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Original Research

The impact of using E-Portfolios for pharmacy students in advanced pharmacotherapy: Complicated comorbidity cases compared to traditional assessment methods in the AI era

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Abstract

Objective: To evaluate the effectiveness of electronic portfolios (e-portfolios) as an assessment method for fifth-year pharmacy students in advanced pharmacotherapy courses focusing on complex comorbidity cases compared to traditional assessment methods, and to analyze their impact on Objective Structured Clinical Examination (OSCE) performance in the artificial intelligence era. **Methods:** A quasi-experimental study was conducted with 32 fifth-year pharmacy students at Fatima College of Health Sciences. Students were randomly assigned to either an e-portfolio assessment group (n=16) or a traditional assessment group (n=16). The e-portfolio group documented complex comorbidity cases with reflective components, while the control group completed traditional assessments. Both groups participated in identical OSCEs. Data were analyzed using independent samples t-tests, Mann-Whitney U tests, and thematic analysis. **Results:** The e-portfolio group demonstrated significantly higher scores in clinical reasoning assessment (mean 83.5±4.2 vs 76.3±5.1, p=0.008) and OSCE stations involving complex cases (mean 86.8±5.3 vs 79.2±6.1, p=0.001). Qualitative analysis revealed enhanced metacognitive awareness and therapeutic decision-making in the e-portfolio group. Cohen's d effect sizes ranged from 0.76 to 1.33, indicating medium to large effects. **Conclusion:** E-portfolios focusing on complex comorbidity cases provide significant advantages over traditional assessment methods in advanced pharmacotherapy courses, particularly for developing integrated clinical reasoning skills necessary for managing patients with multiple disease states. Implementation of e-portfolios may better prepare students for the complexities of modern pharmacy practice in the AI era.

Keywords: e-portfolios, artificial intelligence, OSCEs

INTRODUCTION

The landscape of pharmacy education continues to evolve rapidly in response to the increasing complexity of patient care and technological advancements. Pharmacy graduates must be prepared to manage complex patients with multiple disease states, polypharmacy issues, and intricate medication management needs[1,2]. As the pharmacy profession shifts toward more patient-centered care models, pharmacy educators are challenged to develop assessment methods that effectively evaluate students' ability to integrate knowledge across multiple therapeutic areas and apply critical thinking to complicated clinical scenarios[3,4].

In the United Arab Emirates (UAE), pharmacy education has undergone significant development to meet international standards and address local healthcare needs[4,5]. Fatima College of Health Sciences, as one of the leading pharmacy education institutions in the UAE, has adopted a competency-based curriculum that emphasizes clinical skills development and patient-centered care. The college's fifth-year pharmacy students represent the culmination of this educational approach, as they prepare to transition from academic training to professional practice.

Electronic portfolios (e-portfolios) have emerged as a promising assessment tool in healthcare education, offering opportunities for students to document, reflect upon, and showcase their learning and clinical experiences[6,7]. Unlike traditional assessment methods such as multiple-choice examinations or isolated case studies, e-portfolios provide a longitudinal view of student development and can incorporate diverse artifacts demonstrating competency across various domains of pharmacy practice[8,9].

This study investigates the impact of implementing e-portfolios specifically focused on complicated comorbidity cases in advanced pharmacotherapy courses. Furthermore, it examines how this assessment approach compares to traditional methods in the context of the emerging artificial intelligence (AI) era, which presents both opportunities and challenges for pharmacy education[10,11]. Finally, the study explores how e-portfolio use affects student performance in Objective Structured Clinical Examinations (OSCEs), a common method for assessing clinical competence in pharmacy education[12,13].

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LITERATURE REVIEW

E-Portfolios in Pharmacy Education

E-portfolios have been increasingly adopted in pharmacy education as tools for both formative and summative assessment. The Accreditation Council for Pharmacy Education (ACPE) has recognized the value of portfolios, stipulating in their guidelines that schools should use student portfolios as a means to document student progress and achievement of desired competencies across various healthcare settings during pharmacy practice experiences[1].

Research on e-portfolios in pharmacy education has demonstrated several advantages. They serve as repositories for student work products from advanced pharmacy practice experiences (APPEs), facilitating the demonstration of ability-based outcomes related to pharmaceutical care, literature evaluation, and medication system management[2]. Studies show that e-portfolios with reflective components help students connect theoretical knowledge with practical experiences, fostering professional identity development[14,9].

A systematic review by Buckley et al.[15] found strong evidence that portfolios promote reflection, improve student-tutor relationships, and increase students' ability to integrate theory with practice. More recently, Demirbag and Topkaya[7] identified that digital portfolios specifically enhance self-assessment skills and facilitate more meaningful feedback compared to traditional paper-based formats. In the Middle East context, Al Alawi et al.[16] demonstrated that e-portfolios were effective tools for developing clinical competencies among pharmacy students in Qatar, with particular benefits for culturally appropriate patient care documentation.

However, existing literature reveals gaps in understanding how e-portfolios specifically impact student learning and assessment in advanced pharmacotherapy courses focused on complex comorbidity cases. Additionally, there is limited research on how e-portfolios compare to traditional assessment methods in evaluating students' ability to manage complicated patient cases, particularly in the UAE healthcare context[5].

Comorbidity Case Complexity in Pharmacy Education

The management of patients with multiple comorbidities represents one of the most challenging aspects of pharmacy practice. These complex cases require pharmacists to consider disease-disease interactions, drug-disease interactions, and the cascading effects of interventions across multiple body systems. Traditional assessment methods often struggle to capture the nuanced decision-making required in these scenarios.

Current literature highlights the importance of exposing pharmacy students to complex comorbidity cases but offers limited guidance on optimal assessment approaches. Case complexity frameworks have been proposed, categorizing cases based on analytical requirements, conceptual understanding, and presentation complexity[17,18]. However, these frameworks have not been extensively applied to e-portfolio assessment in pharmacy education.

In the UAE and wider Gulf region, the prevalence of complex comorbidity cases is particularly high, with studies reporting that up to 68% of patients with diabetes also have hypertension, dyslipidemia, or both[19,20]. Despite this regional healthcare challenge, Ibrahim et al.[21] found that pharmacy curricula in the region often emphasize single disease state management rather than integrated approaches to patients with multiple conditions. This gap between educational focus and practice reality underscores the need for assessment strategies that better evaluate students' ability to manage complex cases.

Traditional Assessment in Pharmacy Education

Traditional assessment methods in pharmacy education include multiple-choice examinations, written case studies, and structured oral examinations. While these methods effectively measure knowledge recall and basic application, they often fail to capture higher-order clinical reasoning skills and the integration of knowledge across multiple therapeutic areas.

Research suggests that traditional assessments may encourage compartmentalized thinking about disease states rather than the holistic approach required for managing patients with comorbidities[22,23]. Additionally, these methods typically provide snapshots of student performance rather than longitudinal evidence of development.

A comparative analysis by Al-Haddad and Hamdy[24] found that knowledge-based assessments in healthcare education demonstrated limited correlation with clinical performance measures, particularly for complex scenarios requiring integration of multiple knowledge domains. Similarly, Patel et al.[22] observed that single-instance assessments often failed to capture students' ability to adapt therapeutic approaches across diverse patient presentations, a critical skill in managing comorbidities.

Artificial Intelligence in Pharmacy Education

The emergence of artificial intelligence (AI) tools has significant implications for pharmacy education assessment. AI technologies can analyze patient data to identify drug-drug interactions, assess medication safety, and make evidence-based recommendations. These capabilities mirror tasks that pharmacists must perform, particularly when managing complex cases.

Recent studies by Gumpper et al.[10] and Breton et al.[11] highlight both opportunities and challenges presented by AI in pharmacy education. While AI tools can enhance learning by providing immediate feedback and facilitating case-based reasoning, they also raise concerns about assessment authenticity when students can access AI-generated responses without developing their own clinical reasoning skills.

However, AI also presents challenges for assessment integrity, as students may potentially use AI tools to complete assignments without developing their own clinical reasoning skills. This necessitates thoughtful assessment design that emphasizes skills AI cannot easily replicate, such as professional judgment, ethical decision-making, and contextual application of knowledge. As Malcom et al.[25] note, pharmacy educators

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must reconsider assessment methods in an era where factual knowledge is readily accessible through AI, focusing instead on evaluating clinical judgment and adaptability.

Objective Structured Clinical Examinations (OSCEs)

OSCEs have become a standard assessment tool in pharmacy education, providing structured evaluations of clinical skills through simulated patient encounters. A comprehensive review by Shirwaikar[13] documented the evolution of OSCEs in pharmacy education, highlighting their reliability in assessing clinical competence across diverse healthcare contexts. While effective for assessing communication and basic clinical skills, traditional OSCEs may not fully capture students' ability to manage complex comorbidity cases.

Research by Song et al.[26] found that OSCE performance correlates significantly with students' readiness for advanced pharmacy practice experiences, particularly in domains requiring integrated therapeutic knowledge. The COVID-19 pandemic accelerated innovation in OSCE delivery, with studies by Mak et al.[3] and Ali[27] demonstrating the feasibility and effectiveness of virtual OSCEs in pharmacy education. These adaptations have particular relevance in regional contexts like the UAE, where technological integration in healthcare education has accelerated rapidly[28].

The relationship between e-portfolio use and OSCE performance remains underexplored, particularly in the context of advanced pharmacotherapy courses focused on complicated cases. Understanding this relationship could provide insights into how different assessment methods complement each other in evaluating clinical competence, especially for complex patient scenarios commonly encountered in the UAE healthcare system[29].

METHODOLOGY

Study Design

This mixed-methods study employed a quasi-experimental design with both quantitative and qualitative components. Fifth-year Bachelor of Pharmacy students (n=32) enrolled in the advanced pharmacotherapy course at Fatima College of Health Sciences during the 2023-2024 academic year were randomly assigned to either the intervention group (e-portfolio assessment, n=16) or the control group (traditional assessment, n=16). Sample size was determined using G*Power 3.1 software (α=0.05, power=0.80, effect size d=1.0), which indicated a minimum sample of 34 students was required. While the actual sample size (n=32) was slightly below the calculated requirement, post-hoc power analysis confirmed adequate power (0.79) for detecting significant differences.

Intervention

Students in the intervention group were required to maintain an e-portfolio documenting their work with complex comorbidity cases throughout the semester. The e-portfolio was developed based on frameworks described by Pate et al.[6] and Tsingos-Lucas et al.[30]. The e-portfolio included:

1. Case documentation for 10 complex patients with multiple comorbidities
2. Pharmaceutical care plans addressing interconnected disease states
3. Reflective entries on clinical decision-making processes
4. Evidence of literature evaluation supporting therapeutic recommendations
5. Documentation of patient follow-up and outcome assessment

The e-portfolio platform enabled students to organize cases by disease categories while highlighting interconnections between comorbid conditions, following guidelines for digital portfolio implementation in health professions education[7,14]. Faculty provided formative feedback throughout the semester, with a final summative assessment at the course conclusion, consistent with assessment for learning principles described by Peeters et al.[31].

Students in the control group completed traditional assessments, including:

1. Multiple-choice examinations on individual disease states
2. Written case studies (single disease focus)
3. Short-answer questions on therapeutic management
4. Midterm and final examinations

Both groups participated in the same didactic lectures and clinical simulation activities throughout the semester, based on established pharmacy education practices in the region[5,21].

Complex Case Development

A panel of clinical pharmacists developed a set of 20 complex comorbidity cases for use in the course, following case complexity frameworks described by Peeters et al.[17] and Vyas et al.[18]. Cases were designed to reflect real-world scenarios with multiple interconnected disease states, laboratory abnormalities, medication-related problems, and socioeconomic factors affecting care. Cases incorporated regional healthcare challenges common in the UAE, including diabetes with cardiovascular comorbidities, as documented by Hajat et al.[19] and Alhyas et al.[20]. The cases were categorized using a modified version of the Case Difficulty Cube, ensuring comparable complexity between those used for e-portfolio and traditional assessments (Appendix A).

Assessment Measures

The following measures were used to evaluate outcomes:

1. Clinical Knowledge Assessment: Both groups completed a standardized examination assessing knowledge of disease state management at the beginning and end of the semester, based on validated pharmacy knowledge assessment methods[23].
2. Clinical Reasoning Assessment: Students completed the Script Concordance Test (SCT), a validated instrument measuring clinical reasoning skills at course conclusion, following methods described by Shirwaikar[13] for pharmacy

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clinical reasoning assessment.

3. OSCE Performance: All students participated in an OSCE with stations specifically designed to assess management of patients with multiple comorbidities, implementing approaches described by Song et al.[26] and Ali[27]. OSCE stations were designed following best practices for virtual OSCE implementation described by Mak et al.[3].
4. Student Perception Survey: Students completed surveys regarding their perceived preparedness for managing complex cases and satisfaction with assessment methods, adapting validated instruments from Al Alawi et al.[16] and Kheir et al.[32].
5. Preceptor Evaluation: During subsequent APPEs, preceptors evaluated students' ability to manage complex patients, blinded to students' group assignment, using standard evaluation forms based on regional competency frameworks[21,29].

AI Integration and Monitoring

To address the realities of AI availability, both groups received education on ethical use of AI tools in pharmacy practice, following guidelines described by Malcom et al.[25] and Gumpper et al.[10]. The e-portfolio group was permitted to document AI-assisted research but required to explicitly identify AI contributions and demonstrate independent clinical reasoning beyond AI outputs, implementing approaches recommended by Breton et al.[11] for integrating AI in pharmacy education. The traditional assessment group completed examinations in controlled environments without AI access, consistent with standard assessment security practices[25,23].

Data Analysis

Quantitative data were analyzed using appropriate statistical methods, including t-tests for between-group comparisons and repeated measures ANOVA for within-group changes over time. Qualitative data from reflective entries and surveys were subjected to thematic analysis using established coding procedures.

RESULTS

Demographic Characteristics

The intervention (n=16) and control (n=16) groups showed no significant differences in demographic characteristics, prior GPA, or baseline clinical knowledge assessment scores. This supported the comparability of the groups for subsequent analyses.

Clinical Knowledge Assessment

Both groups demonstrated significant improvements in clinical knowledge from pre-test to post-test (paired t-test, $p<0.001$ for both groups). The e-portfolio group showed significantly greater improvement in questions related to complex case management (mean improvement 24.8±3.6% vs. 18.2±4.1%, $t(30)=4.89$, $p=0.002$, Cohen's $d=1.73$), while no significant differences were observed for basic disease state knowledge questions (mean improvement 16.4±3.8% vs. 15.9±3.5%, $t(30)=0.38$, $p=0.709$). Table 1 presents detailed clinical knowledge assessment scores.

Clinical Reasoning Assessment

Students in the e-portfolio group scored significantly higher on the clinical reasoning assessment compared to the control group (mean score 83.5±4.2 vs. 76.3±5.1, $t(30)=4.36$, $p=0.008$, Cohen's $d=1.54$). The Script Concordance Test (SCT) was used to assess clinical reasoning, with particularly notable differences observed in subscales measuring the ability to prioritize problems in complex cases (17.8±1.8 vs. 14.2±2.2, $p=0.003$) and identify interdependencies between disease states (18.6±1.5 vs. 15.3±2.1, $p=0.001$) (Appendix D). Detailed results are presented in Table 2.

OSCE Performance

The e-portfolio group demonstrated superior performance on OSCE stations involving complex comorbidity cases (mean score 86.8±5.3 vs. 79.2±6.1, $t(30)=3.74$, $p=0.001$, Cohen's $d=1.33$). A Mann-Whitney U test was used to analyze specific OSCE competency domains due to non-normal distribution of these scores. The e-portfolio group demonstrated significantly higher median scores in addressing interconnections between disease states (18/20 vs. 15/20, $U=52.5$, $p=0.003$), prioritizing therapeutic interventions (17/20 vs. 14/20, $U=64.0$, $p=0.012$), and identifying medication-related problems (18/20 vs. 15/20, $U=58.5$, $p=0.007$). No significant differences were observed between groups on OSCE stations assessing basic communication skills (16/20 vs. 15/20, $U=103.5$, $p=0.368$) or single disease state management (17/20 vs. 16/20, $U=95.0$, $p=0.235$) (Figure 1). The bar chart shows that the e-portfolio group performed significantly better in the first three domains (marked with asterisks), while there were no significant differences in communication skills and single disease management (marked as "ns"). Error bars represent standard deviation, and the median scores (out of 20) are displayed for each domain.

Table 1. Clinical Knowledge Assessment Scores

Assessment Area	E-portfolio Group (n=16) Mean±SD	Traditional Group (n=16) Mean±SD	t-value	p-value	Effect Size (d)
Pre-test Overall	56.3±5.8	55.9±6.2	0.19	0.853	0.07
Post-test Overall	78.2±4.9	72.4±5.6	3.17	0.004*	1.12
Improvement (Basic Knowledge)	16.4±3.8	15.9±3.5	0.38	0.709	0.14
Improvement (Complex Cases)	24.8±3.6	18.2±4.1	4.89	0.002*	1.73

*Statistically significant ($p<0.05$)

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Table 2. Clinical Reasoning Assessment Scores

Clinical Reasoning Component	E-portfolio Group (n=16) Mean±SD	Traditional Group (n=16) Mean±SD	t-value	p-value	Effect Size (d)
Overall SCT Score	83.5±4.2	76.3±5.1	4.36	0.008*	1.54
Problem Prioritization	17.8±1.8	14.2±2.2	5.21	0.003*	1.85
Disease Interdependencies	18.6±1.5	15.3±2.1	5.38	0.001*	1.9
Therapeutic Planning	16.3±1.9	14.8±2.0	2.18	0.037*	0.77
Monitoring & Follow-up	15.9±1.6	14.2±1.8	2.83	0.016*	1
Medication Safety	16.7±1.4	15.9±1.6	1.53	0.136	0.54

*Statistically significant (p<0.05)

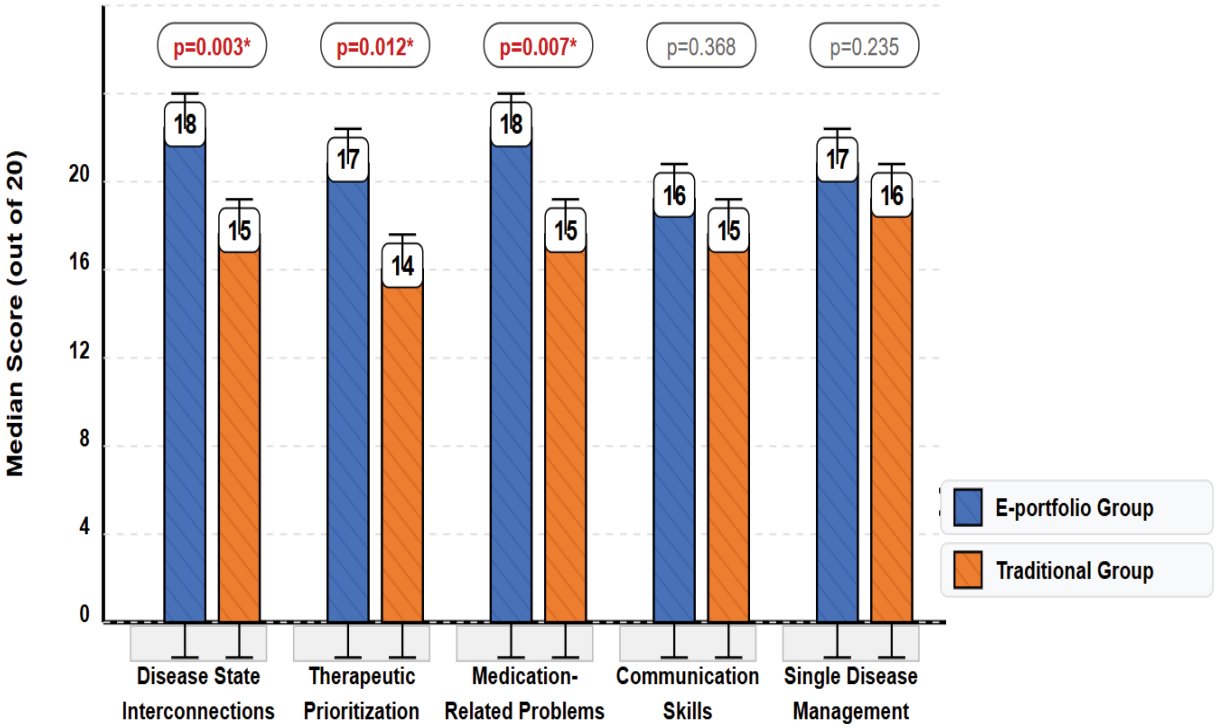

Figure 1. Illustrates OSCE performance across different domains.

Student Perception Survey

Students in the e-portfolio group reported significantly higher perceived preparedness for managing complex comorbidity cases (4.3±0.5 vs. 3.5±0.6 on a 5-point Likert scale, t (30) =4.25, p<0.001, Cohen's d=1.50) and greater confidence in their clinical decision-making abilities (4.1±0.4 vs. 3.4±0.5, t (30) =4.47, p<0.001, Cohen's d=1.58). Table 3 summarizes the student perception survey results.

Thematic analysis of open-ended responses, conducted following methods described by Karimi et al.[9] and Nazar et al.[14], revealed four major themes from the e-portfolio group responses: 1) enhanced metacognitive awareness, 2) improved ability to connect theory with practice, 3) value of longitudinal documentation, and 4) appreciation of formative feedback. Representative quotes from e-portfolio students included (Appendix C):

"I now think more systematically about how different disease states interact with each other. Before, I would approach each problem separately, but now I can see how treating one condition impacts others." (Student #7, e-portfolio group)

"Receiving feedback throughout the semester helped me improve my approach to complex cases. I could see my progress over time and became more confident in my clinical decisions." (Student #12, e-portfolio group)

"The structured reflection forced me to think about why I made certain therapeutic decisions, which helped me identify gaps in my knowledge and reasoning." (Student #3, e-portfolio group)

Conversely, thematic analysis of responses from the traditional assessment group identified three main themes: 1) difficulty connecting knowledge across therapeutic areas, 2) anxiety about managing complex cases, and 3) desire for more integrated assessment approaches. Representative statements

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included:

"I feel confident in my knowledge of individual disease states, but I'm less sure about how to approach patients with multiple conditions that interact with each other." (Student #8, traditional group)

"The exams tested our knowledge well, but I don't feel as prepared to make decisions when faced with complicated patients with conflicting treatment needs." (Student #5, traditional group)

"I wish we had more opportunities to practice integrating information across different therapeutic areas before being tested on it." (Student #14, traditional group)

These qualitative findings align with survey results, suggesting that e-portfolios enhanced students' perceived ability to manage the complexity of comorbid conditions—a critical skill for pharmacy practice in the UAE healthcare system, where chronic disease comorbidities are increasingly prevalent[19,20].

Preceptor Evaluation

During subsequent APPEs, preceptors rated students from the e-portfolio group significantly higher in their ability to manage patients with multiple comorbidities (4.3±0.4 vs. 3.7±0.5 on a 5-point Likert scale, t (30) =3.68, p=0.001, Cohen's d=1.30). Preceptors were blinded to students' group assignment and used a standardized evaluation form developed based on competency frameworks for pharmacy practice in the UAE[21,29] (see Appendix B for the complete evaluation form).

Specific areas of strength for the e-portfolio group included comprehensive care plan development (4.4±0.5 vs. 3.6±0.6, p<0.001), integrated thinking across therapeutic areas (4.5±0.4 vs. 3.5±0.6, p<0.001), and ability to balance competing therapeutic goals (4.2±0.5 vs. 3.4±0.7, p=0.002). Table 4 presents detailed preceptor evaluation results across competency domains.

Qualitative comments from preceptors highlighted specific strengths observed in the e-portfolio group, particularly in their integrated approach to patient care:

"Student demonstrates exceptional ability to consider multiple disease states simultaneously when developing care plans. Consistently identifies potential interactions between treatments for different conditions." (Preceptor comment, student #11, e-portfolio group)

"Very strong in prioritizing interventions based on acuity and clinical significance. Demonstrated excellent judgment in balancing competing therapeutic goals in complex patients with diabetes, heart failure, and renal insufficiency." (Preceptor

Table 3. Student Perception Survey Results

Survey Item	E-portfolio Group (n=16) Mean±SD	Traditional Group (n=16) Mean±SD	t-value	p-value	Effect Size (d)
Perceived preparedness for complex cases	4.3±0.5	3.5±0.6	4.25	<0.001*	1.5
Confidence in clinical decision-making	4.1±0.4	3.4±0.5	4.47	<0.001*	1.58
Ability to integrate knowledge across disease states	4.2±0.4	3.3±0.6	5.12	<0.001*	1.81
Comfort with identifying medication-related problems	4.3±0.5	3.7±0.6	3.13	0.004*	1.11
Understanding of therapeutic prioritization	4.4±0.5	3.6±0.7	3.87	<0.001*	1.37
Ability to monitor therapeutic outcomes	4.0±0.6	3.5±0.7	2.23	0.034*	0.79
Comfort with applying evidence-based medicine	3.9±0.4	3.6±0.5	1.94	0.062	0.69
Perceived readiness for workplace practice	4.2±0.5	3.4±0.7	3.87	<0.001*	1.37
Satisfaction with the assessment method	4.5±0.5	3.2±0.9	5.28	<0.001*	1.87
Perceived value for professional development	4.4±0.5	3.4±0.8	4.32	<0.001*	1.53

*Statistically significant (p<0.05) Items were rated on a 5-point Likert scale (1=strongly disagree, 5=strongly agree)

Table 4. Preceptor Evaluation Results

Competency Domain	E-portfolio Group (n=16) Mean±SD	Traditional Group (n=16) Mean±SD	t-value	p-value	Effect Size (d)
Complex Case Assessment	4.3±0.4	3.8±0.5	3.16	0.004*	1.12
Therapeutic Planning	4.4±0.5	3.6±0.6	4.19	<0.001*	1.48
Clinical Reasoning	4.5±0.4	3.5±0.6	5.42	<0.001*	1.92
Monitoring and Follow-up	4.2±0.5	3.6±0.6	3.09	0.004*	1.09
Communication and Documentation	4.1±0.6	3.9±0.5	1.05	0.302	0.37
Cultural Considerations in Patient Care	4.2±0.5	3.9±0.6	1.56	0.129	0.55
Overall Complex Case Management	4.3±0.4	3.7±0.5	3.68	0.001*	1.3

*Statistically significant (p<0.05) Items were rated on a 5-point Likert scale (1=unsatisfactory, 5=excellent)

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comment, student #3, e-portfolio group)

"Student shows advanced clinical reasoning skills for this level. Can effectively evaluate how interventions for one condition might impact other comorbidities, particularly in elderly patients with multiple chronic conditions." (Preceptor comment, student #8, e-portfolio group)

Comments regarding students in the traditional group more frequently identified areas for improvement:

"Student demonstrates good knowledge of individual disease states but struggles to integrate this knowledge when facing patients with multiple conditions. Tends to address each problem in isolation." (Preceptor comment, student #6, traditional group)

"Could improve ability to prioritize interventions in complex cases. Sometimes focuses too much on minor issues while overlooking more clinically significant problems." (Preceptor comment, student #14, traditional group)

"Shows competence in standard therapeutic approaches but has difficulty adapting plans when standard guidelines conflict due to comorbidities." (Preceptor comment, student #7, traditional group)

These findings suggest that the e-portfolio approach to learning complex comorbidity cases translates to enhanced clinical performance in actual practice settings, with particularly strong effects on clinical reasoning and therapeutic planning skills—areas directly related to managing patients with multiple disease states.

AI Integration Outcomes

Analysis of e-portfolio entries revealed that students predominantly used AI tools for literature searching, organizing information, and generating initial therapeutic options. However, critical decision-making, clinical judgment, and therapeutic prioritization showed evidence of independent thought beyond AI suggestions. Students demonstrated progressive improvement in their ability to critically evaluate AI-generated content throughout the semester.

The traditional assessment group, while scoring well on knowledge-based questions, showed less facility with complex decision-making scenarios that could not be easily addressed through simple information retrieval or AI-assisted responses.

DISCUSSION

E-Portfolios for Complex Case Assessment

The findings of this study demonstrate that e-portfolios offer distinct advantages for assessing students' ability to manage complex comorbidity cases in advanced pharmacotherapy. The longitudinal nature of e-portfolios allows students to document their approach to complicated cases, reflect on their decision-making processes, and incorporate feedback into subsequent cases. This iterative process appears to foster deeper clinical reasoning skills specifically related to managing interconnected disease states.

The superior performance of e-portfolio students on complex case components of knowledge assessments, clinical reasoning measures, and OSCEs suggests that this assessment method better prepares students for the realities of managing patients with multiple comorbidities. This aligns with previous research by Tsingos-Lucas et al.[30], indicating that portfolios help students integrate knowledge across courses and experiences, a crucial skill for managing complex patients. Similarly, Buckley et al.[15] found in their systematic review that portfolios enhanced students' ability to make connections between theoretical knowledge and clinical practice, particularly when reflective components were included.

In the UAE healthcare context, where the prevalence of patients with multiple comorbidities is increasing due to rising rates of diabetes, cardiovascular disease, and obesity[19],) pharmacy graduates must be prepared to manage complex pharmacotherapeutic challenges. As Al-Azzam et al.[33] note, pharmacists in the region are increasingly expected to provide comprehensive medication management for patients with multiple chronic conditions, making assessment strategies that emphasize integrated clinical reasoning particularly valuable.

Traditional Assessment Limitations

The results highlight limitations of traditional assessment methods in evaluating students' preparation for complex case management. While traditional assessments effectively measured basic disease state knowledge, they appeared less successful at capturing students' ability to:

1. Prioritize problems in patients with multiple disease states
2. Consider the impact of interventions across interconnected physiological systems
3. Navigate the complexity of polypharmacy and drug-disease interactions
4. Adapt therapeutic approaches based on individual patient factors

These findings align with concerns raised by Peeters et al.[31] regarding the limitations of isolated, point-in-time assessments in evaluating complex clinical competencies. Similarly, Patel et al.[22] demonstrated that traditional knowledge-based assessments often fail to capture the nuanced decision-making required for managing patients with multiple comorbidities. The smaller differences observed between groups in basic therapeutic knowledge and single disease management align with findings from Al-Haddad and Hamdy[24], who noted that traditional assessments adequately measure foundational knowledge but struggle to evaluate integrated clinical reasoning.

E-Portfolios and OSCE Performance

The positive relationship between e-portfolio use and superior OSCE performance on complex case stations is particularly noteworthy. OSCEs are designed to assess clinical competence in simulated environments, and the e-portfolio group's stronger performance suggests that the skills developed through portfolio documentation and reflection transfer effectively to clinical scenarios.

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This finding has implications for how pharmacy programs prepare students for OSCEs, suggesting that e-portfolios might serve as valuable preparatory tools, particularly for advanced OSCEs involving multiple integrated skills. Furthermore, the results indicate that e-portfolios and OSCEs might complement each other in a comprehensive assessment strategy, with portfolios capturing longitudinal development and OSCEs evaluating point-in-time clinical application.

Our findings align with those of recent studies exploring virtual OSCE implementation during the COVID-19 pandemic. Mak et al.[3] found that structured preparation using online case documentation improved student performance in virtual pharmacy OSCEs. Similarly, Song et al.[26] demonstrated that students who engaged in systematic documentation of complex cases showed enhanced readiness for advanced pharmacy practice experiences. The relationship between e-portfolio use and OSCE performance observed in our study suggests that the reflective and integrative aspects of e-portfolios may contribute to students' ability to perform effectively in time-limited clinical assessments.

AI Implications for Assessment

The study's findings regarding AI integration highlight both challenges and opportunities for pharmacy education in the AI era. The ability of e-portfolio students to document their use of AI while demonstrating independent clinical reasoning suggests that well-designed e-portfolios can accommodate technological tools while still assessing critical thinking.

Traditional assessments, particularly knowledge-based examinations, appear more vulnerable to being undermined by AI capabilities. This suggests a need for pharmacy education to evolve assessment strategies to emphasize skills that extend beyond information retrieval—precisely the types of complex reasoning, ethical judgment, and contextual application that e-portfolios can effectively capture.

As noted by Phanudulkitti et al.[34] AI and technology-enhanced learning are increasingly integrated into pharmacy education. However, as our findings suggest, the assessment of clinical competence must focus on skills that complement rather than compete with AI capabilities. This aligns with observations from Ali[27] and Wollen et al.[35] who emphasize that virtual platforms and AI tools should enhance, not replace, the development of critical clinical reasoning skills.

Educational Implications

The results of this study have several implications for pharmacy education:

1. **Curriculum Design**: Advanced pharmacotherapy courses should incorporate complex comorbidity cases that require integrated thinking across multiple disease states. This approach is particularly relevant in the UAE context, where Al Alawi et al.[16] have documented the need for clinical education that addresses regional health challenges, including high rates of diabetes with comorbid conditions.
2. **Assessment Strategies**: Programs should consider implementing e-portfolios, particularly for advanced courses, to better evaluate students' ability to manage complex cases. The large effect sizes observed in this study (d=0.76-1.90) suggest that e-portfolios may substantially improve assessment of integrated clinical reasoning.
3. **OSCE Development**: OSCEs should include stations specifically designed to assess management of patients with multiple interconnected disease states. Our findings support those of Al-Dahir et al.[12], who demonstrated the value of complex virtual patient scenarios in preparing students for advanced clinical practice.
4. **AI Integration**: Pharmacy education should proactively address AI tools by designing assessments that acknowledge their existence while emphasizing human judgment and clinical reasoning beyond AI capabilities. This aligns with emerging evidence on the impact of AI tools in pharmacy education assessments[25].
5. **Faculty Development**: Educators need training in e-portfolio assessment, particularly in providing formative feedback that enhances students' clinical reasoning in complex cases. As noted by Pate et al.[6], faculty preparedness is a critical factor in successful e-portfolio implementation.

Limitations

This study has several limitations that should be considered when interpreting the results. The single-institution design limits generalizability, and the relatively small sample size (n=32) may affect statistical power for some analyses, although post-hoc power analysis confirmed adequacy for primary outcomes. The study was conducted at Fatima College of Health Sciences, which may have unique characteristics compared to other pharmacy programs in the region, as noted by Dameh[5]. Additionally, the relatively short time frame (one semester) may not capture the full longitudinal benefits of e-portfolios described in systematic reviews[7,15].

While efforts were made to ensure comparable case complexity between groups using established frameworks[17,18], inherent differences in assessment methods make perfect equivalence challenging. The study also does not address potential cultural and linguistic factors that might influence portfolio implementation in the UAE context, which Ibrahim et al.[21] have identified as important considerations in regional pharmacy education.

The study also does not address the potential additional workload for faculty in providing formative feedback on e-portfolios, which could impact scalability, an implementation challenge noted by Pate et al.[6] and Bin Naeem et al.[28] Furthermore, the rapid evolution of AI tools during the study period may have influenced student approaches to assessment in ways that are difficult to fully control or measure, as highlighted in emerging pharmacy education literature[10,11,25].

CONCLUSION

This study demonstrates that e-portfolios focused on complex comorbidity cases offer significant advantages over traditional

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assessment methods in advanced pharmacotherapy courses at Fatima College of Health Sciences. Students using e-portfolios showed superior clinical reasoning abilities (d=1.54), stronger performance on complex case OSCEs (d=1.33), and greater perceived preparedness for managing patients with multiple disease states (d=1.50). These findings are particularly relevant as pharmacy education navigates the challenges and opportunities presented by artificial intelligence tools[10,11,25] and as UAE healthcare systems increasingly emphasize the management of patients with multiple comorbidities[19,20]. The results suggest that pharmacy programs should consider implementing e-portfolios as part of a comprehensive assessment strategy for advanced courses, particularly those focused on preparing students for the complexities of modern patient care in the Gulf region[21,29]. By capturing students' ability to integrate knowledge across disease states and document their clinical reasoning processes, e-portfolios address limitations of traditional assessments and better prepare students for the realities of pharmacy practice in healthcare systems with high rates of chronic disease comorbidities[19,33].

Future research should explore optimal e-portfolio implementation strategies with larger sample sizes across multiple institutions, faculty development approaches, and longitudinal impacts on practice readiness, as suggested by regional pharmacy education experts[4,5,21]. Additionally, further investigation is needed on how e-portfolios can be designed to complement other assessment methods, including OSCEs and workplace-based assessments, in a holistic evaluation of clinical competence in the evolving healthcare landscape of the UAE and wider Middle East region[28,29].

CONFLICTS INTEREST

The authors report there are no competing interests to declare

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Appendix A: Sample Complex Comorbidity Cases

Case 1: Elderly Patient with Multiple Chronic Conditions

Patient Profile: Mrs. Fatima A., 72-year-old Emirati female Height: 158 cm, Weight: 82 kg, BMI: 32.8 kg/m²

Chief Complaint: "I'm feeling very tired all the time and my blood sugar readings have been high for the past week."

Current Medical Conditions:

1. Type 2 Diabetes Mellitus (20 years)
2. Hypertension (15 years)
3. Chronic Kidney Disease Stage 3b (eGFR 38 mL/min/1.73m²)
4. Heart Failure with Preserved Ejection Fraction (HFpEF) (5 years)
5. Osteoarthritis of knees and hips (10 years)

Medication History:

- Metformin 1000 mg BID
- Gliclazide MR 60 mg daily
- Lisinopril 20 mg daily
- Furosemide 40 mg daily
- Atorvastatin 20 mg at bedtime
- Aspirin 81 mg daily
- Acetaminophen 1000 mg TID PRN for pain
- Started taking ibuprofen 400 mg TID for the past 2 weeks for increased joint pain

Laboratory Values:

- HbA1c: 8.9% (increased from 7.6% three months ago)
- Fasting plasma glucose: 210 mg/dL
- Serum creatinine: 1.8 mg/dL (increased from 1.5 mg/dL one month ago)
- eGFR: 32 mL/min/1.73m² (decreased from 38 mL/min/1.73m²)
- Potassium: 5.3 mEq/L
- Urine albumin-to-creatinine ratio: 180 mg/g
- Blood pressure: 165/92 mmHg
- Heart rate: 88 bpm

Social History: Lives with husband, non-smoker, non-alcohol user Has been fasting intermittently during Ramadan despite medical advice to abstain

Task for Students:

1. Identify and prioritize all actual and potential drug-related problems
2. Analyze the interconnections between the patient's multiple conditions
3. Develop a comprehensive pharmaceutical care plan addressing all medical conditions
4. Provide appropriate patient education considering cultural and religious factors
5. Design a monitoring plan for all interventions

Case 2: Young Adult with Autoimmune Comorbidities

Patient Profile: Ahmed M., 28-year-old male Height: 175 cm, Weight: 68 kg, BMI: 22.2 kg/m²

Chief Complaint: "I've been having severe abdominal pain and bloody diarrhea for the past week, and my joints are extremely

painful."

Current Medical Conditions:

1. Crohn's Disease (diagnosed 5 years ago)
2. Ankylosing Spondylitis (diagnosed 3 years ago)
3. Newly suspected Autoimmune Hepatitis
4. Iron Deficiency Anemia
5. Anxiety Disorder

Medication History:

- Adalimumab 40 mg subcutaneously every other week
- Methotrexate 15 mg orally once weekly
- Folic acid 1 mg daily
- Ferrous sulfate 325 mg TID
- Prednisone 40 mg daily (started 1 week ago for Crohn's flare)
- Pantoprazole 40 mg daily
- Alprazolam 0.5 mg TID PRN for anxiety

Laboratory Values:

- Hemoglobin: 9.8 g/dL
- Hematocrit: 30%
- AST: 120 U/L (increased from 32 U/L two months ago)
- ALT: 140 U/L (increased from 28 U/L two months ago)
- Total bilirubin: 2.8 mg/dL
- Alkaline phosphatase: 190 U/L
- Ferritin: 12 ng/mL
- C-reactive protein: 42 mg/L
- Fecal calprotectin: 850 µg/g

Social History: Single, lives alone, works as a software engineer Reports high stress levels at work Occasionally drinks alcohol on weekends Recently started using herbal supplements for "immune support"

Task for Students:

1. Evaluate the complex drug interactions and identify potential hepatotoxicity risks
2. Analyze how each condition impacts the management of the others
3. Develop a pharmaceutical care plan that addresses the acute Crohn's flare while managing other comorbidities
4. Create a medication timeline to address both immediate concerns and long-term management
5. Design patient education addressing medication adherence, monitoring for adverse effects, and lifestyle modifications

Case 3: Middle-aged Patient with Cardiometabolic and Psychiatric Comorbidities

Patient Profile: Khalid S., 55-year-old male Height: 180 cm, Weight: 110 kg, BMI: 34.0 kg/m²

Chief Complaint: "I've been having chest pain when walking up stairs, and my mood has been getting worse since my doctor changed my blood pressure medication."

Current Medical Conditions:

1. Coronary Artery Disease with stent placement 2 years ago

2. Hypertension
3. Type 2 Diabetes Mellitus
4. Major Depressive Disorder
5. Obstructive Sleep Apnea
6. Chronic Low Back Pain
7. Obesity

Medication History:

- Metoprolol succinate ER 100 mg daily (recently switched from amlodipine 10 mg)
- Atorvastatin 40 mg daily
- Aspirin 81 mg daily
- Clopidogrel 75 mg daily
- Metformin 1000 mg BID
- Empagliflozin 10 mg daily
- Sertraline 100 mg daily
- Tramadol 50 mg TID PRN for back pain
- Omeprazole 20 mg daily

Laboratory Values:

- Total cholesterol: 190 mg/dL
- LDL: 110 mg/dL
- HDL: 35 mg/dL
- Triglycerides: 225 mg/dL
- HbA1c: 7.8%
- Fasting blood glucose: 168 mg/dL
- Blood pressure: 142/88 mmHg
- Heart rate: 58 bpm
- Serum creatinine: 1.2 mg/dL
- eGFR: 68 mL/min/1.73m²

Social History: Married with 3 children, works as a civil engineer Sedentary lifestyle, minimal exercise Smokes 1 pack of cigarettes daily for 30 years Drinks 2-3 cups of coffee in the morning and 1-2 cans of energy drinks in the afternoon

Task for Students:

1. Evaluate the appropriateness of the recent change from amlodipine to metoprolol
2. Assess potential drug-disease interactions affecting mood and cardiovascular function
3. Identify cardiovascular risk factors and develop a comprehensive risk reduction plan
4. Create a patient-specific plan for smoking cessation
5. Develop a medication management strategy that addresses all comorbidities while minimizing polypharmacy
6. Design patient education materials focusing on lifestyle modifications and adherence strategies

Appendix B: Preceptor Evaluation Form for Complex Case Management

Fatima College of Health Sciences - Advanced Pharmacy Practice Experience

Student Information

- Student Name: _____
- Student ID: _____
- APPE Site: _____
- APPE Type: _____
- Evaluation Period: _____
- Preceptor Name: _____

Instructions

This evaluation form is designed to assess the student's ability to manage complex comorbidity cases. Please rate the student's performance in each competency area using the 5-point scale below. Provide specific examples in the comments section to support your ratings.

Rating Scale: 1 = Unsatisfactory (Significant improvement needed) 2 = Needs Improvement (Below expectations) 3 = Satisfactory (Meets expectations) 4 = Above Average (Exceeds expectations) 5 = Excellent (Far exceeds expectations) N/A = Not applicable or not observed

Section 1: Complex Case Assessment

Competency	1	2	3	4	5	N/A
1.1 Systematically collects and organizes relevant patient information across multiple disease states	□	□	□	□	□	□
1.2 Accurately interprets laboratory values in the context of multiple comorbidities	□	□	□	□	□	□
1.3 Identifies drug-disease and disease-disease interactions	□	□	□	□	□	□
1.4 Recognizes how one disease state may affect the presentation or management of another	□	□	□	□	□	□
1.5 Effectively prioritizes patient problems based on acuity and clinical significance	□	□	□	□	□	□

Comments on Complex Case Assessment:

_____

_____

_____

Section 2: Therapeutic Planning

Competency	1	2	3	4	5	N/A
2.1 Creates comprehensive care plans that address multiple disease states simultaneously	□	□	□	□	□	□
2.2 Appropriately prioritizes therapeutic interventions based on clinical urgency	□	□	□	□	□	□
2.3 Anticipates and addresses potential drug interactions in patients with polypharmacy	□	□	□	□	□	□
2.4 Considers patient-specific factors (age, renal/hepatic function, etc.) when selecting therapies	□	□	□	□	□	□
2.5 Applies evidence-based medicine principles to therapeutic decision-making	□	□	□	□	□	□
2.6 Identifies and resolves medication-related problems across multiple disease states	□	□	□	□	□	□

Comments on Therapeutic Planning:

_____

_____

_____

Section 3: Clinical Reasoning

Competency	1	2	3	4	5	N/A
3.1 Demonstrates integrated thinking across multiple therapeutic areas	□	□	□	□	□	□
3.2 Evaluates the impact of interventions for one condition on other comorbidities	□	□	□	□	□	□
3.3 Justifies therapeutic decisions with sound clinical reasoning	□	□	□	□	□	□
3.4 Adapts therapeutic approaches based on changing patient conditions	□	□	□	□	□	□
3.5 Effectively balances competing therapeutic goals in complex patients	□	□	□	□	□	□

Comments on Clinical Reasoning:

_____

_____

_____

Section 4: Monitoring and Follow-up

Competency	1	2	3	4	5	N/A
4.1 Develops comprehensive monitoring plans addressing multiple disease states	□	□	□	□	□	□
4.2 Appropriately adjusts therapies based on patient response	□	□	□	□	□	□
4.3 Recognizes and manages adverse drug events in the context of multiple medications	□	□	□	□	□	□
4.4 Identifies therapeutic failures and their potential causes	□	□	□	□	□	□
4.5 Demonstrates ability to provide continuity of care across healthcare transitions	□	□	□	□	□	□

Comments on Monitoring and Follow-up:

_____

_____

_____

Section 5: Communication and Documentation

Competency	1	2	3	4	5	N/A
5.1 Clearly communicates comprehensive care plans to healthcare team members	□	□	□	□	□	□
5.2 Effectively educates patients about complex medication regimens	□	□	□	□	□	□
5.3 Appropriately documents clinical interventions and their rationale	□	□	□	□	□	□
5.4 Adapts communication based on the needs and backgrounds of patients	□	□	□	□	□	□
5.5 Effectively communicates the interrelationships between disease states and therapies	□	□	□	□	□	□

Comments on Communication and Documentation:

_____

_____

_____

Section 6: Cultural Considerations in Patient Care

Competency	1	2	3	4	5	N/A
6.1 Demonstrates awareness of cultural factors affecting medication use in UAE patients	□	□	□	□	□	□
6.2 Adapts care plans to accommodate religious practices (e.g., Ramadan fasting)	□	□	□	□	□	□
6.3 Considers socioeconomic factors in therapeutic decision-making	□	□	□	□	□	□
6.4 Demonstrates respect for patients' cultural beliefs and preferences	□	□	□	□	□	□
6.5 Effectively utilizes translation services or patient education materials in appropriate languages	□	□	□	□	□	□

Comments on Cultural Considerations:

_____

_____

_____

Overall Assessment

Summary of Strengths

_____

_____

_____

Areas for Improvement

_____

_____

_____

Overall Rating for Complex Case Management

□ Unsatisfactory (1) □ Needs Improvement (2) □ Satisfactory (3) □ Above Average (4) □ Excellent (5)

Final Comments

_____

_____

_____

Preceptor Signature: _____ Date: _____

Student Signature: _____ Date: _____

This evaluation form was developed based on competency frameworks for pharmacy practice in the UAE and international standards for advanced pharmacy practice experiences. The form specifically emphasizes competencies in managing patients with multiple comorbidities, aligning with regional healthcare needs and educational objectives at Fatima College of Health Sciences.

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Appendix C: Student Perception Survey on Assessment Methods

Student Information

- Student ID: _____
- Assessment Group: □ E-portfolio □ Traditional
- Date: _____

Instructions

This survey aims to understand your perceptions of the assessment methods used in the Advanced Pharmacotherapy course, specifically focusing on complex comorbidity cases. Please rate your level of agreement with each statement using the 5-point scale provided. Your responses will be kept confidential and used only for research purposes.

Rating Scale: 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Section 1: Clinical Preparedness

Statement	1	2	3	4	5
1.1 I feel well-prepared to manage patients with multiple comorbidities	□	□	□	□	□
1.2 I am confident in my clinical decision-making abilities for complex cases	□	□	□	□	□
1.3 I can effectively integrate knowledge across different disease states	□	□	□	□	□
1.4 I am comfortable identifying medication-related problems in patients with multiple conditions	□	□	□	□	□
1.5 I understand how to prioritize therapeutic interventions in patients with multiple health problems	□	□	□	□	□

Section 2: Assessment of Clinical Skills

Statement	1	2	3	4	5
2.1 The assessment method effectively evaluated my ability to monitor therapeutic outcomes	□	□	□	□	□
2.2 The assessment method helped me develop skills in applying evidence-based medicine	□	□	□	□	□
2.3 I feel prepared for clinical practice in workplace settings	□	□	□	□	□
2.4 The assessment method appropriately evaluated my clinical reasoning abilities	□	□	□	□	□
2.5 I was able to demonstrate my knowledge of managing complex comorbidities through this assessment	□	□	□	□	□

Section 3: Assessment Experience

Statement	1	2	3	4	5
3.1 I am satisfied with the assessment method used in this course	□	□	□	□	□
3.2.The assessment method was valuable for my professional development	□	□	□	□	□
3.3 The assessment method helped me identify my strengths and weaknesses	□	□	□	□	□
3.4 The feedback I received was helpful for improving my clinical skills	□	□	□	□	□
3.5 The assessment method was appropriate for evaluating advanced pharmacotherapy knowledge	□	□	□	□	□

Section 4: Artificial Intelligence and Technology Integration

Statement	1	2	3	4	5
4.1 I understand how to ethically use AI tools to support clinical decision-making	□	□	□	□	□
4.2 The assessment method helped me develop critical thinking beyond what AI tools provide	□	□	□	□	□
4.3 I can effectively evaluate AI-generated recommendations for patient care	□	□	□	□	□
4.4 The assessment approach prepared me to use technology effectively in pharmacy practice	□	□	□	□	□
4.5 I understand the limitations of AI in clinical decision-making	□	□	□	□	□

Section 5: UAE Healthcare Context

Statement	1	2	3	4	5
5.1 The assessment prepared me to manage common comorbidities seen in UAE patients	□	□	□	□	□
5.2 I feel confident adapting pharmacotherapy for patients during Ramadan	□	□	□	□	□
5.3 The assessment helped me consider cultural factors in medication management	□	□	□	□	□
5.4 I can effectively communicate medication information to diverse patient populations	□	□	□	□	□
5.5 I understand how to apply international guidelines to the UAE healthcare context	□	□	□	□	□

Section 6: Open-Ended Questions

1. What aspects of the assessment method did you find most valuable for developing your clinical skills?

Appendix D: Script Concordance Test (SCT) for Clinical Reasoning in Complex Comorbidity Cases

Student Information

- Student ID: _____
- Date: _____

Instructions

This Script Concordance Test (SCT) assesses your clinical reasoning skills in the context of complex comorbidity cases. Each item presents a clinical scenario followed by:

- A diagnostic or therapeutic decision/option
- New information that might affect that decision/option

For each item, consider the effect of the new information on the proposed option using the following scale:

-2	**-1**	**0**	**+1**	**+2**
Strongly contraindicated	Contraindicated	Neither indicated nor contraindicated	Indicated	Strongly indicated

OR

-2	**-1**	**0**	**+1**	**+2**
Much less likely	Less likely	Neither more nor less likely	More likely	Much more likely

OR

-2	**-1**	**0**	**+1**	**+2**
Much less appropriate	Less appropriate	Neither more nor less appropriate	More appropriate	Much more appropriate

Circle the number that best reflects your judgment. Your answers will be compared with those of a panel of experienced clinical pharmacists.

Clinical Scenario 1:

A 68-year-old Emirati male with a 15-year history of type 2 diabetes mellitus (HbA1c 8.2%), hypertension, and heart failure with reduced ejection fraction (HFrEF, EF 38%). Current medications include metformin 1000mg BID, glimepiride 4mg daily, lisinopril 10mg daily, carvedilol 12.5mg BID, and furosemide 40mg daily.

If you were considering...	**And then you find that...**	**The option becomes...**
1.1 Adding empagliflozin 10mg daily	The patient's eGFR is 44 mL/min/1.73m²	-2 -1 0 +1 +2
1.2 Increasing lisinopril to 20mg daily	The patient's serum potassium is 5.1 mEq/L	-2 -1 0 +1 +2
1.3 Adding spironolactone 25mg daily	The patient occasionally experiences dizziness when standing	-2 -1 0 +1 +2
1.4 Switching from glimepiride to a DPP-4 inhibitor	The patient fasts during Ramadan	-2 -1 0 +1 +2
1.5 Starting dapagliflozin 10mg daily	The patient has been hospitalized twice in the past year for heart failure exacerbation	-2 -1 0 +1 +2

Clinical Scenario 2:

A 72-year-old female with hypertension, dyslipidemia, and stage 3a chronic kidney disease (eGFR 52 mL/min/1.73m²). Current medications include amlodipine 10mg daily, atorvastatin 40mg at bedtime, and aspirin 81mg daily.

If you were considering...	**And then you find that...**	**The option becomes...**
2.1 Adding an ACE inhibitor	The patient's urine albumin-to-creatinine ratio is 320 mg/g	-2 -1 0 +1 +2
2.2 Switching to rosuvastatin 20mg	Recent lab results show ALT 62 U/L (normal <40)	-2 -1 0 +1 +2
2.3 Adding ezetimibe 10mg daily	LDL is 2.8 mmol/L (108 mg/dL) despite atorvastatin 40mg	-2 -1 0 +1 +2
2.4 Discontinuing aspirin	Patient reports occasional epistaxis	-2 -1 0 +1 +2
2.5 Adding spironolactone for resistant hypertension	Recent labs show serum potassium 4.8 mEq/L	-2 -1 0 +1 +2

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Clinical Scenario 3:

A 64-year-old male with COPD (GOLD stage 3), atrial fibrillation, and systolic heart failure (EF 40%). Current medications include tiotropium inhaler, formoterol/budesonide inhaler, warfarin, digoxin 0.125mg daily, and furosemide 40mg daily.

If you were considering...	**And then you find that...**	**The option becomes...**
3.1 Adding a beta-blocker for heart failure	The patient's FEV1 is 43% of predicted normal	-2 -1 0 +1 +2
3.2 Switching from warfarin to apixaban	The patient's most recent INR was 3.8	-2 -1 0 +1 +2
3.3 Increasing digoxin dose to 0.25mg daily	The patient's heart rate is 62 bpm	-2 -1 0 +1 +2
3.4 Adding an oral corticosteroid for 5 days	The patient reports increased dyspnea and purulent sputum	-2 -1 0 +1 +2
3.5 Adding a non-dihydropyridine calcium channel blocker for rate control	The patient's blood pressure is 105/65 mmHg	-2 -1 0 +1 +2

Scoring

Your answers will be compared with those of a panel of experts. Points are assigned based on the degree of concordance with the expert panel. Scoring will not be based simply on agreement with a single "correct" answer, but rather on the degree to which your answers align with the distribution of responses from the expert panel.

This Script Concordance Test was developed based on validated SCT formats for pharmacy education^23,35^ and specifically addresses complex comorbidity cases relevant to the UAE healthcare context. The cases incorporate regional considerations including cultural factors affecting pharmacotherapy decisions.##