High Prevalence of Medication Discrepancies Between Home Health Referrals and Centers for Medicare and Medicaid Services Home Health Certification and Plan of Care and Their Potential to Affect Safety of Vulnerable Elderly Adults

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OBJECTIVES: To describe the prevalence of discrepancies between medication lists that referring providers and home healthcare (HH) nurses create.

DESIGN: The active medication list from the hospital at time of HH initiation was compared with the HH agency's plan of care medication list. An electronic algorithm was developed to compare the two lists for discrepancies.

SETTING: Single large hospital and HH agency in the western United States.

PARTICIPANTS: Individuals referred for HH from the hospital in 2012 (N = 770, 96.3% male, median age 71).

MEASUREMENTS: Prevalence was calculated for discrepancies, including medications missing from one list or the other and differences in dose, frequency, or route for medications contained on both lists.

RESULTS: Participants had multiple medical problems (median 16 active problems) and were taking a median of 15 medications (range 1–93). Every participant had at least one discrepancy; 90.1% of HH lists were missing at least one medication that the referring provider had prescribed, 92.1% of HH lists contained medications not on the referring provider's list, 89.8% contained medication naming errors. 71.0% contained dosing discrepancies, and 76.3% contained frequency discrepancies.

CONCLUSION: Discrepancies between HH and referring provider lists are common. Future work is needed to address possible safety and care coordination implications of discrepancies in this highly complex population. **J Am Geriatr Soc 64:e166–e170, 2016.**

Key words: safety; medication reconciliation; care coordination; home health; transitional care

Medication errors are a leading cause of iatrogenic morbidity and mortality.[1] A large body of research has found that medication errors may be particularly prevalent and dangerous during transitions in care, when multiple providers and settings are involved.[2,3] Individuals referred for home healthcare (HH) are often older, have multiple chronic conditions, and are, by definition, limited in their functional capacity.[4] Therefore, HH is an important domain in which to address potential medication errors for this vulnerable population.

Individuals who are homebound as a result of recent illness or surgery often require HH services. Among other clinical data, HH referrals normally include a list of the individual's medications from the referring provider's records. After an assessment in the home, generally performed by a registered nurse, the medications actually being taken in the home are reviewed and included as part of a revised Centers for Medicare and Medicaid Services Home Health Certification and Plan of Care (Form 485) that is sent to the attending provider. The HH clinician may request changes to this medication list (and other elements of the plan of care). Once the provider has approved or edited the plan, the revised plan of care is returned to the HH clinician to enact and, among other tasks, to educate the individual and assist him or her with adherence. Discrepancies between the referring providers'

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records and HH records have been found to occur frequently[3] and are a significant potential source of harm to the individual that is not always addressed.

Although the authors of the current article are unaware of a comprehensive list of the causes of medication discrepancies in this setting, common sources of errors include problems recording the medication history;[5,6] the referrer not being made aware of medications that outside providers have prescribed;[6,7] and individual factors such as adherence or taking an over-the-counter medication, herbal remedy, or supplement.[6]

A number of studies have examined interventions that are intended to reduce medication errors as individuals transition from the hospital to HH. Some of these interventions have been efficacious, but they often require intensive use of human resources and changes in clinical workflow.[8,9] A web-based shared care plan that will facilitate the medication reconciliation and cross-disciplinary communication considered to be necessary to avoid medication errors and reduce readmissions is being developed.[10] The objective of this study was to describe the prevalence of different types of discrepancies between the records of referring providers and HH agencies. The prevalence of these different types of discrepancies was therefore examined between and within a sample of individuals. The information presented in this article will serve as a baseline for future testing of the web-based shared care plan intervention.

METHODS

Data were collected from individuals who providers at a large regional hospital had referred to a large HH agency with a significant rural practice between January 1, 2012, and January 1, 2013. The resulting dataset from 770 individuals included participant demographic data (age, sex, number of active problems) and a pair of medication lists for each participant: one extracted from the hospital electronic health active medication list at time of referral and the second from the HH agency's plan of care.

Medication discrepancies between the provider and HH lists were of different types and may occur for different reasons. For example, a medication may be on one list but not the other, or there may be differences in dose, frequency, form, or route for the same medication between the two lists. An automated algorithm, implemented in the Ruby programming language, was therefore developed to compare the lists and determine for each medication whether there was a discrepancy and, if so, the type. This algorithm required three algorithmic phases: medication list alignment (pairing medications in the HH list with the referring provider list), concept extraction (finding and normalizing mentions of doses, frequencies, route), and detection of discrepancies between the concepts extracted from medication pairs.

The medication list alignment algorithm was created specifically for use with this study's HH referral data. The concept extraction and discrepancy detection algorithms used in this study have been evaluated previously using a corpus of outpatient prescription data from Partners Healthcare in which they were found to identify errors in dosage with 90.3% precision and errors in frequency with 96.6% precision (D. Tresner-Kirsch, unpublished data).

Phase 1: Medication List Alignment

Medications were aligned across the two lists for each participant based on the name field. A greedy matching algorithm[11] was used, finding the best single match for each referred medication (if one could be found) and removing the match from further consideration, resulting in a strict one-to-one mapping, with some items potentially left over on one or both lists. Matches were based on various string similarity criteria and also semantic analysis using the RxNorm ontology.[12]

Phase 2: Concept Extraction

The MedAttrib Ruby library (MITRE Corporation, Bedford, MA) was used to extract and normalize mentions of the name, dosage, frequency, and delivery method fields of each medication list entry. MedAttrib uses regular expression searches and terminology lists from public knowledge bases to identify these concept mentions.[13] For example, mentions of "2× daily" and "twice a day" would both be extracted from surrounding text and labeled with the normalized label BID. The original text data were annotated using the normalized labels for further analysis.

Phase 3: Discrepancy Detection

Once the medication lists were aligned and concepts extracted, detection of discrepancies was a simple task. For each medication pair and for each text field under consideration (name, dosage, frequency, delivery method), the extracted concept was compared. When there was a mismatch in the concepts, the algorithm recorded a discrepancy for the field in which the mismatch occurred for each medication pair.

To evaluate the accuracy of the algorithms in this dataset, they were run on the medication lists from 30 randomly selected participants (681 total medication records) and the output manually inspected for accuracy.

Analysis

R statistical computing software (R Foundation, Vienna, Austria) was used for all analyses. To the participant demographic characteristics the median, range, and standard deviation (SD) of subject age; the number of active medical problems; the proportion of subjects who were male; race and ethnicity; and geographic location (highly rural, rural, urban) were calculated.

The prevalence of discrepancies between records was examined as the proportion of paired participant medication lists with at least one of each type of discrepancy. Discrepancies assessed were medications on one list but not the other (on the referral list but not the HH and vice versa) and differences between the lists in dose, frequency, form, or route for the same medication. For the purposes of this study, discrepancies are defined as differences between the lists. Potential reasons for these differences

and their significance are examined in the Discussion section

To examine the distribution of different types of discrepancies within participants, the median and range for the number of each type of discrepancy within the lists were calculated for individuals. These numbers might be considered to represent the unadjusted risk that such a discrepancy might occur when an individual is referred for HH services. These statistics (rather than mean and SD) were chose because the number of discrepancies per participant was not normally distributed; a small number of participants had very high numbers of discrepancies, leading to a distribution that was skewed to the right.

RESULTS

To verify the accuracy of the medication alignment and discrepancy detection algorithms, the algorithms were run on the medication lists of 30 randomly selected individuals (681 medication records), and the output was manually inspected for accuracy. The alignment algorithm achieved a 5.3% false negative rate, 0% false positive rate, 91.1% recall, and 100% precision. Similarly, the discrepancy detection had a 3.7% false negative rate, 4.5% false positive rate, 95.5% recall and 80.9% precision. Upon completing the validation process, the analysis was performed on the full dataset.

The participant population in this sample (Table 1) was 96.2% male and 94.5% white, had a median age of 71 ± 13.1, had a median of 16 ± 10.4 medical problems, and were taking a median of 15 ± 10.6 medications. A high rate of discrepancies of most types was found (Table 2); 90.1% of participants had at least one medication that was on the provider list but not on the HH list, with a median of 4 medications prescribed but missing from the HH list. Similarly, 92.1% of participants had at least one medication that was on the HH list but not the provider list, with a median number of 4. In addition, 89.8% of lists contained a naming discrepancy in which trade name was used on one list and generic on the other. There were also a significant number of discrepancies between the dosing (71.0% of cases) and frequency (76.3% of cases) of medications between the HH list and provider list but relatively few discrepancies in route of administration (0.8% of cases).

Table 1. Participant Demographic Characteristics (N = 770)

Characteristic	Value
Male, n (%)	745 (96.2)
Age, median (range)	71 (22–94)
Race, n (%)	
White	726 (94.5)
Black	20 (2.6)
Asian	2 (0.3)
American Indian	6 (0.8)
Unknown	16 (2.1)
Hispanic, n (%)	
Yes	36 (4.7)
No	728 (94.5)
Unknown	6 (0.8)
Number of medications, median (range)	15 (1–93)
Number of active medical problems, median (range)	16 (0–73)
Population density of residence, n (%)	
Highly rural	114 (14.8)
Rural	189 (24.5)
Urban	467 (60.6)

Table 2. Medication Discrepancy Rates Between Referring Provider List and Home Healthcare (HH) Centers for Medicare and Medicaid Services Home Health Certification and Plan of Care

Descriptor	Value
HH does not include medications on provider list, n (%)	694 (90.1)
Number not on HH list, median (range)	4 (0–41)
HH contains medications not on provider list, n (%)	709 (92.1)
Number not on provider list, median (range)	4 (0–41)
Differences between lists in:	
Dosing	
n (%)	547 (71.0)
Median (range)	1 (0–16)
Frequency	
n (%)	588 (76.3)
Median (range)	2 (0–18)
Route	
n (%)	5 (0.8)
Median (range)	0 (0–1)
Number of medications with naming discrepancies for same medication between lists (e.g., trade vs generic name), median (range)	5 (0–28)

DISCUSSION

This study examined the prevalence of medication discrepancies between HH referrals and HH plans of care using an automatic discrepancy detection algorithm. To the knowledge of the authors, this is the first study to use an automated process in this setting, and the algorithm showed exceptional sensitivity and specificity, which increases its potential for use in clinical applications versus manual review. Medication discrepancies were defined as any difference between the referring provider's medication list and the medication list included in the HH plan of care. Based on prior discussion with referring physicians, it was expected that significant discrepancies would be found, but it was surprising that every participant record had some type of discrepancy. The most frequent discrepancies identified were medications that were on one list but not the other, followed by differences in dosage or frequency. These findings largely echo previous work that found that 94% of individuals in a sample of 101 individuals discharged from a hospital to HH had a discrepancy,[3] although the depth and breadth of discrepancies was greater than previously reported and in a larger sample. Moreover, they previous study used a time-intensive process of research nurses hand-coding discrepancies, a process that is not practical in daily practice.

Many people do not adhere rigidly to their prescribed medication regimen and may substitute, ration, or

otherwise change their medication list without provider approval.[14] In addition, a large proportion of people are discharged from the hospital to HH, in which case the referring provider is not the primary care provider. During these transitions, there are often significant changes to the person's medication regimen that the primary care provider may be unaware of, even if the primary care provider is aware of the hospitalization itself.[15] Furthermore, many people take over-the-counter medications and supplements that are not accounted for in provider records[16,17] but are on the HH list because the HH nurse has access to everything an individual is taking at home because they are physically in the home. Given this complexity and the fact that homebound elderly adults generally have significant illness and multimorbidity, understanding whether there are medication discrepancies, whether the individual is being optimally medically managed, and whether he or she adherent has significant potential implications for patient care and the healthcare system.[2,18–20] It is this holistic view, focusing on all aspects of the care transition, shared care management, and communication between the provider and HH agency that is critical; medication reconciliation is but one component.

Technology has not been previously used in HH to assist healthcare providers in understanding adherence or discrepancies between what is actually occurring in the home through report of the HH nurse and what the provider believes is occurring. This provides a significant opening for improvement of quality of care. Requiring providers to reconcile two lists manually is time intensive and is often not performed. One study found that reconciliation by a pharmacist took a mean 21.2 ± 13.2 minutes.[5] By integrating electronic tools such as this algorithm into care systems, providers may be able to better their time manage, resolve discrepancies, address adherence problems, and improve provider satisfaction.[10]

Future Work

The prevalence and origins of medication discrepancies discussed above accentuate the need for clear and efficient communication between referring physicians and HH to support care coordination and optimal medical management.

This planned web-based shared care plan is intended to address this need. Use of the tool will begin with the referring provider creating a referral (including the medication list for the individual). As they perform an initial assessment, HH clinicians will have electronic access to the referrer's medication list so that, as they enter medications, discrepancies can be identified and an explanation provided as needed. For example, when a registered nurse finds a medication in the home that another provider has prescribed, the nurse could provide the name of the provider and other prescription data. Similarly, if prescriptions from the referrer are not found in the home, the registered nurse can note the missing medication and expedite a refill or renewal as needed. Concerns about adherence to dose and frequency can also be noted and communicated. When the HH medication list is electronically compared with the referring providers' list, the discrepancies can be automatically highlighted. When the provider views the electronic comparison results, the discrepancies are easily identified, and explanatory text can be viewed. This would support the provider in making a more-informed decision on how to proceed, ideally including an efficient method of communication between providers to clarify and resolve discrepancies.[10]

Strengths and Limitations

This study has a number of strengths. First, it is one of few studies to examine the discrepancies between HH referrals and plans of care. Second, a validated electronic algorithm was used to measure these discrepancies, allowing for replication of this work in other settings and for the application of the same algorithm to the web-based shared care plan. Limitations of this study primarily relate to its scope. Because of limitations in the individual-level data, it was not possible to address the clinical importance of the discrepancies that were counted or why the discrepancies occurred. In addition, the records for this study were drawn from a single referring healthcare facility, and comparisons were performed using records from a single HH agency. The participant population was largely demographically and regionally homogenous, which may limit generalizability. Although these limitations suggest the need for further work, the input that was gathered from physicians and HH registered nurses indicates that the problem of medication discrepancies is not a local problem and requires an efficient, scalable solution. Finally, although the sensitivity and specificity were high using this algorithm, they were not high enough for use without clinician review. In developing a medication reconciliation module for HH, HH clinicians have therefore been required to enter and reconcile portions of the medication record manually to ensure safety.[10]

CONCLUSIONS

The prevalence of discrepancies between the medication lists of referring providers and HH agencies were estimated, and the results suggest that this is an extremely common potential risk to safety. Given the significant attention currently being paid to value-based purchasing, effective care coordination and transitions, and reducing risk of rehospitalization, this study raises ample concern to require further study and solutions. The authors are therefore in the process of developing an electronic intervention to address this problem, reducing potential risk from poor medication reconciliation and adherence.

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REFERENCES

1. Institute of Medicine. Preventing Medication Errors: Quality Chasm Series. Washington, DC: National Academies Press, 2007.
2. Kwan JL, Lo L, Sampson M et al. Medication reconciliation during transitions of care as a patient safety strategy: A systematic review. Ann Intern Med 2013;158(5 Pt 2):397–403.
3. Corbett CF, Setter SM, Daratha KB et al. Nurse identified hospital to home medication discrepancies: Implications for improving transitional care. Geriatr Nurs 2010;31:188–196.
4. Caffrey C, Sengupta M, Moss A et al. Home health care and discharged hospice care patients: United States, 2000 and 2007. Natl Health Stat Report 2011;38:1–27.
5. Gleason KM, McDaniel MR, Feinglass J et al. Results of the Medications at Transitions and Clinical Handoffs (MATCH) study: An analysis of medication reconciliation errors and risk factors at hospital admission. J Gen Intern Med 2010;25:441–447.
6. Orrico KB. Sources and types of discrepancies between electronic medical records and actual outpatient medication use. J Manag Care Pharm 2008;14:626–631.
7. Stewart AL, Lynch KJ. Identifying discrepancies in electronic medical records through pharmacist medication reconciliation. J Am Pharm Assoc 2003;2012:59–66.
8. Boling PA. Care transitions and home health care. Clin Geriatr Med 2009;25:135–148, viii.
9. Sevin C, Evdokimoff M, Sobolewski S et al. How-to Guide: Improving Transitions from the Hospital to Home Health Care to Reduce Avoidable Rehospitalizations. Cambridge, MA: Institute for Healthcare Improvement, 2013.
10. Kramer H, Gibson B, Livnat Y et al. H3IT special topic: Evaluation of an electronic module for reconciling medications in home health plans of care. Appl Clin Inform 2016;7:412–424.
11. Black PE. Greedy algorithm. In: Pieterse P, Black PE, eds. Dictionary of Algorithms and Data Structures. Gaithersburg, MD: National Institute of Standards and Technology. 2005 [on-line] Available at https://xlinux.nist.gov/dads/HTML/greedyalgo.html Accessed August 12, 2016.
12. Liu S, Wei M, Moore R et al. RxNorm: Prescription for electronic drug information exchange. IT Prof 2005;7:17–23.
13. Tresner-Kirsch D, Aberdeen J, Baye S et al. Extracting Detailed Regimen Information from Medication Order Text. NIPS 2015 Workshop on Machine Learning in Healthcare, 2015.
14. Mixon AS, Neal E, Bell S et al. Care transitions: A leverage point for safe and effective medication use in older adults—a mini-review. Gerontology 2015;61:32–40.
15. Arora VM, Prochaska ML, Farnan JM et al. Problems after discharge and understanding of communication with their primary care physicians among hospitalized seniors: A mixed methods study. J Hosp Med 2010;5:385–391.
16. Schmiemann G, Bahr M, Gurjanov A et al. Differences between patient medication records held by general practitioners and the drugs actually consumed by the patients. Int J Clin Pharmacol Ther 2012;50:614–617.
17. Sleath B, Rubin RH, Campbell W et al. Physician-patient communication about over-the-counter medications. Soc Sci Med 2001;53:357–369.
18. Roebuck MC, Liberman JN, Gemmill-Toyama M et al. Medication adherence leads to lower health care use and costs despite increased drug spending. Health Aff (Millwood) 2011;30:91–99.
19. Fitzgerald AA, Powers JD, Ho PM et al. Impact of medication nonadherence on hospitalizations and mortality in heart failure. J Card Fail 2011;17:664–669.
20. Asche C, LaFleur J, Conner C. A review of diabetes treatment adherence and the association with clinical and economic outcomes. Clin Ther 2011;33:74–109.