Received: 10 May 2022 | Revised: 3 June 2022 | Accepted: 3 June 2022

DOI: 10.1002/jac5.1671

CLINICAL PHARMACY RESEARCH REPORT

jaccp Journal of the American College of Clinical Pharmacy

The impact of a clinical pharmacist in an interprofessional intensive care unit recovery clinic providing care to intensive care unit survivors

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Funding information
university of michigan, m-cubed, Grant/Award Number: U065324-111281

Abstract

Introduction: Intensive care unit (ICU) survivors are vulnerable to further health deterioration and medication-related problems (MRPs) with a high rate of potentially preventable hospital readmissions and late death. Therefore, it is critical to identify MRPs of ICU survivors post-hospitalization. ICU-recovery clinics (ICU-RCs) have been proposed as a potential mechanism to address the unmet needs of ICU survivors, and pharmacists should be key members of ICU-RCs.

Objectives: The objective of this study was to evaluate the impact of a pharmacist in an interprofessional ICU-RC on MRPs.

Methods: A retrospective cohort study was conducted in adult ICU survivors with sepsis/septic shock and/or respiratory failure. This study compared MRPs within 6 months of post-hospital discharge between intervention and control groups. The intervention group included patients who were seen by a pharmacist in an ICU-RC. MRPs and interventions between initial and 6-month follow-up visits in the intervention group were also evaluated.

Results: Data were collected for 52 control and 52 intervention patients. There were no significant differences in baseline demographics and hospital characteristics between groups. Eighty-four MRPs were identified in the control vs 110 in the intervention group ($P = .37$). Half of patients in control and intervention groups had at least one MRP identified ($P = .69$). There was a significant decrease in mean number of MRPs at the 6-month follow-up visit (3.5 ± 1.7 with initial vs 2.4 ± 1.3 with follow-up visit; $P = .025$) in the intervention group. Almost all patients in initial and follow-up visits had at least one MRP.

Conclusions: Dedicated ICU-RC pharmacists in an interprofessional ICU-RC can assist with addressing and intervening on MRPs which could further impact clinical outcomes in ICU survivors.

KEYWORDS
critical illness, intensive care unit, intensive care unit recovery clinic, medication-related problems, pharmacist, post-intensive care syndrome

1 | INTRODUCTION

Over 5 million intensive care unit (ICU) hospital admissions occur every year in the United States, with readmission rates of 15% at 30 days, 26% at 90 days and 43% at 1 year.[1,2] ICU survivors frequently experience physical, cognitive, and psychiatric dysfunction, collectively termed post-intensive care syndrome (PICS).[3,4] In addition to PICS, ICU survivors are vulnerable to further health deterioration and medication-related problems (MRPs) with a high rate of potentially preventable hospital readmissions and late death.[5]

During critical illness and care transitions of ICU patients, medications are frequently titrated, adjusted, and discontinued in the setting of multifaceted pathophysiological and physiological changes (eg, hypotension and acute renal insufficiency). Inadvertent acute medication continuation (eg, antipsychotic used for acute delirium) and chronic medication discontinuation (eg, cholesterol or blood pressure medications) are common and have been found to directly contribute to hospital readmissions.[6,7] A recent multicenter, retrospective study (58 ICUs; N = 985) showed that approximately half of patients experienced medication errors (MEs) during care transitions from ICU to non-ICU locations which included medication continuation with ICU-only indication (28.4%), untreated condition (19.4%), and medication without indication (11.9%).[8]

ICU survivors face the risk of PICS, increased medication regimen complexity, new medical conditions, reduced physical, and/or cognitive function and increased responsibilities to self-manage their medications.[9] In addition, ICU survivors may present with complex medical conditions and medication regimens that require care of multiple specialties, and coordination of care is crucial to care for these patients to prevent readmissions, deterioration of their medical conditions, and MRPs. Therefore, it is critical to identify medical- and medication-related needs of ICU survivors after their hospitalization. ICU-recovery clinics (ICU-RCs) have been proposed as a potential mechanism to address the multifaceted unmet needs of ICU survivors, and pharmacists should be key members of ICU-RC staff.[10] ICU-RC pharmacists provide critical skill set to appropriately assess and intervene on potential MRPs, address PICS, and provide patient education on their medications and related issues. These pharmacists are uniquely poised to perform high quality comprehensive medication management (CMMs) and reconciliation of medications. These pharmacists are also key in providing recommendations related to ICU survivor's medication therapy and regimens. Recent retrospective data supports the presence of pharmacists to provide medication management.[11,12] Based on this evidence, the American College of Clinical Pharmacy (ACCP) Critical Care Practice Research Network (PRN) recommended that pharmacists should be involved in ICU-RCs and provided guidance in developing pharmacist services in ICU-RCs.[9] Overall, ICU-RC pharmacists are positioned to promote medication safety, efficacy and adherence.[3,9,11-15]

Currently, ICU-RCs services are available only in select settings and vary in their structure (eg, in-person clinics, telephone follow-up, home visits) and staffing (typically nurses, physiotherapists, or physicians).[16] To date, there is limited data on evaluating the impact of involving a pharmacist as a member of the interprofessional team on medication-related outcomes in ICU survivors.[11,12] Therefore, the objective of this study was to evaluate the impact of a pharmacist in an interprofessional ICU-RC on medication-related outcomes in ICU adult survivors.

2 | METHODS

This was a retrospective cohort study that assessed the impact of pharmacist involvement in an interprofessional ICU-RC on medication-related outcomes in adult (≥18 years old) ICU survivors compared to control. Adult ICU survivors with sepsis/septic shock and/or respiratory failure who were seen in the ICU-RC at a single academic medical center between March 6, 2018 and March 6, 2020 were included in the intervention group. The historical control group included adult ICU survivors admitted between March 1, 2015 and September 1, 2017 matched 1:1 by age, sex, and ICU diagnosis. This study was approved by the Institutional Review Board of the University of Michigan, which waived the need for written informed consent (HUM00159135).

The interprofessional post-ICU clinic (Michigan Medicine, Post ICU Longitudinal Survivor Experience [PULSE] clinic) involved a critical care physician, pharmacist, physical therapist, and social worker (https://med.umich.edu/cvc/pdf/UM-Pulse.pdf). The PULSE clinic patient criteria included only adult ICU survivors with sepsis/septic shock and/or respiratory failure. The ICU-RC pharmacist is a critical care trained pharmacist that has ambulatory care experiences. More details on the development and implementation of ICU-RC pharmacist services is provided by a recent paper by Mohammad et al.[9] The clinic occurred twice a month and each patient would be seen in person by each member of the interprofessional clinic team. Patients had various assessments throughout their visit, which included, but not limited to, pulmonary function tests, mental health assessments (ie, Patient Health Questionnaire [PHQ]-9), cognitive assessments (ie, Montreal Cognitive Assessment [MOCA]), comprehensive medication reviews and management, and physical and social assessment. The ICU-RC pharmacist conducted medication reconciliation and CMM for each patient during their initial and 6-month follow-up visits. Tools used during the ICU-RC pharmacist assessment included standardized note and medication reconciliation templates, medication adherence

assessment tool (MAAT), and CMM questionnaire. The CMM is a thorough assessment of patient's medication-related needs, evaluation of patient's medication therapy by optimizing therapy (eg, identifying and addressing MRPs, assessing efficacy and safety of each medication, assessing medication-taking behaviors), development and implementation of a care plan in collaboration with the patient and their providers, and performance of follow-up evaluations and provide medication monitoring plans.[17] The MAAT is a standardized, validated tool that systematically assesses (a) medication access, (b) medication knowledge, (c) medication adverse drug events (ADEs), and (4) medication-taking behaviors.[18]

MRPs were categorized as: (a) indication-related, (b) cost-related, (c) effectiveness-related, (d) safety-related, (e) need for assessment/monitoring, (6) knowledge-related, (f) adherence-related, and (g) worsening patient condition. MRPs were further categorized based on therapeutic and drug-related categories. Therapeutic-related categories were considered indications of the drugs (ie, cardiology, endocrinology) and drug-related categories were considered drug class (ie, allergy, pain). MRPs were identified through chart review of outpatient notes and communications in both intervention and control groups. A detailed tool (see Table A1 in Appendix) defining the MRPs categories was used to collect the MRPs in both groups.[19] This approach allowed for consistency related to identifying MRPs and data collection.

Medication-related interventions were also collected and categorized as the following: (a) medication changes, (b) ADE review/information provided, (c) drug interaction (DI) review/information provided, (d) lab monitoring, (e) patient education provided, (f) coordination of care, (g) provider review request, and (h) other. The interventions were identified through chart review of the ICU-RC pharmacist notes during the patient encounter in the ICU-RC for both initial and 6-month follow-up visits. Table A2 includes the tool used to identify and collect medication-related interventions in only the intervention group, which defines the medication-related interventions categories further. In addition, data collected in both groups included demographics, patient and hospital characteristics, and the Charlson

TABLE 1 Demographics and hospital information between the control and intervention groups

Description	Control (n = 52)	Intervention (n = 52)	*P*-value
Age (years), mean ± SD	55.8 ± 16.0	53.3 ± 15.3	.44
Sex, male, n (%)	23 (44.2%)	26 (50.0%)	.69
Hospital length of stay (days), mean ± SD	22.46 ± 39.8	25.58 ± 36.4	.44
ICU length of stay (days), mean ± SD	13.12 ± 37.2	16.67 ± 37.4	.28
Race, n (%)			
White	47 (90.4%)	46 (88.5%)	>.99
Black	4 (7.7%)	5 (9.6%)	
Asian	1 (1.9%)	0 (0%)	
Unknown	0 (0%)	1 (1.9%)	
Type of ICU admission, n (%)			
Medical ICU	50 (96.2%)	44 (89.8%)	.41
Other	2 (3.8%)	5 (10.2%)	
Primary ICU diagnosis, n (%)			
Acute respiratory failure	28 (53.8%)	35 (67.3%)	.28
Septic shock	23 (44.2%)	22 (42.3%)	.67
Sepsis	5 (9.6%)	1 (1.9%)	.20
Other	8 (15.4%)	9 (17.3%)	>.99
Mechanical ventilation, n (%)	46 (88.5%)	44 (84.6%)	.77
Invasive	38 (82.6%)	41 (93.2%)	.20
Duration of mechanical ventilation (days), mean ± SD	10.0 ± 12.3	12.7 ± 24.8	.25
Discharge destination, n (%)			
Home	25 (48.1%)	32 (64.0%)	.15
Facility	25 (48.1%)	18 (36.0%)	
Hospice	2 (3.8%)	0 (0%)	
Number of medications at discharge, mean ± SD (range)	13.9 ± 6.1 (3-35)	13.0 ± 6.4 (1-24)	.48
Renal replacement therapy use, n (%)	8 (15.4%)	9 (17.3%)	>.99
Charlson comorbidity index, mean ± SD	5.0 ± 3.7	4.0 ± 3.1	.17

Abbreviations: ICU, intensive care unit; LOS, length of stay.

TABLE 2 Comparison of MRPs identified within 6 months post-hospital discharge between intervention and control groups

Description, n (%)	Control (n = 52)	Intervention (n = 52)	*P*-value
Total number of MRPs identified	84	110	–
Mean number of MRP per patient, mean ± SD	1.6 ± 2.3	2.1 ± 2.8	.37
Percentage of patients with any MRP	26 (50%)	29 (55.8%)	.69
Type of MRP per patient, n (%)			
Indication (or drug selection)	7 (13.5%)	9 (17.3%)	.79
Cost	0 (0%)	0 (0%)	>.99
Effectiveness	8 (15.4%)	9 (17.3%)	>.99
Safety	15 (28.8%)	16 (30.8%)	>.99
Overdosage	5 (9.6%)	0 (0%)	.057
Drug interaction	3 (5.8%)	7 (13.5%)	.32
Adverse drug event	11 (21.2%)	11 (21.2%)	>.99
Need for assessment/monitoring	4 (7.7%)	9 (17.3%)	.23
Knowledge	0 (0.0%)	2 (3.8%)	.49
Adherence	10 (19.2%)	9 (17.3%)	>.99
Worsening patient condition	12 (23.1%)	16 (30.8%)	.51
MRPs therapeutic category per patient (indication), n (%)			
Liver	4 (7.7%)	2 (3.8%)	.68
Cardiology	9 (17.3%)	11 (21.2%)	.80
Dermatology	0 (0.0%)	1 (1.9%)	>.99
Electrolyte/Fluid	1 (1.9%)	1 (1.9%)	>.99
Endocrinology	2 (3.8%)	4 (7.7%)	.68
Ear/Nose/throat	2 (3.8%)	2 (3.8%)	>.99
Gastroenterology	2 (3.8%)	1 (1.9%)	>.99
General health	2 (3.8%)	6 (11.5%)	.27
Hematology	0 (0.0%)	4 (7.7%)	.12
Oncology	2 (3.8%)	0 (0.0%)	.49
Infectious disease	1 (1.9%)	6 (11.5%)	.11
Mental Health	1 (1.9%)	6 (11.5%)	.11
Neurology	3 (5.8%)	4 (7.7%)	>.99
Pain	5 (9.6%)	5 (9.6%)	>.99
Renal	2 (3.8%)	1 (1.9%)	>.99
Respiratory	3 (5.8%)	1 (1.9%)	.62
Rheumatology	1 (1.9%)	1 (1.9%)	>.99
Sleep disorder	5 (9.6%)	4 (7.7%)	>.99
Transplant	0 (0.0%)	1 (1.9%)	>.99
Other	1 (1.9%)	1 (1.9%)	>.99
MRPs drug category per patient (drug-involved), n (%)			
Allergy	1 (1.9%)	1 (1.9%)	>.99
Cardiology	9 (17.3%)	12 (23.1%)	.63
Endocrinology	4 (7.7%)	6 (11.5%)	.74
Gastroenterology/liver	4 (7.7%)	2 (3.8%)	.68
General health	2 (3.8%)	5 (9.6%)	.44
Hematology/oncology	2 (3.8%)	6 (11.5%)	.27
Infectious disease	3 (5.8%)	6 (11.5%)	.49
Mental health	5 (9.6%)	6 (11.5%)	>.99
Neurology	2 (3.8%)	4 (7.7%)	.68

TABLE 2 (Continued)

Description, n (%)	Control (n = 52)	Intervention (n = 52)	*P*-value
Pain	4 (7.7%)	5 (9.6%)	>.99
Renal/electrolyte/fluid	1 (1.9%)	1 (1.9%)	>.99
Respiratory	1 (1.9%)	0 (0.0%)	>.99
Other	3 (5.8%)	4 (7.7%)	>.99

Abbreviation: MRP, medication-related problem.

TABLE 3 Comparison of interventions and MRPs identified during the clinic visit between initial visit and follow-up visit in the intervention group

Description	Initial visit (n = 23)	Follow-up visit (n = 23)	*P*-value
Total number of medication interventions, n	60	45	
Percentage of patients with any medication intervention, n (%)	23 (100%)	21 (91.3%)	.48
Mean number of medication interventions per patient, mean ± SD	3.5 ± 1.7	2.4 ± 1.3	.025
Number of interventions related to recent hospitalization, n (%)	20 (87.0%)	12 (52.2%)	.027
Mean ± SD	1.8 ± 1.5	0.7 ± 0.9	.002
Number of interventions related to other medical problems, n (%)	17 (73.9%)	18 (78.3%)	>.99
Mean ± SD	1.7 ± 1.6	1.5 ± 1.3	.64
Type of intervention per patient, n (%)			
Medication changes	17 (73.9%)	12 (52.2%)	.13
Adverse drug reaction review/information provided	4 (17.4%)	8 (34.8%)	.39
Drug interaction review/information provided	4 (17.4%)	6 (26.1%)	.72
Lab monitoring	7 (30.4%)	2 (8.7%)	.13
Patient education provided	21 (91.3%)	19 (82.6%)	.68
Coordination of care	17 (73.9%)	13 (56.5%)	.42
Provider review request	16 (69.6%)	11 (47.8%)	.27
Other	2 (8.7%)	1 (4.3%)	>.99
Total number of MRPs identified	162	98	
Percentage of patients with any MRP	23 (100%)	21 (91.3%)	.48
Mean number of MRP per patient, mean ± SD	3.5 ± 1.7	2.4 ± 1.3	.025
MRPs therapeutic category per patient (indication), n (%)			
Liver	1 (4.3%)	2 (8.7%)	>.99
Cardiology	9 (39.1%)	10 (43.5%)	>.99
Dermatology	0 (0.0%)	1 (4.3%)	>.99
Drug–drug interaction	0 (0.0%)	1 (4.3%)	>.99
Electrolyte/fluid	3 (13.0%)	0 (0.0%)	.25
Endocrinology	5 (21.7%)	1 (4.3%)	.13
Gastroenterology	4 (17.4%)	2 (8.7%)	.62
General Health	7 (30.4%)	5 (21.7%)	.75
Hematology	1 (4.3%)	0 (0.0%)	>.99
Infectious disease	2 (8.7%)	0 (0.0%)	.48

(Continues)

TABLE 3 (Continued)

Description	Initial visit (n = 23)	Follow-up visit (n = 23)	*P*-value
Mental health	10 (43.5%)	7 (30.4%)	.45
Neurology	2 (8.7%)	1 (4.3%)	>.99
Pain	3 (13.0%)	2 (8.7%)	>.99
Renal	2 (8.7%)	1(4.3%)	>.99
Respiratory	5 (21.7%)	2 (8.7%)	.25
Rheumatology	1 (4.3%)	0 (0.0%)	>.99
Sleep disorder	4 (17.4%)	8 (34.8%)	.29
Other	2 (8.7%)	2 (8.7%)	>.99
MRPs drug category per patient (drug-involved), n (%)			
Allergy	0 (0.0%)	1 (4.3%)	>.99
Cardiology	6 (26.1%)	9 (39.1%)	.50
Endocrinology	5 (21.7%)	4 (17.4%)	>.99
Gastroenterology/liver	5 (21.7%)	4 (17.4%)	>.99
General health	9 (39.1%)	3 (13.0%)	.15
Hematology/oncology	5 (21.7%)	2 (8.7%)	.45
Infectious disease	2 (8.7%)	0 (0.0%)	.48
Mental health	9 (39.1%)	3 (13.0%)	.04
Neurology	1 (4.3%)	2 (8.7%)	>.99
Pain	5 (21.7%)	5 (21.7%)	>.99
Renal/electrolyte/fluid	3 (13.0%)	0 (0.0%)	.25
Respiratory	3 (13.0%)	1 (4.3%)	.62
Other	1 (4.3%)	1 (4.3%)	>.99

Abbreviation: MRP, medication-related problem.

comorbidity index. Note template, CMM questionnaire, and MAAT tool are included in Tables A3-A5.

The primary outcome included the number of MRPs within 6 months of post-hospital discharge in the intervention and control groups. Secondary outcomes included MRPs and interventions between initial and 6-month follow-up visits in the intervention group; and number and type of MRPs in both the intervention and control groups.

Descriptive statistics (means, SDs, counts, percentages) were used to describe patient and hospital characteristics, MRPs, and interventions. Fisher's exact test was used in comparing independent categorical variables. When the categorical variables were repeated, McNemar's test was used to control for the correlation within subjects. Negative binomial regression was used to compare numeric MRPs between the intervention and control groups. Negative binomial regressions are a generalized linear model (glm) designed for count data outcomes. They are designed with a scale parameter used in estimating overdispersion, which is not accounted for in a Poisson regression. Repeated measures negative binomial regression was used to compare MRPs and interventions within the intervention group (initial and 6-month follow-up visits). The repeated measures analysis accounted for the correlation between results within subjects. The a priori level of significance was $P < .05$ and the R statistical software, version 4.4.1 (Vienna, Austria) was used for analysis.

3 | RESULTS

One-hundred and four patients were included in the study (52 in the intervention group and 52 in the control group). Table 1 summarizes the demographics and characteristics of both groups. There were no statistically significant differences in patient demographics and hospital characteristics between the control and intervention groups. The mean age was 55.8 ± 16.0 in the control group vs 53.3 ± 15.3 in the intervention group ($P = .44$), 44.2% vs 50% were male ($P = .69$), and most were Caucasian (90%) ($P > .99$). The mean Charlson comorbidity index (5.0 ± 3.7 in the control group vs 4.0 ± 3.1 in the intervention group; $P = .17$), mean hospital (22.5 ± 39.8 vs 25.6 ± 36.4; $P = .44$) and ICU (13.1 ± 37.2 vs 16.7 ± 37.4; $P = .28$) length of stay, type of ICU admission (most common was medical ICU at approximately 90%; $P = .41$) and primary ICU diagnosis (most common was septic shock and acute respiratory failure; $P > .1$) were similar in both groups.

There were 84 MRPs identified within 6-month post-hospital discharge (mean MRP per person: 1.6 ± 2.3) in the control group compared to 110 MRPs (mean MRP per person: 2.1 ± 2.8) in the intervention group ($P = .37$) (see Table 2). Half of patients in the control and 55.8% in the intervention group had at least one MRP identified ($P = .69$). The most common MRP identified in both groups were safety-related (28.8% in the control group vs 30.8% in the intervention group; $P > .99$), worsening patient condition (23.1% vs 30.8%;

$P = .51$), adherence-related (19.2% vs 17.3%; $P > .99$), effectiveness-related (15.4% vs 17.3%; $P > .99$), and indication-related (13.5% vs 17.3%; $P = .79$). The most common safety-related problems were due to ADEs (21.2% in each group; $P > .99$) and excessive drug dosing (overdosage) (9.6% in the control group vs 0% in the intervention group; $P = .057$). The most common therapeutic category associated with MRPs included cardiology (17.3% in the control group vs 21.2% in the intervention group; $P = .80$), followed by general health (vaccination and herbals) (3.8% vs 11.5%; $P = .27$), infectious disease (1.9% vs 11.5%; $P = .11$) and mental health (1.9% vs 11.5%; $P = .11$). The most common drug categories associated with MRPs were cardiology (17.3% in the control group vs 23.1% in the intervention group; $P = .63$), followed by mental health (9.6% vs 11.5%; $P > .99$), endocrinology (7.7% vs 11.5%; $P = .74$), infectious disease (5.8% vs 11.5%; $P = .49$), pain (7.7% vs 9.6%; $P > .99$) and hematology/oncology (3.8% vs 11.5%; $P = .27$).

Table 3 summarizes the results comparing interventions and MRPs identified during the clinic visit between the initial and 6-month follow-up visits. There was a statistically significant decrease in the mean number of interventions and MRPs identified at the 6-month follow-up visit (3.5 ± 1.7 with initial visit vs 2.4 ± 1.3 with follow-up visit for both interventions and MRPs; $P = .025$). Almost all patients in the initial and follow-up visit had at least one intervention done and MRP identified during the clinic visit. There was a statistically significant decrease in the percentage of patients with interventions related to recent hospitalization between the initial and follow-up visits (87.0% vs 52.2%; $P = .027$). There were no statistically significant differences in the type of intervention and therapeutic/drug category related to the MRP between the initial and follow-up visits, except for mental health drug category related to MRPs (39.1% vs 13.0%; $P = .04$). The most common interventions included patient education (91.3% with initial visit vs 82.6% with follow-up visit; $P = .68$), coordination of care (73.9% vs 56.5%; $P = .42$), medication changes (73.9% vs 52.2%; $P = .13$) and provider review request (69.6% vs 47.8%; $P = .27$). The most common therapeutic and drug categories related to MRPs included mental health, cardiology, and general health.

4 | DISCUSSION

This study is the first study to report on the prevalence of MRPs in ICU survivors in the ICU-RC compared to matched controls. This study also assessed the impact of an ICU-RC pharmacist involvement on MRPs and interventions in ICU survivors at initial and 6-month follow-up visits. These findings support the benefits of a pharmacist in ICU-RC which may improve patient outcomes for ICU survivors.

Several studies have shown that pharmacist involvement in the interprofessional ICU-RC team resulted in pharmacy intervention in approximately 70% to 100% of ICU survivors.[11,12] One study showed that of those pharmacy interventions, approximately 86% were classified as clinically significant.[11] Another study further categorized pharmacy interventions with the most common included medications stopped (39%), new medications started (32%), ADEs identified (16%), ADE preventive measures implemented (32%), and vaccination administrated (27%).[12] This study is the first study that compares pharmacy interventions between initial and 6-month follow-up visits. Similar to prior work, this study showed that all patients had at least one pharmacy intervention at the initial visit.[12] Of note, 91.3% of patients had at least one pharmacy intervention at the 6-month follow-up visit. At initial visit, the mean number of medication interventions was 3.5 ± 1.7 per patient. This study found a statistically significant reduction of pharmacy interventions between initial and 6-month follow-up visits ($P = .025$). This reduction suggests that pharmacy interventions at the initial visit may be effective in addressing MRPs. In addition, these results suggest that there were still MRPs identified at the follow-up visit, which stresses the importance of pharmacist involvement during follow-up visit. This study showed similar types of interventions reported in other studies with the most common interventions being patient education, coordination of care, and medication changes.[11,12]

This study identified 162 MRPs in the intervention group at the initial visit and all patients at initial visit had at least one MRP. The most common drug categories associated with MRPs included cardiology, followed by mental health, endocrinology, infectious disease, pain, and hematology/oncology. In addition, this study is the first to show a statistically significant reduction in the mean number of MRPs per patient (3.5 vs 2.4; $P = .025$) between initial and 6-month follow-up visits. As for MRPs, one recent study ($n = 183$) identified 171 medications associated with a MRP out of 1216 medications, and a total of 198 MRPs identified.[11] The most common drug categories associated with MRPs included neurological drugs, which included analgesic and psychiatric medications, followed by cardiovascular, gastrointestinal, and nutritional medications. Combined, these results show that pharmacy interventions addressing these MRPs may be effective at reducing MRPs in ICU survivors after the initial visit.

The needs of ICU survivors are broad and include medication optimization, addressing physical function and psychological needs, coordination of care, and other interventions that may help improve patient recovery, and reduce the rate of preventable readmissions.[5] Unfortunately, there is limited data showing the impact of ICU-RC pharmacist involvement on MRPs compared to controls. This study is the first to compare MRPs between intervention and control groups. This study did not show a statistically significant difference in MRPs between the intervention and control groups; however, these results may be limited by the retrospective nature of this study. These results show that pharmacist involved in an ICU-RC may help improve medication-related outcomes in ICU survivors.

The strengths of this study include having a matched comparative group, and assessment of MRPs. This study had several limitations which included its retrospective, observational, single-center study design. This was an observational study, and residual confounding, such as age, race, and sex, is possible. In addition, due to the retrospective nature of this study, it depends on the accuracy of documentation in the electronic medical record. This study was conducted in a single center; therefore, this study may not be fully generalized to the general population.

Despite these limitations, this study demonstrates that pharmacist involvement in an interprofessional ICU-RC is associated with decreased MRPs and need for medication-related interventions in ICU survivors after hospitalization. Overall, pharmacists in ICU-RCs can play a critical role within the interprofessional team to promote education on PICS, improve medication adherence, facilitate appropriate referrals to primary care physicians and specialists, ensure CMMs and medication reconciliation, provide assessment of inappropriate and appropriate medications after hospitalization, address ADEs, MEs, and DIs, promote preventive measures, and facilitate medication acquisition and logistics with the goal of improving patient outcomes and reducing healthcare system costs.[9]

5 | CONCLUSION

Dedicated ICU-RC pharmacists who are part of an interprofessional ICU-RC can assist with addressing and intervening on MRPs which could further impact clinical outcomes in ICU survivors. Future, large, multi-centered studies are needed to evaluate the impact of ICU-RC pharmacist involvement in ICU-RC on MRPs, interventions, and clinical outcomes.

ACKNOWLEDGEMENTS

This work was supported by the University of Michigan Interprofessional Exchange (IP-X) Research Stimulus grant, Ann Arbor, MI [grant number U065324-111281].

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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How to cite this article: Mohammad RA, Eze C, Marshall VD, et al. The impact of a clinical pharmacist in an interprofessional intensive care unit recovery clinic providing care to intensive care unit survivors. *J Am Coll Clin Pharm*. 2022;5(10):1027-1038. doi:10.1002/jac5.1671

APPENDIX A

TABLE A1 Medication-related problems categories

- Type of MRP
  - Indication (or drug selection)
    - Untreated medical problem (H/S[19] untreated indication)
    - No indication for medication prescribed (H/S[19] drug use without indication)
    - Treatment not optimal based on current evidence/guidelines (H/S[19] improper drug selection)
    - Dosage form is not reasonable for patient
    - Drug not available in prescribed strength/patient did not receive medication (H/S[19] failure to receive drug)
  - Cost
    - Nonformulary/not cost-effective drug choice
  - Effectiveness
    - Drug dose not adequate for treatment goals (dose, interval, duration) (H/S[19] Subtherapeutic Dosage)
  - Safety
    - Drug dosing excessive for treatment goals (goals, interval, duration-provider overprescribing) (H/S[19] overdosage)
    - Polypharmacy
    - Duplication
    - Adverse drug reaction (H/S[19] adverse drug reaction)
    - Drug interaction (H/S[19] drug interaction)
    - Inappropriate monitoring
    - Incomplete/improper instructions
  - Need for assessment/monitoring
  - Knowledge
    - Need for information (includes patient/family concerns)
  - Adherence
    - Non-adherence to medication
    - Inadequate patient self-management of lifestyle and other non-drug variables
    - No follow-up appointment with provider
    - Pill burden
  - Worsening patient condition
  - Other
- MRPs therapeutic category (indication)
  - Liver
  - Cardiology
  - Dermatology
  - Drug-drug interaction
  - Electrolyte/fluid
  - Endocrinology
  - Ear/nose/throat
  - Gastroenterology
  - General health
    - Nutrition
    - Vaccination
    - Nicotine dependence
    - Over-the-counter
    - Herbals
    - Other
  - Hematology/oncology
  - Infectious disease
  - Mental health
    - Anxiety
    - Depression
    - Alcoholism
    - Substance abuse
    - Bipolar disorder
    - Other
  - Neurology
  - Pain
  - Renal
  - Reproductive
  - Respiratory
  - Rheumatology
  - Sleep disorder
  - Transplant
  - Other
- MRPs drug category
  - Allergy
  - Cardiology
  - Dermatology
  - Endocrinology
  - Gastroenterology/liver
  - General health
    - Nutrition replacement
    - Herbal supplements
    - Vitamins/minerals
    - Vaccine
    - Other
  - Hematology/oncology
  - Infectious disease
  - Mental health
  - Neurology
  - Pain
  - Renal/electrolyte/fluid
  - Respiratory
  - Other

Abbreviations: H/S, Hepler and Strand; MRP, medication-related problem.

TABLE A2 Medication-related intervention categories

Type of intervention/recommendation
Medication changes
Start medication
Stop medication
Change medication
Adjust dose
Adjust interval
Adverse drug reaction review/information provided
Drug interaction review/information provided
Lab monitoring
Patient education provided
Medication related
Care related
Appointment related
Smoking cessation
Coordination of care
Refer to other services
Made/requested appointment
Outreach to pharmacy
Communication of information to provider
Refills
Other
Provider review request
Symptom monitoring
Objective monitoring
Medication therapy
Other
Other

TABLE A3 Standardized note template

POST-ICU PHARMACY SERVICE:
Encounter date:
Supervising physician:
Subjective:

@NAME@ is a @AGE@ @GENDER@ was recently hospitalized from *** to *** for ***. The {patient/caregiver} was seen for a comprehensive medication review and Post-ICU evaluation. {Patient/Caregiver} states {he/she} {patient/caregiver} is doing {well/fairly well/poorly} since discharge.
Assessment/plan:

A comprehensive medication evaluation was conducted using patient's electronic medical record, patient's outpatient pharmacy and medication list provided by the {patient/caregiver}.
RECONCILED MEDICATIONS:

Pre-Hospital Medication List (DATE)	Hospital Discharge Medication List (DATE)	Current Outpatient Medication List (DATE)	Patient or MD Changes (Patient Added, Patient Omitted, Patient taking different dose, MD Omitted, MD Added, MD prescribing error)	Action (Medication List Changes) (Added, Stopped, Changed, Duplicate, Other)	COMMENTS

Allergies:
***
Reviewed medication regimen with {patient / caregiver} and identified the following:
- {Adherence}***
- Discrepancies found based on discussion with patient and # of changes made: ***
  Medications added: ***
  Medications stopped: ***
  Medications dose changed: ***
  Duplicate medications: ***
  Other (specify discrepancy type): ***
- Medication list was updated based on discrepancies above.

MEDICATION PROBLEMS AND INTERVENTIONS
PROBLEM
Assessment…
Recommendation/Plan…
POST-INTENSIVE CARE SYNDROME (PICS) ASSESSMENT
Patient was recently admitted to the hospital for ***. Patient was in the ICU from *** to ***. Patient was discharged home (OR FACILITY) on ***. Today, patient reports *** since hospital discharge. {His-Her} insomnia, anxiety (GAD score is ***), depression (PHQ-9 score is ***), EQ-5D-5L and PTSS scores {is/are} *** significant. {His-Her} *** score is ***, which is interpreted as ***. ***I discussed strategies to help the patient with {his-her} insomnia (ie, sleep hygiene) and recommended *** for sleep. ***I reviewed coping mechanisms to potentially help {his-her} depression/anxiety. ***I instructed patient to contact {his-her} primary care physician if {his-her} mental status worsens. I provided patient education on PICS. Patient verbalized understanding of information provided.
I discussed recommendations with multidisciplinary team.
I spent *** minutes assessing and educating the {patient / caregiver}.
Total Encounter Time (preparation and visit): *** minutes

TABLE A4 Medication adherence assessment tool (MAAT)[18]

1. How sure are you that you need medications to treat your health problems?
   - ☐ Very sure (0 points)
   - ☐ Somewhat sure (1 point)
   - ☐ Not sure at all (2 points)
2. How sure are you that you can take your medication every day as prescribed when you are at home?
   - ☐ Very sure (0 points)
   - ☐ Somewhat sure (1 point)
   - ☐ Not sure at all (2 points)
3. When you are at home, how often do you skip doses of your medication or stop taking your medications?
   - ☐ Very often (3 points)
   - ☐ Somewhat often (2 point)
   - ☐ Not often at all (1 points)
   - ☐ Never (0 point)
4. How difficult is it for you to pay for your medications?
   - ☐ Very difficult (2 points)
   - ☐ Somewhat difficult (1 point)
   - ☐ Not difficult at all (0 points)
5. How often do you experience adverse effects from your medications?
   - ☐ Very often (3 points)
   - ☐ Somewhat often (2 point)
   - ☐ Not often at all (1 points)
   - ☐ Never (0 point)

TABLE A5 Comprehensive medication review checklist

Pharmacist will interview patient/caregiver conduct medication assessment and education (***using checklist below***)

Pharmacist will conduct medication access and adherence tool (MAAT) survey and education

Pharmacist will follow-up with team for any medication-related problems identified

Pharmacist will document intervention(s) and any medication related problems identified in electronic health record (outpatient pharmacy note)

Medication Assessment and Plan Checklist

- ☐ Prior to interview, have these things available to you:
  - ☐ Patient's name, hospital discharge date, allergy list
  - ☐ Important follow-up clinical monitoring issues (eg, INR) from discharge note
  - ☐ Patient's discharge medication list
- ☐ Introduce yourself and remind the patient/caregiver the purpose of the interview
- ☐ Ask the patient/with caregiver's help to gather their medications or medication list for the interview
- ☐ Ask questions on the MAAT survey and identify any concerns about medication access; adherence-attitude; adherence-ability; adherence-finance; adherence-ADEs; ADEs; drug cost
- ☐ Ask about any medication changes since hospital discharge
- ☐ Ask the patient/with caregiver's help if they were able to fill any new medications from their hospital stay and if they have a supply of their medications that were continued

TABLE A5 (Continued)

- ☐ Ask the patient/with caregiver's help what OTC/herbal medications they are currently taking.
- ☐ With the discharge medication list in front of you, ask the patient to tell you (a) the name of each of their current prescription medications, (b) what dose they are taking, and (c) what they are taking it for. Check for any discrepancies
- ☐ Ask the patient/with caregiver's help about any medications that were on the discharge list that they did not mention
- ☐ If there are differences (eg, dose change, discontinued med) in the patient's medications prior to hospitalization vs at discharge, make sure the patient understands these changes and is currently taking the correct medicine and dose
- ☐ Ask the patient/with caregiver's help if they are experiencing any problems or side effects to any of their medications
- ☐ For medications with potentially serious safety concerns, make sure the patient/with caregiver's help knows what main side effects to look out for and knows what to do if they experience a side effect
- ☐ Ask the patient/with caregiver's help how many doses of their medications they missed since hospital discharge
- ☐ Ask the patient/with caregiver's help if they feel any of their medications have not helped or made things worse
- ☐ Provide any additional recommendations you have (eg, use of a pill box) to the patient
- ☐ Record any follow-up you need to make with other care providers
- ☐ Ask specific post-intensive care syndrome (PICS) and post-ICU-related questions, and other complications related to their critical illness

Abbreviation: ADEs, adverse drug events; ICU, intensive care unit; INR, international normalized ratio, OTC, over-the-counter.