

RESEARCH ARTICLE

Gamified learning during Ramadan: Feasibility, completion metrics, and learner perceptions in a virtual Beers Criteria escape room among PharmD students

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Abstract

Background: Ramadan fasting affects sleep, energy, and cognition for millions of Muslims. Healthcare education concerns include scheduling cognitive assessments during fasting. Gamified methods like virtual escape rooms involve reasoning, collaboration, and time pressure. This study assessed the feasibility and student perceptions of a virtual Beers Criteria escape room during Ramadan among fifth-year PharmD students. **Methods:** This study involved 122 fasting students who took part in a Geriatric Virtual Escape Room (G-VER) during the third week of Ramadan. Metrics included completion time and hints used. A survey assessed concentration, problem-solving, confidence, sleep, energy, collaboration, and engagement. **Results:** All students completed the activity within 90 minutes (100% rate). The average time was 32.4 ± 3.9 minutes, with 1.45 ± 0.95 hints used. Although 69.7% reported reduced concentration and 51.6% perceived impairment during fasting, performance remained high. Most reported moderate energy (53.3%) and found the activity more enjoyable than traditional tests (73%). Female students completed faster ($p < 0.001$), but males showed higher confidence ($p = 0.046$). **Conclusion:** Implementing a gamified pharmacotherapy assessment during Ramadan was feasible and well received. Many students faced cognitive challenges while fasting but completed the activity on time despite perceived strain. These findings support scheduling interactive learning during Ramadan and highlight the need to address student perceptions of cognitive strain.

Introduction

Gamified learning has become increasingly prominent in pharmacy education as educators seek engaging, student-centred approaches to teach complex pharmacotherapy concepts. Escape rooms, in particular, use timed, puzzle-based scenarios that require learners to apply prior knowledge, collaborate, and solve problems, and have been widely adopted across healthcare programs as an experiential, game-based strategy (Hope et al., 2023; Quek et al., 2024). In pharmacy curricula, escape rooms are most commonly used to review or reinforce previously taught content. They have been reported to enhance clinical

knowledge, teamwork skills, and learner motivation compared with traditional teaching methods, although robust comparative evidence on educational outcomes remains limited (López-Belmonte et al., 2020; Hope et al., 2023; Quek et al., 2024). Virtual escape rooms delivered through online platforms have expanded rapidly since the COVID-19 pandemic, demonstrating high feasibility, positive learner perceptions, and improved topic-specific knowledge in areas such as hepatitis pharmacotherapy and self-care for sexual health (Gerber & Fischetti, 2022; Krishnan et al., 2023)

Safe and effective prescribing for older adults is a core competency for PharmD students. The American Geriatrics Society (AGS) Beers Criteria is an explicit,

evidence-based list of potentially inappropriate medications (PIMs) in older adults that is widely used in clinical practice, education, and quality measurement to identify medications whose harms may outweigh benefits (By the 2023 American Geriatrics Society Beers Criteria® Update Expert Panel, 2023). Repeated updates in 2012, 2015, 2019, and 2023 reflect evolving evidence on drug-related problems and adverse events in older adults and underscore the importance of training future pharmacists to recognise PIMs, avoid high-risk drug-disease and drug-drug combinations, and recommend safer alternatives. Innovative educational tools have been developed to support Beers Criteria learning, including a geriatric virtual escape room for fifth-year PharmD students and a board game for practising pharmacists, both of which were feasible, well received, and perceived as useful for learning about PIMs (Badr, 2022; Wahab *et al.*, 2022; Krishnan *et al.*, 2023).

Despite growing evidence that virtual escape rooms are viable and engaging methods to teach Beers Criteria content, key questions remain about their implementation under conditions that may influence cognition and learning. Existing pharmacy gamification research has largely focused on design, feasibility, and satisfaction, with limited attention to contextual factors such as fasting or altered sleep patterns (Hope *et al.*, 2021; Badr, 2022; Gerber & Fischetti, 2022; Hintze *et al.*, 2023; Krishnan *et al.*, 2023; Quek *et al.*, 2024). Ramadan fasting, commonly observed by pharmacy students in many regions, may raise concerns about scheduling cognitively demanding assessments and group activities. However, empirical evidence on its impact on performance and learner experience in gamified learning environments remains limited. To address this gap, this study evaluated the feasibility, completion metrics, and learner perceptions associated with implementing a virtual Beers Criteria escape room during Ramadan among fifth-year PharmD students.

Methods

Study design

This prospective observational feasibility study evaluated the implementation, completion metrics, and learner perceptions associated with delivering a previously developed virtual escape room activity (G-VER) during Ramadan among fifth-year PharmD fasting students (Badr, 2022), without altering routine curricular scheduling or introducing comparator interventions.

The study was conducted during the third week of Ramadan in the 2024–2025 academic year at King Abdulaziz University, Saudi Arabia. The Unit of Biomedical Ethics, Research Ethics Committee (REC), at King Abdulaziz University approved the study (NCBE registration #HA-02-J-008). Clinical trial registration was not applicable.

Participants and setting

The study population comprised fifth-year male and female PharmD students enrolled in the clinical pharmacy course during the study period. Students were eligible for inclusion if they were enrolled in the fifth-year clinical pharmacy course, participated in the geriatric pharmacotherapy module, were fasting during Ramadan, and provided informed consent for inclusion of their data in the study analysis. Students were excluded if they had known medical conditions that could independently affect cognitive performance unrelated to fasting.

Educational intervention: Geriatric Virtual Escape Room (G-VER)

The Geriatric Virtual Escape Room (G-VER) is a previously developed and published gamified educational activity designed to reinforce the application of the 2023 American Geriatrics Society (AGS) Beers Criteria in older adults (Badr, 2022). Following completion of a two-week geriatric pharmacotherapy module (10 lecture and 2 tutorial hours), students completed the G-VER during a scheduled two-hour tutorial session using Google Forms® with in-class faculty facilitation.

The escape room consisted of five sequential, case-based puzzles aligned with the course learning outcomes. These included identifying PIMs using the AGS Beers Criteria, justifying medication avoidance in older adults, recommending safer pharmacotherapeutic alternatives, identifying active ingredients in over-the-counter (OTC) products that may pose risks to older adults, and reviewing updates introduced in the 2023 Beers Criteria.

Students worked collaboratively in groups of 4–5, with 90 minutes allocated to complete the escape room. Although the activity was completed as a group, each student independently submitted a Google Forms® response using a unique student identifier when the group completed the final puzzle. This approach preserved individual-level responses while allowing submission timestamps to reflect group-level completion time, resulting in identical or near-identical timestamps among students within the same group.

Each puzzle required a correct response before students could proceed to the next stage of the Google Forms® sequence. Groups could retry incorrect responses and request facilitator hints when needed. Successful completion was defined as progressing through all puzzle stages; no separate accuracy scoring or rubric-based grading was performed.

Male and female students completed the activity in gender-segregated classrooms in accordance with institutional norms. The same instructor facilitated both sessions using the same standardised instructions, timing, and hint policy to minimise instructor-related variability. Each group was permitted a maximum of four hints upon request. Hints were provided verbally by the facilitator. Students had access to the Beers Criteria as a reference throughout the activity.

Participation in the escape room contributed 2 marks toward the course assessment. Marks were awarded for participation rather than successful escape to minimise task-completion pressure.

Educational-study evaluation

Ramadan escape room implementation

The G-VER was administered during the third week of Ramadan. Students completed the activity within the allocated 90-minute period. Activity-related data were automatically captured through Google Forms® submission timestamps and facilitator documentation. The session was conducted around midday during fasting hours (approximately 04:00–19:00). Primary activity-completion indicators were completion time (minutes), number of hints requested, and overall completion within the allocated time.

Post-activity perception survey

The post-activity survey was developed by the study team based on findings from prior literature on cognition during Ramadan fasting and the local educational context. The questionnaire items were reviewed for face validity by two faculty members with relevant expertise, and minor wording modifications were made to improve clarity and contextual appropriateness. As the instrument was developed specifically for this study, no previously validated questionnaire was used, and formal psychometric validation was not undertaken. Immediately following the activity, students completed the structured questionnaire assessing self-perceived cognitive and experiential factors during fasting.

Responses were collected using categorical options (Yes/No/Unsure) and Likert-type scales. Gender information was collected to allow subgroup analyses.

Statistical analysis

Data were exported from Google Forms® into Microsoft Excel and subsequently analysed using IBM SPSS Statistics. Continuous variables, including completion time and number of hints requested, were summarised as mean $\pm$ standard deviation, while categorical variables were summarised as frequencies and percentages. Completion rate was expressed as the percentage of students who completed the activity within the allocated 90-minute period. Gender-based subgroup analyses were conducted descriptively. Completion time was analysed descriptively because students within the same group submitted their responses at the group's completion point, resulting in identical or near-identical completion times and non-independent observations at the student level. Accordingly, inferential comparisons of completion time were not performed. Statistical significance was set at $p < 0.05$ for inferential analyses.

Results

Participation and feasibility

A total of 122 fifth-year PharmD students participated in the G-VER during Ramadan, including 67 (54.9%) female students and 55 (45.1%) male students. All participating students were fasting at the time of implementation. The activity achieved a 100% completion rate within the allocated 90-minute timeframe, with all groups successfully progressing through the five sequential puzzles.

Completion metrics

The overall mean completion time for the virtual escape room was 32.4 ± 3.9 minutes. Female groups demonstrated shorter mean completion times descriptively compared with male groups (31.14 ± 3.73 vs 33.89 ± 3.83 minutes, respectively). However, inferential interpretation should be made cautiously because completion time was determined at the group level rather than the individual student level. The fastest group completed the activity in 21.12 minutes, whereas the last group completed it in 39.04 minutes.

The overall mean number of hints used was 1.45 ± 0.95 . Female groups used a mean of 1.4 ± 0.9 hints, while male groups used a mean of 1.5 ± 1.2 hints. Hint requests were made collaboratively at the group level during the activity. Additional gender-based completion metrics are presented in Table I.

Table I: Gender-based subgroup analysis of completion metrics during Ramadan fasting

Completion metric	Female students (n=67)	Male students (n=55)
Completion time (minutes), Mean $\pm$ SD	31.14 $\pm$ 3.73	33.89 $\pm$ 3.83
Number of hints used, mean $\pm$ SD	1.4 $\pm$ 0.9	1.5 $\pm$ 1.2

Post-activity perception survey

All 122 students completed the post-activity perception questionnaire (100% response rate) (Table II).

Table II: Post-activity student self-perception of fasting and performance survey (n=122, 67 female and 55 male)

Question	Possible answer	N(%)	Male n(%)	Female n(%)	P-value
Perceived cognitive effects of fasting					
Did you feel your concentration was affected during fasting?	Yes	85 (69.7)	37 (67.3)	48 (71.6)	0.573
	No	24 (19.7)	13 (23.6)	11 (16.4)	
	Not sure	13 (10.7)	5 (9.1)	8 (11.9)	
How many hours of sleep did you typically get during Ramadan?	< 4 hours	73 (59.8)	31 (56.4)	42 (62.7)	0.428
	4 to 6 hours	34 (27.9)	15 (27.3)	19 (28.4)	
	6 to 8 hours	10 (8.2)	7 (12.7)	3 (4.5)	
	> 8 hours	5 (4.1)	2 (3.6)	3 (4.5)	
Did you feel fasting affected your problem-solving skills?	Yes	63 (51.6)	25 (45.5)	38 (56.7)	0.109
	No	29 (23.8)	18 (32.7)	11 (16.4)	
	Not sure	30 (24.6)	12 (21.8)	18 (26.9)	
Was it difficult to recall information due to fasting?	Yes	74 (60.7)	28 (50.9)	46 (68.7)	0.091
	No	33 (27)	20 (36.4)	13 (19.4)	
	Not sure	15 (12.3)	7 (12.7)	8 (11.9)	
How would you rate your confidence in your answers during the escape room?	Very low	4 (3.3)	0 (0)	4 (6)	0.046*
	Low	9 (7.4)	2 (3.6)	7 (10.4)	
	Moderate	53 (43.4)	23 (41.8)	30 (44.8)	
	High	44 (36.1)	21 (38.2)	23 (34.3)	
	Very high	12 (9.8)	9 (16.4)	3 (4.5)	
Collaboration and engagement					
Did you find it difficult to collaborate and participate as a group while fasting?	Yes	30 (24.6)	6 (10.9)	24 (35.8)	0.005*
	No	79 (64.8)	43 (78.2)	36 (53.7)	
	Not sure	13 (10.7)	6 (10.9)	7 (10.4)	
How fun was the escape room compared to other assessments during Ramadan?	Less fun	6 (4.9)	3 (5.5)	3 (4.5)	0.861
	Similar	27 (22.1)	11 (20)	16 (23.9)	
	More fun	89 (73)	41 (74.5)	48 (71.6)	
Perceived challenge and difficulty of G-VER during fasting hours					
How challenging was the escape room compared to previous assessments? (during Ramadan)	Easier	22 (18)	13 (23.6)	9 (13.4)	0.076
	Similar	54 (44.3)	27 (49.1)	27 (40.3)	
	More challenging	46 (37.7)	15 (27.3)	31 (46.3)	
How would you rate your energy levels while completing the escape room during Ramadan?	Very low	12 (9.8)	5 (9.1)	7 (10.4)	0.106
	Low	18 (14.8)	7 (12.7)	11 (16.4)	
	Moderate	65 (53.3)	24 (43.6)	41 (61.2)	
	High	19 (15.6)	13 (23.6)	6 (9)	
	Very high	8 (6.6)	6 (10.9)	2 (3)	

* Statistically significant ($p < 0.05$)

Most students reported perceived cognitive effects during fasting, including reduced concentration (69.7%), difficulty recalling information (60.7%), and impaired problem-solving ability (51.6%). In addition, most students reported sleeping fewer than 4 hours per night during Ramadan (59.8%). Despite these perceived challenges, over half of students (53.3%) reported moderate energy levels while completing the activity. No statistically significant gender differences were observed in concentration, perceived problem-solving ability, recall difficulty, sleep duration, or energy levels.

Most students reported moderate-to-high confidence in their answers during the activity, with 43.4% reporting moderate confidence and 36.1% reporting high confidence. Male students reported significantly higher confidence levels compared with female students ($p = 0.046$).

Regarding collaboration, most students did not report difficulty participating in group work during fasting (64.8%), although female students reported collaborative difficulty more frequently than male students ($p = 0.005$).

Most students perceived the escape room as either similar in challenge (44.3%) or more challenging (37.7%) than other Ramadan assessments. The activity was also viewed positively, with 73% of students reporting that the escape room was more enjoyable than traditional assessments. No statistically significant gender differences were observed in perceived challenge or enjoyment.

Discussion

This study evaluated the feasibility, completion metrics, and learner perceptions associated with a cognitively demanding, gamified pharmacotherapy assessment during Ramadan. The G-VER was successfully implemented during fasting hours, with a 100% completion rate and strong completion metrics, suggesting that a structured, collaborative escape room can be delivered with a 100% completion rate and efficient completion times, supporting feasibility during Ramadan fasting hours. These results are consistent with broader escape room literature showing high feasibility, engagement, and learning support in health professions education (Seoane *et al.*, 2020; Almutairi *et al.*, 2023; Jaramillo-Mediavilla *et al.*, 2024; Attash *et al.*, 2025; Fatima Arshad Majeed, 2025; Ameer *et al.*, 2026) and with studies indicating that well designed virtual or interactive learning tools can enhance achievement

without increasing cognitive load (Chang *et al.*, 2015; Yiin & Chern, 2023).

A key finding was the divergence between perceived cognitive strain and the observed ability of groups to complete the activity within the allotted time. Most students reported reduced concentration and problem-solving ability, yet all groups completed the activity efficiently with limited use of hints. Similar dissociations are seen in Ramadan research, where fasting and sleep disruption are associated with fatigue and perceived difficulty, but academic performance can remain stable—particularly among highly motivated or high-achieving students (Almutairi *et al.*, 2023; Attash *et al.*, 2025; Fatima Arshad Majeed, 2025). Recent data even show that stress and sleep disturbances during Ramadan may correlate with better performance, likely reflecting reverse causality in high performers who maintain intense study habits despite fatigue (Attash *et al.*, 2025). This aligns with work on academic self-concept in medical education, where confidence and performance are only modestly correlated and may diverge systematically across subgroups (Gudden *et al.*, 2021). From a cognitive load perspective, the sequenced puzzles, clear narrative, and explicit grounding in previously taught geriatric content may have reduced extraneous load and supported performance, similar to other interactive or simulation-based pharmacology and nursing tools that improved outcomes while keeping cognitive load manageable (Chang *et al.*, 2015; López-Belmonte *et al.*, 2020; Yiin & Chern, 2023).

The gamified design likely played a central role in sustaining engagement under fasting conditions. Escape rooms typically integrate narrative, time pressure, collaboration, and immediate feedback, and are consistently rated as more enjoyable and motivating than traditional instruction in medical, nursing, and pharmacy education (Seoane *et al.*, 2020; Almutairi *et al.*, 2023; Attash *et al.*, 2025; Fatima Arshad Majeed, 2025; Khaled *et al.*, 2025). Some studies report superior knowledge gains or similar learning with greater satisfaction compared with standard approaches (Almutairi *et al.*, 2023; Attash *et al.*, 2025; Fatima Arshad Majeed, 2025; Khaled *et al.*, 2025). The strong engagement reported by students may suggest that gamified learning remained well accepted during fasting conditions.

Gender based differences observed in this study—faster completion among female students but higher reported confidence among male students, and greater reported collaboration difficulty among females—mirror patterns described in the medical education and gender literature, where women often equal or outperform men while reporting lower confidence or different self-efficacy profiles (Qasrawi *et al.*, 2017; Rachid *et al.*, 2020;

Gudden *et al.*, 2021; Fatima Arshad Majeed, 2025). Escape room and game-based studies have also identified gender differences in dimensions such as dominance or perceived control within team activities (Yiin & Chern, 2023; Ameer *et al.*, 2026). The consistency of descriptively faster completion by female groups across both the original and Ramadan G-VER implementations may suggest underlying differences in group interaction or problem-solving approaches; however, direct comparison between the studies should be interpreted cautiously because the studies differed in context and were not designed as controlled comparative analyses. Given the absence of a comparator, this cannot be confirmed. Qualitative and mixed methods research could clarify how gendered roles, leadership, and communication shape performance and experience in gamified team assessments (Qasrawi *et al.*, 2017; Rachid *et al.*, 2020; Gudden *et al.*, 2021).

The high prevalence of reduced sleep duration in this observational study is notable in light of strong evidence linking sleep restriction with impaired attention, executive function, and academic performance in medical students (Khan & Al-Jahdali, 2023; Muzafar *et al.*, 2025; Rizwan *et al.*, 2025). Ramadan-specific work has documented substantial sleep disruption and fatigue, with mixed or context-dependent impacts on academic outcomes (Attash *et al.*, 2025; Fatima Arshad Majeed, 2025). The maintenance of G-VER performance despite short sleep may reflect the relatively short, bounded nature of the task, compensatory effort in a novel and engaging setting, or the resilience of high-achieving health professions students (Khan & Al-Jahdali, 2023; Muzafar *et al.*, 2025; Rizwan *et al.*, 2025). However, studies focusing on class attendance, test scores, and sleep quality during Ramadan have also reported poorer sleep associated with reduced academic performance and attendance, underscoring that negative effects can emerge in less gamified, routine assessment contexts (Fatima Arshad Majeed, 2025). Future work should directly relate sleep quantity and quality to performance across multiple tasks and time points during Ramadan.

From an educational policy perspective, these findings suggest that interactive, team-based assessments such as escape rooms can be thoughtfully scheduled during Ramadan in Muslim-majority or religiously diverse institutions without evident compromise in immediate task completion. This aligns with evidence that, although Ramadan fasting commonly leads to sleep disruptions, fatigue, and reduced desire to study, academic outcomes are not uniformly degraded and may depend on task design, motivation, and support structures (Almutairi *et al.*, 2023; Attash *et al.*, 2025; Fatima Arshad Majeed, 2025). Given the well-documented adverse

effects of chronic sleep deprivation on cognition and long term academic performance, institutions should nonetheless be attentive to workload distribution, clustering of high-stakes exams, and provision of wellbeing support across the fasting month (Khan & Al-Jahdali, 2023; Muzafar *et al.*, 2025; Rizwan *et al.*, 2025).

Limitations

This study has several limitations. It was conducted at a single institution among one cohort of fifth-year PharmD students, with the sample size constrained by the enrolled cohort during one academic year, which may limit the generalizability of the findings to other academic programs, health disciplines, or educational contexts with different curricular and cultural characteristics. The prospective observational, single-session design and absence of a concurrent non-fasting comparison group preclude causal inferences regarding the direct cognitive effects of fasting; therefore, the findings should be interpreted as descriptive of performance and perceptions within this specific educational context. Although progression through the puzzles required completion of each activity stage, detailed rubric-based scoring or standardised accuracy assessment was not performed, and completion metrics should therefore not be interpreted as comprehensive measures of clinical performance quality. Furthermore, because completion time was determined at the group level, individual-level variability in task performance may have been masked. Self-reported measures of sleep duration, perceived cognitive effects, and related factors were also subject to recall and response bias, and objective measures of sleep quality, hydration status, or physiological markers were not collected. Finally, the assessment was conducted during a single week of Ramadan; consequently, potential cumulative effects of repeated fasting, circadian rhythm disruption, or sustained sleep deprivation over the full month were not examined. Longitudinal or repeated-measures studies are needed to better characterise temporal patterns and potential changes across Ramadan.

Conclusion

This study demonstrates that a geriatric virtual escape room can be feasibly implemented during Ramadan fasting, with strong student engagement and no apparent reduction in task-completion metrics despite high levels of self-reported fatigue, reduced concentration, and short sleep duration. The divergence between subjective perceptions of cognitive strain and observed completion metrics

highlights the complexity of interpreting academic performance during fasting. Gender-related differences in completion time and confidence were also observed, potentially reflecting variations in collaborative dynamics, self-efficacy, or problem-solving strategies within team-based learning. Overall, these findings suggest that well-structured, gamified, and collaborative learning activities may remain viable during Ramadan. However, the findings should be interpreted cautiously given the study design and limited objective assessment of performance. Further rigorous, longitudinal, and mixed-methods research incorporating objective accuracy measures, standardised cognitive assessments, and qualitative exploration of team processes is warranted to better understand how fasting, sleep patterns, and instructional design interact in health professions education.

Conflict of interest

The authors declare no conflict of interest.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the author used ChatGPT (OpenAI, San Francisco, CA, USA) to assist with language editing and structural refinement of the manuscript. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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