

# Repeat Medication Errors in Nursing Homes: Contributing Factors and Their Association With Patient Harm

Daniel J. Crespin, MSPH<sup>1</sup>; Anuja V. Modi, MPharm<sup>2</sup>; David Wei, MS<sup>3</sup>; Charlotte E. Williams, MPH<sup>4</sup>; Sandra B. Greene, DrPH<sup>1,4</sup>; Stephanie Pierson, MSHI<sup>4</sup>; and Richard A. Hansen, PhD<sup>3</sup>

<sup>1</sup>Department of Health Policy and Management, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; <sup>2</sup>Welsh School of Pharmacy, Cardiff University, Cardiff, Wales, United Kingdom; <sup>3</sup>Division of Pharmaceutical Outcomes and Policy, Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; and <sup>4</sup>Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

## ABSTRACT

**Background:** Medication errors are highly prevalent in long-term care facilities and are responsible for preventable injury. Repeat medication errors, or identical events occurring multiple times in the same patient, may be particularly preventable.

**Objectives:** This study assessed the factors that contribute to repeat medication errors and the association between repeat medication errors and patient harm.

**Methods:** In this cross-sectional analysis, medication error reports submitted by licensed nursing homes to North Carolina's Medication Error Quality Initiative—Individual Error Web-based incident reporting system were analyzed for fiscal years 2006–2008. When reporting errors, the sites were asked whether the event was identically repeated within the same patient. *Repeat medication errors* were defined as identical events in terms of patient characteristics, drug involved, error type, potential cause, phase of the medication care process, and personnel involved. Repeat errors were compared with nonrepeat errors. Multivariate logistic regression was used to explore whether certain patient or error characteristics were related to a higher likelihood of repeat errors, and a similar analysis was used to explore whether repeat errors were related to patient harm.

**Results:** Of the total 15,037 errors reported by 294 unique nursing homes, 5615 (37.3%) were repeated one or more times. Among the repeat errors, the associated event within each error was repeated a mean (SD) of 10.7 (14.3) times. Wrong dosage (65.1% [3654/5615]) and wrong administration (10.2% [571/5615]) were the most frequent repeated events. In multivariate analysis, repeat errors occurred less frequently among younger residents (aged <75 years) than among older residents (aged ≥75 years) (odds ratio [OR] = 0.85; 95% CI, 0.79–0.93) and among residents able to direct their own care compared with cognitively impaired residents (OR = 0.87; 95% CI, 0.81–0.95). Patient harm was reported in only 1.2% (68/5615) of repeat errors and 0.6% (55/9422) of nonrepeat errors. A multivariate analysis of patient harm found that repeat errors were more likely to be harmful than were nonrepeat errors (OR = 2.11; 95% CI, 1.43–3.11).

**Conclusions:** Repeat medication errors in nursing homes are a common occurrence and have greater odds of being associated with harm than do nonrepeat errors. Future patient-safety research should focus on factors related to repeat errors. (*Am J Geriatr Pharmacother.* 2010;8:258–270) © 2010 Excerpta Medica Inc.

**Key words:** medication errors, repeat errors, nursing homes, patient safety.

## INTRODUCTION

Approximately 1.9 million adverse drug events occur annually in long-term care facilities in the United States, and an estimated 800,000 are preventable.<sup>1,2</sup> A cohort study of 18 community-based nursing homes in Massachusetts found that preventable errors occurred at a rate of ~1 per 100 resident-months, and >60% of these events were considered to be fatal, life threatening, or serious.<sup>1</sup> The magnitude of harm caused by medication errors is large considering that >1.6 million residents are living in nursing homes in the United States.<sup>2</sup> In 1997, it was estimated that for every dollar spent on drugs in nursing homes, \$1.33 was spent on treatment of drug-related morbidity and mortality, resulting in an annual cost of \$7.6 billion for the nation as a whole.<sup>2-4</sup>

Because the number of adults requiring long-term care is rapidly growing, it is important to identify commonly occurring and potentially dangerous errors in long-term care settings.<sup>5,6</sup> Repeat medication errors may be particularly harmful and preventable. *Repeat medication errors* can be defined as errors that occur more than once in an individual patient and that involve identical events in terms of patient characteristics, drug involved, error type, potential cause, phase of the medication care process, and personnel involved. An example of a repeat error is a daily event in which a resident receives the wrong dose of medication because of confusing instructions written during the documentation phase.

We conducted a literature search on MEDLINE for English-language, peer-reviewed articles from any year and setting that investigated repeat medication errors in the same patient. Our search terms included *repeat medication errors, multiple medication errors, repeat adverse events, multiple adverse events, error same patient, and adverse event same patient*. From these searches, we included any publication that referenced identical errors occurring in the same patient. We found the literature on repeat medication errors to be sparse, but indirect evidence and case reports suggested an increased likelihood of harm when errors were repeated. For example, a study of 905 medication prescribing errors in a teaching hospital found that prescribing errors in drugs such as warfarin and pyrimethamine could lead to severe or serious adverse consequences when these drugs were given 3 times a day instead of once a day.<sup>7</sup> Similarly, in a case report of a patient mistakenly given glipizide 7.5 mg TID instead of baclofen 15 mg, initially the patient was able to tolerate the wrong medication, but by the third day of the regimen, she experienced an increase in emesis and by the seventh day, she was severely diaphoretic and hypoglycemic.<sup>8</sup>

Nursing home residents are predisposed to repeat medication errors. Approximately 75% of nursing home residents have some level of cognitive impairment,<sup>9</sup> and 61% of nursing home residents take  $\geq 9$  medications per day<sup>10</sup>; in comparison, only 29% of community-dwelling older adults take  $\geq 5$  medications per day.<sup>11,12</sup> Nursing homes have been slow to adopt health information technologies,<sup>13</sup> which have been shown in hospital settings to reduce medication errors through features such as electronic prescribing and computerized decision support systems.<sup>14,15</sup> In particular, nursing homes that do not offer diverse medical services are more likely to lack the financial resources needed to implement the latest health information technologies.<sup>16</sup> For example, a study of 1174 nursing homes from the 2004 National Nursing Home Survey found that each additional service a nursing home offered was associated with a ~1.2-fold increase in the odds of using electronic information systems for drug dispensing and medication administration records.

The long-term goal of this study was to improve patient safety in nursing homes by identifying factors that contribute to harmful medication errors. This study described the frequency of repeat medication errors documented among North Carolina nursing homes during fiscal years 2006–2008. The study also assessed the association between repeat medication errors and patient harm; the hypothesis was that repeat errors in the same resident would be more harmful than nonrepeat errors because of the compound effects of the recurring error. For example, patients repeatedly given the wrong medication or wrong dosage may be exposed to additive negative effects each time the medication is administered, eventually causing harm. Additionally, the study explored the factors that contributed to repeat errors. Understanding these factors can guide efforts to prevent errors from being repeated.

## PATIENTS AND METHODS

### Design and Setting

This was a cross-sectional analysis of medication error reports submitted by North Carolina nursing homes to the Medication Error Quality Initiative–Individual Error (MEQI-IE) system during fiscal years 2006–2008. Beginning in 2003, North Carolina required all licensed nursing homes to report all actual medication errors (ie, incidents) and potential medication errors (ie, near misses and unsafe conditions).<sup>17</sup> During the first 3 years of data collection, the sites submitted summary annual data using an online annual summary reporting format. The MEQI-IE system was

developed and piloted beginning in spring of 2005 to collect more useful data and to offer greater functionality and access to data for the nursing homes.<sup>18</sup> Data from the MEQI-IE system provide details on repeat events and therefore allow an opportunity to study repeat errors in the nursing home setting. Individual medication error reports were submitted to the MEQI-IE online Web-based system by the nursing homes participating in the pilot program during 2006 and by early adopters voluntarily participating in the MEQI-IE program during 2007 and 2008.

### Measures

The MEQI-IE reporting system guides users through a step-by-step process to document each error incident and prompts users with specific questions depending on the type of error.<sup>18</sup> When a user is recording an overdose, for example, the system prompts the user to enter the intended dose and the actual dose administered. The data collected include information relevant to the error, including patient information, incident information, impact on the patient, primary error type, phase of the medication care process when the error first occurred, personnel involved, potential cause of the error, and specific medication(s) involved in the error. For each error report, sites were asked to indicate whether the event had multiple identical occurrences in the same patient, and, if yes, how many times the event was repeated. Each error report represented one error for a single resident. If the nursing home indicated that the event occurred more than once, then the series of repeat events was considered to be a single repeat error. Therefore, each repeat-error observation included multiple instances of identical events.

All measures used in our analyses were based on the self-reported data collected by the MEQI-IE reporting system. Aspects of the event and patient characteristics included date of the incident, shift when the error occurred or was first detected, whether the error occurred within 7 days of a transition into the facility, and patient age, sex, and cognitive ability. Cognitive ability was reported by each nursing home based on whether the patient was able to direct his or her own care, unable to direct care, or unknown. Details of the event included error type, medication phase when the error occurred, possible causes, and impact on the patient. Primary error type was divided into 6 categories: wrong patient, wrong drug, wrong dosage, wrong administration, wrong follow-up, or other. These factors are detailed in **Table I**. The medication phase when the error began was coded as 1 of 5 phases: prescribing, dispensing,

documentation, administration, or monitoring. Nursing homes indicated 1 of 6 possible causes for each error: product issues, recording issues, dispensing issues, facility issues, personnel issues, or other (**Table I**). Patient impact was reported using the 9 impact categories developed by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) categorization schema.<sup>19</sup> The most severe category—errors that may have contributed to a patient's death—was not observed in our sample. We combined the remaining 8 categories to create 3 impact types as suggested by the NCC MERP, which included circumstances, no-harm errors, and harm errors. *Circumstances* included potential errors that did not involve a specific patient. *No-harm errors* included errors that either did not reach the patient (including unsafe conditions and near misses) or reached the patient but did not result in harm. *Harm errors* included errors that reached the patient and resulted in temporary harm, a transfer to an emergency department, permanent harm, or an intervention to sustain life.

### Statistical Analysis

Data collected during fiscal years 2006–2008 were aggregated into a single analytic data set. Counts of error reports were used to calculate the frequency of repeat and nonrepeat events. Odds ratio (OR) estimates from a multivariate logistic regression model were used to explore whether certain patient or error characteristics were related to a higher likelihood of repeat errors. Factors included in the multivariate model were age, sex, cognitive ability, impact on the patient, shift when the error occurred, whether the error occurred within 7 days of transition to the facility, error type, phase when the error began, personnel involved, and possible cause. For each category, a reference group was chosen according to the variable that had the most overall errors. Another multivariate logistic regression model was used to explore whether repeat errors were related to patient harm after controlling for the same covariates as in our repeat-error multivariate analysis and also including as an explanatory variable whether an error was repeated. Circumstances were excluded from all multivariate analyses because patients were not involved in these types of errors; thus, patient characteristics were not collected. In all analyses, repeated events were treated as a single error and did not take into account the number of times the event was repeated. We tested for multicollinearity using variance inflation factor analysis. Goodness of fit was assessed using the Hosmer-Lemeshow test. All

**Table I. Error types and possible causes in nursing home patients according to the Medication Error Quality Initiative–Individual Error reporting system.**

Category	Explanation	Category	Explanation
Error type		Possible error cause (cont.)	
Wrong patient	Medication administered to wrong patient	Recording issues	Illegible handwriting Use of abbreviations
Wrong drug	Wrong product Wrong product strength Wrong form of product Expired product	Dispensing issues	Inadequate information Transcription error Medication unavailable Pharmacy closed Pharmacy delivered to wrong facility Pharmacy delivered wrong medication or product
Wrong dosage	Dose omission Overdose or multiple dose Underdose	Facility issues	Other pharmacy dispensing issues Poor working conditions Shift change Following faulty policies and procedures
Wrong administration	Wrong route Wrong time Wrong technique Wrong rate of administration Wrong duration Expired order	Personnel issues	Frequent distraction on floor; multiple care changes Poor communication Basic human error Emergency situation on floor Exhaustion Too much workload or overtime Improper change
Wrong follow-up	Monitoring error Laboratory error Wrong documentation	Other issues	Other error cause
Other	Other error type		
Possible error cause			
Product issues	Medication name confusion Packaging design Product labeling		

analyses were performed with SAS version 9.2 (SAS Institute Inc., Cary, North Carolina).

An institutional review board waiver at the University of North Carolina at Chapel Hill approved this analysis. No patient identifiers were collected by the MEQI-IE system. All nursing home identifiers collected by the MEQI-IE system were deidentified for this study.

## RESULTS

Error reports were submitted to MEQI-IE by 23 nursing home sites during the pilot program in fiscal year 2006, by 203 sites in 2007, and by 288 sites in 2008. When these data were pooled for all 3 years, there were 294 unique licensed nursing homes in the data set. Over this period, a total of 395 licensed nursing homes were subject to reporting requirements in North Carolina.

Nursing homes that used the MEQI-IE reporting system, rather than the summary system, had similar characteristics when compared with all North Carolina nursing homes (Table II).<sup>20</sup> MEQI-IE nursing homes had a mean of 24.9 errors per 100 beds, compared with 29.0 errors for the entire state. However, the MEQI-IE reporting system allows for a series of repeat errors to be reported within a single error incident, and this may bias the number of MEQI-IE errors downward in comparison with the state average. Although sites using the original summary system were asked to report repeat errors as a single error incident, anecdotal evidence and conversations with the sites suggested that some of these sites reported each repeat occurrence as a separate error.

Of the total 15,037 errors collected by the MEQI-IE reporting system, 5615 (37.3%) were repeat errors and

**Table II. Descriptive statistics on North Carolina (NC) nursing home facilities and medication errors according to the Medication Error Quality Initiative–Individual Error (MEQI-IE) reporting system. Data are expressed as number (%), except as indicated.**

Statistic	MEQI-IE Nursing Homes (n = 294)*	All NC Nursing Homes (N = 395)*
Beds per home, mean	120.5	120.2
For-profit status	227 (77.2)	310 (78.5)
Chain ownership†	211 (71.8)	287 (72.7)
Metro area	157 (53.4)	208 (52.7)
Total errors reported, no.‡	15,037	42,331
2006	616	15,766
2007	5613	13,572
2008	8808	12,993
Errors per 100 beds, mean per home‡	24.9	29.0
2006	31.4	32.9
2007	24.8	27.5
2008	24.5	26.7
Errors by cause (2007 and 2008)§	(n = 14,421)	(n = 26,565)
Human error	10,177 (70.6)	17,996 (67.7)
Transcription error	3594 (24.9)	6925 (26.1)
Distractions	1215 (8.4)	2696 (10.1)
Following faulty policies and procedures	786 (5.5)	1084 (4.1)
Poor communication	695 (4.8)	1440 (5.4)
Incorrect pharmacy dispensing	365 (2.5)	1011 (3.8)
Medication unavailable	274 (1.9)	821 (3.1)
Medication name confusion	218 (1.5)	485 (1.8)
Inadequate information	175 (1.2)	389 (1.5)
Wrong medication delivered	167 (1.2)	430 (1.6)

\*Unique nursing homes that reported at least once during fiscal years 2006–2008. The category *All NC Nursing Homes* includes nursing homes using either the MEQI-IE reporting system or the annual summary system.

†Rural-urban commuting area code = 1 according to the US Dept. of Agriculture, Economic Research Service.<sup>20</sup>

‡Facilities using the MEQI-IE reporting system can designate an error that recurs over several days as a single repeat error. Facilities not using the MEQI-IE system were asked to report repeat errors in this way, but tended to report repeat errors as separate incidents. This artifact of the reporting system causes error incidences to appear higher in the *All NC Nursing Homes* category, which includes homes not using the MEQI-IE system.

§Cause categories for the MEQI-IE system did not match those in the annual reporting system used by all other homes in 2006; therefore, only error causes for 2007 and 2008 are shown.

9422 (62.7%) were nonrepeat errors. The mean number of repeat incidents reported per nursing home over the 3-year period ranged from 0 to 314 (median, 12.0). Among the repeat errors, the associated event within each error was repeated a mean (SD) of 10.7 (14.3) times.

Among all errors reported to MEQI-IE, only 0.8% (123/15,037) caused harm to a patient (Table III). Patient characteristics (not collected for circumstan-

es) associated with medication errors included age  $\geq 75$  years (62.5% [9134/14,615] of errors) and cognitive impairment (69.9% [10,223/14,615]). Women experienced 69.6% (10,173/14,615) of errors. Errors involving wrong dosage were the most common type (56.5% [8500/15,037]). Most errors occurred during the administration phase (49.1% [7385/15,037]) or in the documentation phase (38.8% [5829/15,037]), and

just over half of all errors occurred in the 7:00 AM to 3:00 PM shift (52.6% [7914/15,037]). Personnel issues were cited for 71.5% (10,751/15,037) of errors.

Key differences were found between repeat and non-repeat errors (Table III). The percentage of harm events was 1.2% (68/5615) for repeat errors compared with 0.6% (55/9422) for nonrepeat errors ( $P < 0.01$ ,  $\chi^2$  test). Likewise, 14.8% (830/5615) of repeat errors occurred within 7 days of a transition into the facility,

whereas only 6.9% (654/9422) of nonrepeat errors occurred during a transition ( $P < 0.01$ ). The most common error type for both repeat and nonrepeat errors was wrong dosage; however, 65.1% (3654/5615) of repeat errors were reported as wrong dosage compared with 51.4% (4846/9422) of nonrepeat errors ( $P < 0.01$ ). For repeat errors, 37.4% (2099/5615) occurred during the administration phase and 50.8% (2855/5615) during the documentation phase; non-

**Table III. Medication errors for years 2006–2008 in North Carolina nursing homes according to the Medication Error Quality Initiative–Individual Error reporting system. Data are expressed as number (%).**

Variable	All Errors (N = 15,037)	Repeat Errors* (n = 5615)	Nonrepeat Errors (n = 9422)	P <sup>†</sup>
Age group, <sup>‡</sup> y				
≥75	9134 (62.5)	3806 (69.4)	5328 (58.3)	<0.01
<75	5481 (37.5)	1675 (30.6)	3806 (41.7)	<0.01
Sex <sup>‡</sup>				
Female	10,173 (69.6)	3790 (69.1)	6383 (69.9)	0.35
Male	4442 (30.4)	1691 (30.9)	2751 (30.1)	0.35
Cognitive ability <sup>‡</sup>				
Unable to direct own care	10,223 (69.9)	3943 (71.9)	6280 (68.8)	<0.01
Able to direct own care	4392 (30.1)	1538 (28.1)	2854 (31.2)	<0.01
Impact/effect on patient <sup>§</sup>				
Circumstances	422 (2.8)	134 (2.4)	288 (3.1)	0.02
No-harm errors	14,492 (96.4)	5413 (96.4)	9079 (96.4)	0.89
Harm errors	123 (0.8)	68 (1.2)	55 (0.6)	<0.01
Shift when error occurred				
7:00 AM to 3:00 PM	7914 (52.6)	3351 (59.7)	4563 (48.4)	<0.01
3:00 PM to 11:00 PM	5690 (37.8)	1872 (33.3)	3818 (40.5)	<0.01
11:00 PM to 7:00 AM	1433 (9.5)	392 (7.0)	1041 (11.0)	<0.01
Error occurred within 7 days of transition into the facility				
No	13,553 (90.1)	4785 (85.2)	8768 (93.1)	<0.01
Yes	1484 (9.9)	830 (14.8)	654 (6.9)	<0.01
Primary type of error				
Wrong patient	635 (4.2)	58 (1.0)	577 (6.1)	<0.01
Wrong drug	1703 (11.3)	481 (8.6)	1222 (13.0)	<0.01
Wrong dosage	8500 (56.5)	3654 (65.1)	4846 (51.4)	<0.01
Wrong administration	1336 (8.9)	571 (10.2)	765 (8.1)	<0.01
Wrong follow-up	1181 (7.9)	468 (8.3)	713 (7.6)	0.09
Other	1682 (11.2)	383 (6.8)	1299 (13.8)	<0.01

(continued)

Table III (continued).

Variable	All Errors (N = 15,037)	Repeat Errors* (n = 5615)	Nonrepeat Errors (n = 9422)	P†
Phase when error began				
Prescribing	251 (1.7)	117 (2.1)	134 (1.4)	<0.01
Dispensing	1275 (8.5)	478 (8.5)	797 (8.5)	0.91
Documentation	5829 (38.8)	2855 (50.8)	2974 (31.6)	<0.01
Administration	7385 (49.1)	2099 (37.4)	5286 (56.1)	<0.01
Monitoring	297 (2.0)	66 (1.2)	231 (2.5)	<0.01
Primary personnel involved				
Licensed practical nurse	10,107 (67.2)	3879 (69.1)	6228 (66.1)	<0.01
Registered nurse	3546 (23.6)	1156 (20.6)	2390 (25.4)	<0.01
Nurse aide	788 (5.2)	312 (5.6)	476 (5.1)	<0.01
Clinician‡	596 (4.0)	268 (4.8)	328 (3.5)	0.20
Temporary, contract, or agency staff				
No	14,491 (96.4)	5449 (97.0)	9042 (96.0)	<0.01
Yes	546 (3.6)	166 (3.0)	380 (4.0)	<0.01
Possible cause of error				
Product issue	161 (1.1)	30 (0.5)	131 (1.4)	<0.01
Recording issue	2029 (13.5)	1235 (22.0)	794 (8.4)	<0.01
Dispensing issue	509 (3.4)	234 (4.2)	275 (2.9)	<0.01
Facility issue	728 (4.8)	213 (3.8)	515 (5.5)	0.19
Personnel issue	10,751 (71.5)	3624 (64.5)	7127 (75.6)	<0.01
Other	859 (5.7)	279 (5.0)	580 (6.2)	<0.01

\*Repeat medication errors were defined as identical events that occurred more than once in the same resident. The number of repeat errors reported reflects the number of errors that were repeated at least once, not the total number of repeated events within each repeat error.

†Pearson  $\chi^2$  test for repeat errors versus nonrepeat errors.

‡Circumstances are not included for patient age, sex, or cognitive ability because the error did not involve a specific patient. For these factors, n = 14,615 (all errors); n = 5481 (repeat errors); and n = 9134 (nonrepeat errors).

§Circumstances included potential errors that did not involve a specific patient. No-harm errors either did not reach the patient (including unsafe conditions and near misses) or reached the patient but did not result in harm. Harm errors reached the patient and resulted in temporary harm, transfer to an emergency department, permanent harm, or an intervention to sustain life.

||Clinicians included physicians, pharmacists, and physician assistants.

repeat errors had the reverse pattern, with 56.1% (5286/9422) beginning in the administration phase and 31.6% (2974/9422) beginning in the documentation phase (both phases,  $P < 0.01$ ). Recording issues were cited as the possible cause for 22.0% (1235/5615) of repeat errors compared with only 8.4% (794/9422) of nonrepeat errors ( $P < 0.01$ ). The percentages of repeat and nonrepeat errors were significantly different by the staff type (permanent or temporary staff): temporary staff members were involved in 3.0% (166/5615) of repeat errors and 4.0% (380/9422) of nonrepeat errors ( $P < 0.01$ ).

Results of the multivariate logistic regression for possible factors predicting repeat versus nonrepeat errors are shown in Table IV. Each factor is compared with the other factors within its contributory factor category. These contributory factor categories correspond to the subheadings in Table III (eg, impact on patient; type of error). For each contributory factor category, a reference group was chosen according to the contributing factor that had the most overall errors. After controlling for patient and error characteristics, repeat errors were significantly less likely to occur among patients aged <75 years compared with those  $\geq 75$  years

(OR = 0.85; 95% CI, 0.79–0.93) and among patients who were able to direct their own care compared with the cognitively impaired (OR = 0.87; 95% CI, 0.81–0.95). Errors occurring within 7 days of a patient's transition to a nursing home were more likely to be repeated than were errors unrelated to a transition in care (OR = 1.93; 95% CI, 1.71–2.17). Using wrong dosage as the reference group, wrong-drug errors were less likely to be repeated (OR = 0.56; 95% CI, 0.49–0.63). Compared with the administration phase, errors related to the documentation phase were more likely to be repeated (OR = 2.55; 95% CI, 2.34–2.78). Errors related to recording issues were more likely to be repeated than were errors related to personnel issues

(OR = 1.95; 95% CI, 1.74–2.17). We found no evidence of problems in the model due to multicollinearity because no covariate had a variance inflation factor >1.16. However, the model rejected the Hosmer-Lemeshow goodness-of-fit test ( $P < 0.01$ ), indicating that there was a statistically significant difference between the observed and predicted values of whether an error was repeated. This rejection signals that the model may not correctly fit our data, although it is more likely due to the binary predictors in our model.

To determine whether repeat errors were more likely than nonrepeat errors to be involved in patient harm, an OR estimate was obtained from a multivariate model. This model controlled for the same factors as in

**Table IV. Multivariate analysis of potential predictors of repeat medication errors in North Carolina nursing homes.**

Variable	Odds Ratio (95% CI)	P*	Variable	Odds Ratio (95% CI)	P*
Age group, y			Primary type of error (cont.)		
≥75	Reference	–	Wrong administration	0.92 (0.81–1.04)	<0.01
<75	0.85 (0.79–0.93)	<0.01	Wrong follow-up	0.55 (0.48–0.64)	0.06
Sex			Other	0.29 (0.25–0.33)	<0.01
Female	Reference	–	Phase when error began		
Male	1.05 (0.97–1.14)	0.20	Prescribing	2.25 (1.69–2.99)	<0.01
Cognitive ability			Dispensing	1.42 (1.21–1.66)	0.41
Unable to direct own care	Reference	–	Documentation	2.55 (2.34–2.78)	<0.01
Able to direct own care	0.87 (0.81–0.95)	<0.01	Administration	Reference	–
Impact/effect on patient			Monitoring	0.95 (0.70–1.29)	<0.01
No-harm errors	Reference	–	Primary personnel involved		
Harm errors	2.13 (1.44–3.15)	<0.01	Licensed practical nurse	Reference	–
Shift when error occurred			Registered nurse	0.75 (0.69–0.82)	<0.01
7:00 AM to 3:00 PM	Reference	–	Nurse aide	0.87 (0.74–1.03)	0.16
3:00 PM to 11:00 PM	0.72 (0.67–0.78)	0.02	Clinician <sup>†</sup>	1.28 (1.02–1.61)	<0.01
11:00 PM to 7:00 AM	0.65 (0.57–0.74)	<0.01	Temporary, contract, or agency staff		
Error occurred within 7 days of transition into the facility			No	Reference	–
No	Reference	–	Yes	0.84 (0.68–1.02)	0.08
Yes	1.93 (1.71–2.17)	<0.01	Possible cause of error		
Primary type of error			Product issue	0.57 (0.37–0.87)	<0.01
Wrong patient	0.17 (0.13–0.22)	<0.01	Recording issue	1.95 (1.74–2.17)	<0.01
Wrong drug	0.56 (0.49–0.63)	0.03	Dispensing issue	1.52 (1.20–1.93)	<0.01
Wrong dosage	Reference	–	Facility issue	0.67 (0.57–0.80)	<0.01
			Personnel issue	Reference	–
			Other	0.98 (0.84–1.16)	0.65

\*Based on multivariate logistic regression model. Dash denotes reference factor for category.

<sup>†</sup>Clinicians included physicians, pharmacists, and physician assistants.

the repeat-error multivariate analysis, plus whether an error was repeated (Table V). This analysis found that repeat errors were more likely to be involved in patient harm than were nonrepeat errors (OR = 2.11; 95% CI, 1.43–3.11). We found no evidence of problems in the model due to multicollinearity because no factor had a variance inflation factor >1.18. The model failed to reject the Hosmer-Lemeshow goodness-of-fit test ( $P = \text{NS}$ ), indicating that the model correctly fit the data.

## DISCUSSION

This report found that over a 3-year period, nursing home residents were at risk of experiencing repeat medication errors, and these errors had a higher likelihood of

being associated with harm than did nonrepeat errors. A plausible explanation is that repeat errors have additive or synergistic adverse effects on patients compared with experiencing the medication error only once.

Older age of patients and decreased cognitive ability were significantly associated with an increased risk of repeat errors. These patients have less control over their own care and may be unaware of errors in their medication prescriptions and administration. Cognitively impaired patients may also be likely to continue taking medications after an illness has run its course because of lack of clinical review and the patient's inability to communicate with the nursing home staff, which can lead to adverse events.<sup>21</sup> Errors within cognitively impaired

**Table V. Multivariate analysis of potential predictors of harmful medication errors in North Carolina nursing homes.**

Variable	Odds Ratio (95% CI)	P*	Variable	Odds Ratio (95% CI)	P*
Repeat error			Primary type of error (cont.)		
No	Reference	–	Wrong administration	0.62 (0.28–1.35)	0.25
Yes	2.11 (1.43–3.11)	<0.01	Wrong follow-up	0.56 (0.23–1.38)	0.20
Age group, y			Other	1.31 (0.73–2.36)	0.17
≥75	Reference	–	Phase when error began		
<75	1.12 (0.76–1.65)	0.57	Prescribing	2.39 (0.95–6.00)	0.20
Sex			Dispensing	1.42 (0.73–2.78)	0.89
Female	Reference	–	Documentation	0.80 (0.51–1.26)	<0.01
Male	1.20 (0.82–1.75)	0.35	Administration	Reference	–
Cognitive ability			Monitoring	2.60 (0.86–7.88)	0.21
Unable to direct own care	Reference	–	Primary personnel involved		
Able to direct own care	1.28 (0.87–1.87)	0.21	Licensed practical nurse	Reference	–
Shift when error occurred			Registered nurse	1.04 (0.67–1.61)	0.87
7:00 AM to 3:00 PM	Reference	–	Nurse aide	1.11 (0.51–2.42)	0.76
3:00 PM to 11:00 PM	0.76 (0.50–1.14)	0.04	Clinician <sup>†</sup>	0.88 (0.35–2.20)	0.72
11:00 PM to 7:00 AM	1.43 (0.92–2.50)	0.07	Temporary, contract, or agency staff		
Error occurred within 7 days of transition into the facility			No	Reference	–
No	Reference	–	Yes	2.26 (1.17–4.40)	0.02
Yes	1.49 (0.92–2.44)	0.11	Possible cause of error		
Primary type of error			Product issue	0.95 (0.13–7.18)	0.80
Wrong patient	1.68 (0.75–3.75)	0.08	Recording issue	1.50 (0.89–2.50)	0.44
Wrong drug	0.77 (0.41–1.46)	0.54	Dispensing issue	1.50 (0.60–3.79)	0.58
Wrong dosage	Reference	–	Facility issue	0.99 (0.39–2.46)	0.66
			Personnel issue	Reference	–
			Other	1.34 (0.68–2.65)	0.72

\*Based on multivariate logistic regression model. Dash denotes reference factor for category.

<sup>†</sup>Clinicians included physicians, pharmacists, and physician assistants.

populations may also occur because nursing home staff have a priority to ensure that all medications ordered are administered to patients.<sup>22</sup> The complex drug regimens taken by nursing home residents may exacerbate this problem. As mentioned earlier, 61% of nursing home residents take  $\geq 9$  medications per day,<sup>10</sup> whereas only 29% of community-dwelling older adults take  $\geq 5$  medications per day.<sup>11,12</sup> Given that three quarters of nursing home residents have some level of cognitive impairment, ranging from mild to very severe,<sup>9</sup> any quality-improvement intervention initiated by a nursing home to reduce repeat errors will need to include a strategy that accounts for these high-risk patients.

The findings of this study could be applied to improve the quality of care for residents of nursing homes in the future; an improved understanding of factors related to error repetition can guide interventions or changes in care processes that might reduce repeat errors. For example, because cognitively impaired residents, older residents, and residents experiencing a transition in care are at greater risk for repeat errors, targeted changes in patient-care processes might be implemented specifically among residents with these risk factors. One strategy might involve a structured intervention such as the one reported by Klinger et al,<sup>23</sup> which could be modified to include safety checks for these risk factors. In this intervention, 7 hospitals used nurse-led project teams to improve safety processes, including medication reconciliation, medication labeling, and patient-identification checks; this strategy improved the accuracy of medication administration from 85% to 96% over an 18-month period.

Nursing homes could benefit from a decrease in adverse events through greater use of health information technology.<sup>24</sup> Use of improved information technology for medication systems can simplify record keeping, make orders easier to read and understand, and provide better access to information across care providers.<sup>25</sup> As well, it can facilitate the management of each patient's dosages, drug allergies, and drug interactions in one easily accessed record. Bar-code medication administration systems can allow nursing home staff to verify that the correct medication is given to the correct patient, using bar codes affixed to both the medication packaging and a wristband or other identification on the patient.<sup>26</sup> Although such systems have not been widely investigated in nursing homes, studies in hospitals have shown promising results. For example, in a pre- and postintervention analysis of 6771 adult inpatients in surgical and intensive care units, computerized physician order entry was associated with a 56% reduction in

nonintercepted serious medication errors.<sup>27</sup> A randomized controlled trial with a crossover design in 7490 adult inpatients with renal insufficiency found that computerized physician order entry was associated with a 13% decrease in inappropriate doses and a 24% decrease in incorrect medication frequency.<sup>28</sup> The implementation of a bar-code medication administration system within a Veterans Administration medical center reduced medication error rates from 21.7 to 3.0 errors per 100,000 medication units dispensed between 1993 and 2001.<sup>29</sup> It is possible, although not yet proven with empiric evidence, that these systems can be efficacious in nursing homes as well. However, most nursing homes still lag behind hospitals in the adoption of health information technologies.<sup>13</sup> Nursing homes may be less likely to implement electronic systems such as bar-coded medication administration, electronic medication reconciliation, or computerized physician order entry with clinical decision support because of substantial barriers such as initial costs, hiring and training of staff, and integration with current systems.<sup>24,30</sup>

Transitional care, which was highly associated with repeat medication errors in this study, should be targeted as well. Studies have found that discrepancies may exist in patients' medication histories when transferring from one setting to another and that these discrepancies can lead to medication errors.<sup>31,32</sup> A prospective cohort study of 151 patients admitted to a hospital who used at least 4 regular prescription medications found that 81% of patients had at least one discrepancy in their medication history and that 39% of these discrepancies could lead to harm.<sup>31</sup> Medication reconciliation can be used to prevent such errors. Medication reconciliation is mandated by the Joint Commission for accredited long-term care facilities to reduce medication errors that occur during the transition from one setting to another.<sup>33</sup> These interventions have been reported to reduce the number of medication errors in several studies.<sup>34-37</sup> In a pre- and postintervention study of 168 nursing home residents transferred there after a hospital stay, Boockvar et al<sup>35</sup> found that medication reconciliation reduced the prevalence of discrepancies from 15% to 2% of transfers. Nursing home staff compared the medication orders of these residents with their previous medication history at the nursing home to decrease discrepancies such as redundant medications.<sup>35</sup>

This study had several limitations. First, the data collection relied purely on medication errors self-reported by the nursing homes. Many medication errors may not have been reported and would therefore be missing

from the data set. This could bias the results of the study if the contributory factors for the unreported errors were distributed differently from the contributory factors for the reported errors. In particular, there may be a reporting bias for repeat errors, which could influence the analysis presented here. Second, the self-reported nature of the data collection could lead to measurement error in several of the explanatory variables if nursing homes interpreted the repeat indicator or any of the explanatory variables differently. Third, this study aggregated data from 3 years, with the first year representing participants in a pilot study and the later years representing voluntary participants in the MEQI-IE program. We chose to aggregate these data realizing that the early participants might be different from the later participants and that all of the participants might differ from the rest of the nursing homes in the state. Although the characteristics of the homes in our analysis did not differ substantially from those in the rest of the state, the fact that they voluntarily participated in this program might indicate that these homes are more actively engaged in error reporting. Thus, the data might not be generalizable to the state as a whole. The MEQI-IE program was mandated statewide beginning in fiscal year 2009,<sup>18</sup> and, when available, further data will provide additional insight into the issue of repeat errors.

Our repeat-error multivariate analysis rejected the Hosmer-Lemeshow goodness-of-fit test, indicating that the model may not correctly fit our data. The goodness-of-fit test result may have been driven by the small sample size of some variables, such as product issues (error causes) and the prescribing and monitoring medication phases. Dropping these variables from the analysis resulted in no statistically significant difference between the predicted and observed values of whether an error was repeated, and indicated that the model did fit the data. However, we hypothesized that these factors were related to repeat errors and thus included them in the model.

The results indicated that most medication errors occurred during the day shift (7:00 AM to 3:00 PM). Unfortunately, data were not available to indicate the frequency of medication administered during each shift, so the study could not determine whether this finding indicated a higher frequency of administration or a higher likelihood of reporting during this time. Furthermore, because the MEQI-IE system does not collect patient identifiers, the medication errors could not be linked to particular patients; therefore, the study analysis could not control for repeat medication errors in the same patient.

The use of varying definitions of harm from medication errors is a limitation that restricts the comparability of findings across studies in the literature on medication errors. The categorization of errors into circumstances, no-harm errors, and harm errors may differ depending on the setting. This study followed the NCC MERP guidelines<sup>19</sup> and found that 0.8% (123/15,037) of all errors were harmful errors; similarly, Hicks et al<sup>38</sup> found that 1.7% of errors were harmful using the same guidelines in their investigation of 192,477 medication errors at 482 hospitals. Of particular interest are errors that require monitoring or an intervention to ensure no harm, which are classified as no-harm errors by the NCC MERP. These errors, which accounted for 8.2% (1232/15,037) of the medication errors in our sample, are critical because they consume resources of the nursing home or hospital. Although these errors do not contribute directly to patient harm, they may indirectly cause other errors, including harmful errors, through a lack of resources and overworked staff. Because of the importance of these errors, we performed a sensitivity analysis by categorizing these errors as harmful errors. The results of our analysis predicting repeat errors and harmful errors were robust to this change.

## CONCLUSIONS

Repeat medication errors in nursing homes are a common occurrence and have greater odds of being associated with harm than do nonrepeat errors. Older patients and the cognitively impaired had an increased risk of experiencing repeat errors in this study. Future patient-safety research should focus on factors related to repeat errors.

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**Address correspondence to:** Richard A. Hansen, PhD, Division of Pharmaceutical Outcomes and Policy, Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, Campus Box 7360, Chapel Hill, NC 27599. E-mail: rahansen@unc.edu