Roles of the emergency medicine pharmacist: A systematic review

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Purpose. Results of a systematic literature review to identify roles for emergency medicine (EM) pharmacists beyond traditionally reported activities and to quantify the benefits of these roles in terms of patient outcomes are reported.

Summary. Emergency department (ED)–based clinical pharmacy is a rapidly growing practice area that has gained support in a number of countries globally, particularly over the last 5–10 years. A systematic literature search covering the period 1995–2016 was conducted to characterize emerging EM pharmacist roles and the impact on patient outcomes. Six databases were searched for research publications on pharmacist participation in patient care in a general ED or trauma center that documented interventions by ED-based pharmacists; 15 results satisfied the inclusion criteria. Six reported studies evaluated EM pharmacist involvement in the care of critically ill patients, 5 studies evaluated antimicrobial stewardship (AMS) activities via pharmacist review of positive cultures, 2 studies assessed pharmacist involvement in generating orders for nurse-administered home medications and 2 reviewed publications focused on EM pharmacist involvement in management of healthcare-associated pneumonia and dosing of phenytoin. A diverse range of positive patient outcomes was identified. The included studies were assessed to be of low quality.

Conclusion. A systematic review of the literature revealed 3 key emerging areas of practice for the EM pharmacist that are associated with positive patient outcomes. These included involvement in management of critically ill patients, AMS roles, and ordering of home medications in the ED.

Keywords: emergency medicine, pharmacists, pharmacy service hospital, resuscitation, trauma centers

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Emergency medicine (EM) clinical pharmacy is a rapidly growing area of global practice. There is increasing evidence of improved patient outcomes and decreased medication errors associated with EM pharmacists practicing in the emergency department (ED).[1-10] North America has established and led the development of EM pharmacy practice for over 20 years.[11] More recently, other countries, including Australia, Canada, and the United Kingdom, have recognized the benefits associated with EM pharmacist roles that are now well established in the literature.[12-14] National pharmacy bodies are beginning to identify and incorporate these traditional EM pharmacist roles into professional practice standards. Both the Society of Hospital Pharmacists of Australia standards of practice and the American Society of Health-System Pharmacists (ASHP) guidelines on EM pharmacy practice recommend EM pharmacist responsibility for accurate medication history taking and identification of medication-related problems in the ED.[14,15] Other roles identified as standard of care include discharge prescription review and patient counseling; medication al-

lergy and error reporting; health professional education; attendance on medical rounds; review of medication orders; provision of medication information, including advice on drug selection, dosing, and drug interactions; therapeutic drug monitoring; medication procurement; and development of medication guidelines.[11,14,15]

In addition to well-established clinical activities, other EM pharmacist roles are being developed and implemented, particularly in the United States. EM pharmacist participation in cardiopulmonary resuscitation was reported as widespread by Thomas et al.[11] in a recent national survey of U.S. EM pharmacy practice. Although EM pharmacist participation in resuscitation efforts in the ED is recommended as an essential role in the ASHP guidelines, relatively little is known about this emerging role and the impact it may have on patient outcomes. EM pharmacy practice standards published outside of the United States are yet to prominently include this role as a standard of care.[15]

The primary aims of this systematic review are to identify emerging roles for the EM pharmacist beyond traditional, previously established EM pharmacist activities and to quantify the benefits of these roles in terms of patient outcomes.

KEY POINTS

- A literature search identified 3 emerging areas of practice for emergency medicine (EM) pharmacists: management of critically ill patients, antimicrobial stewardship, and involvement in generating orders for home medications to be administered by nurses to patients in the ED.
- EM pharmacist involvement in these emerging practice areas was associated with a diverse range of positive patient outcomes.
- All studies identified in the literature review were of low quality, indicating a need for further research to inform future study design, develop best-practice standards, and guide development of EM pharmacist roles.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for the design and reporting of the review.[16]

Literature search. Six databases were searched: Ovid MEDLINE (Ovid Technologies, New York, NY), Embase (Elsevier BV, Amsterdam, Netherlands), International Pharmaceutical Abstracts (EBSCO Health, Ipswich, MA), the Cumulative Index to Nursing and Allied Health Literature (EBSCO Health), CENTRAL and Ovid MEDLINE In-Process & Other Non-Indexed Citations (Ovid Technologies). The search coverage period was January 1, 1995–May 11, 2016. Search terms were developed for 2 categories: ED and pharmacy. The search terms were initially developed for the Ovid MEDLINE database and modified for each of the other queried databases. Backward searching of references and forward searching of citations from included studies were performed to identify additional studies for screening.

Eligibility criteria. Peer-reviewed, English-language publications on comparative studies reporting patient-related outcomes were included. Included studies were those that investigated patients in a general ED or trauma center; a predefined intervention by an EM pharmacist on an interprofessional team must have been present. The clinical interventions included were emerging clinical roles not previously well described and supported in the literature and widely adopted as standards of care by multiple international professional bodies.

Studies evaluating medication history taking and identification of drug-related problems as sole interventions, studies evaluating the standard-of-care roles listed above, and publications reporting on summary intervention analysis and economic outcomes exclusively were excluded.

Information extraction. Data were extracted from the included studies independently by 2 investigators. Discrepancies in data interpretation were resolved by discussion until a consensus was reached. If a consensus could not be reached, a third investigator reviewed the article at issue. Data extracted included year of publication; study country; study design and level of evidence, as defined in the Australian National Health and Medical Research Council classification system[17]; study sample size; number of participants in each study group; inclusion and exclusion criteria; data collection methodology; power calculation; intervention and comparator descriptions; primary outcome assessed; and other relevant outcomes and results. Risk of bias was graded using the Newcastle–Ottawa Quality Assessment Scale.[18]

Results

The database and manual searches yielded a total of 3,576 results for title and abstract screening. There were 56 unique citations identified for full-text review. The eligibility criteria were applied to the full text of references, and 15 studies met the inclusion criteria and were included in the review. There were 13 U.S.-based studies conducted either in large teaching hospitals or otherwise in association with a university. Two studies were conducted in Australia, both in tertiary referral hospitals. All included research was conducted using nonrandomized study designs. Methods for determining intervention and control groups varied greatly. In 6 of the 15 included studies, outcomes of "in-hours" interventions (i.e., those performed during usual working hours) were compared with outcomes in after-hours control groups; 5 studies involved a combination of all-hours intervention and

control groups, and 4 involved comparison of in-hours intervention versus all-hours interventions (Table 1).

There were 6 studies[19-24] that identified EM pharmacist involvement in the care of critically ill patients, including trauma and resuscitation roles, and 5 studies[25-29] involving EM pharmacist review of positive cultures for appropriateness of empirical antimicrobial treatment in the ED or after discharge. Another 2 studies assessed EM pharmacist involvement in medication history taking and ordering of home medications for administration by nurses in the ED.[30,31] Other studies focused on EM pharmacist involvement in healthcare-associated pneumonia (HCAP) management and dosing of phenytoin.[32,33] Summary information on studies, interventions, and study designs is presented in Tables 1 and 2.

An assessment of study quality and bias is presented in Table 2. Retrospective record review was the method of data collection in 11 studies, with the remainder involving use of a combination of prospective and retrospective record reviews or prospective data collection exclusively (2 studies).

In 1 study, double data extraction methods were used; in 7 studies, explicitly defined variables were collected; 7 studies utilized blinded outcome assessment; in 7, a power calculation was performed to estimate sample size; and in 3 studies, researchers attempted to account for potential confounders. We assigned only 1 study a risk of bias score of 9 out of 9 (Table 2). Included studies were assessed to be of low quality.

EM pharmacist involvement in the care of critically ill patients was identified in 4 studies of acute trauma and resuscitation roles,[20,22-24] and 2 other studies focused specifically on EM pharmacist involvement in management of acute stroke and ST-segment elevation myocardial infarction (STEMI).[19,21]

The primary outcome reported by Amini et al.[22] and Montgomery et al.[24] was mean time to analgesia in patients with acute major trauma requiring rapid-sequence induction (RSI), also called rapid-sequence intubation. Both research teams found a statistically significant difference in mean times to analgesia with EM pharmacist presence versus absence (21 minutes versus 44 minutes [p = 0.05] and 17 minutes versus 21 minutes [p = 0.03]) (Table 3). Additionally, Amini et al.[22] found a significant reduction in time to post-RSI sedation favoring the presence of EM pharmacists (9 minutes versus 28 minutes, $p <$ 0.007) in the setting of acute trauma.

Robey-Gavin and Abuakar[20] evaluated the benefit of EM pharmacist participation in RSI, with the majority of patients intubated for nontrauma indications. The proportion of patients who received analgesia after RSI was significantly higher when the EM pharmacist was present (49% versus 20%, p = 0.005).

Ernst et al.[23] compared medication error rates in both acute major trauma and medical resuscitation populations at times when an EM pharmacist was present and times when a pharmacist was not present. In the pharmacist-present group, as compared with the pharmacist-absent group, errors were 13.5-fold less likely to occur across all dispositions (overall error rate, 2.5% versus 30.3%; absolute difference, 27.8% [95% confidence interval (CI), 23–32%]).

Acquisto et al.[21] demonstrated that EM pharmacist involvement in acute STEMI evaluations was independently associated with a significant reduction in times from ED arrival and/or STEMI diagnosis to cardiac catherization laboratory (CCL) evaluation (mean change, 13.1 minutes; p = 0.0324) and initiation of balloon angioplasty (mean change, 11.5 minutes; p = 0.0487). Additionally, with adjustment for confounders, the results indicated that patients were more likely to have a time to CCL evaluation of ≤30 minutes (adjusted odds ratio [OR], 3.1; 95% CI, 1.3–7.8) or ≤45 minutes (adjusted OR, 2.9; 95% CI, 1.0–8.5) when an EM pharmacist was present.

Gosser et al.[19] found that the presence of an EM pharmacist during responses to acute stroke calls resulted in significant improvements in the median time from ED arrival to thrombolysis initiation (69.5 minutes, as compared with a median time of 89.5 minutes without a pharmacist present; $p < 0.0027$) but did not find a significant difference in terms of the proportion of patients with arrival-to-thrombolysis times of <60 minutes (29.9% versus 15.8%, p = 0.1087).

Five included publications reported on EM pharmacist review of positive cultures for patients discharged home from the ED or patients in the ED. Miller et al.[25] concluded that when an EM pharmacist, a nurse, and an emergency physician collaborated in reviewing positive cultures (blood, urine, genital, skin and soft tissue, throat, and stool) and making antimicrobial recommendations, the proportion of patients with inappropriate antimicrobial therapy was significantly lower than the proportion when a pharmacist was not involved (14.7% versus 46.6%, $p < 0.0001$). In a study by Davis et al.,[27] EM pharmacist involvement versus noninvolvement was associated with a higher rate of interventions for unsuitable empirical therapy (80% versus 50%, p = 0.01). Randolph et al.[29] concluded that EM pharmacist review of positive cultures was associated with a significant reduction in the proportion of ED patients readmitted within 96 hours (to 7% from 19%, $p < 0.001$). In contrast, the findings of Dumkow et al.[26] in their study of pharmacist-conducted culture review at ED discharge did not reach significance for the outcome of ED readmissions (rates of readmission were 10.2% with and 16.9% without pharmacist review, p = 0.079). The median time to positive-culture review was shown to be significantly shorter (2 days versus 3 days, p = 0.0001) with EM pharmacist involvement in a study by Baker et al.[28]; however, in a similar study Davis et al.[27] were not able to demonstrate a significant time reduction with EM pharmacist involvement (mean times

Table 1. Summary Information From Included Publications, With Ratings of Level of Evidence[a]

Lead Author	Study Design (Level of Evidence[b])	Study Country (Dates)	Area of Practice Evaluated	EM Pharmacist Intervention Group	Control Group
Gosser R[19]	Cohort study (III-2)	U.S. (2008–12)	Stroke call response	Stroke call responses with pharmacist present during working hours (*n* = 67)	Stroke call responses without pharmacist present in after hours (*n* = 38)
Acquisto N[21]	Cohort study (III-2)	U.S. (2005–06)	STEMI management	STEMI evaluations with pharmacist present during working hours (*n* = 52)	STEMI evaluations without pharmacist present in after hours (*n* = 68)
Robey-Gavin E[20]	Historical control study (III-3)	U.S. (2010–11)	Major trauma and resuscitation	All patients who received RSI with or without pharmacist present (*n* = 41)	All patients who received RSI without pharmacist present (*n* = 41)
Amini A[22]	Cohort study (III-2)	U.S. (2009–11)	Major trauma and resuscitation	Trauma patients who received RSI with pharmacist present during working hours (*n* = 30)	Trauma patients who received RSI with pharmacist not present in after hours (*n* = 70)
Ernst A[23]	Cohort study (III-2)	U.S. (2009)	Major trauma and resuscitation	Major trauma and resuscitation cases with pharmacist present during working hours (*n* = 242)	Major trauma and resuscitation cases without pharmacist present in after hours (*n* = 452)
Montgomery K[24]	Cohort study (III-2)	U.S. (2009–13)	Major trauma and resuscitation	Trauma patients who received RSI with pharmacist present during working hours (*n* = 170)	Trauma patients who received RSI without pharmacist present in after hours (*n* = 170)
Miller K[25]	Historical control study (III-3)	U.S. (2012–13)	Culture review	Patients with positive culture results reviewed, with pharmacist present, after discharge home (*n* = 459)	Patients with positive culture results reviewed, without pharmacist present, after discharge home (*n* = 411)
Dumkow L[26]	Historical control study (III-3)	U.S. (2011–12)	Culture review	Patients with pharmacist-managed review of positive culture results after discharge home, excluding patients who received standard care in after hours (*n* = 197)	Patients with positive culture results reviewed, without pharmacist present, after discharge home (*n* = 124)
Davis L[27]	Historical control study (III-3)	U.S. (2009–10)	Culture review	Patients with positive culture results reviewed by pharmacist after discharge home (*n* = 76)	Patients with positive culture results reviewed by nursing manager after discharge home (*n* = 64)
Baker S[28]	Historical control study (III-3)	U.S. (2007–09)	Culture review	Patients with pharmacist-managed review of positive culture results after discharge home, excluding patients who received standard care in after hours (*n* = 73)	Patients whose positive culture results were reviewed after discharge home without pharmacist present (*n* = 104)
Randolph T[29]	Historical control study (III-3)	U.S. (2007–08)	Culture review	Review of positive culture results obtained in ED with pharmacist present (*n* = 2,361)	Review of all positive cultures results obtained in ED without pharmacist present (*n* = 2,278)
Vasileff H[30]	Cohort study (III-2)	Australia (2007)	Medication history taking and ordering of home medications	Patients targeted for medication history taking and ordering of home medications by pharmacist, excluding patients who received standard care after hours (*n* = 29)	Patients whose medication history was obtained and home medications ordered by medical officer (*n* = 45)

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Table 1. Summary Information From Included Publications, With Ratings of Level of Evidence[a]

Lead Author	Study Design (Level of Evidence[b])	Study Country (Dates)	Area of Practice Evaluated	EM Pharmacist Intervention Group	Control Group
Weeks G[31]	Cohort study (II-2)	Australia (2008–09)	Medication history taking and ordering of home medications	Patients targeted for medication history taking and ordering of home medications by pharmacist, excluding patients who received standard care after hours (n = 205)	Patients whose medication history was obtained by a pharmacist, with home medications ordered by medical officers (n = 140)
DeFrates S[32]	Cohort study (II-2)	U.S. (2008–10)	HCAP	Patients with HCAP who arrived in ED while pharmacist present during working hours (n = 81)	Patients with HCAP who arrived in ED while pharmacist not present in after hours (n = 70)
Brancaccio A[33]	Historical control study (III-3)	U.S. (2010–13)	Phenytoin dosing	Patients administered phenytoin loading doses with or without pharmacist present (n = 71)	Patients administered phenytoin loading doses without pharmacist present (n = 50)

[a]EM = emergency medicine, STEMI = ST-segment elevation myocardial infarction, RSI = rapid-sequence induction, ED = emergency department, HCAP = healthcare-associated pneumonia.
[b]As graded by the authors of this review according to the Australian National Health and Medical Research Council Designation of Levels of Evidence hierarchy,[17] in which evidence is graded on 4 levels: I, systematic review of level II studies; II, randomized controlled trial; III-1, pseudo-randomized controlled trial; III-2, comparative study with concurrent controls; III-3, comparative study without concurrent controls; and IV, case series.

to culture review with and without pharmacist involvement were 3.5 and 3.4 days, respectively; $p = 0.81$). Baker et al.[28] also demonstrated a reduction in the median time to provider or patient notification regarding inappropriate empirical antimicrobial therapy (2 days versus 3 days, $p = 0.01$) with ED pharmacist involvement.

Two studies in Australia evaluated the benefits of EM pharmacist medication history taking and involvement in ordering of home medications to be administered by nurses while in the ED. Vasileff et al.[30] showed that EM pharmacist medication history taking and involvement in ordering of medications was associated with significantly fewer unintentional discrepancies compared to medical officer generated medication orders for home medications (0.024 missed doses versus 2.35 missed doses per patient, $p < 0.05$). Weeks et al.[31] confirmed that result, demonstrating a significantly higher accuracy rate for EM pharmacist–versus physician-generated orders for home medications (96.8% versus 25.7%, $p < 0.001$).

A study by DeFrates et al.[32] demonstrated that EM pharmacist involvement in identification and HCAP management significantly improved the proportion of patients with appropriate empirical antimicrobial therapy, as assessed by a blinded panel of pharmacists using American Thoracic Society and Infectious Diseases Society of America (IDSA) guidelines, to 49.38% (the appropriateness rate was 25.7% without pharmacist involvement; [$p = 0.005$]).

Brancaccio et al.[33] showed that EM pharmacist dosing of phenytoin improved the proportion of patients with optimal phenytoin loading doses to 82%, compared with 50% for nonpharmacists ($p = 0.007$). There was no significant difference in the primary outcome of overall optimization of all phenytoin loading doses (optimal-(the optimal dosing rates for pharmacists and nonpharmacists combined was 62%, as compared to

Table 2. Assessment of Study Methods, Quality, and Bias

Lead Author of Study Report	Data Collection Methodology	Double Data Extraction[a]	Explicit Records Review[b]	Blinded Assessment[c]	Power Calculation	Bias Scoring[d]			
						Selection	Comparability	Exposure	Total Score
Gosser R[19]	Retrospective records review	No	No	Yes	Yes	4	0	3	7
Robey-Gavin E[20]	Retrospective records review	No	No	No	No	3	0	3	6
Acquisto N[21]	Retrospective records review	No	Yes	No	No	4	2	3	9
Amini A[22]	Retrospective records review	No	No	Yes	Yes	4	0	3	7
Ernst A[23]	Prospective (intervention group) and retrospective records review (control group)	No	Yes	Yes	Yes	3	1	2	6
Montgomery K[24]	Retrospective records review	No	Yes	No	No	4	0	3	7
Miller K[25]	Retrospective records review	Yes	Yes	No	No	4	0	3	7
Dumkow L[26]	Retrospective records review, prospective identification of exposure	No	No	Yes	Yes	4	1	3	8
Davis L[27]	Retrospective records review	No	Yes	No	No	4	0	3	7
Baker S[28]	Retrospective records review	No	No	Yes	Yes	4	0	3	7
Randolph T[29]	Retrospective records review	No	No	No	No	4	0	3	7
Vasileff H[30]	Prospective recruitment and assessment by researcher	No	No	No	No	3	0	2	5
Weeks G[31]	Prospective recruitment and assessment by researcher	No	No	No	No	3	0	2	5
DeFrates S[32]	Retrospective records review	No	Yes	Yes	Yes	3	0	2	5
Brancaccio A[33]	Retrospective records review	No	Yes	Yes	Yes	3	0	2	5

[a]Same data extracted by 2 independent reviewers.
[b]Variables and data to be collected are defined prior to data collection.
[c]Assessment of outcomes is blinded or measurement is unlikely to influence outcomes.
[d]Studies were scored using the Newcastle–Ottawa Quality Assessment Scale for cohort studies.[18] A maximum of 4 points can be awarded in the selection and exposure categories, and a maximum of 2 points can be assigned in the comparability category; total scores of 1 and 9 indicate the highest and lowest risk of bias, respectively.

Table 3. Summary of Data on Evaluated Outcomes, Analytic Methods, and Results From Included Publications[a]

Lead Author	Outcomes	Method of Statistical Analysis	Results With vs. Without Pharmacist Intervention[b]	*p* or 95% CI
Gosser R[19]	Median time from ED arrival to thrombolysis initiation	Mann–Whitney *U* test	69.5 min vs. 89.5 min	<0.0027
	Time to thrombolysis initiation of <60 min	Chi-square test	29.9% vs. 15.8%	0.1087
	Appropriate thrombolytic dosing	Student's *t* test	96.6% vs. 95.6%	0.8953
Acquisto N[21]	Change in mean time from arrival and/or diagnosis to CCL evaluation	Multivariate OLS regression (covariates: CCL staff, arrival by EMS)	–13.1 min	0.0324
	Change in mean time from arrival and/or diagnosis to balloon angioplasty initiation	Multivariate OLS regression (covariates: CCL staff, arrival by EMS)	–11.5 min	0.0487
	Time from arrival and/or diagnosis to CCL evaluation (≤30 min vs. >30 min)	Multivariate logistic regression (covariates: CCL staff, arrival by EMS)	OR = 3.1	1.3–7.8
	Time from arrival and/or diagnosis to CCL evaluation (≤45 min vs. >45 min)	Multivariate logistic regression (covariates: CCL staff, arrival by EMS)	OR = 2.9	1.0–8.5
	Time from arrival to balloon angioplasty (≤90 min vs. >90 min)	Multivariate logistic regression (covariates: CCL staff, arrival by EMS)	OR = 1.9	0.7–5.5
Robey-Gavin E[20]	Post-RSI initiation of analgesia	Chi-square test	49% vs. 20%	0.005
	Mean time to post-RSI analgesia	. . .[c]	45 min vs. 98 min	NA
Amini A[22]	Mean time to postintubation sedation	Student's *t* test	9 min vs. 28 min	<0.007
	Mean time to postintubation analgesia	Student's *t* test	21 min vs. 44 min	0.057
Montgomery K[24]	Mean time from ED arrival to first analgesic dose	Student's *t* test	17 min vs. 21 min	0.03
	Mean change in pain score from ED arrival to transfer	Mann–Whitney *U* test	2.4 points vs. 2.8 points	0.57
Ernst A[23]	Rate of medication errors	Chi-square test	2.5% vs. 30.3%	23–32%
	Likelihood of medication error with and without pharmacist present	Multivariate logistic regression (covariates: disposition, age, race)	OR = 13.5	6–32
Miller K[25]	Rate of postvisit regimen revision	. . .	16.3% vs. 17.8%	NA
	Inappropriate postvisit antimicrobial regimen	*z* test	14.7% vs. 46.6%	<0.0001
Dumkow L[26]	ED revisit within 72 hours or admission within 30 days	Chi-square test or Fisher's exact test	10.2% vs. 16.9%	0.079
Davis L[27]	Regimen revision required	. . .	46.8% vs. 55.3%	NA
	Regimen revision made if required	Chi-square test	80% vs. 50%	0.01
	Mean time to regimen revision	Student's *t* test	3.5 days vs. 3.4 days	0.81
Baker S[28]	Median time to review of positive culture	Wilcoxon rank sum test	2 days vs. 3 days	0.0001
	Median time to inappropriate-therapy notification	Wilcoxon rank sum test	2 days vs. 3 days	0.01

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Table 3. Summary of Data on Evaluated Outcomes, Analytic Methods, and Results From Included Publications[a]

Lead Author	Outcomes	Method of Statistical Analysis	Results With vs. Without Pharmacist Intervention[b]	*p* or 95% CI
Randolph T[29]	Proportion of antimicrobial regimens modified	. . .	15% vs. 12%	NA
	Rate of unplanned ED readmissions within 96 hr	*z* test	7% vs. 19%	<0.001
Vasileff H[30]	Mean no. unintended discrepancies on home medication orders vs. medication history	. . .	0.034 vs. 2.51	<0.05
Weeks G[31]	Percentage accuracy of medication records	Chi-square test	96.8% vs. 25.7%	<0.001
DeFrates S[32]	Rate of antibiotic therapy adherence to HCAP guidelines	Chi-square test or Fisher's exact test	49.38% vs. 25.7%	0.005
	Mean time to appropriate final antibiotic therapy	Student's *t* test	11.37 hr vs. 15.56 hr	0.272
	Rate of appropriate antibiotic dosing	Chi-square test or Fisher's exact test	85.2% vs. 77.1%	0.29
Brancaccio A[33]	Rate of administration of optimal phenytoin loading doses	Chi-square test or Fisher's exact test	62% vs. 50%	0.19

[a]CI = confidence interval, ED = emergency department, CCL= cardiac catherization laboratory, OLS = ordinary least-squares, EMS = emergency medical services, OR = odds ratio, RSI = rapid-sequence induction, NA = not applicable, HCAP = healthcare-associated pneumonia.
[b]Intervention versus control.
[c]No statistical analysis performed.

50% for nonpharmacists alone before the intervention).

Discussion

Beyond the previously established clinical pharmacist roles, this systematic review identified several evolving areas of practice in which EM pharmacist involvement is associated with a diverse range of positive patient outcomes.

A large proportion of the reviewed studies involved EM pharmacist participation in the management of critically ill patients and in antimicrobial stewardship (AMS) activities. A third key area for the future is EM pharmacist–generated medication orders for ED patients. The data from this systematic review suggest that the ED environment is a fertile setting for novel practices.

EM pharmacist involvement in acute trauma and resuscitation roles can have direct benefits for patients. Early analgesia and sedation constitute a key area of clinical impact, particularly since much of the literature demonstrates that patients undergoing RSI in the ED frequently receive inadequate postintubation sedation and analgesia.[34,35] Indeed, this review indicates that the EM pharmacist may not only improve time to medication administration in the acute trauma and resuscitation environment but may also reduce the number of errors that occur.[23] This may be particularly pertinent in the hectic stages of resuscitation, where assessment and diagnosis remain the focus of clinical practice and little consideration may be afforded to the optimization of medication therapy. Furthermore, the high-risk nature of medications commonly used in this setting, often with little clinical information being immediately available, adds to the potential for medication-related problems.[36-40]

AMS in the ED is a novel area of practice. AMS has been associated with reductions in inappropriate antimicrobial use, lower drug costs, decreased treatment duration and adverse events, and reduced antibiotic resistance.[41,42] EDs are a particularly important setting for addressing inappropriate antimicrobial prescribing given the frequent use of antibiotics and that EDs serve as the interface between the community and hospital admission.[43] However, the ED environment is a difficult area in which to implement strategies commonly used by hospital AMS programs.[44,45] Challenges to implementation of AMS in the ED include constant patient turnover, the need for rapid decision-making with incomplete diagnostic information being available, the lack of access to follow-up of ED patients, and large staffs with different levels of expertise.[46]

A recent survey targeting Australian EDs confirmed that the EM pharmacist's role in AMS is varied and often multifaceted.[47] The findings of our review build on previous guidelines that recommend the utilization of EM

pharmacists in various AMS strategies in the ED.[45] In the United States, new AMS standards established by the Joint Commission became effective in January 2017 in all hospitals. The standards align with those recommended in guidelines of IDSA and the Society of Healthcare Epidemiology. The EM pharmacist can play a crucial role to assist in meeting the new mandates.[48,49] Undeniably, AMS in the ED is an emerging and important role for the EM pharmacist that will require the development of unique practices tailored to the ED setting. EM pharmacist–conducted culture review represents a promising intervention for adoption as the standard of care as further research builds in the future. Involvement of the EM pharmacist in identifying patients at risk for resistant infections such as HCAP requires further exploration.

The process of EM pharmacist–led medication history taking, identification of medication-related problems, and generation of orders for nurse-administered home medications might be highly effective at reducing medication errors.[1,30,31,50] This proactive role may also ensure that delays in ordering of important medications are avoided and that home medications are considered early in a patient's hospital stay. There is great potential for further exploration of this role as part of various models of care in the ED.

This review builds on the previous literature by beginning to fill the gap in knowledge about emerging clinical roles for the EM pharmacist and associated patient outcomes.

In 2009, a systematic review established the baseline scope of clinical pharmacist involvement in the ED, activities performed, and associated outcomes.[51] Over 50 elements of job responsibilities were identified. The most commonly reported role of the EM pharmacist was in conducting consultations. Other common activities were answering drug information questions, aiding in toxicology cases, providing patient counseling, documenting interventions, obtaining medication histories, participating in drug distribution, pharmacokinetic monitoring, educating staff, and serving as a preceptor for students. Participation in trauma and resuscitation teams was reported in 40% of articles; however, the reviewed studies were descriptive in nature, with no patient outcomes assessed.[51] Other, international research has confirmed the evidence in support of traditional clinical pharmacist roles in the ED setting.[4,9,10,52-58]

The strengths of this review stemmed from the comprehensive literature search and evidence review by a blinded pair of reviewers. However, because of the retrospective nature of the included studies, a notable limitation was the likelihood of publication and reporting biases. Some EM pharmacist roles that have been classed as emerging may have been in place for many years in certain institutions, offering many practical benefits that are difficult to quantify and research objectively. It is also plausible that studies with negative findings were conducted but not published. However, the initial title and abstract screens identified a number of clinically relevant results meeting 1 or more exclusion criteria. These results contained 6 citations of articles describing an EM pharmacist role in the management of sepsis and septic shock, 5 describing EM pharmacists' attending stroke calls, 2 describing EM pharmacist participation in microbiological culture review, and 1 result reporting on EM pharmacist involvement in generating home medication orders for ED patients. Many of these cited publications were descriptive in nature or reported as conference abstracts. This gives us confidence that our findings provide an accurate representation of emerging roles for the EM pharmacist.

The changes in healthcare that occur after hours are important confounders that were not controlled for except in 1 study in this review.[59,60] This is particularly relevant with regard to the studies evaluating EM pharmacist involvement in critically ill patients, as significant proportions of such patients may arrive at an ED after hours—a period when an EM pharmacist is typically not available.[60] Further research into the benefits of a 24-hour EM pharmacy service focused on critically ill patients is needed.

Financial constraints remain as a key barrier to implementation and expansion of EM pharmacy services.[61] While reductions in drug costs and cost avoidance have been identified in studies not included in this review, a comprehensive economic analysis of costs and benefits associated with implementation of ED pharmacists' services does not exist.[61] In many countries, the opportunity for medication cost savings is limited, as the average cost per patient per episode of care represents a small fraction of the total cost of care in the ED.[62] Thus, implementation of emerging EM pharmacist roles on the basis of cost savings alone is difficult to justify, and the applicability of results internationally is also questionable. None of the studies included in this review measured economic outcomes.

Conclusion

A systematic review of the literature revealed 3 key emerging areas of practice for the EM pharmacist that are associated with positive patient outcomes. These included involvement in management of critically ill patients, AMS roles, and ordering of home medications for administration in ED.

Disclosures

The authors have declared no potential conflicts of interest.

References

1. Tong EY, Roman C, Mitra B et al. Partnered pharmacist charting on admission in the general medical and emergency short-stay unit—a cluster-randomised controlled trial in patients with complex medication regimens. *J Clin Pharm Ther.* 2016; 41:414-8.
2. Patanwala AE, Sanders AB, Thomas MC et al. A prospective, multicenter study of pharmacist activities result-

ing in medication error interception in the emergency department. *Ann Emerg Med.* 2012; 59:369-73.
3. Ratz Y, Shafir I, Berkovitch S et al. The importance of the pharmacist in reporting adverse drug reactions in the emergency department. *J Clin Pharmacol.* 2010; 50:1217-21.
4. Rothschild JM, Churchill W, Erickson A et al. Medication errors recovered by emergency department pharmacists. *Ann Emerg Med.* 2010; 55:513-21.
5. Brown JN, Barnes CL, Beasley B et al. Effect of pharmacists on medication errors in an emergency department. *Am J Health-Syst Pharm.* 2008; 65:330-3.
6. Crook M, Ajdukovic M, Angley C et al. Eliciting comprehensive medication histories in the emergency department: the role of the pharmacist. *Pharm Pract.* 2007; 5:78-84.
7. De Winter S, Spriet I, Indevuyst C et al. Pharmacist versus physician-acquired medication history: a prospective study at the emergency department. *Qual Saf Health Care.* 2010; 19:371-5.
8. Hayes BD, Donovan JL, Smith BS et al. Pharmacist-conducted medication reconciliation in an emergency department. *Am J Health-Syst Pharm.* 2007; 64:1720-3.
9. Cesarz JL, Steffenhagen AL, Svenson J et al. Emergency department discharge prescription interventions by emergency medicine pharmacists. *Ann Emerg Med.* 2013; 61:209-14.,e1.
10. DeClifford JM, Caplygin FM, Lam SS et al. Impact of an emergency department pharmacist on prescribing errors in an Australian hospital. *J Pharm Pract Res.* 2007; 37:284-6.
11. Thomas MC, Acquisto NM, Shirk MB et al. A national survey of emergency pharmacy practice in the United States. *Am J Health-Syst Pharm.* 2016; 73:386-94.
12. Wanbon R, Lyder C, Villeneuve E et al. Clinical pharmacy services in Canadian emergency departments: a national survey. *Can J Hosp Pharm.* 2015; 68:191.
13. Collignon U, Oborne CA, Kostrzewski A. Pharmacy services to UK emergency departments: a descriptive study. *Pharm World Sci.* 2010; 32:90.
14. Fitzgerald C, Welch S, Taylor S et al. SHPA standards of practice in emergency medicine pharmacy practice: SHPA Committee of Specialty Practice in Emergency Medicine. *J Pharm Pract Res.* 2015; 45:423-30.
15. Eppert HD, Reznek AJ. ASHP guidelines on emergency medicine pharmacist services. *Am J Health-Syst Pharm.* 2011; 68:e81-95.
16. Moher D, Liberati A, Tetzlaff J et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ.* 2009; 339:b2535.
17. Merlin T, Weston A, Tooher R. Extending an evidence hierarchy to include topics other than treatment: revising the Australian 'levels of evidence'. *BMC Med Res Methodol.* 2009; 9:34.
18. Wells GA, Shea B, O'Connell D et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses (2014). www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed 2018 Feb 23).
19. Gosser RA, Arndt RF, Schaafsma K et al. Pharmacist impact on ischemic stroke care in the emergency department. *J Emerg Med.* 2016; 50:187-93.
20. Robey-Gavin E, Abuakar L. Impact of clinical pharmacists on initiation of postintubation analgesia in the emergency department. *J Emerg Med.* 2016; 50:308-14.
21. Acquisto NM, Hays DP, Fairbanks RJ et al. The outcomes of emergency pharmacist participation during acute myocardial infarction. *J Emerg Med.* 2012; 42:371-8.
22. Amini A, Faucett EA, Watt JM et al. Effect of a pharmacist on timing of postintubation sedative and analgesic use in trauma resuscitations. *Am J Health-Syst Pharm.* 2013; 70:1513-7.
23. Ernst AA, Weiss SJ, Sullivan IA et al. On-site pharmacists in the ED improve medical errors. *Am J Emerg Med.* 2012; 30:717-25.
24. Montgomery K, Hall AB, Keriazes G. Pharmacist's impact on acute pain management during trauma resuscitation. *J Trauma Nurs.* 2015; 22:87-90.
25. Miller K, McGraw MA, Tomsey A et al. Pharmacist addition to the post-ED visit review of discharge antimicrobial regimens. *Am J Emerg Med.* 2014; 32:1270-4.
26. Dumkow LE, Kenney RM, MacDonald NC et al. Impact of a multidisciplinary culture follow-up program of antimicrobial therapy in the emergency department. *Infect Dis Ther.* 2014; 3:45-53.
27. Davis LC, Covey RB, Weston JS et al. Pharmacist-driven antimicrobial optimization in the emergency department. *Am J Health-Syst Pharm.* 2016; 73(suppl 1):S49-56.
28. Baker SN, Acquisto NM, Ashley ED et al. Pharmacist-managed antimicrobial stewardship program for patients discharged from the emergency department. *J Pharm Pract.* 2012; 25:190-4.
29. Randolph TC, Parker A, Meyer L et al. Effect of a pharmacist-managed culture review process on antimicrobial therapy in an emergency department. *Am J Health-Syst Pharm.* 2011; 68:916-9.
30. Vasileff HM, Whitten LE, Pink JA et al. The effect on medication errors of pharmacists charting medication in an emergency department. *Pharm World Sci.* 2009; 31:373-9.
31. Weeks GR, Ciabotti L, Gorman E et al. Can a redesign of emergency pharmacist roles improve medication management? A prospective study in three Australian hospitals. *Res Social Adm Pharm.* 2014; 10:679-92.
32. DeFrates SR, Weant KA, Seamon JP et al. Emergency pharmacist impact on health care-associated pneumonia empiric therapy. *J Pharm Pract.* 2013; 26:125-30.
33. Brancaccio A, Giuliano C, McNorton K et al. Impact of a phenytoin loading dose program in the emergency department. *Am J Health-Syst Pharm.* 2014; 71:1862-9.
34. Bonomo JB, Butler AS, Lindsell CJ et al. Inadequate provision of postintubation anxiolysis and analgesia in the ED. *Am J Emerg Med.* 2008; 26:469-72.
35. Weingart GS, Carlson JN, Callaway CW et al. Estimates of sedation in patients undergoing endotracheal intubation in US EDs. *Am J Emer Med.* 2013; 31:222-6.
36. Chisholm CD, Collison EK, Nelson DR et al. Emergency department workplace interruptions: are emergency physicians "interrupt-driven" and "multitasking"? *Acad Emerg Med.* 2000; 7:1239-43.
37. Patanwala AE, Hays DP. Pharmacist's activities on a trauma response team in the emergency department. *Am J Health-Syst Pharm.* 2010; 67:1536-8.
38. Patanwala AE, Hays DP, Sanders AB et al. Severity and probability of harm of medication errors intercepted by an emergency department pharmacist. *Int J Pharm Pract.* 2011; 19:358-62.
39. Peth HA Jr. Medication errors in the emergency department: a systems approach to minimizing risk. *Emerg Med Clin North Am.* 2003; 21:141-58.
40. Brown M. Medication safety issues in the emergency department. *Crit Care Nurs Clin North Am.* 2005; 17:65-9.
41. Kaki R, Elligsen M, Walker S et al. Impact of antimicrobial stewardship in critical care: a systematic review. *J Antimicrob Chemother.* 2011; 66:1223-30.

42. Ohl CA, Dodds Ashley ES. Antimicrobial stewardship programs in community hospitals: the evidence base and case studies. *Clin Infect Dis.* 2011; 53(suppl 1):S23-8; quiz, S29-30.
43. May L, Cosgrove S, L'Archeveque M et al. A call to action for antimicrobial stewardship in the emergency department: approaches and strategies. *Ann Emerg Med.* 2013; 62:69-77,e2.
44. Bishop BM. Antimicrobial stewardship in the emergency department: challenges, opportunities, and a call to action for pharmacists. *J Pharm Pract.* 2016; 29:556-63.
45. May L, Cosgrove S, L'Archeveque M et al. Antimicrobial stewardship in the emergency department and guidelines for development. *Ann Emerg Med.* 2013; 62:10.
46. Almatar MA, Peterson GM, Thompson A et al. Factors influencing ceftriaxone use in community-acquired pneumonia: emergency doctors' perspectives. *Emerg Med Australas.* 2014; 26:591-5.
47. Welch S. Antimicrobial stewardship in Australian emergency departments. *Emerg Med Australas.* 2015; 27:427-30.
48. Goff DA, Kullar R, Goldstein EJ et al. A global call from five countries to collaborate in antibiotic stewardship: united we succeed, divided we might fail. *Lancet Infect Dis.* 2017; 17:e56-63.
49. Goff DA, Kullar R, Bauer KA et al. Eight habits of highly effective antimicrobial stewardship programs to meet the Joint Commission standards for hospitals. *Clin Infect Dis.* 2017; 64:1134-9.
50. Tong EY, Roman CP, Smit de V et al. Partnered medication review and charting between the pharmacist and medical officer in the emergency short stay and general medicine unit. *Australas Emerg Nurs J.* 2015; 18:149-55.
51. Cohen V, Jellinek SP, Hatch A et al. Effect of clinical pharmacists on care in the emergency department: a systematic review. *Am J Health-Syst Pharm.* 2009; 66:1353-61.
52. Crook M, Ajdukovic M, Angley C et al. Eliciting comprehensive medication histories in the emergency department: the role of the pharmacist. *Pharm Pract (Granada).* 2007; 5:78-84.
53. Ajdukovic M, Crook M, Angley C et al. Pharmacist elicited medication histories in the emergency department: identifying patient groups at risk of medication misadventure. *Pharm Pract (Granada).* 2007; 5:162-8.
54. Kent AJ, Harrington L, Skinner J. Medication reconciliation by a pharmacist in the emergency department: a pilot project. *Can J Hosp Pharm.* 2009; 62:238-42.
55. Galvin M, Jago-Byrne MC, Fitzsimons M et al. Clinical pharmacist's contribution to medication reconciliation on admission to hospital in Ireland. *Int J Clin Pharm.* 2013; 35:14-21.
56. Mills PR, McGuffie AC. Formal medicine reconciliation within the emergency department reduces the medication error rates for emergency admissions. *Emerg Med J.* 2010; 27:911-5.
57. De Winter S, Spriet I, Indevuyst C et al. Pharmacist- versus physician-acquired medication history: a prospective study at the emergency department. *Qual Saf Health Care.* 2010; 19:371-5.
58. Patanwala AE, Warholak TL, Sanders AB et al. A prospective observational study of medication errors in a tertiary care emergency department. *Ann Emerg Med.* 2010; 55:522-6.
59. Gantner D, Farley K, Bailey M et al. Mortality related to after-hours discharge from intensive care in Australia and New Zealand, 2005–2012. *Intensive Care Med.* 2014; 40:1528-35.
60. Mitra B, Cameron PA, Fitzgerald MC et al. "After-hours" staffing of trauma centres and outcomes among patients presenting with acute traumatic coagulopathy. *Med J Aust.* 2014; 201:588-91.
61. Jacknin G, Nakamura T, Smally AJ et al. Using pharmacists to optimize patient outcomes and costs in the ED. *Am J Emerg Med.* 2014; 32:673-7.
62. Harding AM, Welton CG, Yeoh MJ. Medication costs in an emergency department. *J Pharm Pract Res.* 2015; 45:419-22.