of this study build on earlier results and support the potential value of further evaluation of the impact of these programs on quality metrics for improved health outcomes.

**Conclusion**
A community-based staff trained to make home visits and equipped with culturally sensitive skills and science-based decision support tools can uncover significant and otherwise undetected medical and social needs in a vulnerable population of patients recently discharged from the hospital or rehabilitation care. The feasibility, cost of training and operation of this combined approach deserves further evaluation in additional studies that focus on vulnerable populations. Because of the education level and focused training required for health coaches, compared to nurses or pharmacists, recruitment and ramp up should be fast and the relatively modest expense should be more than balanced by the savings incurred from reduced redundancy in health services and timely targeting of medical care and social services to those with greatest need. Health policymakers should consider these factors and the added value of integrating software programs that, when linked, can fill gaps in both the social and medical determinants of health.

**Abbreviations**

HM = HomeMeds, MSS = MedSafety Scan, LACE+ = Length of Stay, Acuity, Comorbidities, ER (Emergency Room) Visits (hospital index), AHRQ = Agency for Healthcare Research and Quality, CERTs = Centers for Education and Research on Therapeutics, AZCERT = Arizona Center for Education and Research on Therapeutics, FDA = Food and Drug Administration, TdP = Torsades de pointes

**Declarations**

**Ethics approval and consent to participate:** Not applicable, this is a quality improvement project to evaluate the added information from combining two technologies

**Consent for publication:** Not applicable

**Availability of data and materials:** The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy policies but de-identified data are available from the corresponding author on reasonable request.

**Competing interests:** The authors declare that they have no competing interests.

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**Authors’ contributions:** RLW analyzed and interpreted the data from HomeMeds and MedSafety Scan. JS and WR assisted in study design, data analysis and in writing the initial draft of the manuscript. EMS directed all data collection for HomeMeds and MedSafety Scan. SA and KB provided technical expertise for HomeMeds and MedSafety Scan respectively. All authors read, edited and approved the final manuscript.

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**Tables**

Table 1. Patient Demographics

| Patient Demographics N =108 |
|----------------------------|
| Age (mean, range)           | 77 (32-101) |
| Sex (Female/Male)           | 59/49       |
| Diagnoses                  |             |
| Hypertension                | 70 (65%)    |
| Diabetes (all)              | 39 (36%)    |
| Congestive Heart Failure    | 35 (32%)    |
| Diabetes taking insulin     | 18 (17%)    |
| Atrial Fibrillation         | 19 (18%)    |
| Hypothyroidism              | 14 (13%)    |
| Prior Myocardial Infarction | 13 (12%)    |
| Renal Failure               | 8 (7%)      |
| Liver Cirrhosis             | 3 (3%)      |
| Medicines/person at Discharge (Mean ± SD) | 11.7 ± 5.1 |
| Medicines/person at Home Visit (Mean ± SD) | 10.4 ± 5.1 |

Table 2. Summary of HomeMeds Visit Reports (DDI = Drug-Drug Interaction)
### Summary of HomeMeds Visit Reports (%)

| Category                                                   | Number | Percentage |
|------------------------------------------------------------|--------|------------|
| Recent Falls Reported                                      | 24     | (22%)      |
| New Symptoms Reported Since Hospital Discharge             |        |            |
| Dizziness/Vertigo                                          | 37     | (34%)      |
| Dizziness on Standing                                      | 11     | (10%)      |
| Confusion                                                  | 27     | (25%)      |
| Uncontrolled Pain                                          | 37     | (34%)      |
| Medication Risk Detected                                   |        |            |
| Bleeding Risk                                              | 25     | (23%)      |
| Improper medicine adherence                                | 4      | (4%)       |
| Beers Criterion-risk for elderly                           | 22     | (20%)      |
| Duplicate Therapies                                        | 12     | (11%)      |
| Potential Serious DDI*                                     | 25     | (23%)      |
| Referral to Consulting Pharmacist                          | 84     | (78%)      |
| Pharmacists’ Recommendations                               |        |            |
| Medical Re-evaluation of Rx                                | 75     | (69%)      |
| Patient Education on topic                                 | 59     | (55%)      |
| Psychotropic and confusion                                 | 11     | (10%)      |
| Opiate-use re-evaluation                                   | 20     | (19%)      |

Table 3. Summary of MedSafety Scan Reports  (DDIs = Drug-Drug Interactions)
### Summary of MedSafety Scan Reports n=108 (%)

| Category                                                                 | Count | Percentage |
|--------------------------------------------------------------------------|-------|------------|
| Contraindicated drug combinations                                        | 3     | 3%         |
| Therapeutic duplications                                                 | 15    | 14%        |
| Increased risk of cardiac arrhythmia (Torsades de Pointes)               |       |            |
| Very High Risk (QT score ≥16)                                            | 1     | 1%         |
| High Risk (QT score 12 - 15)                                             | 3     | 3%         |
| Moderate (QT score 9 -11)                                                | 18    | 17%        |
| Recommendations for action to reduce risk of arrhythmia                  |       |            |
| Change to alternative drug                                               | 8     | 7%         |
| Obtain ECG to check QTc                                                  | 15    | 14%        |
| Check Serum Electrolytes                                                 | 8     | 7%         |
| Drug-Drug Interactions (DDIs) detected per patient (Mean ± SD)           |       |            |
| All serious DDIs/patient                                                 | 6.2 ± 5.6 |            |
| Major DDIs/patient (Severity ≥7)                                         | 4.2 ± 3.9 |            |

### Figures
Figure 1

QT Risk Score Report for patient with Very High Risk of QT Prolongation.