The Relationship of Medication Regimen Complexity and Health Care Utilization

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By

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Chair

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The Relationship of Medication Regimen Complexity and Health Care Utilization

Abstract

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Objectives: To determine whether medication regimen complexity (MRC) could predict likelihood for occurrence of adverse drug events (ADE) and 30-day readmits or emergency department visits in patients transitioning from hospital to home care.

Methods: Hospital discharge medication lists and medication lists developed in the patients homes were analyzed for 213 participants. MRC was quantified with the Medication Regimen Complexity Index© (MRCI).\(^1\) The potential for ADEs was estimated from the criteria established by Weingart et al., based on medication discrepancies detected between the discharge and patient reported home medication lists.\(^2\) Acute care utilization in the thirty days following the index hospitalization was tracked. Logistic regression analyses were used to approximate the odds for an ADE and post-discharge acute care utilization from MRCI scores.

Results: Home medication lists were less complex than hospital discharge medication lists. Higher MRCI scores increased the odds for a potential ADE and for 30-day hospital readmission, but did not significantly elevate odds for emergency department use.
Conclusions: MRC is an independent variable that can be used to assess patients’ potential for ADEs and hospital readmission. MRC may be useful in identifying patients that would benefit from additional transitional care interventions. Results indicate that simplifying medication regimens may favorably impact post-discharge outcomes.

Key Words: Medication Regimen Complexity Index, Hospital Readmission, Discharge, Medication Complexity, Care Transition, Safety
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The Relationship of Medication Regimen Complexity and Health Care Utilization.

The cost of preventable adverse drug events (ADE) that result in emergency department visits and hospital readmissions has demanded much attention to better understand and address characteristics that lend to this risk. Because 17-20% of Medicare patients are readmitted to the hospital within 30 days after an initial hospitalization,\(^3\),\(^4\) costing approximately $17.4 billion annually,\(^5\) reducing preventable hospital readmissions is a national priority for patient safety and better utilization of healthcare resources. Furthermore, 76% of readmissions are believed to be preventable by the Medicare Payment Advisory Commission (MedPAC), which could save over $12 billion annually.\(^4\)

Medication errors are the most prevalent adverse effect following hospital discharge.\(^6\) Medication discrepancies have a known impact on adverse drug events (ADEs) that lead to preventable emergency department visits, and hospital readmissions. Hospital readmission rates among patients with medication discrepancies at discharge were reported to be more than twice that of patients without medication discrepancies.\(^7\) While nearly 54% of patients are admitted to hospitals with at least one medication discrepancy,\(^8\) an increased number of discrepancies are reported to occur at hospital discharge.\(^9\) In various studies, 41-94% of patients had at least one medication discrepancy at different points in transition,\(^8,10,11,12\) and 29-38% of those discrepancies had the potential to cause harm.\(^8,12\)

Common transition-related medication problems include duplications arising from formulary substitutions during hospitalization, complete omissions of medicines,\(^9\) and incomplete prescriptions – either lacking dose, proper directions or are simply illegible.\(^12\) Medication discrepancies during the hospital-to-home transition occur across all classes of medications, including those considered to be high risk for ADE such as insulin and warfarin.\(^11\)
Medication regimen complexity (MRC) is a factor that increases the likelihood of medication discrepancies which may then have an effect on preventable ADEs.\textsuperscript{6,13} Research examining factors that influence medication adherence implicate MRC as a barrier.\textsuperscript{14,15,16,17,18} Gatti and colleagues (2009) suggest that an increase in MRC leads to decreased adherence and the possibility of hospital readmission.\textsuperscript{19} There remains a significant gap in the literature addressing the relationship between MRC, medication discrepancies, the potential for ADEs, and recurrent health care utilization. Greater knowledge about these associations may offer insight about ways to enhance care delivery to improve safety.

A modified model of Donabedian’s Structure, Process, and Outcome Conceptual Framework guided this study.\textsuperscript{20} The Patient Safety Management Framework (Figure 1) suggests that health care delivery structures and processes can be adjusted to reduce risks and the potential for adverse outcomes. One process that may be improved upon for some patients is MRC. The purpose of this research was to evaluate the impact of MRC on: a) the potential for an ADE; b) 30-day hospital readmits; and c) 30-day emergency department visits.

**Methods**

Secondary data analysis was conducted using medication lists collected from a study that was designed to improve home health nurses’ abilities to identify and resolve medication discrepancies that occurred during the transition from the hospital to home. Participants were at least 50 years of age, admitted into the home care agency upon hospital discharge, able to speak English, and had one of the following co-morbid conditions: peripheral vascular disease, coronary artery disease, congestive heart failure, hypertension, diabetes, hyperlipidemia, major orthopedic condition, and/or chronic obstructive pulmonary disease (COPD). More detailed information about the methods of the primary study is published elsewhere.\textsuperscript{11} All participants
received a home visit from a pharmacist to document the medication discrepancies between the electronic medication list generated at the time of hospital discharge and the medications patients reported taking in the home. The discharge medication list and the medication list developed in the patient’s home, as well as the medication discrepancies between the two lists, provided the data for this study.

The tool used to quantify complexity of the discharge and home medication lists was the Medication Regimen Complexity Index (MRCI). This tool gives a numeric value that reflects the complexity of a medication regimen based on number of medications in the regimen, dosage form, dosing frequency, and additional instructions. The tool has been shown to have inter-rater and test-retest reliability coefficients of 0.90 or higher, and is valid with respect to scores derived and an expert rating of regimen complexity. In the current study, two bachelor’s-prepared nurses scored the regimen complexity of the hospital discharge medication list for each patient, and the medication list that was generated during the pharmacist’s home visit assessment. Inter-rater reliability, based on the two nurses independently scoring 21 medication lists (10% of sample), was 0.99, with no significant difference between the two raters’ scores (p = 0.11). These analyses indicated that the MRCI ratings from the two raters accurately and reliably captured the complexity of the patient’s medication regimen; thus, a single scorer was subsequently used for the remaining MRCI calculations.

As guided by the study’s conceptual framework, a risk management model, we evaluated the potential for an ADE, based on the medication discrepancies identified between the hospital discharge medication list and the list constructed in the patient’s home, which reflected medications the patient was actually taking following hospital discharge. Two doctorally prepared pharmacists used the rating scale developed by Weingart et al. to determine risk of an
ADE as a consequence of each medication discrepancy.\textsuperscript{2} Acute care utilization was tracked via electronic medical record data that accurately captured participants’ emergency department use or inpatient admission at any of 23 hospitals in the region. Emergency department use or inpatient admissions were evaluated within 30 days of each participant’s index hospitalization date of discharge. MRCI scores from participants’ medication lists were then used to determine relationships between the risk for an ADE and the use of acute care services (emergency department or hospital readmission).

**Data Analyses**

Institutional Review Board approval was obtained prior to initiating the secondary analyses and applicable HIPAA protections were followed in completing this project. Data were analyzed with a type I error rate of $p \leq 0.05$. All analyses were conducted with SPSS version 19.

**Analyses of Variance.** Several baseline demographic variables were evaluated to determine whether differences existed among groups formed based on the potential for an ADE (discrepancies present or no discrepancies present) that might confound risk for an adverse outcome or increase utilization of inpatient or emergent care aside from regimen complexity. Independent t-tests were utilized to compare means among the groups classified by potential for an ADE for the dependent measures: age, index hospital length of stay, number of co morbid conditions listed in patient record, and health literacy level as characterized by the REALM-SF score.\textsuperscript{21} Chi-square tests of association were utilized to determine whether the proportion of males and females differed among groups, or whether groups differed by proportion with probable cognitive impairment, as assessed by the Mini-Cog.\textsuperscript{22} A 2 x 5, MRCI Instance (discharge or home list) by Primary Diagnosis (cardiac, diabetes, COPD, major orthopedic condition, other medical condition) two-factor analysis of variance (ANOVA) was employed to
determine whether mean discharge and home MRCI scores differed, or whether MRCI scores varied by diagnosis.

**Logistic Regression Analyses.** Binary logistic regression was employed to determine whether an MRCI score that was dichotomized to reflect the complexity of the medication regimen could predict the potential for an ADE, 30-day hospital readmission, or 30-day ED visit. The odds of experiencing any of these adverse outcomes was predicted from a dichotomous variable created from employing the mean discharge and home visit MRCI scores for those not at risk for an ADE as the classification criterion. The mean was used as a cutoff score under the assumption that it represented the most efficient population estimate for patients who would not experience adverse outcomes. Although establishing a cutoff score based on the mean resulted in an arbitrary discrimination among regimen complexities, no literature exists to suggest an empirical standard for an MRCI score that increases odds for an adverse outcome. The mean split for each MRCI resulted in a higher complexity group and a lower complexity group for the discharge MRCI and the home MRCI.

**Results**

**Analyses of Variance on Baseline Characteristics and Regimen Complexity**

Baseline characteristics of patients classified by the Potential ADE variable are in Table 1. No significant differences among groups were detected on any measures (all $p > 0.05$).

The 2-way ANOVA indicated that complexity of the home medication regimen was significantly less complex than the discharge medication regimen ($p < 0.001$). In addition, MRCI scores differed among diagnostic groups ($p = 0.045$). Pair wise comparisons among Primary Diagnosis group means indicated that home regimens were significantly more complex for
patients with diabetes or COPD than patients with any other conditions. Means for each main
effect are in Table 2. The interaction effect was not significant (p = 0.180).

**Prediction of Adverse Outcomes from Regimen Complexity**

The mean discharge MRCI score for those not at risk for a potential ADE, rounded to the
nearest whole number, was 21 points. Patients with MRCI scores of 22 or above were classified
into the higher MRCI score group. Logistic regression indicated that the odds of the potential for
an ADE were 2.07 times greater for those with a discharge MRCI score of 22 or above (95% CI
= 0.971 to 4.422; p = 0.06). The odds of experiencing a 30-day readmission were 6.24 times
greater for those with a discharge MRCI score of 22 or above (95% CI = 1.407 to 27.640; p =
0.016). The odds of experiencing a 30-day ED visit were not significantly elevated for those with
a discharge MRCI score of 22 or above (Odds ratio = 1.34, 95% CI = 0.528 to 3.481; p = 0.528).

The mean home MRCI score for those not at risk for a potential ADE, rounded to the
nearest whole number, was 14 points. Patients with MRCI scores of 15 or above were classified
into the higher MRCI score group. Logistic regression indicated that the odds of experiencing a
potential ADE were 4.03 times greater for those with a home care MRCI score of 15 or above
(95% CI = 1.838 to 8.816; p = 0.001). The odds of experiencing a 30-day readmission were 2.23
times greater for those with a home MRCI score of 15 or above (95% CI = 0.716 to 6.921; p =
0.167). The odds of experiencing a 30-day ED visit were not significantly elevated for those with
a home MRCI score of 15 or above (Odds ratio = 0.83, 95% CI = 0.360 to 2.263; p = 0.827).

**Discussion**

The rate of discrepancies between hospital discharge list and home list were found to be
nearly 90%, which is greater than previous research that has shown discrepancy rates of 14% -
76%. As a result, mean MRCI scores for the discharge medication list and the home
medication list were significantly different, with the home medication list being less complex. Thus, the medications patients actually take at home immediately following a hospital discharge are appreciably different and less complex than those prescribed at the time of hospital discharge. These findings are particularly important for health professionals providing outpatient follow-up care. A comprehensive and thorough outpatient medication evaluation is essential for patients following up with health care professionals after a hospital discharge. It is imperative that healthcare professionals evaluate the medications patients are actually taking after hospital discharge with those on the hospital discharge list. Both intentional and unintentional discrepancies are common and appear to lead to the potential for ADEs and hospital readmissions. Improving medication information transfer between patients and both inpatient and outpatient providers may reduce these adverse outcomes. None-the-less, the burden for evaluating medications that the patient is taking once at home and providing counseling and other interventions to ensure optimal pharmacotherapy will continue to fall upon outpatient providers.

In our study, medication discrepancies placed 85% of the participants at risk for an ADE. The odds for experiencing a potential ADE were significantly greater for participants having a home MRCI score that was 15 points or higher. In our study, the model of defining a potential ADE was drawn from a study by Weingart et al. As noted, this was consistent with our conceptual framework that focuses on risk reduction to improve care quality and patient safety.

Research by others suggests that there is a relationship between MRC, ADEs and healthcare utilization. In a systemic review by Kongkaew and colleagues, 10.6% of elderly hospitalizations were related to an adverse drug event. In a cross-sectional, observation study, Rogers et al. reported that 14% of admissions had a drug-related cause and greater numbers of
medications increased the risk of being hospitalized for a preventable ADE. These findings were confirmed by our results in that odds of 30-day hospital readmission was significantly elevated for patients with more complex discharge regimens (e.g., discharge MRCI scores of 22 or greater). Conversely, MRCI score did not increase individual risk for emergency department (ED) use.

Participants with diabetes or COPD had higher MRCI scores. The MRCI assigns higher scores for non-oral dosage forms and for greater dosing frequency. Medications used by people with diabetes often include insulin, which is given by injection, while medications used by people with COPD include inhalers and/or nebulizers. Medication dosing is often frequent for both of those conditions. These factors contributed to higher MRCI scores for participants with diabetes and COPD. However, no single diagnosis dominated the sample and most participants had multiple co-morbid conditions that required the use of multiple medicines. Among these participants, MRC was shown to be a factor independent of illness severity. MRC had an independent influence on hospital readmission and the potential to experience an ADE.

Rates of hospital readmissions were only 11.1%, which is significantly lower than the national average for Medicare patients. However, all of the participants in this study received post-hospital home health care services, which may have contributed to a lower readmission rate. Rates of hospital readmissions were statistically significantly higher in patients with a discharge MRCI score of 22 or greater. Rate of ED visits following discharge were 9.3%, which is lower than what was found in other studies, but no national data is available to compare. We cannot definitively link 30-day acute care utilization to medication problems. However, Coleman and colleagues found that patients with medication discrepancies following hospital discharge were more likely to be readmitted to the hospital than patients who did not have medication
discrepancies at the time of hospital discharge. The risk of medication discrepancies increases at points of transition. Research shows 49-60% of medications are changed during hospitalizations and 37% of medications are changed in the month following discharge. According to Ma, et al. (2004), greater than 65% of managed care patients and greater than 75% of fee for service patients had two or three transitions of settings following their hospital discharge. This high frequency of transitions and medication regimen changes puts this older population, who are already at higher risk for readmissions, at an even further increased risk due to medication errors. Due to these compounding factors that increase the patients’ risks, improving transitional care has been an effective intervention strategy to help address these risks associated with transition points. There have been different proposed methods in addressing the transitions in a way that emphasize safety and that take into consideration time and resource limitations. A few examples include the Care Transitions Intervention, TeamSTEPPS and ReEngineered Discharge. The Care Transitions Intervention is a simple, low-cost intervention that focuses on giving patients the tools to take charge of their transition and is shown to decrease acute care utilization following hospitalization. TeamSTEPPS is a program that emphasizes changing the culture and initiating teamwork based interventions. The ReEngineered Discharge (RED) process has been adopted by the National Quality Forum as “Safe Practices” and is a thorough, comprehensive program to prepare patients for discharge and has eleven components to address for a successful and safe discharge process. Improving medication reconciliation and post-discharge medication management is a key component of these evidence-based transitional care strategies. In a recent multi-site translational study, Parrish et al. discovered that medication management was one of the most important, yet challenging, aspects of successful care transitions.
While each of these transition models acknowledge the risk of medication errors on discharge, none of them addresses reducing MRC, but rather giving patients the tools and support to manage their medications, as prescribed. The Care Transitions Intervention that includes home health care for high risk patients has been shown to significantly reduce acute care utilization.\textsuperscript{4,26} Because rates of hospital readmission in this study were statistically significantly higher among patients with a discharge MRCI score of 22 or greater, simplifying medication regimen complexity to the extent possible may be an important consideration during transitional care. Wolf, et al. reported finding that patients do not intuitively simplify their medication doses by clustering times.\textsuperscript{34} The technique of grouping medications to decrease the number of dosing times is one way of reducing regimen complexity, and patients may need specific instruction to cluster medication dosing times.

The current study adds empiric knowledge about the importance of medication regimen complexity in reducing acute care utilization following hospital discharge. Implications of this knowledge are that patients may benefit from interventions designed to simplify medication regimens and that patients who do have complex medications regimens may benefit the most from medication-focused transitional care interventions. Another potential implication is to develop a computer-generated MRCI score as part of the red flagging that is addressed in the RED program. One of the eleven components for the RED program states that in addition to patients receiving a comprehensive discharge plan, patients at risk for hospital readmission should have their discharge plan reinforced after leaving the hospital. The MRCI could be a factor in that risk assessment.

\textbf{Study Limitations}
The use of secondary data limited the researchers to interpreting the data as collected in the primary study. In an effort to increase the inter-rater reliability of the MRCI tool, scoring was done with the intent to not make assumptions about the medication regimens. Unfortunately, the raters discovered that some interpretations had to be made, which were applied consistently. One example was that if the prescription was a powder, dosing would entail dissolving it in a fluid. Instructions for doing so were not included on the medication lists, but powders were scored based on the necessity of dissolving prior to use. Another example is that when medication instructions were present on the list, but specific scoring parameters were not defined in the MRCI, they were assigned the “take as directed” score. Despite this potential limitation, inter-rater reliability between the two raters was high. This study was done in conjunction with patients from one healthcare system hospitalized in one city in the Northwest United States and may not be generalizable to other healthcare systems or patients receiving care in other geographic locations. In addition, study participants were limited to people 50 years of age and older and may not be reflective of younger age groups.

Conclusion

The MRCI is a tool that can be utilized in a variety of settings to assess the complexity of a person’s medication regimen. Based on our findings, it appears that it is a valid tool in assessing a patient’s risk for a potential ADE as well as hospital readmission. Because those with higher home regimen complexity were at increased risk for an ADE, and those with higher discharge regimen complexity had increased risk for hospital readmission, simplifying medication regimens, when possible, may reduce this risk. When simplifying MRC is not possible, ensuring adequate medication self-management support and outpatient follow-up are important implications.
Acknowledgements

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References


Table 1. Baseline characteristics of patients classified based on their potential for an ADE. All values are means (with standard errors) except for the female and Mini-Cog status variables, which are reported as proportions. Also displayed are p-values from t-tests making pairwise comparisons among group means, and chi-square tests for dichotomous baseline variables.

<table>
<thead>
<tr>
<th>Baseline Characteristic</th>
<th>Potential for an ADE</th>
<th>n</th>
<th>Mean</th>
<th>Standard Error</th>
<th>p-value for Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>No</td>
<td>32</td>
<td>74.06</td>
<td>1.94</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>181</td>
<td>70.85</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Index Hospitalization</td>
<td>No</td>
<td>32</td>
<td>5.22</td>
<td>0.53</td>
<td>0.430</td>
</tr>
<tr>
<td>Length of Stay (days)</td>
<td>Yes</td>
<td>181</td>
<td>5.93</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Number of Co-morbidities</td>
<td>No</td>
<td>32</td>
<td>8.66</td>
<td>0.67</td>
<td>0.075</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>181</td>
<td>10.13</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>REALM-SF Score (0-7 scale)</td>
<td>No</td>
<td>29</td>
<td>6.76</td>
<td>0.13</td>
<td>0.359</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>176</td>
<td>6.57</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>No</td>
<td>22</td>
<td>68%</td>
<td></td>
<td>0.254</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>105</td>
<td>58%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Mini-Cog Screen for Presence of Cognitive Impairment</td>
<td>No</td>
<td>25</td>
<td>78%</td>
<td></td>
<td>0.240</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>150</td>
<td>86%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Means MRCI scores (and standard errors) tested in the 2-factor ANOVA. The MRCI Instance and Primary Diagnosis main effects were significant ($p < 0.05$).

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>n</th>
<th>Mean MRCI Score</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MRCI Instance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated from Discharge Medication List</td>
<td>213</td>
<td>26.79</td>
<td>1.50</td>
</tr>
<tr>
<td>Calculated from Home Care Medication List</td>
<td>213</td>
<td>19.57</td>
<td>1.49</td>
</tr>
<tr>
<td><strong>Primary Diagnosis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>38</td>
<td>20.97</td>
<td>1.64</td>
</tr>
<tr>
<td>Diabetes</td>
<td>14</td>
<td>29.41</td>
<td>2.51</td>
</tr>
<tr>
<td>COPD</td>
<td>10</td>
<td>28.72</td>
<td>4.96</td>
</tr>
<tr>
<td>Major Orthopedic</td>
<td>79</td>
<td>17.51</td>
<td>1.67</td>
</tr>
<tr>
<td>Other Condition</td>
<td>72</td>
<td>22.32</td>
<td>1.60</td>
</tr>
</tbody>
</table>
Figure 1: Patient Safety Management Framework  (Battles & Lilford, 2003, p. ii3)

Adjust structure and process to eliminate or minimize risks of health care associated injury before they have an adverse event that impacts the outcomes of care.