

Original Article

Association Between Family Caregiver Health Literacy and Nurse-Documented Medication Administration Errors During Home-Based Chronic Disease Management

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ABSTRACT

Background: Informal family caregivers frequently undertake complex medication-management responsibilities for people with chronic diseases, making their ability to understand and apply health information potentially important for medication safety. **Objective:** To determine the association between family caregiver health literacy and nurse-documented medication administration errors during home-based chronic disease management. **Methods:** This cross-sectional analytical study included 85 caregiver-patient dyads recruited consecutively through home health agency networks in industrial and urban areas of Punjab between September 2025 and January 2026. Caregiver functional health literacy was assessed using the S-TOFHLA, while medication administration errors documented in nursing records and medication-reconciliation records during the preceding 30 days were evaluated as binary and count outcomes. Independent-samples t testing, Pearson correlation, and multivariable logistic regression were performed. **Results:** Mean caregiver S-TOFHLA score was 58.4 ± 12.6 , and 38/85 dyads (44.7%) had at least one documented medication error. Caregivers in error-positive dyads had lower S-TOFHLA scores than those without errors (51.2 ± 10.8 vs 64.2 ± 10.5 ; mean difference -13.0 , 95% CI -17.61 to -8.39 ; $p < 0.001$; Cohen's $d = -1.22$). Health-literacy score correlated inversely with total error count ($r = -0.58$, 95% CI -0.71 to -0.42 ; $p < 0.001$). After adjustment for caregiver age, care-recipient age, and daily medication count, higher S-TOFHLA score remained associated with lower odds of a documented medication error (aOR = 0.89 per point, 95% CI 0.84–0.94; $p < 0.001$). **Conclusion:** Lower caregiver functional health literacy was independently associated with nurse-documented medication administration errors in this cross-sectional home-care sample. These findings support further evaluation of literacy-sensitive caregiver medication-support strategies. **Keywords:** Caregivers, Chronic Disease, Health Literacy, Home Care Services, Medication Errors, Medication Safety, Patient Safety.

EDITORIAL INFORMATION

Author Contributions: FDB: Concept, Design, Analysis, Drafting; KM: Data Collection, Analysis, Drafting; FM: Design, Data Collection, Drafting.**Ethical Approval:** National University of Medical Sciences, Rawalpindi, Pakistan**Informed Consent:** Written informed consent was obtained from all participants**Conflict of Interest:** The authors declare no conflict of interest; **Funding:** No external funding; **Data Availability:** Available from the corresponding author on reasonable request; **Acknowledgments:** N/A.

INTRODUCTION

The increasing prevalence of long-term conditions has shifted a substantial component of chronic disease management from hospitals to community and home settings, where family members frequently assume responsibility for day-to-day care. Informal caregivers perform a wide range of medication-related tasks, including obtaining medicines, organizing doses, interpreting instructions, administering treatment, monitoring responses, and making practical decisions about prescribed regimens. These responsibilities become particularly demanding when care recipients have multimorbidity or require multiple long-term medications with different dosing schedules and administration requirements (1,2). Consequently, the caregiver's ability to understand and correctly apply health and medication information is an important component of safe home-based disease management.

Health literacy encompasses the skills required to access, understand, appraise, and use health information when making health-related decisions. For informal caregivers, these skills are relevant not only to their own health but also to their ability to perform health-related tasks on behalf of another person. Recent evidence indicates that caregivers with lower health literacy perform less well on everyday health-management tasks, including interpretation of written health information and recall of health-related communication (3). A systematic review of unpaid caregivers of older adults similarly identified lower educational attainment, cognitive limitations, reduced care capacity, poor ability to interpret medication information, and limited social support among factors associated with lower caregiver health literacy (4). Despite its potential importance, intervention research specifically targeting health literacy among informal caregivers remains limited and heterogeneous (5).

Medication management in the home presents additional patient-safety challenges because medicines are often administered outside continuously supervised clinical environments. A recent cross-sectional study of 685 informal caregivers found that medication errors were reported in home care and varied according to caregiver training and other caregiver characteristics (6). Analyses of home-care medication incidents have also identified problems involving medication administration, documentation, information exchange, cooperation between professionals and relatives, and continuity of medication information across settings (7). A recent scoping review further concluded that medication safety in home care is multifactorial and may require coordinated approaches involving medication reconciliation, multidisciplinary care, information-sharing systems, and caregiver support rather than reliance on a single preventive strategy (8).

Although health literacy has been studied in relation to medication adherence and chronic disease self-management, the association is not uniform across populations, and much of the available evidence concerns patients managing their own medicines rather than family caregivers administering medicines for dependent adults (9). Caregiver-focused health-literacy research has also concentrated more frequently on knowledge, task performance, caregiver burden, or self-reported medication management than on objectively documented administration errors (3,5,6). Evidence directly linking caregiver functional health literacy with medication errors identified through routine nursing documentation in home-based chronic disease care therefore remains limited. The present study aimed to determine whether family caregiver health literacy was associated with nurse-documented medication administration errors during home-based chronic disease management. It was hypothesized that lower caregiver health-literacy scores would be associated with a greater occurrence and frequency of documented medication administration errors.

MATERIALS AND METHODS

A cross-sectional analytical study was conducted from September 2025 to January 2026 through home health agency networks serving industrial and urban areas of Punjab. The study population consisted of informal family caregivers and the patients for whom they provided medication-related care within routine home healthcare services. Eligible caregivers were aged 18 years or older, were the primary unpaid person responsible for managing and administering the care recipient's daily medications, and cared for an individual with at least one chronic condition, including type 2 diabetes mellitus, hypertension, or heart failure, for which three or more medications were prescribed daily. Paid healthcare workers and caregivers with severe cognitive impairment that prevented completion of the study assessment were excluded, as were dyads in which the care recipient resided in an institutional facility. Participants were recruited consecutively during the study period. A target sample of 85 caregiver–patient dyads was established from the available prior cross-sectional literature on caregiver health literacy and home medication safety, in which relatively small caregiver cohorts had been studied, and the targeted sample was achieved.

Data were collected during structured face-to-face home visits conducted in conjunction with routine encounters by supervising registered nurses. Information was obtained on caregiver age, sex, educational attainment, duration of caregiving, care-recipient age and primary chronic condition, and the number of prescribed medications administered daily. Caregiver functional health literacy was assessed using the

Short Test of Functional Health Literacy in Adults (S-TOFHLA), a validated measure developed from the Test of Functional Health Literacy in Adults (10). The study records contained results for the 36-item reading-comprehension component, recorded on a 0–72 scale, with higher scores indicating greater functional health literacy. For descriptive reporting, the study dataset classified scores of 0–53 as inadequate, 54–66 as marginal, and 67–72 as adequate health literacy. These categories were used descriptively; the primary inferential analyses treated the health-literacy score as a continuous variable.

Medication administration errors were identified from clinical nursing records and home medication-reconciliation documentation covering the preceding 30 days. A dyad was classified as having a documented medication administration error when at least one medication-related discrepancy had been recorded during this period. Documented errors were categorized as an incorrect dose, missed dose, incorrect administration time, incorrect administration technique, or administration of a medication that had not been prescribed. In addition to the binary outcome of any documented error versus no documented error, the total number of documented medication administration errors was recorded for the analysis of error frequency. Use of nursing documentation and medication-reconciliation records enabled outcome ascertainment to be based on routinely recorded clinical information rather than caregiver recall alone. Caregiver demographic characteristics, educational attainment, duration of caregiving, care-recipient characteristics, and daily medication count were collected as potential explanatory or contextual variables.

Data were analysed using IBM SPSS Statistics version 28.0. Continuous variables were summarized using means and standard deviations, whereas categorical variables were summarized using frequencies and percentages. Distributional normality of continuous variables was assessed using the Shapiro–Wilk test. S-TOFHLA scores were compared between dyads with and without documented medication errors using an independent-samples t-test. The between-group mean difference and its 95% confidence interval were additionally calculated from the reported group statistics, and the standardized between-group difference was expressed using Cohen's *d*. Pearson's correlation coefficient was used to assess the relationship between continuous S-TOFHLA score and total documented medication-error count, with a 95% confidence interval calculated for the correlation coefficient. Multivariable binary logistic regression was used to examine the independent association between S-TOFHLA score and the presence of at least one documented medication error while adjusting for caregiver age, care-recipient age, and number of medications prescribed daily. Effect estimates are presented as odds ratios (ORs) and adjusted odds ratios (aORs) with 95% confidence intervals. Analyses were based on the 85 dyads with complete study data. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

RESULTS

Of 92 caregiver–patient dyads invited during the study period, 85 contributed complete data and were included in the analysis, corresponding to 92.4% of those invited. Caregivers had a mean age of 42.6 ± 11.4 years; 55 (64.7%) were women and 30 (35.3%) were men. Twenty-two caregivers (25.9%) had primary education or lower, 39 (45.9%) had secondary education, and 24 (28.2%) had higher education. Care recipients had a mean age of 63.8 ± 9.2 years. Their recorded primary-condition categories comprised type 2 diabetes mellitus in 31 (36.5%), hypertension or another cardiovascular condition in 34 (40.0%), and heart failure or another chronic condition in 20 (23.5%). Caregivers managed a mean of 5.8 ± 2.1 prescribed medications daily and had provided care for a mean of 3.4 ± 1.8 years (Table 1).

The mean caregiver S-TOFHLA score was 58.4 ± 12.6 . Based on the descriptive categories recorded in the study dataset, 24 caregivers (28.2%) were classified as having inadequate health literacy, 30 (35.3%) as having marginal health literacy, and 31 (36.5%) as having adequate health literacy. At least one nurse-documented medication administration error during the 30-day assessment period was identified in 38 of 85 dyads (44.7%), whereas 47 (55.3%) had no documented error. Missed doses and incorrect administration timing were the most frequently reported error categories, accounting for 42.1% and 31.6%, respectively, of the reported error-type distribution; incorrect dosage accounted for 15.8% and incorrect administration technique for 10.5% (Table 2).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (N=85)

Variable	Category/measure	Total sample
Caregiver age, years	Mean ± SD	42.6 ± 11.4
Caregiver sex	Female, n (%)	55 (64.7)
	Male, n (%)	30 (35.3)
Caregiver education	Primary or lower, n (%)	22 (25.9)
	Secondary, n (%)	39 (45.9)
	Higher education, n (%)	24 (28.2)
Care-recipient age, years	Mean ± SD	63.8 ± 9.2
Primary chronic-condition category	Type 2 diabetes mellitus, n (%)	31 (36.5)
	Hypertension/cardiovascular, n (%)	34 (40.0)
	Heart failure/other, n (%)	20 (23.5)
Daily prescribed medication count	Mean ± SD	5.8 ± 2.1
Duration of caregiving, years	Mean ± SD	3.4 ± 1.8

Table 2. Caregiver Health Literacy and Nurse-Documented Medication Error Status

Measure	Category	n (%) or mean ± SD
S-TOFHLA score	Overall	58.4 ± 12.6
Health-literacy category	Inadequate	24 (28.2)
	Marginal	30 (35.3)
	Adequate	31 (36.5)
Medication-error status	≥1 documented error	38 (44.7)
	No documented error	47 (55.3)

The categorical health-literacy distribution reflects the scoring bands recorded in the study dataset. Inferential analyses used the continuous S-TOFHLA score.

Caregivers in dyads with documented medication errors had substantially lower S-TOFHLA scores than those in dyads without documented errors (51.2±10.8 versus 64.2±10.5). The mean difference for the error group relative to the no-error group was -13.0 points (95% CI -17.61 to -8.39), corresponding to a large standardized difference (Cohen's $d=-1.22$). The independent-samples comparison was statistically significant, $t(83)=-5.61$, $p<0.001$. Continuous S-TOFHLA score was also inversely correlated with the total number of documented medication errors ($r=-0.58$, 95% CI -0.71 to -0.42; $p<0.001$), indicating that lower functional health-literacy scores were associated with greater documented error frequency (Table 3).

Table 3. Association Between Caregiver S-TOFHLA Score and Medication Errors

Analysis	Estimate	95% CI	Test statistic	p-value
S-TOFHLA, documented-error group, mean ± SD	51.2 ± 10.8	—	—	—
S-TOFHLA, no-error group, mean ± SD	64.2 ± 10.5	—	—	—
Mean difference, error minus no-error group	-13.0	-17.61 to -8.39	$t(83)=-5.61$	<0.001
Standardized mean difference, Cohen's d	-1.22	—	—	—
S-TOFHLA versus total error count	$r=-0.58$	-0.71 to -0.42	—	<0.001

In the multivariable logistic regression model, caregiver S-TOFHLA score remained independently associated with the presence of documented medication administration errors after adjustment for caregiver age, care-recipient age, and daily medication count.

Table 4. Logistic Regression Analysis of Factors Associated with Nurse-Documented Medication Administration Errors

Variable	Crude OR (95% CI)	Adjusted OR (95% CI)	Adjusted p-value
S-TOFHLA score, per 1-point increase	0.88 (0.83–0.93)	0.89 (0.84–0.94)	<0.001
Caregiver age, per year	1.02 (0.98–1.06)	1.01 (0.96–1.05)	0.724
Care-recipient age, per year	1.03 (0.98–1.09)	1.02 (0.97–1.08)	0.412
Daily medication count, per medication	1.28 (1.02–1.61)	1.21 (0.95–1.54)	0.118

Outcome: presence of at least one nurse-documented medication administration error. Adjusted models include caregiver age, care-recipient age, daily medication count, and continuous S-TOFHLA score. OR odds ratio; CI, confidence interval; S-TOFHLA, Short Test of Functional Health Literacy in Adults.

Each one-point increase in S-TOFHLA score was associated with lower odds of a documented medication error (aOR=0.89, 95% CI 0.84–0.94; $p<0.001$). Caregiver age (aOR=1.01, 95% CI 0.96–1.05; $p=0.724$), care-recipient age (aOR=1.02, 95% CI 0.97–1.08; $p=0.412$), and daily medication count (aOR=1.21, 95% CI 0.95–1.54; $p=0.118$) were not statistically significant in the adjusted model (Table 4). These estimates support an independent inverse association between caregiver functional health-literacy score and the odds of a

nurse-documented medication administration error within this cross-sectional sample, without establishing a causal relationship.

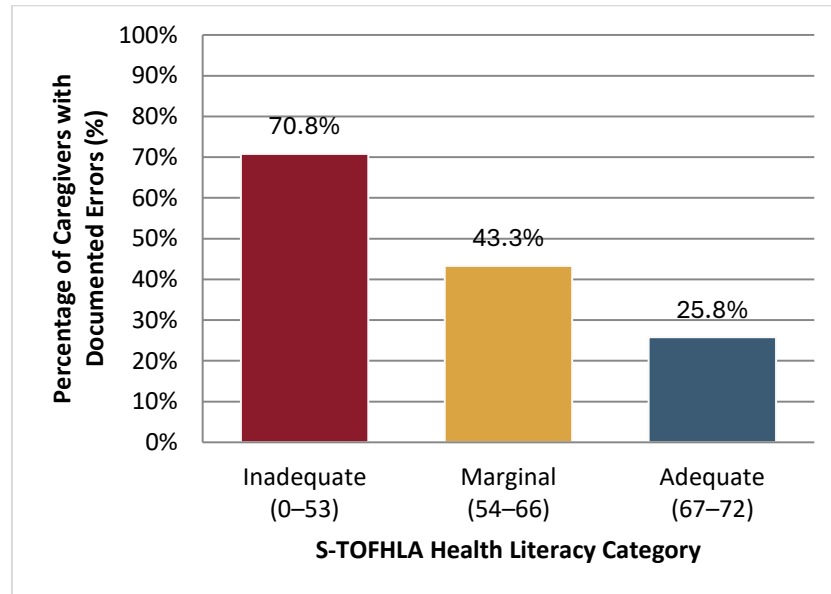


Figure 1 prevalence of Nurse-Documented Medication Errors Across Caregiver Health Literacy Levels

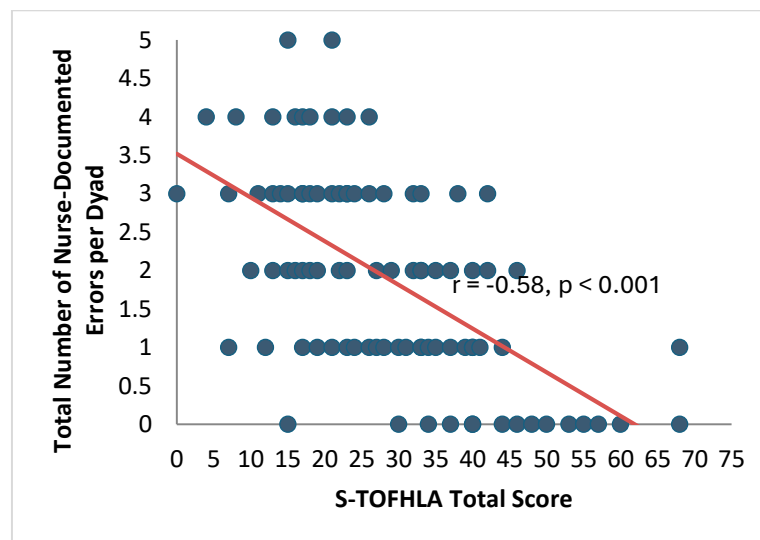


Figure 2 Correlation Between Caregiver Health Literacy Score and Total Medication Administration Errors

DISCUSSION

This study demonstrated a substantial inverse association between family caregiver functional health literacy and nurse-documented medication administration errors during home-based chronic disease management. Caregivers in dyads with documented errors scored, on average, 13 points lower on the S-TOFHLA than caregivers in dyads without documented errors, representing a large standardized between-group difference. Health-literacy score was also moderately to strongly inversely correlated with the number of documented errors. Most importantly, the association persisted after adjustment for caregiver age, care-recipient age, and daily medication count, with each one-point increase in S-TOFHLA score associated with an 11% lower adjusted odds of a documented medication error. These findings support the study hypothesis while remaining appropriately interpreted as associations because of the cross-sectional design.

The observed relationship is consistent with emerging caregiver-specific evidence suggesting that health literacy influences the ability to perform health-management tasks on behalf of another person. In the LitCog caregiver cohort, caregiver health literacy was associated with performance on practical healthcare tasks, emphasizing that caregiving requires more than general knowledge and depends on the capacity to

obtain, interpret, remember, and apply health information (3). Recent research among caregivers of individuals with diabetes has similarly linked higher caregiver health literacy with stronger caregiving activities and supportive behaviours, while a home-care caregiver study found educational attainment to be an important predictor of caregiver health literacy (11,12). Together with the present findings, this literature suggests that functional health literacy may be clinically relevant when caregivers are responsible for medication schedules, dose interpretation, and treatment-related decision-making in the home.

The pattern of medication errors observed in this study also accords with contemporary evidence from home-care settings. Missed doses and incorrect timing were the predominant documented error categories, followed by incorrect dosage and administration-technique errors. Gil-Hernández et al. identified medication errors among informal caregivers in home settings and reported that caregiver training and contextual characteristics influenced error occurrence, while Vellonen et al. showed that home-care medication incidents commonly involve administration and failures in the flow of medication information between professionals, patients, and relatives (6,7). More recent home-visit research involving family caregivers has identified administration errors such as dose omission, wrong timing, incorrect doses, and problems related to medication instructions, and qualitative evidence among low-literacy older adults and their caregivers has highlighted medication mismanagement, communication difficulties, inadequate education, and health-system factors as interacting contributors to medication errors (13,14). The similarity between these reported error patterns and those observed in the present study supports the clinical plausibility of caregiver literacy as one component within a broader medication-safety system.

Medication management becomes particularly demanding when multiple medicines must be coordinated across different schedules and instructions. In the present study, each additional daily medication was associated with greater odds of an error in the crude analysis, although this association attenuated after adjustment and was no longer statistically significant. This pattern should not be interpreted as evidence that medication burden is unimportant; rather, it suggests that medication count alone did not independently explain error status within this relatively small adjusted model. Systematic-review evidence shows that older adults receiving multiple medicines frequently require strategies to support medication-taking ability and adherence, while the relationship between health literacy and medication adherence across chronic diseases is heterogeneous and influenced by medication knowledge, beliefs, self-efficacy, and sociodemographic factors (2,9). Studies of medication safety during the transition from hospital to home likewise emphasize the combined influence of health literacy, communication, family support, treatment complexity, and coordination of care, while qualitative work involving home-dwelling polymedicated adults and informal caregivers has identified communication and coordination failures as important threats to safe medication management (15,16).

The findings have practical implications but do not establish that any specific educational intervention would prevent errors in this population. Evidence nevertheless supports evaluating literacy-sensitive communication as part of caregiver medication support. A systematic review of interventions for informal caregivers found that caregiver health-literacy interventions have targeted disease understanding, treatment knowledge, day-to-day care, self-care, and engagement with healthcare professionals, although the evidence remains limited and heterogeneous (5). In a randomized clinical trial involving caregivers, a health-literacy-informed medication-communication intervention incorporating pictogram-based instructions, dosing demonstration, and structured teach-back/show-back reduced caregiver medication errors compared with standard counselling (17). A recent rapid review likewise found that some caregiver health-literacy interventions improved health-literacy or health-related outcomes, although intervention content, intensity, populations, and evidence quality varied substantially (18). Broader systematic reviews of chronic-disease interventions also suggest that interventions targeting health literacy, patient activation, or both can improve selected self-management outcomes, medication adherence, disease knowledge, and self-efficacy, while effects across all clinical outcomes remain inconsistent (19,20). Accordingly, the present results support testing caregiver-focused strategies rather than assuming effectiveness from association alone.

Measurement of caregiver health literacy also deserves careful consideration. The S-TOFHLA was developed as a measure of functional health literacy and remains useful for evaluating the comprehension skills needed to work with health-related written information (10). However, contemporary caregiver-health-literacy research increasingly recognizes that caregiving encompasses broader competencies, including accessing, understanding, appraising, and applying information across symptom management, daily care, care coordination, communication, and caregiver self-care. A recently developed family-caregiver-specific health-literacy scale for caregivers of older adults with chronic illness demonstrated a multidimensional structure encompassing these broader domains (21). In the present study, the principal inferential analyses appropriately treated the available S-TOFHLA score as a continuous measure; categorical literacy distributions should therefore be interpreted as descriptive characteristics of this study sample rather than assumed to be directly interchangeable with estimates obtained using different instruments or scoring conventions.

An important methodological strength of the study was the use of medication errors documented in nursing and medication-reconciliation records rather than relying exclusively on retrospective caregiver self-report. This approach provides clinically recorded information about medication discrepancies occurring during routine home care and reduces dependence on caregiver recall alone. It does not, however, eliminate ascertainment bias because undocumented or transient errors may remain undetected. Previous investigations of home-care medication incidents have demonstrated the value of professional documentation for identifying administration, information-flow, and coordination problems, while recent qualitative work involving home-care nurses has continued to identify standardized information exchange, adequate professional resources, consistent practices, and collaboration with patients and relatives as central components of medication safety (7,22). The present study therefore contributes a caregiver-literacy dimension to an increasingly systems-oriented understanding of medication safety in the home.

Several limitations should be considered when interpreting the findings. First, the cross-sectional design precludes determination of temporal direction or causality; lower health literacy may increase difficulty with medication-management tasks, but the present data cannot establish that it caused the documented errors. Second, consecutive recruitment and the relatively small sample of 85 dyads from industrial and urban areas of Punjab restrict population-level generalizability, particularly to rural populations and caregivers outside organized home-health services. Third, medication errors were identified over a 30-day documentation period and may underestimate events that were not observed or recorded by nursing personnel. Fourth, although the adjusted model incorporated caregiver age, care-recipient age, and medication count, residual confounding by educational attainment, socioeconomic circumstances, caregiver burden, cognitive characteristics, medication-specific complexity, and other contextual factors remains possible. The modest number of error-positive dyads also limits the complexity of multivariable modelling. Finally, participants were recruited through home health agency networks, and potential service- or nurse-level clustering was not incorporated into the reported model. These limitations warrant cautious interpretation of the magnitude and generalizability of the observed association.

Future research should use prospective, adequately powered multicentre cohorts to establish the temporal relationship between caregiver health literacy and medication errors and to evaluate whether changes in caregiver literacy correspond to changes in medication safety over time. Research should also incorporate multidimensional caregiver-health-literacy measures, detailed indicators of regimen complexity, caregiver burden and cognition, socioeconomic factors, and standardized methods for detecting medication errors (5,21). Randomized trials are particularly needed to determine whether caregiver-tailored strategies such as teach-back, visual medication schedules, simplified written instructions, medication reconciliation, pharmacist or nurse support, and coordinated information-sharing systems reduce objectively verified medication errors in adults receiving chronic disease care at home. Such interventions should be evaluated within the broader organizational and communication systems in which caregivers manage medicines rather than treating health literacy as an isolated individual characteristic (17,22).

CONCLUSION

Lower family caregiver functional health literacy was independently associated with a greater occurrence of nurse-documented medication administration errors among caregiver–patient dyads receiving home-based chronic disease care. Caregivers in dyads with documented errors had substantially lower health-literacy scores, and lower scores were also associated with greater documented error frequency. The findings identify caregiver health literacy as a potentially relevant component of medication safety in home care but do not establish causality or the effectiveness of any specific intervention. Prospective studies and controlled trials are needed to determine whether literacy-sensitive caregiver support can reduce medication administration errors and improve the safety of chronic disease management at home.

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