Pharmacist intervention on prescribing errors: Use of a standardized approach in the inpatient setting

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Purpose. The objective of this study was to implement a standardized process across health systems to determine the prevalence and clinical relevance of prescribing errors intercepted by pharmacists.

Methods. This prospective, multicenter, observational study was conducted across 11 hospitals. Pharmacist-intercepted prescribing errors were collected during inpatient order verification over 6 consecutive weeks utilizing a standardized documentation process. The potential harm of each error was evaluated using a modified National Coordinating Council for Medication Error Reporting and Prevention (NCC-MERP) index with physician validation, and errors were stratified into those with potentially low, serious, or life-threatening harm. Endpoints included the median error rate per 1,000 patient days, error type, and potential harm with correlating cost avoidance.

Results. Pharmacists intervened on 7,187 errors, resulting in a mean error rate of 39 errors per 1,000 patient days. Among the errors, 46.6% (*n* = 3,349) were determined to have potentially serious consequences and 2.4% (*n* = 175) could have been life-threatening if not intercepted. This equates to $874,000 in avoided cost. The top 3 error types occurring with the highest frequency were "wrong dose/rate/frequency" (*n* = 2,298, 32.0%), "duplicate therapy" (*n* = 1,431, 19.9%), and "wrong timing" (*n* = 960, 13.4%). "Wrong dose/rate/frequency" (*n* = 49, 28%), "duplicate therapy" (*n* = 26, 14.9%), and "drug-disease interaction" (*n* = 24, 13.7%) errors occurred with the highest frequency among errors with potential for life-threatening harm. "Wrong dose/rate/frequency" (*n* = 1,028, 30.7%), "wrong timing" (*n* = 573, 17.1%), and "duplicate therapy" (*n* = 482, 14.4%) errors occurred with the highest frequency among errors with potentially serious harm.

Conclusion. Documentation of pharmacist intervention on prescribing errors via a standardized process creates a platform for multicenter analysis of prescribing error trends and an opportunity for development of system-wide solutions to reduce potential harm from prescribing errors.

Keywords: health-system pharmacy, medication safety, prescribing errors

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Medication prescribing errors are a frequent occurrence for hospital inpatients, affecting up to 50% of admissions and 7% of medication orders.[1] Adverse drug events (ADEs) as a result of prescribing errors are often preventable. Literature suggests that computerized physician order entry has reduced preventable prescribing errors by over 50%,[2] but this has introduced new vulnerabilities. Examples include placing orders for the wrong patient while toggling between multiple patient charts, misselection or incomplete evaluation of defaults, and alert fatigue leading to clinical decision support being overridden.[3]

Studies involving multiple sites in inpatient areas suggest that the incidence of prescribing errors ranges from 8.8 to 14.7 errors per 100 orders.[4,5] Pharmacists play a critical role during order verification in clinically

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evaluating patients to ensure appropriate medication use. In a study by Folli et al,[6] clinical pharmacists at 2 children's hospitals intercepted 4.5 to 4.9 errors per 1,000 medication orders. Other studies have explored the role of the pharmacist in intercepting errors in various patient populations and settings, including in the context of patient care in the emergency department and hospitalized pediatric and oncology patients, with similar conclusions.[7-10]

Pharmacist documentation of prescribing errors intercepted facilitates and augments ongoing quality improvement efforts to address prescribing vulnerabilities. Although there have been several attempts to quantify the frequency and significance of pharmacist interventions on prescribing errors, a standardized methodology and metrics have not been adopted by the pharmacy profession. The heterogeneity in methods[4-12] used to study these interventions prevents multisite comparisons demonstrating the value of pharmacists in preventing harm. See the eAppendix for a summary of the published methods to date.

The objective of this study was to implement a standardized process for interception of prescribing errors by pharmacists at the point of order verification, to explore the prevalence and clinical relevance of these errors. The primary outcome was the median error rate per 1,000 patient days. Secondary outcomes included the rate of errors with serious and life-threatening harm and a breakdown by error type. Additionally, the cost avoidance associated with preventing patient harm was calculated.

KEY POINTS

- A standardized process for documenting pharmacist interception of prescribing errors was implemented across multiple health systems.
- Pharmacist interception of prescribing errors prevents significant patient harm and provides substantial cost savings to health systems.
- Approximately half of reported errors could have resulted in serious or life-threatening patient harm.

Methods

This was a prospective, multicenter, observational study conducted between January 1, 2019, and March 31, 2019. Institutional review board exempt status was obtained for each site before the study was conducted.

Setting. Vizient is the largest member-driven healthcare performance improvement company in the United States and encompasses more than 3,200 acute care hospitals, including a majority of US academic medical centers. The Vizient member pharmacy network includes 1,000 Vizient member hospitals, and the academic medical center pharmacy network includes 120 US academic medical centers and their affiliates.

Eleven hospitals from the Vizient Health System Consortium volunteered to participate in this initiative, including 8 academic medical centers and 3 community medical centers across the United States. Nine (82%) sites described having patient-centered or integrated pharmacy practice models, whereas clinical pharmacist–centered and decentralized models were each practiced at 1 site.[13] Eight sites had processes in place before the study to document pharmacist intervention on prescribing errors, while this was an entirely new workflow for 3 centers. Hospital demographics are reported in Table 1.

Study design. The Vizient pharmacy network research committee reviewed published prescribing error documentation strategies and derived 14 error categories (eAppendix) for use across participating sites. The local principal investigator was responsible for educating clinical pharmacy staff about identifying, rectifying, and documenting interventions on erroneous orders. Participating institutions could choose to deploy this documentation workflow across the entire inpatient area or in designated patient care areas. Two local pharmacist reviewers determined the potential severity of each error intercepted using a modified National Coordinating Council for Medication Error Reporting and Prevention (NCC-MERP) index, derived to adjudicate potential capacity for harm.[14] NCC-MERP categories A to C were considered to represent "low" capacity for harm, categories D to F were considered to represent "serious" capacity for harm, and categories G to I were considered to represent "life-threatening" capacity for harm. Definitions can be found in the eAppendix. A local physician reviewer adjudicated the severity ratings for all errors categorized as having potentially life-threatening harm and 10% of all potentially serious errors, up to 100 total errors at each site. Any disagreements about potential severity were resolved by discussion, and consensus was established by the 3 local reviewers. This methodology had previously been implemented at one of the participating sites.[15]

All pharmacist-initiated, physician-accepted interventions were eligible for inclusion. Interventions made before order entry (ie, during rounding), after initial order verification (ie, through routine monitoring), or through pharmacist actions taken per policy or protocol were excluded from analysis.

Program implementation. An extensive written guide was developed by the investigators to ensure standardized practices across health systems before initiation of the study. The study guide included details regarding the project methods and workflows, example documentation and adjudication practices, and training materials for frontline staff. In addition, site leads received live training sessions conducted by the study team where processes and implementation strategies were discussed. Virtual training sessions were coordinated by the study team, which included hypothetical

Table 1. Hospital Demographics

Hospital Code	Hospital Type	Number of Licensed Beds	Case Mix Index	EHR	Documented Prescribing Errors Intercepted Before Study	Bed to Pharmacist Ratio[b]
1	Community	250	1.7	Epic	Yes	20:1
2	Academic	886	1.9	Epic	Yes	30:1
3	Academic	360	NR	Epic	Yes	11:1
4[a]	Academic	809	1.96	Epic	Yes	30:1
5[a]	Academic	900	1.7	Epic	No	NR
6	Community	250	2	Epic	Yes	25:1
7[a]	Academic	477	2.51	Epic	No	NR
8	Academic	685	1.91	Cerner	Yes	13:1
9	Academic	627	1.99	Epic	No	18:1
10[a]	Academic	846	1.82	Epic	No	30:1
11	Community	144	NR	Allscripts	Yes	NR

Abbreviations: EHR, electronic health record; NR, not reported.
[a]Implementation in select patient care areas by designated pharmacist personnel.
[b]Pharmacists participating in order verification activities.

error scenarios to promote standardized processes across sites. Ongoing live question and answer sessions were also sponsored by the study team to address questions from individual sites and resolve operational challenges leading up to the study period.

Seven hospitals implemented the methods described above across all inpatient areas, whereas 4 hospitals pilot tested these workflows in predetermined patient care areas. Seven hospitals utilized frontline staff in addition to a secondary pharmacist reviewer to establish capacity for harm, whereas 4 hospitals leveraged 2 secondary pharmacist reviewers following documentation of the error.

Data collection. Each institution collected intervention details for a period of 6 consecutive weeks during the 3-month study period. Hospitals utilized documentation systems internal to their respective electronic health record (EHR) to capture errors. A data collection form was provided to aid in data collection for sites that did not document errors directly through the EHR (eFigure 1).

Documentation by pharmacists included:

- Type of prescribing error
- Significance/capacity for harm: low, serious, or life-threatening
- Problem statement and corresponding recommendation
- Additional elements as listed in the data collection form

Aggregate data summarizing the frequency of different error types and a breakdown of errors by capacity for harm were collected by the investigators.

Outcomes. Outcomes included the number of errors intercepted and the corresponding capacity for harm, as well as the error type. Each site also reported the top 3 most frequently implicated therapeutic drug classes (according to the AHFS Pharmacologic-Therapeutic Classification System [ASHP, Bethesda, MD]). The number of intercepted errors was normalized by patient days across institutions. Descriptive statistics (median and frequency) were primarily used to characterize results across institutions.

Results

A total of 7,187 interventions were reported across all sites. A median of 39 intercepted errors per 1,000 patient days was observed across institutions. There was wide variability, with reported rates ranging from 4 to 87 errors per 1,000 patient days (Table 2).

Table 3 highlights the capacity for harm avoided by each respective institution. Almost half of the errors were determined to have the capacity for life-threatening (n = 175, 2.4%) or serious (n = 3,349, 46.6%) injury, and the remaining errors were determined to have a low capacity for harm (n = 3,663, 51.0%).

Table 4 presents the frequency of each error type, with errors stratified by capacity for harm, across all participating institutions. The top 3 error types occurring with the highest frequency were "wrong dose/rate/frequency" (n = 2,298, 32.0%), "duplicate therapy" (n = 1,431, 19.9%), and "wrong timing" (n = 960, 13.4%). These 3 intervention types accounted for 65.3% of all interventions. Of errors that were considered potentially life-threatening, "wrong dose/rate/frequency" (n = 49, 28%), "duplicate therapy" (n = 26, 14.9%), and "drug-disease interaction" (n = 24, 13.7%) errors had the highest

Table 2. Overall Harm Avoided by Institution

Hospital Code	Hospital Type	Practice Model[a]	Pharmacist-Managed Services, No. (%)[b]	Location of Select Unit Implementation	Documented Prescribing Errors Intercepted Before Study	Errors Per 1,000 Patient Days[c]	
						Serious + Life-Threatening	All
1	Community	Patient centered	11 (85)	NA	Yes	23	71
2	Academic	Patient centered	9 (69)	NA	Yes	16	25
3	Academic	Patient centered	12 (92)	NA	Yes	1	22
4	Academic	Patient centered	13 (100)	Med/Surg, pediatrics, ICU, cardiac progressive care, step-down CCU	Yes	43	54
5	Academic	Patient centered	10 (77)	Med/Surg, Heme/Oncol	No	27	39
6	Community	Clinical pharmacist centered	12 (92)	NA	Yes	3	4
7	Academic	Patient centered	12 (92)	ICU, ED	No	32	48
8	Academic	Patient centered	8 (62)	Med/Surg	Yes	9	35
9	Academic	Patient centered	10 (77)	NA	No	32	87
10	Academic	Patient centered	11 (85)	NA	No	15	33
11	Community	Decentralized	4 (31)	NA	Yes	25	43
			Overall, median			23	39

Abbreviations: CCU, cardiac care unit; Heme/Oncol, hematology/oncology; ED, emergency department; ICU, intensive care unit; Med/Surg, medicine/surgical; NA, not applicable.
[a]Practice model definitions can be found in the eAppendix.
[b]Sites reported offering the following services: vancomycin pharmacokinetics, renal dosing, aminoglycoside pharmacokinetics, anticoagulation management, nutrition, intravenous to oral transition, antimicrobial stewardship, pain and palliative care, emergency department clinical pharmacy services, admission medication history and reconciliation, discharge medication reconciliation, other discharge planning, and patient education.
[c]Rates were normalized for patient days in participating patient care areas.

frequencies. "Wrong dose/rate/frequency" (n = 1,028, 30.7%), "wrong timing" (n = 573, 17.1%), and "duplicate therapy" (n = 482, 14.4%) were the error types identified most frequently for errors with serious potential harm.

The majority of sites reported the highest rates of prescribing errors for medications in the following therapeutic classes: anti-infectives, cardiovascular agents, and blood formation/coagulation/thrombosis agents.

Examples of life-threatening errors included the following:

- Wrong dose/rate/frequency: 18 units of insulin glargine was changed to 16 units/kg (984 units total) instead of the intended 16 units. The pharmacist intercepted this error and recommended adjusting to 16 units.
- Drug-lab interaction: a 95-year-old female was admitted for rectal pain with bleeding and was on warfarin at home. The patient was started on heparin IV upon admission. The pharmacist recommended not initiating heparin, given that there was no acute indication and to prevent worsening bleeding.

Additional errors classified as having a low capacity for harm and a serious capacity for harm can be found in the eAppendix.

Table 3. Harm and Cost Avoidance by Institution

Hospital Code	Capacity for Harm[a]			Total Errors	Cost Avoidance (Cost Per Week)[b]
	Life-Threatening	Serious	Low		
1	2 (0.4)	174 (32.6)	357 (67.0)	533	$7,274.67
2	25 (3.1)	484 (60.5)	291 (36.4)	800	$21,038.67
3	0	11 (4.2)	253 (95.8)	264	$454.67
4[c]	11 (1.0)	847 (78.8)	217 (20.2)	1,075	$35,464.00
5[c]	36 (9.7)	222 (60.0)	112 (30.3)	370	$10,664.00
6	2 (5.3)	29 (76.3)	7 (18.4)	38	$1,281.33
7[c]	45 (8.2)	318 (58.0)	185 (33.8)	548	$15,004.00
8	13 (1.9)	162 (23.3)	520 (74.8)	695	$7,233.33
9	0	781 (37.0)	1,327 (63.0)	2,108	$32,281.33
10[c]	21 (3.6)	239 (41.3)	319 (55.1)	579	$10,746.67
11	20 (11.3)	82 (46.3)	75 (42.4)	177	$4,216.00
Total	175 (2.4)	3,349 (46.6)	3,663 (51.0)	7,187	$145,658.67

[a]Data shown as number of errors (%).
[b]Cost avoidance per week = ($248 × [sum of serious + life-threatening errors])/6 study weeks.
[c]Implementation in select patient care areas by select pharmacist personnel.

Table 4. Potential Harm Avoided by Error Type

Error Type	Capacity for Harm[a]			Total Errors
	Life-Threatening	Serious	Low	
Allergy	10 (11.5)	62 (71.3)	15 (17.2)	87
Drug-disease interaction	24 (8.7)	194 (70.6)	57 (20.7)	275
Drug-drug interaction	7 (4.3)	120 (74.1)	35 (21.6)	162
Drug-lab interaction	8 (4.8)	110 (66.7)	47 (28.5)	165
Duplicate therapy	26 (1.8)	482 (33.7)	923 (64.5)	1,431
Incomplete order	5 (1.8)	73 (26.3)	200 (71.9)	278
Therapy omission	8 (3.1)	191 (73.7)	60 (23.2)	259
Wrong concentration	4 (5.0)	56 (70.0)	20 (25.0)	80
Wrong dose/rate/frequency	49 (2.1)	1,028 (44.8)	1,221 (53.1)	2,298
Wrong duration	6 (2.6)	135 (57.7)	93 (39.7)	234
Wrong medication ordered	10 (2.3)	193 (45.1)	225 (52.6)	428
Wrong patient	2 (4.2)	24 (50.0)	22 (45.8)	48
Wrong route/dosage form	10 (2.1)	108 (22.4)	364 (75.5)	482
Wrong timing	6 (0.6)	573 (59.7)	381 (39.7)	960
Total	175 (2.4)	3,349 (46.6)	3,663 (51.0)	7,187

[a]Data shown as the number of errors (%).

A probability-weighted cost analysis was conducted to describe the estimated cost avoided as a result of pharmacist intervention. In 1997, Bates et al[16] established that a preventable serious ADE could cost up to $5,857 and account for 4.6 days of additional hospitalization. Using the inflation calculator from the US Bureau of Labor Statistics,[17] this suggests that an ADE could cost up to $9,568 as of August 2020. Intervention tracking systems estimate that routine intervention prevents an ADE in a median of 5.2% of cases.[18] Therefore, a conservative estimate of 2.6% ($248) was applied to the results described.

Discussion

The methods described above were implemented across health systems to develop standardized documentation processes to capture the frequency of intercepted prescribing errors and corresponding harm avoided. Although the rates documented here are higher than previously reported rates in the literature, with up to 50% of interventions made to prevent serious or life-threatening harm, they are associated with physician-validated processes, unlike previously published methods.

Pharmacist intervention on prescribing errors demonstrates the critical role that pharmacists play in preventing patient harm. Documentation generates robust near-miss reporting and expands the ability to analyze prescribing error trends and implement system solutions to reduce patient harm. Standardized documentation across health systems creates unique opportunities for collaboration to develop a profession-wide pharmacist-driven medication safety metric, improve system designs and workflows, and reduce risk of adverse events.

Limitations. This study captured interventions that were accepted by physicians; further study is needed to quantify the intervention acceptance rate across institutions. The frequency of errors that are missed during order verification also requires further study.

Only errors identified during order verification were included, and therefore the errors intercepted represent only a fraction of pharmacist impact on medication therapy management. Clinical pharmacists often proactively address potential prescribing errors during clinical rounding and other interactions with providers, which were not captured in this study. Clinical pharmacists also play a critical role in drug monitoring as clinical status evolves; interventions made during follow-up activities were also not captured in this study.

Documentation of prescribing errors was voluntary and could have been influenced by pharmacist workload and staffing models. In some organizations, documentation of intercepted prescribing errors was a new process, which also could have impacted the number of reported errors. Conversely, rates could have been higher than typical reporting rates given the recognition by participants that this process was part of a study. Ongoing assessment of intervention rates may clarify the accuracy of the rates reported. Additionally, time studies may be helpful to assess the impact of documentation practices on workflows. Given the significant time commitment associated with collecting data in this manner, weekly or monthly data collection strategies may be pursued to represent pharmacist productivity and value.

Although this study reports the median error rate based on aggregate data, it is important to note the variability in prescribing error rates across participating institutions. In addition to factors impacting documentation as described above, this variability can be attributed to differences in practice models; hospital-approved scope of practice; policies, protocols, and standard pharmacist workflows; clinical decision support functionality; and use of order sets. For example, sites that had "per pharmacy" policies in place to adjust the timing for next doses and had more refined order sets (ie, for pain management) would have had fewer "wrong timing" and "duplicate therapy" interventions, respectively. Similarly, sites that had "per pharmacy" policies for dosing medications (ie, vancomycin and aminoglycosides, anticoagulants, and nutrition) could have seen fewer "wrong dose/rate/frequency" interventions.

Financial impact. On the basis of the conservative estimates described above, interception of 3,349 serious errors and 175 life-threatening errors across 11 sites could have contributed up to $874,000 in avoided cost and 421 hospital days during the 6-week study period. This translates to a median cost avoidance of $10,664 per week per institution.

Further refinement of documentation methodologies is needed to capture the probability of an adverse event, to provide a more accurate summary of cost avoidance as a measurement of pharmacist contributions to value-based care. Future study is also warranted to establish standardized cost avoidance calculations that correlate with stratification by NCC-MERP–derived capacity for harm.

Institution-level evaluation. In addition to evaluating the error types and severity of harm reported in this study, institutions are encouraged to evaluate errors in the context of trends, physician specialties (including for those in postgraduate training programs), levels of care, and therapeutic drug classes stratified by severity of potential harm, which are readily retrievable from the EHR. Gathering data in this manner may help institutions identify high-risk prescribing patterns that can be targeted and resolved with order set revision and/or workflow changes. Additionally, gathering these data will allow sites to monitor a key safety metric that demonstrates the pharmacist's role in safe medication use.

Establishing service lines and levels of care with high rates of serious intercepted prescribing errors may also help pharmacy leadership advocate for expanded pharmacy services to prevent harm.

Acting on near misses to design safer systems. Gathering data on near-miss errors helps to identify

opportunities for order set revision, clinical decision support innovation, and improved staff awareness around frequent prescribing pitfalls. Examples of systematic issues identified by sites and corresponding action plans are described below:

- Incomplete instructions for continuous infusions. Targeted education for providers and nurses was conducted. Order panels were built to standardize language for titration and bolus dosing.
- Duplicate indications for pain orders. A house-wide multimodal pain order set was developed for use across acute care services as a means to standardize prescribing.

Using a standardized method to capture these prescribing near misses across institutions creates a platform to compare and contrast processes and brainstorm innovative solutions to ongoing challenges. While this initiative focused on implementing a standardized process, future efforts will include creation of a more formal framework for review of error trends to brainstorm system solutions across health systems.

Developing sustainable practices. Health systems are encouraged to share trends with pharmacist and physician trainees and staff to gain feedback and insight into prescribing pitfalls as a means to work toward system solutions. To continue obtaining quality data that can help identify trends, sites are encouraged to have a method in place to ensure ongoing staff re-education on prescribing error documentation. This can be done by monitoring a subset of prescribing errors (ie, high-alert medication prescribing errors and life-threatening prescribing errors) to assess the consistency and quality of the data reported and identifying pharmacy staff champions to provide peer-to-peer recommendations.

Of note, median error rates for sites new to documentation were higher than for sites with preestablished documentation in place (30 vs 16). This may be due, in part, to reporting fatigue. Therefore, it is recommended that processes be established to help sustain data capture (ie, ongoing staff education, incorporation into staff performance reviews or the career ladder, and sharing results with staff). This also suggests that weekly or monthly data collection strategies may provide a more accurate representation of intervention rates while minimizing documentation resources.

Physician reviewers adjudicated severity rankings for life-threatening and a subset of serious errors to validate the accuracy of the reported harm avoided. Two sites also captured physician consensus on pharmacy stratification of harm avoided, reporting a 98% congruence rate. This suggests that pharmacists and physicians are in agreement on the capacity for harm prevented by pharmacists.

Sharing practices. While there is significant opportunity for quality improvement work within an institution, sharing trends across institutions creates a unique opportunity to identify universal trends and collaborate on system solutions to improve prescribing practices. Hospitals with outlier rates and upward trends (ie, significantly lower reporting rates or high rates of errors with capacity for severe harm) can compare their workflows and systems to those of other hospitals and develop safety strategies to help improve prescribing.

Conclusion

This multicenter initiative developed and implemented a standardized process for pharmacist interception of prescribing errors during order verification. A median error rate of 39 intercepted errors per 1,000 patient days was observed across participating institutions. Approximately half of all reported errors had the capacity for serious or life-threatening harm, thus validating the pharmacist's critical role in medication order review. However, this is only one of the many ways by which pharmacists prevent patient harm and contribute to quality care delivery.

Additional studies are warranted to quantify the clinical significance of proactive pharmacist recommendations made during clinical rounding activities and ongoing drug monitoring in patients with changing clinical status. Future efforts should include the identification of opportunities for institutional benchmarking and pursuit of system solutions to reduce risk associated with prescribing errors.

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