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RESEARCH ARTICLE

Training students on the Pharmacist Patient Care Process using an electronic health record and simulations

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Abstract

Objective: To measure the impact of an electronic health record (EHR) and simulated physician encounters on student knowledge and skills related to the implementation phase of the Pharmacist Patient Care Process (PPCP). Secondary objectives were to measure students' self-perceived abilities.

Methods: Students enrolled in a therapeutics course worked-up patient cases within an EHR. Students entered orders/prescriptions into the computerised provider order entry (CPOE) platform. Faculty graded student work using a rubric. Students completed an instructor-developed pre-post attitudes survey and knowledge quiz.

Results: Two hundred students participated in this study and worked-up seven cases. Scores ranged from 67.7% to 88.2% on the case work-ups and 78.6% to 91.1% on the order/prescription-entry components. Individual scores on the quiz improved from 15.3/20 to 17.3/20 (p<0.001). Aggregate ratings on the attitudes survey increased from 23.2 to 31.0 (p<0.001).

Conclusion: Use of an EHR coupled with simulation was well-received and improved student understanding of the PPCP.

Keywords: *Computerised Provider Order Entry, Electronic Health Record, Pharmacist Patient Care Process, Simulation, Virtual Patient Cases*

Introduction

In 2014, the Joint Commission of Pharmacy Practitioners (JCPP) created the Pharmacist Patient Care Process (PPCP), which is a consistent model of patient care delivery across the profession (JCPP, 2014; Bennett *et al*., 2015). The PPCP must be incorporated into the pharmacy curricula as noted in the 2016 Accreditation Council for Pharmacy Education (ACPE) Standards (ACPE, 2015). The PPCP consists of five continuous phases: 1) collect pertinent subjective and objective data; 2) assess the patient using the data collected; 3) develop an individualised plan; 4) implement that plan; and 5) develop a follow up and monitoring plan. While these components are familiar to pharmacists involved in direct patient care, a deliberate effort must be made to introduce the PPCP to novice students (Boyce, 2017). Rivkin described a plan for introducing the PPCP in a systematic manner (Rivkin, 2016). This included understanding each component in relation to deconstructing a patient case, collecting data from a medication history, and finally documenting the plan using a SOAP (Subjective, Objective, Assessment, Plan) note. Rivkin provided important foundational information on the implementation of the PPCP in an introductory course focusing on the collect, assessment, and plan sections of the PPCP. Rebitch and colleagues described a case-based learning course that used video portrayal of patient cases and integrated the PPCP

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through question prompts throughout the module (Rebitch *et al*., 2017). This course was well received by students with statistically significant improvement in student performance on the plan, follow up, and total scores on disease state assessments. Both of these studies demonstrate the importance of early and deliberate integration of the PPCP into learning experiences to teach students how to systematically approach a patient case. However, some phases of the PPCP may be more challenging for students to comprehend and require more targeted training and practice. One example is the implementation step, which includes actions such as initiating, modifying, discontinuing, and administering medication therapy in collaboration with a healthcare provider. Rebitch and colleagues were unable to show statistical improvement in the implementation aspect of the PPCP (Rebitch *et al*., 2017). In the United States (US), most institutions have implemented the electronic health record (EHR) and computerised provider order entry (CPOE). Pharmacists must be able to use the EHR and verify/enter orders within the context of the PPCP. Skelley and colleagues used an electronic medical record simulation to expose students to EHR as well as to provide experience in the various steps of the PPCP. This study described an elective course, which used EHR simulations across three class sessions. Overall, authors noted positive changes in student attitudes and confidence (Skelley *et al*., 2018). Another important component of the implementation is collaboration within an inter-professional context. While there are several studies focusing on inter-professional teamwork and collaboration, a literature search did not result in any studies that focus on inter-professional communication as part of the PPCP. In general, there appears to be a paucity of studies that specifically focus on the implementation aspect of the PPCP. The primary objective of this current study was to measure the impact of using an EHR and simulated physician encounters on student knowledge and skills related to the implementation phase of the PPCP. Secondary objectives were to measure student ratings of their ability to perform select tasks related to the implementation phase of the PPCP.

Method

This study was approved by the institutional review board (IRB) at the University of the Pacific (the University) and informed consent was obtained. The University offers a three-year, accelerated Doctor of Pharmacy programme that consists of six semesters of didactic course work and two semesters of advanced pharmacy practice experiences (APPEs). The PPCP is introduced in the first semester and is used longitudinally across various skills and therapeutics courses. Introductory (1st year) skills courses focus on the collect and assess phase of the PPCP while advanced (2nd year) courses focus on the plan, implementation, and follow-up phases. The Therapeutics of Gastrointestinal diseases/ Hepatic diseases/Nutrition course is a required two-credit unit course divided into one hour of lecture and two hours of application-based discussion and is offered in the fourth semester of the Doctor of Pharmacy programme. This course was chosen for this pilot study as it is one of the first therapeutics courses of the curriculum and allows for more clinical coursework focusing on the implementation phase of the PPCP. Students enrolled in this course were eligible to participate in the study. This course used a team-based learning (TBL) format and the students were randomly assigned to teams of three or four and remained within those teams for the duration of the semester. The first lecture in the course was introductory and served to reinforce the components of the PPCP which were previously taught in foundational courses.

To facilitate application, virtual patient charts were developed in EHR Go, an educational EHR system. A PPCP template developed by course faculty was provided to students to standardise the patient work-up process (Figure I). The application portion of the course comprised of patient work-up by teams (90 minutes), team reporting (10 minutes), and discussion of the optimal plan (20 minutes). Patient charts were made available on EHR Go at least five days before each application session so that individual students could prepare ahead of their team-based discussions. During the application session, teams worked on the case and completed the PPCP template, which broke down the PPCP into each of its five steps. Each patient case was comprehensive and included therapeutic topics from previous coursework. In addition to working up any disease/disorder identified in each case, students were also instructed to assess any preventative care needs and lifestyle modifications, when applicable. Teams were required to verify or discontinue existing orders/ prescriptions and enter any new orders/prescriptions, in the CPOE portal within EHR Go. To aid in the understanding of the monitoring and follow-up piece of

Figure 1: Pharmacist Patient Care Process template

PHARMACIST PATIENT CARE PROCESS (PPCP)- Collect, Assess, Plan, Implement (occurs in the EHR), and Follow-up
Beverley Diaz

Problem/ Disease	Data Collected	Drug related problem (DRP) identified	Assessment of the DRP	Plan	Rationalize your pharmacologic plan. What alternatives could you recommend?	Implement ation	Follow-up

Figure II: Rubric for grading case work-up submissions

Criteria	Ratings				Pts
Collect	3.0 pts Excellent: Complete and concise summary of subjective/objective data	2.0 pts Competent: Partial (>80%) but accurate summary of pertinent information	1.0 pts Needs Improvement: Poorly organized or limited (50%-80%) summary of pertinent information	0.5 pts Not Acceptable: Grossly incomplete (<50%) or inaccurate or irrelevant information	3.0 pts
Assessment	6.0 pts Excellent: Assessment is optimal and thorough for each problem	4.0 pts Competent: Assessment is mostly (>80%) complete, accurate and appropriate	2.0 pts Needs Improvement: Assessment is partially (50-80%) complete, accurate and appropriate	1.0 pts Not Acceptable: Assessment is <50% complete or accurate and appropriate	6.0 pts
Plan	40.0 pts Excellent: Treatment plan (including drug name, strength, route, frequency, and duration of therapy) is specific, appropriate and justified for each problem	35.0 pts Competent: Treatment plan is mostly (>80%) complete, accurate and appropriate	25.0 pts Needs Improvement: Treatment plan is partially (50-80%) complete, accurate and appropriate	15.0 pts Not Acceptable: Treatment plan is <50% complete, accurate and appropriate	40.0 pts
Implementation	6.0 pts Excellent: Specific implementation strategies are outlined including edu points, referal plan, order/rx entry plan for each problem	4.0 pts Competent: Mostly (>80%) complete and appropriate	2.0 pts Needs Improvement: 50%-80% accurate and appropriate	1.0 pts Not Acceptable: Less than 50% accurate and appropriate	6.0 pts
Follow up/ Monitoring	3.0 pts Excellent: Specific monitoring parameters and follow up date are accurate for each problem	2.0 pts Competent: Mostly (>80%) complete and appropriate	1.0 pts Needs Improvement: Poorly organized or limited (50-80%) summary of pertinent information	0.5 pts Not acceptable: Grossly incomplete (<50%) or inaccurate or irrelevant information	3.0 pts
Patient harm	0.0 pts Error that caused death (0 on the full assignment)	0.0 pts Error that caused permanent harm (-10)	0.0 pts Error that caused temporary harm (-5)	0.0 pts No error but potential for harm (-2)	0.0 pts
					Total Points: 58.0

Figure III: Rubric for grading order-entry submissions

Criteria	Ratings				Pts
Drug sig, Drug, dose, route, freq, PRN indication, refills, quantity are provided	10.0 pts Excellent- 100% complete	7.0 pts Competent- 80-100%	3.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	10.0 pts
Appropriate Drug formulation chosen	6.0 pts Excellent (100% complete)	4.0 pts Competent- 80-100%	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
Appropriate Route	6.0 pts Excellent (100% complete)	3.0 pts Competent (80-100%)	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
Appropriate Frequency chosen	6.0 pts Excellent (100% complete)	4.0 pts Competent- 80-100%	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
Appropriate PRN indication provided	6.0 pts Excellent (100% complete)	4.0 pts Competent- 80-100%	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
Appropriate Auxiliary labels or RN instructions are provided	6.0 pts Excellent (100% complete)	4.0 pts Competent (80-100%)	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
PPCP and NEEHR Perfect order match	6.0 pts Excellent 100% of new rx/labs/discontinued meds. Everything matched PPCP and EHR are updated into EHR)	4.0 pts Competent (missing 1 rx) 80-100% of orders match PPCP	2.0 pts Needs improvement (missing 2 rx) or 50-80% match PPCP	1.0 pts Not acceptable (missing 3 or more rx) Less than 50% match PPCP	6.0 pts
For parenteral drug-appropriate diluent chosen	6.0 pts Excellent (100% complete)	4.0 pts Competent- 80-100%	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
For parenteral drug-rate provided in ml/hr or ml/min	6.0 pts Excellent- 100% complete	4.0 pts Competent- 80-100%	2.0 pts Needs Improvement (50-80%)	1.0 pts Not acceptable (<50%)	6.0 pts
Patient harm	0.0 pts Error but not likely to cause harm (-1)	0.0 pts Error that caused death (-10)	0.0 pts Error that could cause permanent harm (-5)	0.0 pts Error with minimal or temporary harm to the patient (-2)	0.0 pts
					Total Points: 58.0

the PPCP, students were informed that under protocol, they could order any relevant laboratory panels in the CPOE portal. Just prior to the team report, teams were instructed to upload their completed PPCP template and EHR CPOE document onto Canvas, which is the University's learning management system. Case work-up and EHR CPOE were worth 9% of the overall course grade. Students completed a total of seven cases in the EHR. Faculty members reviewed all seven cases and determined overall difficulty on a scale of easiest, middle, and hardest. Hardest cases were deemed to be those which featured hospitalised patients with multiple co-morbidities and requiring intravenous medications. Easiest cases were those which featured fewer co-morbidities and relatively few oral medications.

In addition to the in-class virtual patient cases, two simulated physician encounters were designed to facilitate student understanding of inter-professional collaboration within the context of the PPCP. For the first simulation, students were assigned an inpatient EHR case on an acute upper gastrointestinal bleed (UGIB) due to a gastric ulcer and were instructed to work-up the case individually with any resources they deemed fit. Within the patient's profile, the attending physician had already input certain medication orders. Some of those orders were either without any indication, not the optimal choice given the patient's presentation, or had dosing errors. Students were instructed to develop a plan and collaborate with the attending physician (standardised simulated actor) on the care of the patient. To provide a systematic approach to this collaboration, students were instructed to use the SBAR (Situation-Background-Assessment-Recommendation) technique and defend their recommendation if they encountered any resistance from the simulated physician (Institute for Healthcare Improvement, 2018). Each of these encounters lasted approximately 15 minutes, including five minutes of feedback from the 'physician' on the student's performance. For the second simulation, students were assigned a different inpatient EHR case focusing on complications related to cirrhosis. The format was similar to the first simulation; however for this case, students from the Master's of Physician Assistant (PA) programme served as the primary healthcare provider.

The assessment of student abilities was performed through grading of the PPCP work-up, SOAP notes, EHR CPOE, simulation encounters, pre- and post-quiz, and pre- and post-attitude survey. All student case work-up and CPOE documents were graded using a self-constructed grading rubric (Figure II and III). A total of ten faculty graders were assigned to provide feedback and grade student submissions each week. The case work-up rubric assessed student performance on each step in the PPCP and was utilised throughout semester. A

freeform comment section was built into the rubric to allow graders to provide targeted feedback on areas of improvement. The CPOE rubric assessed student performance on various aspects of order entry such as dose, signature, drug formulation, etc. On all rubrics, there was the option to deduct points for any errors that had the potential for patient harm. To assess the effectiveness of these activities on student knowledge regarding the PPCP, students completed an instructor-develop 20-question pre- and post-quiz on the various steps of the PPCP. Questions on the test were designed as short clinical vignettes outlining one step in the PPCP (or in the instance of Q1, a general question regarding the PPCP). Students were asked to determine which phase of the PPCP was highlighted in the vignette. At the beginning and end of the course, students also completed an attitudes survey to determine any changes in student self-perceived abilities to perform select tasks related to the implementation phase of the PPCP.

Data analysis

Pearson's correlation was utilised for the correlations on the team performance on the case work-up/EHR CPOE activities. Paired *t*-tests were used for the pre-post quiz. Statistical significance was defined as p-value < 0.05. To account for any differences in case difficulty from week to week, correlation with case difficulty was also performed. These calculations were performed using Excel. SPSS was used to perform Wilcoxon signed-rank tests to analyse the pre-post attitudes survey comparisons and a two-way ANOVA to determine impact of case sequence and case difficulty on student performance.

Results

A total of 201 students were enrolled in the course and completed all learning activities. One hundred and eighty-two students completed all surveys and quizzes which were deemed part of this study (overall response rate 90.5%). A total of 52 teams completed the seven cases, with mean percentage scores ranging from 67.7% to 88.2% on the case work-up components and from 78.6% to 91.1% on the EHR CPOE components (Table I and II). In general, case work-up component percentage scores increased as students completed more cases (r= 0.14; p=0.009), but scores decreased with more difficult cases (r= -0.19, p<0.001).

TABLE I: Student team performance on steps in the Pharmacist Patient Care Process (N=201)

Case Number	1	2	3	4	5	6	7
Case Difficulty*	Easiest	Easiest	Hardest	Hardest	Middle	Hardest	Middle
Mean Score	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Collect (3 pts)	1.6 (0.7)	1.9 (0.4)	2.3 (0.5)	2.3 (0.6)	2.6 (0.5)	2.6 (0.6)	2.7 (0.5)
Assess (6 pts)	3.3 (1.5)	4.0 (0.4)	4.5 (1.0)	4.2 (1.1)	4.9 (1.3)	4.4 (1.5)	4.7 (1.0)
Plan (40 pts)	29.2 (7.6)	37.1 (4.7)	33.9 (4.0)	32.7 (6.1)	30.4 (6.6)	28.7 (6.2)	35.6 (1.6)
Implement (6 pts)	3.5 (1.6)	5.5 (1.2)	4.7 (1.9)	4.6 (1.5)	5.0 (1.2)	4.7 (1.6)	5.5 (1.1)
Monitor/Follow-up (3 pts)	2.1 (0.9)	2.6 (0.6)	2.0 (0.4)	2.0 (0.6)	2.3 (0.6)	2.0 (0.7)	2.5 (0.5)
Patient Harm	0 (0)	0 (0)	1.6 (0.9)	0.2 (0.8)	0.1 (0.3)	0.9 (1.0)	0 (0)
Total Percent Score	**67.7 (16.9)**	**88.2 (8.7)**	**71.9 (10.7)**	**75.8 (14.5)**	**78.3 (12.8)**	**68.8 (16.2)**	**88 (4.8)**

SD = standard deviation; pts = points
*As deemed by faculty members

TABLE II: Student team performance on computerised Provider Order Entry (CPOE) components (N=201)

Case Number	1	2	3	4	5	6	7
Case Difficulty*	Easiest	Easiest	Hardest	Hardest	Middle	Hardest	Middle
Mean Score	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Oral Drug Sig (10 pts)	6.9 (2.9)	8.8 (1.5)	8.6 (1.5)	9.1 (1.4)	8.6 (1.8)	9.7 (0.9)	8.5 (1.7)
Drug Formulation (6 pts)	5.8 (0.7)	5.9 (0.4)	5.8 (0.6)	5.5 (0.9)	5.7 (0.7)	5.8 (0.6)	5.9 (0.4)
Route (6 pts)	5.8 (0.8)	6.0 (0)	5.9 (0.4)	5.9 (0.4)	5.8 (0.7)	5.8 (0.8)	5.9 (0.4)
Frequency (6 pts)	5.3 (1.1)	5.4 (1.0)	4.9 (1.0)	5.3 (1.0)	5.7 (0.7)	5.2 (1.1)	5.6 (0.9)
PRN drug indication (6 pts)	5.6 (1.3)	5.6 (1.0)	5.7 (1.0)	5.9 (0.5)	5.7 (0.8)	5.7 (0.7)	5.8 (0.7)
Auxiliary Label (6 pts)	4.6 (1.6)	4.8 (1.1)	5.0 (1.0)	5.1 (1.0)	5.0 (1.0)	4.7 (1.0)	5.1 (1.0)
IV Diluent chosen (6 pts)	NA	NA	4.6 (2.0)	4.9 (1.5)	NA	4.2 (1.0)	NA
IV Rate provided (6 pts)	NA	NA	3.0 (1.6)	5.1 (1.2)	NA	4.5 (1.1)	NA
Patient Harm	0.4 (0.6)	0.3 (0.6)	1.5 (1.8)	1.2 (1.4)	0.4 (0.8)	1.5 (1.7)	0.6 (1.1)
Total Percent (%) Score	**88 (7.4)**	**90.6 (6.9)**	**78.6 (10.3)**	**86.4 (9.8)**	**91.1 (7.1)**	**83.5 (9.3)**	**90 (6.3)**

SD = standard deviation; PRN = as needed; IV = intravenous; NA = not applicable; pts = points
*As deemed by faculty members

Table III: Correlation of student team performance on case work-up to case order and case difficulty (N=201)

	Correlation with case order		Correlation with case difficulty	
Item	***r***	***p*-value**	***r***	***p*-value**
Collect	0.53	<0.001	0.37	<0.001
Assess	0.31	<0.001	0.21	<0.001
Plan	-0.02	0.8	-0.10	0.06
Implement	0.22	<0.001	0.02	0.7
Follow-up/ Monitoring	0.04	0.47	-0.23	<0.001
Harm	0.02	0.68	0.47	<0.001
Total Case Work-up Score	0.14	0.01	-0.19	0.003

r = correlation coefficient

The EHR order entry total scores did not change with more cases (r=0.03, p=0.6), but were significantly lower with more difficult cases (r=-0.32, p<0.001) (Table III and IV).

TablesIV: Correlation of student team performance on order/prescription entry to case number and case difficulty (N=201)

	Correlation with case #		Correlation with difficulty	
Item	***r***	***p*-value**	***r***	***p*-value**
Oral Sig	0.25	<0.001	0.28	<0.001
Drug Formulation	0.01	0.80	-0.09	0.1
Route	-0.01	0.89	0.0	<0.001
Frequency	0.10	0.05	-0.12	0.03
PRN	0.06	0.29	0.06	0.28
Aux Label	0.08	0.11	0.09	0.1
IV Diluent	-0.15	0.06	NA	NA
IV Rate	0.33	<0.001	NA	NA
Patient Harm	0.1	0.06	0.35	<0.001
Total Order Entry score	0.16	0.002	0.58	<0.001
Percent Order entry Score	0.03	0.57	-0.32	<0.001

r = correlation coefficient; PRN = as needed; Aux = auxiliary; IV = intravenous; NA = not applicable

TABLE V: Individual student performance on the pre-activities and post-activities knowledge quiz (N=196)

Question Item*		Step in the PPCP process	Pre-activities Average-1 pt (SD)	Post-activities Average-1 pt (SD)	*p*-value
1.	Main steps in the PPCP	NA	0.90 (0.30)	0.98 (0.12)	<0.001
2.	Monitoring HgbA1c	Monitoring	0.94 (0.24)	0.94 (0.24)	<0.001
3.	Monitoring INR to determine if the warfarin dose is appropriate	Monitoring	0.87 (0.34)	0.84 (0.37)	0.34
4.	You instruct a nurse to draw the level of vancomycin	Implementation	0.43 (0.50)	0.91 (0.28)	<0.001
5.	You note patient's blood pressure is 170/90	Collect	0.72 (0.45)	0.82 (0.38)	0.01
6.	Write a SOAP note in your patient's chart	Implementation	0.00	0.11 (0.31)	<0.001
7.	Relay medication recommendations to the attending physician	Implementation	0.36 (0.48)	0.77 (0.42)	<0.001
8.	You note down that the patient does not have insurance	Collect	0.85 (0.36)	0.93 (0.25)	0.06
9.	You determine that the patient is hyperkalemic	Assessment	0.92 (0.28)	0.89 (0.31)	0.32
10.	Educate a patient how to use an inhaler	Implementation	0.78 (0.41)	0.88 (0.33)	0.01
11.	Enter new orders for IV ondansetron	Implementation	0.52 (0.50)	0.78 (0.41)	<0.001
12.	Follow-up call to see if pain is controlled	Monitoring	0.99 (0.10)	0.97 (0.17)	0.16
13.	Follow up visit to see if the medications are effective	Monitoring	0.97 (0.17)	0.93 (0.26)	0.021
14.	Schedule a referral to a nutritionist	Implementation	0.53 (0.50)	0.87 (0.34)	<0.001
15.	You decide that esomeprazole 40mg po daily is optimal for this patient	Plan	0.88 (0.33)	0.87 (0.34)	0.74
16.	Perform a physical exam on a patient	Collect	0.85 (0.36)	0.89 (0.31)	0.17
17.	Determine that the GERD is not being effectively controlled by calcium carbonate	Assessment	0.92 (0.28)	0.95 (0.22)	0.16
18.	Administer the flu vaccine	Implementation	0.91 (0.29)	0.96 (0.20)	0.03
19.	Patient has not yet had the flu vaccine. You note this down	Collect	0.99 (0.07)	0.99 (0.10)	0.57
24.	Patient mentions that she sometimes forgets to take her medications. You note that down in your notes	Collect	0.94 (0.23)	0.99 (0.10)	0.01
All (Total 20 points)			15.26 (2.00)	17.27 (1.76)	<0.001

* Not actual questions on the exam. Truncated for space.
Question Stem: Which part of the PPCP does this information lend itself to? Answer Choices included: a) Collect; b) Assessment; c) Adherence; d) Plan; e) Implementation; f) Medicine; g) Comprehend; h) Follow-up/monitoring
PPCP = Pharmacist Patient Care Process; SD = standard deviation; NA = not applicable; HgbA1c = hemoglobin A1c; INR = international normalised ratio; SOAP = subjective objective assessment plan; IV = intravenous; GERD = gastroesophageal reflux disease; pt = point

TABLE VI: Individual student ratings on the pre-activities and post-activities attitudes survey (N=182)

Survey Item	Pre Mean (SD)	Post Mean (SD)
Use the pharmacist patient care process to work-up a patient	2.94 (0.75)	3.35 (0.78)*
Navigate a patient chart in an EHR	2.53 (0.88)	3.40 (0.87)*
Review and verify outpatient prescriptions in an EHR	2.51 (0.93)	3.15 (0.82)*
Verify inpatient medication orders in a CPOE system	2.11 (0.91)	2.97 (0.83)*
Order new oral medications using CPOE	1.88 (0.88)	3.12 (0.84)*
Order new intravenous medications using CPOE	1.60 (0.76)	2.44 (0.82)*
Order new laboratory data to monitor drug therapy in an EHR	1.85 (0.83)	2.99 (0.81)*
Communicate medication recommendations to a physician	2.47 (0.91)	3.25 (0.81)
Convince a physician to change a patient's medication regimen based on your recommendations	2.14 (0.92)	3.06 (0.84)*
Total	**23.22 (6.01)**	**31.02 (6.21)***

Questions stem: What is your current level of confidence on the following items on a scale of 1 to 5 with being 5 = "Extremely confident"; 4 = "Very Confident"; 3 = "Confident"; 2 = "Slightly confident"; and 1 = "Not at all confident"
EHR = electronic health record; CPOE = computerised physician order entry; SOAP = subjective objective assessment and plan; SD = standard deviation
* Indicates a *p*-value of less than 0.05nt

As students completed more cases, team performance improved on collection, assessment, and implementation items in the case work-up component; on 'oral medication sig and intravenous rate' items in EHR CPOE component; and 'fewer errors which could have resulted in patient harm' on the case work-up component as well as the EHR CPOE components.

Individual student mean scores (n=196, response rate 97.5%) on the 20-point pre-post quiz showed statistically significant improvement from 15.3/20 (76.5%) on the pre-test to 17.3/20 (86.5%) on the post-test ($p<0.001$, Table V). Student performance improved on Q1 (general PPCP format), Q4 (monitoring), Q5 (implementation), Q6 (collect), Q7 (implementation), Q8 (collect), Q10 (implementation), Q11(implementation), Q13 (follow-up and monitoring), Q14 (implementation), Q18(implementation) and Q20 (collect) but worsened on Q13 (monitoring).

Individual composite ratings on the 10-item attitudes surveys (N=182, response rate 90.5%), using a 5-point Likert scale, increased from 23.2 to 31.0 on the pre- to post-attitudes survey ($p<0.001$, Table VI). The only item that did not show an increase was students' self-assessment of writing a SOAP note related to a patient's care (mean change +0.08, $p=0.25$). Mean ratings for the other nine self-assessment items increased by 0.42 to 1.24 points ($p<0.001$, Table VI). Of note, students felt more confident in the post-survey in making a recommendation to another healthcare provider (mean change +0.78, $p<0.001$).

Discussion

This study details one approach to integrate the PPCP into a therapeutics course and the outcomes associated with that approach. It also highlights the implementation aspect of the PPCP, which the authors perceive as the most difficult aspect for students to grasp. Student knowledge was enhanced through participation in the course as evidenced by improved quiz scores at the end of the course, including on those questions that were specific to implementation. Student performance decreased on a question related to monitoring, but it is unclear why this may have occurred. Weekly feedback by experienced faculty graders was crucial in providing comments on each step of the PPCP with specific strategies to improve student performance in each area. A reduction in errors that could have caused patient harm was seen with more difficult cases, which was encouraging. Additionally, improved team performance on several steps of the PPCP showed that student abilities can improve with practice and targeted feedback. In order to improve student accountability, in-class activities were worth a significant portion of the overall course grade. This gave students an incentive to complete their assignments and truly benefit from the feedback provided by graders. However, performance on the 'plan' and 'monitoring/follow-up' component of the case work-up component did not improve over time. It is likely that with each new case, students were learning new therapeutic regimens and monitoring parameters for new drugs and therapies which were unfamiliar to them. This may explain the lack of movement in team scores in these areas; however this will continue to be an area of emphasis for future iterations of this course. Additionally, team total scores on the EHR CPOE components did not improve over time, exposing a deficiency in student abilities in this area. Of note, this was the students' first exposure to this EHR and CPOE portal which may explain student difficulty in entering new orders/prescriptions in the portal. Case difficulty was varied across the semester, but based on team scores, the most difficult case was the sixth of the seven cases and involved an inpatient case. This case was associated with lower global scores than all other cases except the first case and also was contrary to the general improvement in scores seen as students progressed through the cases. Team performance on more difficult cases may have influenced student confidence in their own abilities as they did not see continued and consistent improvement in their longitudinal performance.

Student self-perceived rating of their ability to use and apply the PPCP into their patient work-up improved after the course with the average scores indicating that students felt more positive on each of the items on the attitudes survey. Students also felt more positive about their ability to navigate through the EHR, enter and review intravenous and oral medications, as well as laboratory order entry even though their performance on EHR order entry did not improve. Proficient EHR skills are critical for nearly any pharmacist involved in direct patient care; therefore it is important to help students prepare for clinical practice through early exposure to EHR and CPOE. Lastly, students' confidence in making and defending their recommendations about their medication plan improved, indicating that the simulation exercises were effective in training students on how to communicate with other healthcare professionals.

Study limitations

This study had some limitations. Student teams were expected to work-up cases in a limited amount of time which can be challenging for students and may have prevented them from truly reflecting on their patient work-up. Additionally, since this was a TBL course, there could be some students who relied on their teammates to complete submissions and may not have fully grasped all steps in the PPCP individually. There may have also been inter-evaluator reliability issues encountered through the use of the rubrics, despite efforts to educate and train all evaluators. Another limitation was that only one therapeutics course was chosen for this pilot. Additionally, only a single student cohort was studied and additional data within other clinical courses and with multiple cohorts, would make this study more powerful. Another limitation was that the impact of EHR and simulations was measured in aggregate and the authors did not separate out the impact of EHR versus simulations. This limits the use of this strategy by those programmes who wish to use employ one strategy, either EHR or simulated provider encounters. In addition, this study used an attitudes survey which was not validated. Course faculty were unable to find a validated survey which specifically measured attitudes regarding students abilities to perform various tasks related to the implementation phase of the PPCP. A lack of validated survey reduces the external applicability of the attitudes data.

Workload is a concern when implementing these types of activities into a required, didactic-based course in a large class setting. Faculty workload associated with the development and incorporation of cases into the EHR was significant. In order to grade comprehensive cases with a large number of students, there was a need for several graders who could provide focused feedback each week. While this feedback was vital, it was time consuming and required a lot of faculty commitment. Ten faculty evaluators spent at least two hours each week to grade and provide feedback on areas of improvement. There was a subscription cost associated with EHR Go which also needs to be taken into account and should be a consideration before adopting this type of course design. Future work in this area will include an analysis of how to incorporate the PPCP in other therapeutics courses and to determine if this would lead to improved student competence during APPEs.

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Conflicts of interest

There was no conflict of interest.

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