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# Emergency medicine pharmacist interventions reducing exposure to costs (EMPIRE-C)

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ABSTRACT

*Introduction:* Emergency Medicine (EM) pharmacists are considered essential healthcare providers in the Emergency Department (ED). Limited data are available representing the types of interventions performed by ED pharmacists, especially in community-based health systems.
*Methods:* Retrospective, multi-centered, observational review of documented EM clinical pharmacist interventions into the electronic medical record (EMR) across five separate EDs between July 1, 2020 and June 30, 2021. Interventions were separated into three categories: ED Intervention, ED Outpatient Culture Review, and ED Discharge Antimicrobial Review. Interventions with supporting literature related to cost avoidance were also analyzed.
*Results:* A total of 23,794 interventions were logged by the EM pharmacy team between the three categories. Of those, 9181 were cost avoidance interventions resulting in $5,350,755.63 in total cost avoidance, or $582.81 per intervention.
*Conclusion:* EM pharmacists practicing in community settings have a substantial impact on patients as evidenced by the large quantity and variety of interventions logged which also results in significant cost avoidance to the healthcare system.



## 1. Introduction

The American College of Emergency Physicians and the American College of Medical Toxicology both consider emergency medicine (EM) pharmacists to be essential healthcare providers [1,2]. The Emergency Department (ED) is a unique practice environment for clinical pharmacists given the wide range of disease states and acuity of patients seen in the ED in which critically ill patient care is occurring simultaneously with ambulatory/outpatient patient care. ED pharmacist positions are quickly expanding. The first accredited Postgraduate Year Two (PGY2) EM Pharmacy Residency was accredited by the American Society of Health System Pharmacy (ASHP) in the early 2000s. As of 2021, ASHP has 77 different PGY2 EM Pharmacy residency programs listed, most with one position, but several with two positions [3]. A 2016 survey conducted among 162 EM pharmacists showed 50% had completed a PGY2 in EM and approximately 70% of the responding pharmacists indicated EM staffing hours greater than 8 h per day, with 12% providing 24-h coverage [4]. An additional 2016 EM pharmacist survey with 208 respondents showed EM pharmacists were evenly split between academic and community settings, but a higher proportion (47%) practiced at Level I trauma centers compared to Level II (28%) or Level III (16%) facilities [5].

EM clinical pharmacists' roles in hospital settings (when excluding operational duties) include prospective order review, antimicrobial stewardship, monitoring and prevention of adverse drug events, pharmacokinetic monitoring, bedside patient care (e.g., Code Stroke, Rapid Sequence Intubation (RSI), Cardiac Arrest, Trama Alerts, etc.) as well as education and scholarly activities [4-8]. Pharmacist involvement in overall patient care has been shown to reduce Medicare charges, lower medication costs, decrease intensive care unit (ICU) length of stay, and decrease mortality [9,10]. A recent multi-centered review with 88 pharmacists at 49 participating hospitals highlighted almost 14,000 EM pharmacist interventions over the span of approximately 17 shifts per pharmacist resulting in a cost avoidance of $8213.59 per EM pharmacist shift or $1,971,262 annualized per pharmacist [11]. The majority of EM pharmacist intervention and cost avoidance data originates from academic or community teaching hospitals while non-teaching institutions are underrepresented in the literature. The purpose of this study is to describe EM clinical pharmacist interventions made in a non-teaching community hospital ED setting as well as quantify cost avoidance for the EM pharmacy group over a one year period.

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## 2. Methods

### 2.1. Study design, setting, and population

This was a retrospective, multi-centered, observational review of documented EM clinical pharmacist interventions into the electronic medical record (EMR, Epic EHR Software [Epic Systems Corporation]). Five study sites were all part of a regional health system and consisted of three community hospitals and two freestanding EDs. Two of the hospitals have a dedicated ED pharmacist for 16 h a day on weekdays and 12 h a day on weekends. The third hospital has 8 h of coverage on weekdays and 12 h of coverage on weekends and the pharmacist is also responsible for all clinical duties related to one of the nearby freestanding EDs. The other freestanding ED is staffed 24 h a day by a pharmacist given it is a hybrid model as it also contains a retail pharmacy to serve the ED and general population. Combined, the EDs have approximately 125,000 patient visits per year. The ED pharmacist team is made up of 14 full-time positions and 2 part-time/as needed positions. The full-time pharmacists had an average of 7.8 years of hospital pharmacy experience in 2021, 79% completed a post-graduate year 1 (PGY1) residency, 21% completed a PGY2 residency, and 64% have additional board certifications in pharmacotherapy. Interventions logged between July 1, 2020 and June 30, 2021 were identified via reports from the EMR. The report data generated via the EMR does not include patient identifiers and no patient-specific information was included in the data collection, data review, or analysis of this study. Our study was exempt from institutional review board approval given the lack of identifiable patient data or protected health information.

EM pharmacists are encouraged, but not required, to log interventions into the EMR to track clinical activities in the ED. The interventions are grouped into three broad categories: ED Intervention, ED Outpatient Culture Review, and ED Discharge Antimicrobial Review. Each category has multiple subcategories to more specifically capture the type of activity performed. ED Interventions are related to clinical activities performed during the care of patients in the ED (Table 1). Multiple interventions are commonly logged for singular interactions to encompass all aspects of the pharmacist's recommendations. Interventions reported for Stroke Alert participation represented any Stroke Alert attended by an EM pharmacist whether or not thrombolytic therapy was administered. Sepsis alerts generated on ED patients prompts the ED pharmacist to review the patient's chart for previous admissions, previous culture history, recent inpatient or outpatient antibiotic administrations, and allergies. The ED pharmacist then discusses their findings with the treating provider and makes therapy recommendations (if necessary), and finally, expedites medication delivery to the bedside.

**Table 1**
ED interventions.

| ED intervention | Number | Cost avoided per intervention (2021 USD, $) | Total cost avoidance (2021 USD, $) |
|---|---|---|---|
| Admission Medication Reconciliation | 119 | – | |
| Allergy Clarification or Update | 745 | 646.48 | 481,627.60 |
| Anaphylaxis Participation | 25 | 407.90 | 10,197.50 |
| Antimicrobial Stewardship | 809 | 646.48 | 523,002.32 |
| Avoidance of Inappropriate Therapy | 132 | 407.72 | 53,819.04 |
| Cardiac Alert Participation | 90 | 407.90 | 36,711 |
| Code Blue Participation | 73 | 1614.21 | 117,837.33 |
| Discontinue Medication | 118 | – | |
| Discharge Medication Reconciliation | 17 | – | |
| Dose Optimization or Adjustment | 1251 | 181.09 | 226,543.59 |
| Drug Information | 358 | 130.29 | 46,643.82 |
| Drug Interaction | 28 | – | |
| IV Compatibility | 35 | 130.29 | 4560.15 |
| IV Pump Verification | 32 | 407.90 | 13,052.80 |
| IV to PO | 7 | – | – |
| Laboratory Test Addition | 91 | – | – |
| Medication Selection | 1443 | 505.58 | 729,546.17 |
| Outpatient Prescription Voucher | 40 | – | – |
| Optimize Therapy – Additional Agent | 19 | – | – |
| Order Clarification | 232 | – | – |
| Other | 232 | – | – |
| Patient Education | 185 | 719.58 | 133,122.30 |
| PDMP | 122 | – | – |
| Poison Control Information | 100 | 444.53 | 44,453.00 |
| Procedural Sedation | 228 | 291.18 | 66,389.04 |
| QTc Monitoring | 145 | 407.72 | 59,119.40 |
| Renal Dosing | 18 | 181.09 | 3259.62 |
| Retail Pharmacy Clarification | 436 | – | – |
| Rapid Sequence Intubation | 116 | 291.18 | 33,776.88 |
| Sepsis Alert Chart Review | 477 | 1663.93 | 793,694.61 |
| Staff Education | 74 | – | – |
| Stroke Alert Participation | 301 (77 with thrombolysis) | 1717.99 | 132,285.23 |
| Trauma Alert Participation | 146 | 407.90 | 59,553.4 |
| Treatment Committee Referral | 8 | – | – |
| Total ED Interventions | 8252 | – | |
| Total Cost Avoidance Interventions | 6650 | | 3,569,194.80 |

### 2.2. Outcomes measured

ED Outpatient Culture Review interventions are created when the EM pharmacist acts upon an EM-specific culture callback queue generated within the EMR (Table 2). Certain laboratory studies and/or cultures drawn during an ED encounter which have not resulted by the time of patient discharge are routed to the callback queue upon result finalization for EM pharmacist review and action, if required. Examples include blood, urine, tissue, abscess, or fluid cultures; sexually transmitted infection results; vaginosis panels; throat cultures; and coronavirus/respiratory viral panel results. These activities are required to be reviewed daily by the ED pharmacist staffing the location of the index encounter, but intervention documentation is voluntary. The EM pharmacist is responsible for determining if additional action is required such as addition or discontinuation of therapy, patient well checks, and/or patient education. The EM pharmacy team has implemented collaborative practice agreements with the EM providers for Group A *Streptococcus* throat cultures and Vaginosis Panels. For these test results, the pharmacist follows an algorithm and does not need to routinely consult with an ED physician if generating new prescriptions. For non-collaborative practice results, the EM pharmacist is expected to present the patient case along with their recommendation(s) and plan (s) to an ED physician on site. The ED physician ultimately decides on the plan of care and the EM pharmacist is responsible for enacting that plan by contacting patients or caregivers via telephone, patient health information portal, or certified letter when patients cannot be reached within 72 h of result. If a new prescription is required, EM pharmacists will either verbally call in the prescription to the patient's designated pharmacy or send it electronically through the EMR. For interactions which require changes in therapy or recommendations for patients to return to the ED for reevaluation, the EM pharmacist will also generate a note in the EMR outlining the case, recommendations, and plan. Critical result interventions occur when a critical lab value (most commonly a positive preliminary blood culture) triggers a phone call from the clinical laboratory staff to the EM pharmacist to relay the information. The EM pharmacist then assesses the result and reviews the patient's ED encounter and presents the case to an ED physician to determine if the patient should return to the ED for reevaluation or if outpatient management and continued monitoring of culture results are appropriate. The EM pharmacist then contacts the patient

**Table 2**
ED outpatient culture review interventions.

| ED outpatient culture review interventions | Number | Cost avoided per intervention (2021 USD, $) | Total cost avoidance (2021 USD, $) |
|---|---|---|---|
| BV Result Consultation | 79 | 789.70 | 62,386.30 |
| Critical Result | 301 | 789.70 | 237,699.70 |
| D/C Therapy – Agent Not Active Against Isolate | 109 | 646.48 | 70,466.32 |
| D/C Therapy – Culture Negative | 121 | 646.48 | 78,224.08 |
| Dose Optimization/Adjustment | 111 | 646.48 | 20,100.99 |
| Drug/Bug Information | 89 | 177.72 | 11,595.81 |
| Duration of Therapy Optimization | 72 | 110.65 | 46,546.56 |
| MRSA Notification/Education | 5 | 789.70 | 3948.50 |
| MDRO Notification/Education | 8 | 789.70 | 6317.60 |
| Optimize Therapy – Additional Agent | 240 | 789.70 | 155,155.20 |
| Optimize Therapy – Alternative Agent | 187 | 646.48 | 120,891.76 |
| Optimize Therapy – Asymptomatic Bacteriuria | 8 | 646.48 | 5171.84 |
| Patient Education | 394 | 789.70 | 311,141.80 |
| Public Health Department Treatment Review | 1 | – | – |
| Review Only – Appropriate Therapy | 8491 | – | – |
| STI Notification, Education, and Counseling | 187 | 789.70 | 147,673.90 |
| Well Check | 491 | 789.70 | 387,742.70 |
| Total ED Culture Review Interventions | 10,894 | – | |
| Total Cost Avoidance Interventions | 2402 | | 1,665,063.06 |

or caregivers to discuss the results and recommended plan of care. Review Only/Appropriate Therapy interventions are logged when culture results do not require any intervention from the ED pharmacist. Similar to ED Interventions, ED Outpatient Culture Review Interventions may have more than one documented intervention per encounter.

ED Discharge Antimicrobial Review Interventions are created when the EM pharmacist reviews an EM-pharmacy specific queue in the EMR which is generated upon any ED discharge with a new antimicrobial, antifungal, or antiviral prescription (Table 3). This queue became active September 1, 2020. The EM pharmacist staffing the index encounter site is responsible for determining the appropriateness of the therapy including drug, dose, interval, and duration. If a change is recommended by the EM pharmacist, they will consult with the prescribing provider and implement the agreed upon changes. Review of the discharge antimicrobial queue and logging of interventions are not required by the EM pharmacist, but are encouraged when time allows. Multiple interventions may be logged for single encounters similar to other ED interventions.

All cost avoidance data was applied to applicable interventions based on the work previously published by Hammond et al. except for one intervention related to stroke alert participation, in which cost avoidance was based on data published by Boudreau et al. [7,12]. While most interventions likely have a cost avoidance amount associated, if published data was not available, we chose not to include them in the cost avoidance portion of this analysis. Dollar amounts assigned to interventions were based on previously published pharmacist cost avoidance literature and were converted to 2021 US dollars if published prior to 2021. We chose to assign Allergy Clarifications/Updates the same dollar amount as Antimicrobial Stewardship interventions as the vast majority of allergy updates resulted in clarification or deletion of penicillin allergies, which ultimately resulted in increased cephalosporin utilization and decreased fluoroquinolone use and there are no published cost avoidance data for allergy clarifications. Pharmacist Stroke Alert cost avoidance literature varies with regards to published dollar amounts but typically only refer to cases in which thrombolytic therapy was administered. While we acknowledge pharmacist participation in stroke cases which do not receive thrombolytic therapy likely result in cost avoidance from assessing contraindications (and avoiding inappropriate thrombolysis), treating and monitoring elevated blood pressures, medication reconciliation, and bedside monitoring, we chose to focus on thrombolysis cases for cost avoidance. Data was pulled from Stroke Committee Databases at each center to determine the number of thrombolytic cases occurring during EM pharmacist hours. Cost avoidance for QTc monitoring was extrapolated as a Minor ADE Prevention. Although prolonged QT intervals increase the risk of Torsades-de-Pointes (a major ADE), previous literature has shown that between 1100 and 28,000 patients require QTc monitoring to prevent one case of Torsades-de-Pointes [13]. Therefore, we chose to use a cost avoidance comparison of Minor ADE Prevention ($407.72) as we felt the cost avoidance of a major ADE ($3516.09) was too high given the number of required monitoring interventions to avoid a major ADE [7]. In regards to Medication Selection interventions, previous literature has separated antibiotic and non-antibiotic medication recommendations with a fairly large difference in cost avoidance between the two, $646.48 and $176.80 respectively [7]. Given we did not have separate interventions for antibiotic or non-antibiotic Medication Selection, we chose a priori to review individual intervention comments to determine the proportion of antibiotic vs non-antibiotic interventions made. We will then assign a weighted average between $646.48 (antibiotic) and $176.80 (non-antibiotic)

**Table 3**
ED discharge antimicrobial review interventions.

| ED discharge antimicrobial review interventions | Number | Cost avoided per intervention (2021 USD, $) | Total cost avoidance (2021 USD, $) |
|---|---|---|---|
| D/C Medication | 12 | 181.09 | 2173.08 |
| Dose Optimization/Adjustment | 159 | 646.48 | 28,793.31 |
| Duration of Therapy Optimization | 82 | 646.48 | 53,011.36 |
| Optimize Therapy – Alternative Agent | 50 | 789.70 | 32,324.00 |
| Patient Education | 3 | 789.70 | 2369.10 |
| Retail Pharmacy Clarification or Communication | 17 | – | – |
| Review Only, Appropriate Therapy | 4325 | – | – |
| Total ED Discharge Antimicrobial Review Interventions | 4648 | – | |
| Total Cost Avoidance Interventions | 306 | | 116,497.77 |

based on those results to utilize for our cost avoidance analysis to reflect the proportion of antibiotic vs non-antibiotic interventions documented.

Cost avoidance dollar amounts of several ED Culture Review interventions fell under Antimicrobial Stewardship and Streamlining outcomes. Despite several interventions all falling under the same general category, we chose to report each one separately to provide more transparency on the specific types of interventions made by the EM pharmacy team. Several interventions including STI Notifications, BV results, and MRSA/MDRO Notifications include the EM pharmacist educating the patient about the significance of the result and how it may impact future health care encounters. As a result, cost avoidance data for Patient Education were applied to these interventions. Interventions for Critical Results and Well Checks were assigned a cost avoidance value based on literature regarding "culture review follow up after ED visit."

## 3. Results

### 3.1. Main results

A total of 23,794 interventions were logged by the EM pharmacy team during the study period with ED Culture Review Interventions being the most common (10,894), followed by ED Interventions (8252), and ED Discharge Antibiotic Interventions (4648; Tables 1, 2, and 3). The most frequent ED Interventions were Medication Selection (1443) and Dose Optimization or Adjustment (1251) which combined accounted for 71.5% of all ED Interventions. Among ED Culture Review Interventions, 8491 were logged as Review Only/Appropriate Therapy which made up 77.9% of all interventions logged in that category. Of the ED Culture review interventions requiring direct pharmacist involvement ($n = 2403$), the most common was Patient Education which accounted for 16.4% ($n = 394$). A total of 15,247 discharge prescriptions for an antimicrobial agent were identified during the study period and the EM pharmacy team logged 4648 interventions documenting review on approximately 30% of those prescriptions. The majority of interventions logged (4325) were on the review of appropriately prescribed discharge antimicrobials which accounted for 93% of the ED Discharge Antimicrobial Review Interventions. The most common Discharge Antimicrobial Intervention logged requiring pharmacist intervention was Dose Optimizations/Adjustment which made up 49.2% ($n = 159$) of ($n = 323$).

The EM pharmacy team logged 9181 cost avoidance interventions across the three categories which resulted in $5,350,755.63 in cost avoidance (Tables 1, 2, and 3). ED Intervention cost avoidance of $3,569,194.80 made up 68.1% of all costs avoided, with ED Outpatient Culture Review at 29.7% and ED Discharge Antimicrobial Review at 2.2%. The largest cost avoidance intervention was Sepsis Alert Chart Review which accounted for 22.1% of avoided costs in the ED Intervention category. In the ED Outpatient Culture Review category, Patient Education represented the largest amount of cost avoidance and accounted for 22.6% of all costs avoided. For the ED Discharge Antimicrobial Review category, Duration of Therapy Optimizations accounted for the largest portion of costs avoided at 45.6%.

Based on the 1443 Medication Selection interventions, 820 were associated with antimicrobial therapies, 346 were associated with non-antimicrobial medications, and 277 did not have specific medication orders associated within Epic. This proportion was confirmed to be consistent by utilizing a random sample of 100 of the 277 interventions without associated medication orders which were manually reviewed for comments and found to have a similar ratio of 70% antimicrobial to 30% non-antimicrobial. Using that information, we calculated a weighted average of $505.58 for Medication Selection cost avoidance and applied that to the 1443 logged interventions. The EM pharmacy team logged 301 Stroke Alert Participation interventions, and of those, 77 resulted in administration of thrombolysis and were included in the cost avoidance analysis. Intervention totals were stratified by location of the patient's index encounter with the hospital locations having numerically higher total logged interventions for all categories compared to the freestanding EDs (Fig. 1).

## 4. Discussion

Our data and analysis adds to the growing body of literature supporting the presence of dedicated EM pharmacists in the ED. While the patient centered outcomes of improved medication safety and medication utilization with direct pharmacist involvement have been extensively reported in the literature, only three studies have described the financial impact of EM pharmacist's work.

The first study published in 2007 by Lada et al. calculated the cost avoidance of four different interventions at a single academic teaching ED staffed 24 h a day by EM pharmacists. Over a four month period 1393 interventions were documented for a total cost avoidance of $1,359,730.47 (2021 USD) or $976.12 per intervention [6]. In 2009 Alridge et al. published results of cost avoidance interventions logged over a seven month period after the implementation of a ED pharmacy program at a Veterans Affairs teaching hospital. A total of 668 interventions spread over six categories were documented for a total cost avoidance of $1,077,339.11 (2021 USD) or $1612.78 per intervention [14]. This high dollar per intervention was due to Alridge et al. having a much higher dollar amount associated with their two most common interventions. For "Adjust dosage or frequency" Alridge calculated a cost avoidance of $1804 (2021 USD) compared to only $181.09 in our study and "Prevent or manage adverse drug event" was calculated at $2,106.76 (2021 USD) compared to only $407.72 in our study. These early publications highlighting the impact of EM pharmacists were helpful in their own right but only reported limited intervention categories. Newer publications have been more exhaustive in cataloging a wider variety of cost avoidance interventions and have shown significantly more impact than previous works.

The PHARM-EM study published by Rech et al. in 2021 reported the interventions of 88 EM pharmacists at 49 centers spread over 917 shifts. In total, 13,894 interventions were logged as "accepted" with a total potential cost avoidance of $7,531,862. Compared to our study, 80% of the pharmacists involved staffed at a teaching hospital, with the remainder representing a non-teaching community or government hospital. Additionally, pharmacists in PHARM-EM were much more likely to proactively log interventions given it was required to participate in the study whereas our interventions were completely voluntary. With regards to total cost avoidance, it is somewhat difficult to effectively compare our overall results to Rech's given the number of EM pharmacists participating with PHARM-EM was more than four-times the number of pharmacists in our group (88 vs 16), involved significantly more EDs (49 vs 5), and the data collection period was over 719 shifts compared to one year in our study. Furthermore, $750,789 in cost avoidance reported in PHARM-EM resulted from medication reconciliation interventions totaling approximately 10% of their overall cost avoidance compared to $0 reported in our study. Our hospital system has a strong team of pharmacy admission technicians who take responsibility for all admission medication reconciliations. These are not performed or checked by EM pharmacists except in rare circumstances and therefore were not included in the cost avoidance portion of our study. Overall, we logged 9181 cost avoidance interventions compared to 13,984 in PHARM-EM and had a very similar cost avoided per intervention of $582.21 vs $536.81, respectively.

While not performed in the ED, a 2019 study published by Hammond et al. assessed the cost avoidance after the addition of a clinical pharmacist to a 28-bed medical intensive care unit (MICU) at a tertiary academic medical center [15]. Similar types of interventions to our study were catalogued and analyzed utilizing the same cost avoidance metrics. A total of 8866 interventions were documented by one pharmacist in a 12-month period. Hammond attributed the high number

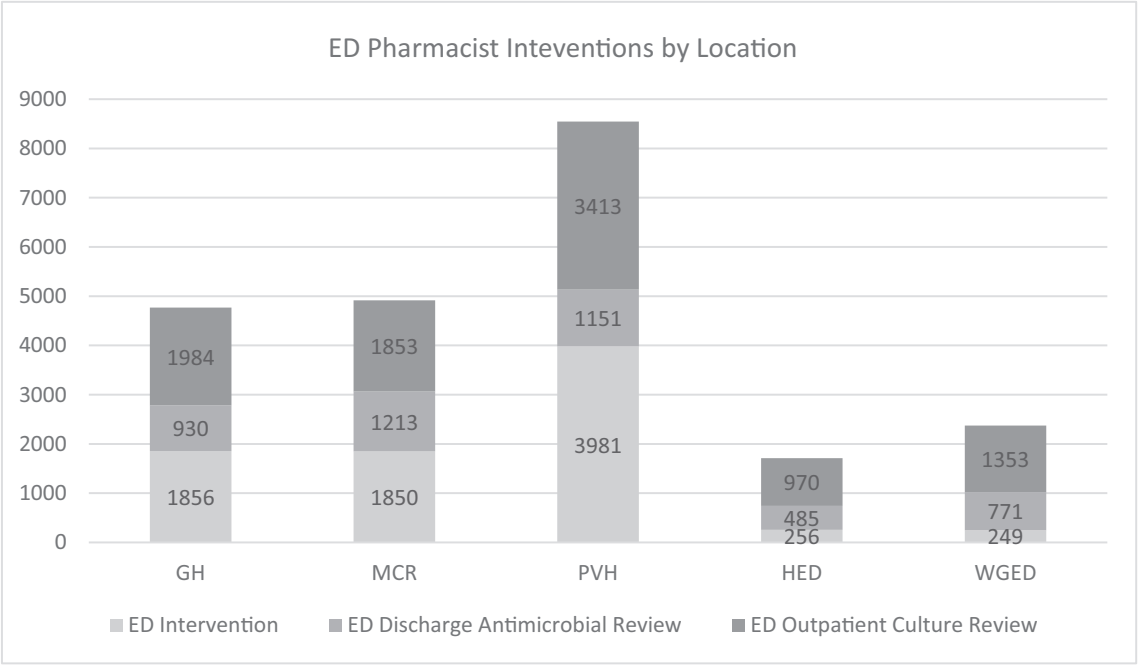


**Fig. 1.** ED pharmacist interventions by location.
GH = Greeley Hospital, MCR = Medical Center of the Rockies, PVH = Poudre Valley Hospital, HED = Harmony Freestanding ED, WGED = West Greeley Freestanding ED.

of interventions logged to the teaching model of the institution. Our practice sites lack this crucial interaction time and ability to provide more education to new interns and residents as they gain more autonomy given the fact we practice in community hospitals. Similar to the PHARM-EM study, the pharmacist in Hammond's study was more likely to be proactive with documentation of interventions versus the voluntary documentation seen by our group. Additionally, our study differs from Hammond's as interventions were logged by 16 EM pharmacists on 8 to 12 h shifts versus one pharmacist during weekday rounds lasting approximately 4 h. The total cost avoidance of Hammond's study was calculated to be $3,508,766.72 (2021 USD) or $395.76 per intervention.

In regards to discharge antimicrobial prescription review, Gregory et al. published a study analyzing all discharge prescriptions generated from an academic medical center ED and found errors in 16.5% of 115,993 prescriptions [16]. Antibiotic prescriptions made up approximately 25% of all discharge prescriptions analyzed but had a lower overall rate of errors at 3.1%.[16] While differences exist between our studies, if all cost avoidance interventions logged in our study were to be considered an error in the original prescription, our error rate is nearly double at 6.5% (306/4648) compared to Gregory et al. Our error rate may be skewed slightly higher given multiple cost avoidance interventions can be logged for a single prescription, the low overall rate of documentation among our group, and there is a higher likelihood of intervention documentation on a corrected issue than a prescription which required no intervention. Our results when combined with Gregory et al. highlight the need for timely review of discharge antimicrobial prescriptions to mitigate prescription errors in the ED.

There were several limitations with this study. Logging of interventions is completely voluntary, and 73% of our reported interventions were documented by only six of the 16 pharmacists included. This can be explained by differences in documentation habits and methods, as well as times EM pharmacists may be unable to log interventions due to workload and time constraints. Overall, the number of interventions reported very likely underrepresent the true number for the whole EM pharmacy team. Second, published cost avoidance data is limited and does not encompass all duties of EM clinical pharmacists which likely further underestimates the total impact of the EM pharmacy team. For stroke alerts in particular, previous publications focus on patients who receive thrombolytics and do not assess cost avoidance of inappropriate thrombolytic usage. EM pharmacists responded to 301 stroke alerts in this study; however, cost avoidance was only calculated for the 77 alerts in which thrombolytic therapy was given. EM pharmacists are a valuable resource to stroke teams assessing a patient's thrombolytic eligibility and contraindication criteria and are often relied upon in complicated cases. Therefore, true impact is likely greater than reported, but limited data exist to determine cost avoidance potential in cases where thrombolysis is not administered. Our team is based in community hospitals and freestanding emergency departments in Northern Colorado with lower frequency of high acuity triages than seen at academic and tertiary care centers. Our robust antimicrobial stewardship program, which has a large focus on patients discharged from the ED, skews our reported interventions toward those more common in ambulatory and outpatient settings with lower acuity and lower cost avoidance than some higher acuity interventions like cardiac arrest. Due to unforeseen delays, the ED Discharge Antimicrobial Review queue did not go live until two months into the data collection period and therefore the number of interventions logged only represented ten months of data compared to twelve months for the other categories. Lastly, our daily patient volume and workflows, and therefore opportunities for cost avoidance interventions, are potentially unique and may not be generalizable to all community-based EM pharmacy teams.

## 5. Conclusion

EM pharmacists practicing in community settings have a substantial impact on patients as evidenced by the large quantity and variety of interventions logged which also results in significant cost avoidance to the healthcare system. Additional research is warranted to determine cost avoidance data on more pharmacist interventions in the ED.

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## Declaration of Competing Interest

None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2022.01.054.

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