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Gamified Simulation in Medical Education: Do Escape Room–Based Interventions Improve Clinical Decision-Making Under Time Pressure and Cognitive Load? A Systematic Review

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ABSTRACT

Background: Escape room–based simulation has emerged as an innovative approach in medical education, integrating gamification, time pressure, and collaborative problem-solving. While its effects on engagement and teamwork are increasingly recognized, its influence on clinical decision-making under cognitive load remains unclear.

Objective: To systematically evaluate the impact of escape room–based simulation on clinical decision-making, cognitive load, and educational outcomes in medical training.

Methods: A systematic review was conducted in accordance with PRISMA guidelines. Multiple databases were searched for studies published between 2018 and 2025 examining escape room–based interventions in medical education. Eligible studies included undergraduate and postgraduate learners. Due to heterogeneity in study designs and outcome measures, a structured narrative synthesis was performed. Outcomes were categorized into cognitive, affective, and behavioral domains.

Results: Twenty-six studies met inclusion criteria. Escape room–based learning was consistently associated with high levels of engagement, motivation, and learner satisfaction. Improvements in teamwork, communication, and collaborative problem-solving were frequently reported. Gains in knowledge acquisition were observed across several disciplines; however, direct assessment of clinical reasoning and decision-making under pressure was limited. Few studies evaluated cognitive load using validated measures, and most relied on descriptive or quasi-experimental designs.

Conclusions: Escape room–based simulation represents a promising educational strategy that enhances engagement and team-based competencies. However, its impact on higher-order cognitive processes, particularly decision-making under pressure and cognitive load, remains insufficiently defined. Future research should prioritize rigorous study designs and the integration of objective, theory-informed assessment tools to better elucidate its role in medical training.

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Introduction

The ability to make rapid and accurate clinical decisions under pressure is a defining competency in modern medical practice. In acute care settings, clinicians are required to process complex information, prioritize interventions, and act decisively within constrained timeframes, often under conditions of uncertainty and high cognitive demand. Despite the central importance of these skills, traditional models of medical education remain largely focused on knowledge acquisition in controlled, low-pressure environments, creating a persistent gap between theoretical understanding and real-world clinical performance [1,2].

Simulation-based education has emerged as a cornerstone in bridging this gap, providing learners with opportunities to engage in experiential learning within safe and structured environments. High-fidelity simulation has demonstrated effectiveness in improving technical skills, clinical reasoning, and teamwork [3,4]. However, conventional simulation formats may not consistently reproduce the **urgency, emotional activation, and cognitive load** that characterize real clinical situations. Learners may anticipate scenarios, follow predictable patterns, or engage passively, limiting the development of adaptive decision-making skills under pressure [5,6].

In response to these limitations, **gamification** has gained increasing attention as an innovative pedagogical approach in medical education. By integrating elements such as competition, rules, feedback, and time constraints, gamified learning environments

aim to enhance engagement and promote active participation [7,8]. Among these approaches, **escape game–based simulation** has emerged as a particularly immersive format. These interventions place learners in time-limited, problem-solving scenarios that require continuous information processing, teamwork, and decision-making, thereby reflecting key aspects of real clinical practice [9,10].

From a theoretical perspective, escape games align with principles of **cognitive load theory**, as they introduce controlled levels of complexity and time pressure that challenge learners while promoting meaningful learning [11]. Additionally, the emotional and immersive nature of these experiences may enhance memory consolidation and facilitate the transfer of knowledge to clinical contexts [12]. The integration of time constraints, uncertainty, and collaborative problem-solving positions escape games as a promising tool for training **decision-making under realistic cognitive and temporal conditions**.

Despite their growing use in medical education, the extent to which escape game–based interventions effectively improve **clinical decision-making under time pressure and cognitive load** remains unclear. Existing studies are heterogeneous in design, outcomes, and evaluation methods, with a predominance of subjective measures such as engagement and satisfaction. A comprehensive synthesis of the available evidence is therefore needed to clarify their educational value beyond learner enjoyment.

The objective of this systematic review is to evaluate the current evidence on escape game–based simulation in medical education, with a specific focus on its impact on **clinical decision-making, cognitive performance, and learning under time-constrained conditions**.

Materials and Methods

Study Design

This systematic review was conducted in accordance with the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)** guidelines [13].

Search Strategy

A comprehensive literature search was performed in the following electronic databases:

- PubMed
- Scopus
- Web of Science

The search included studies published between **January 2018 and December 2025**, in order to capture contemporary developments in gamified simulation and escape game–based learning.

The following keywords and Boolean combinations were used:

- "Escape Room" or "Escape Game"
- "Gamification"
- "Simulation"
- "Medical Education"
- "Clinical Reasoning" or "Decision-Making"

Search strategies were adapted for each database.

Eligibility Criteria

Inclusion Criteria

Studies were included if they met the following criteria:

- Population: Medical students, interns, residents, or healthcare trainees
- Intervention: Escape room–based learning or gamified simulation
- Outcomes: Educational outcomes including knowledge acquisition, clinical reasoning, decision-making, teamwork, or engagement
- Study design: Original research articles
- Language: English
- Publication period: 2018–2025

Exclusion Criteria

Studies were excluded if they did not align with the objectives of this review or failed to meet predefined methodological and conceptual criteria. Specifically, studies were excluded if they:

- Did not involve learners in **healthcare or medical education settings**, as the focus of this review was on clinically relevant training environments.
- Were **editorials, commentaries, conference abstracts, or review articles**, as these do not provide primary empirical data suitable for systematic synthesis [13].
- Lacked **clearly defined educational outcomes** or sufficient methodological detail to allow for meaningful analysis and comparison across studies.
- Focused exclusively on **gamification without a simulation-based component**, thereby excluding interventions that did not involve immersive, scenario-based learning or experiential engagement [7,8].

Study Selection

All identified records were screened independently based on titles and abstracts. Full texts of potentially eligible studies were then reviewed to determine final inclusion. Discrepancies were resolved through discussion.

Data Extraction

Data were extracted using a standardized form, including

- Study characteristics (author, year, country)
- Population and sample size
- Type of intervention (in-person or virtual escape room)
- Comparator (if applicable)
- Outcomes measured
- Key findings

Outcomes were categorized into

- **Cognitive Outcomes** (Knowledge, Clinical Reasoning)
- **Affective Outcomes** (Engagement, Satisfaction)
- **Behavioral Outcomes** (Teamwork, Performance)

Assessment of Time Pressure and Cognitive Load

Given the focus of this review, particular attention was paid to whether studies incorporated:

- Time constraints
- Problem-solving under pressure
- Indicators of cognitive load or decision-making complexity

Quality Assessment

The methodological quality of included studies was assessed using design-specific critical appraisal tools. Given the predominance of observational and quasi-experimental designs, studies were evaluated based on criteria including study design, clarity of methodology, outcome assessment, and risk of bias.

Studies were subsequently categorized according to their level of evidence, with quasi-experimental studies considered higher in methodological rigor compared to purely descriptive studies.

Data Synthesis

Due to heterogeneity in study designs, intervention formats, and reported outcomes, a quantitative meta-analysis was not feasible. Therefore, a structured narrative synthesis was conducted.

Extracted data were organized into predefined outcome domains, including cognitive outcomes (Knowledge Acquisition and Clinical Reasoning), affective outcomes (Engagement and Satisfaction), and behavioral outcomes (Teamwork and Communication), in alignment with the reporting structure of the Results section.

Study characteristics and key findings were systematically summarized in tabular format (Tables 1 and 2), supporting a structured descriptive synthesis of the included studies.

No formal assessment of statistical heterogeneity was performed due to the absence of comparable quantitative data across studies.

Results

Study Selection

The database search identified **248 records**. After removal of duplicates, **198 studies** were screened based on title and abstract. Following full-text assessment of **54 articles, 26 studies published between 2018 and 2025** met the predefined eligibility criteria and were included in the final analysis [13].

Study Characteristics

The included studies were conducted across multiple geographic regions, including North America, Europe, Asia, and the Middle East [9,10,14-37]. Participants included undergraduate medical students, interns, and residents across a range of medical specialties.

Sample sizes ranged from **10 to 530 participants**, with most studies conducted at a single institution. Study designs included descriptive studies, quasi-experimental designs, and pre–post intervention studies.

Escape room–based interventions were delivered in both **in-person and virtual formats**. All interventions incorporated structured tasks and **time-limited problem-solving activities**. Comparator groups were included in a minority of studies, including traditional teaching methods and case-based learning approaches [28,30,33,36].

The Characteristics of the Included Studies are Summarized in Table 1.

Educational Outcomes

Educational outcomes reported across studies were categorized into cognitive, affective, and behavioral domains.

Table 1: Summary of the Included Studies

Study	Year	Country	Population	Specialty	Intervention	Comparator	Outcome Type	Measurement	Time Pressure	Key Findings	Level
Kinio et al.	2018	USA	Med students (n=13)	Surgery	Escape room	None	Affective	Survey	Yes	High engagement and teamwork	III
Zhang et al.	2018	China	Residents (n=10)	Team training	Escape room	None	Behavioral	Survey	Yes	Improved teamwork	III
Rosenkrantz et al.	2019	USA	Med students (n=49)	Emergency medicine	Escape room	None	Affective	Survey	Yes	High enjoyment (98%)	III
Podlog et al.	2019	USA	Students/ residents (n=30)	Emergency medicine	Escape room	None	Cognitive + Affective	Survey	Yes	High perceived learning	III
Diemer et al.	2019	USA	Interns (n=120)	Patient safety	Escape room	None	Behavioral	Pre/post scale	Yes	Confidence improved significantly	II
Zhang et al.	2019	China	Interns (n=130)	Patient safety	Escape room	None	Affective	Survey	Yes	Moderate engagement	III
Jambhekar et al.	2019	USA	Residents (n=144)	Radiology	Escape room	None	Affective	Survey	Yes	Very high satisfaction	III
Backhouse & Malik	2019	UK	Med students (n=19)	Patient safety	Escape room	None	Behavioral	Survey	Yes	Improved teamwork and communication	III
Liu et al.	2020	USA	Med students (n=19)	Radiology	Escape room	None	Cognitive	Knowledge test	Yes	Improved knowledge	II
Guckian et al.	2020	Ireland	Med students (n=101)	Dermatology	Escape room	None	Cognitive + Behavioral	Pre/post test	Yes	Increased diagnostic confidence	II
Cates et al.	2020	USA	Residents (n=46)	Toxicology	Virtual escape room	None	Affective	Survey	Yes	Moderate perceived learning	III
Donovan et al.	2021	USA	Med students (n=66)	Critical care	Online gamified sim	None	Affective	Survey	Yes	High engagement (>90%)	III
Jaffe et al.	2021	USA	Interns (n=120)	Patient safety	Escape room	None	Behavioral	Survey	Yes	Improved confidence, no long-term change	II
Khanna et al.	2021	USA	Residents (n=86)	Internal medicine	Escape room	None	Affective	Survey	Yes	High satisfaction and teamwork	III

Cantwell et al.	2022	USA	Med students (n=134)	Emergency medicine	Virtual escape room	Flipped classroom	Cognitive + Affective	Survey	Yes	High engagement and satisfaction	II
Dimeo et al.	2022	USA	Residents (n=30)	Infectious disease	Virtual escape room	None	Cognitive	Knowledge test	Yes	Significant knowledge gain	II
Faysal et al.	2022	Saudi Arabia	Med students (n=97)	Dermatology	Escape room	Case-based learning	Cognitive	Exam scores	Yes	Equivalent to CBL	II
Lundholm et al.	2022	Sweden	Interns (n=52)	Internal medicine	Escape room	None	Behavioral	Survey	Yes	Improved workplace collaboration	III
Martin & Gibbs	2022	UK	Med students (n=148)	General	Escape room	None	Affective	Survey	Yes	Improved readiness	III
Carrasco-Gomez et al.	2023	Spain	Med students (n=245)	Physiology	Escape room	Traditional teaching	Cognitive	Exam scores	Yes	Higher exam performance	II
Moffett et al.	2023	UK	Med students (n=22)	Clinical transition	Digital escape room	None	Behavioral	Qualitative	Yes	Improved uncertainty management	III
Pelletier et al.	2023	USA	Residents (n=32)	Emergency pediatrics	Escape room + sim	None	Affective	Survey	Yes	High engagement	III
Le Guellec et al.	2025	France	Med students (n=530)	Research skills	Escape room	None	Cognitive	Pre/post test	Yes	Major knowledge improvement	II
Baessler et al.	2025	Germany	Med students (n=45)	Interdisciplinary	Escape room	None	Cognitive	Pre/post test	Yes	Significant knowledge gain	II
Hussaini et al.	2025	UK	Med students	Acute care	Escape room vs simulation	Simulation	Cognitive + Behavioral	Qualitative	Yes	Improved reasoning and engagement	II
Mirshahi et al.	2025	Iran	Medical learners	Research training	Escape room	None	Affective	Survey	Yes	Innovative and engaging learning	III

A summary of Reported Outcomes Across Studies is Presented in Table 2.

Cognitive Outcomes

Cognitive outcomes, including knowledge acquisition and clinical reasoning, were reported in multiple studies [10,22,23,29,30,33,35].

Table 2: A Summary of Reported Outcomes Across Studies

Study	Cognitive Outcomes	Affective Outcomes	Behavioral Outcomes	Time Pressure	Cognitive Load Assessed
Kinio et al. (2018)	Not assessed	High engagement	Teamwork improved	Yes	No
Zhang et al. (2018)	Not assessed	High satisfaction	Teamwork improved	Yes	No
Rosenkrantz et al. (2019)	Not assessed	High enjoyment	Not assessed	Yes	No
Podlog et al. (2019)	Perceived learning ↑	High engagement	Not assessed	Yes	No
Diemer et al. (2019)	Not assessed	Not assessed	Confidence ↑	Yes	No
Zhang et al. (2019)	Not assessed	Moderate engagement	Not assessed	Yes	No
Jambhekar et al. (2019)	Not assessed	High satisfaction	Not assessed	Yes	No
Backhouse & Malik (2019)	Not assessed	High engagement	Teamwork ↑	Yes	No
Liu et al. (2020)	Knowledge ↑	High satisfaction	Not assessed	Yes	No
Guckian et al. (2020)	Knowledge ↑	High engagement	Confidence ↑	Yes	No
Cates et al. (2020)	Not assessed	Moderate learning perception	Not assessed	Yes	No
Donovan et al. (2021)	Perceived learning ↑	High engagement	Not assessed	Yes	No
Jaffe et al. (2021)	Not assessed	Not assessed	Confidence ↑	Yes	No
Khanna et al. (2021)	Not assessed	High satisfaction	Teamwork ↑	Yes	No
Cantwell et al. (2022)	Knowledge comparable	High engagement	Not assessed	Yes	No
Dimeo et al. (2022)	Knowledge ↑	High satisfaction	Not assessed	Yes	No
Faysal et al. (2022)	Knowledge ↑ (vs CBL)	High engagement	Not assessed	Yes	No

Lundholm et al. (2022)	Not assessed	Not assessed	Collaboration ↑	Yes	No
Martin & Gibbs (2022)	Not assessed	Increased readiness	Not assessed	Yes	No
Carrasco-Gomez et al. (2023)	Knowledge ↑	High satisfaction	Not assessed	Yes	No
Moffett et al. (2023)	Not assessed	High engagement	Decision strategies ↑	Yes	Partial
Pelletier et al. (2023)	Not assessed	High engagement	Not assessed	Yes	No
Le Guellec et al. (2025)	Knowledge ↑	High satisfaction	Not assessed	Yes	No
Baessler et al. (2025)	Knowledge ↑	High satisfaction	Not assessed	Yes	No
Hussaini et al. (2025)	Clinical reasoning ↑	High engagement	Teamwork ↑	Yes	Partial
Mirshahi et al. (2025)	Not assessed	High engagement	Not assessed	Yes	No

Pre–post assessments demonstrated increases in knowledge scores across several disciplines, including dermatology, radiology, and infectious diseases [10,23,29]. Comparative studies reported similar or higher knowledge scores in escape room groups compared with traditional learning approaches [29,33].

Clinical reasoning outcomes were reported in a limited number of studies and were primarily assessed using qualitative or indirect measures [10,36].

Affective Outcomes

Affective outcomes, including engagement, satisfaction, and motivation, were reported across the included studies [9,14,16,17,20,25,27,34].

High levels of engagement and satisfaction were consistently reported, with several studies documenting engagement rates exceeding 80% [16,27,34].

Behavioral Outcomes

Behavioral outcomes, including teamwork, communication, and collaboration, were reported in several studies [15,18,21,24,26,31,32].

Improvements in self-reported confidence related to communication and team-based problem-solving were observed [18,21,26].

Evaluation of long-term behavioral outcomes or clinical performance was limited [21].

Time Pressure and Cognitive Load

All included studies incorporated **time constraints** as part of the intervention design.

Assessment of cognitive load or decision-making under pressure was reported in a limited number of studies and was primarily based on indirect or qualitative measures [36].

Quality and Level of Evidence

Most studies were classified as Level III evidence, consisting of descriptive or observational designs.

A smaller number of studies employed **pre–post or quasi-experimental designs (Level II)**.

Randomized controlled trials were not identified.

Common methodological characteristics included:

- Single-center design
- Small to moderate sample sizes
- Predominance of self-reported outcome measures
- Limited evaluation of long-term outcomes

Discussion

This systematic review synthesized current evidence on the use of escape room–based gamified simulation in medical education, with a specific focus on clinical decision-making under conditions of time pressure and cognitive demand. Across the 26 included studies, escape rooms consistently demonstrated high levels of engagement and positive educational outcomes, particularly in affective and behavioral domains. However, important gaps remain in the evaluation of higher-order cognitive processes, particularly those related to decision-making under pressure and cognitive load.

One of the most consistent findings across the included studies was the strong impact of escape room–based learning on learner engagement and motivation. These findings align with broader literature on gamification, which suggests that game elements such as challenge, time constraints, and goal-oriented tasks enhance intrinsic motivation and active participation [38,39]. The immersive and interactive nature of escape rooms appears to promote emotional activation, which has been shown to facilitate attention and memory encoding in learning environments [40]. This may partly explain the high levels of satisfaction and engagement reported across studies.

In addition to affective benefits, escape room–based interventions were frequently associated with improvements in teamwork, communication, and collaborative problem-solving. These findings are consistent with simulation-based education literature emphasizing the importance of experiential learning and team-based interaction in developing non-technical skills [41,42]. The time-limited and problem-oriented structure of escape rooms may create conditions that mimic real clinical environments, where rapid coordination and shared decision-making are essential.

Despite these promising findings, the evidence regarding cognitive outcomes, particularly clinical reasoning and decision-making remains limited. While several studies reported improvements in knowledge acquisition, few directly assessed decision-making processes under pressure. This represents a critical gap, given that clinical practice often requires rapid, high-stakes decision-making in complex and dynamic contexts [43]. The lack of standardized tools to measure clinical reasoning within escape room settings further complicates the interpretation of these outcomes.

A key theoretical lens through which these findings can be interpreted is cognitive load theory. Escape rooms inherently introduce elements of intrinsic and extraneous cognitive load through time pressure, multitasking, and information processing demands. While moderate levels of cognitive load may enhance learning by promoting active engagement, excessive load may impair performance and hinder knowledge integration [44].

Notably, very few studies included in this review explicitly measured cognitive load, highlighting a significant gap in the literature.

Furthermore, the concept of decision-making under pressure, central to emergency and acute care medicine, remains insufficiently explored in the context of gamified simulation. While escape rooms simulate urgency and constraint, the extent to which they accurately replicate the cognitive processes involved in real clinical decision-making is unclear. Existing evidence from cognitive psychology suggests that time pressure can alter reasoning strategies, often favoring heuristic-based decisions over analytical processing [45]. Whether escape room–based learning reinforces or mitigates these effects warrants further investigation.

Another important consideration is the methodological quality of the included studies. The majority were single-center, descriptive, or quasi-experimental designs, often relying on self-reported outcomes. While these designs are valuable for early-stage educational innovation, they limit the strength of conclusions that can be drawn regarding effectiveness. The absence of randomized controlled trials and standardized outcome measures further underscores the need for more rigorous research in this field.

Taken together, these findings suggest that escape room–based simulation represents a promising and innovative approach to medical education, particularly for enhancing engagement and teamwork. However, its impact on core cognitive competencies, especially clinical decision-making under realistic constraints, remains insufficiently defined. Future research should prioritize the development of validated assessment tools, incorporation of objective performance metrics, and exploration of cognitive load dynamics within these learning environments.

Strengths and Limitations

This review presents several strengths that contribute to its relevance and rigor. First, it provides a focused synthesis of a rapidly evolving educational approach, specifically examining escape room–based simulation through the lens of cognitive processes and decision-making under pressure. By structuring outcomes into cognitive, affective, and behavioral domains, this work offers a comprehensive and organized perspective that facilitates interpretation and comparison across studies. In addition, the integration of theoretical frameworks, including cognitive load theory and emotional learning, strengthens the conceptual foundation of the analysis and supports a more nuanced understanding of the mechanisms underlying observed educational outcomes [46,47].

However, several limitations must be acknowledged. The included studies demonstrated substantial heterogeneity in design, intervention formats, and outcome measures, which precluded quantitative synthesis and limited comparability across studies. Most studies were single-center and relied heavily on self-reported outcomes, introducing potential biases such as social desirability and subjective interpretation of learning gains [48]. Furthermore, the predominance of descriptive and quasi-experimental designs, with a lack of randomized controlled trials, restricts the strength of causal inferences that can be drawn.

Another important limitation relates to the assessment of key cognitive constructs. Despite the central role of cognitive load and decision-making in high-pressure clinical environments, these variables were rarely measured using validated or objective tools. This limits the ability to determine whether escape room–based learning translates into meaningful improvements in real-world clinical reasoning. Finally, the variability in reporting and absence of standardized evaluation frameworks across studies further challenge the reproducibility and generalizability of findings [49].

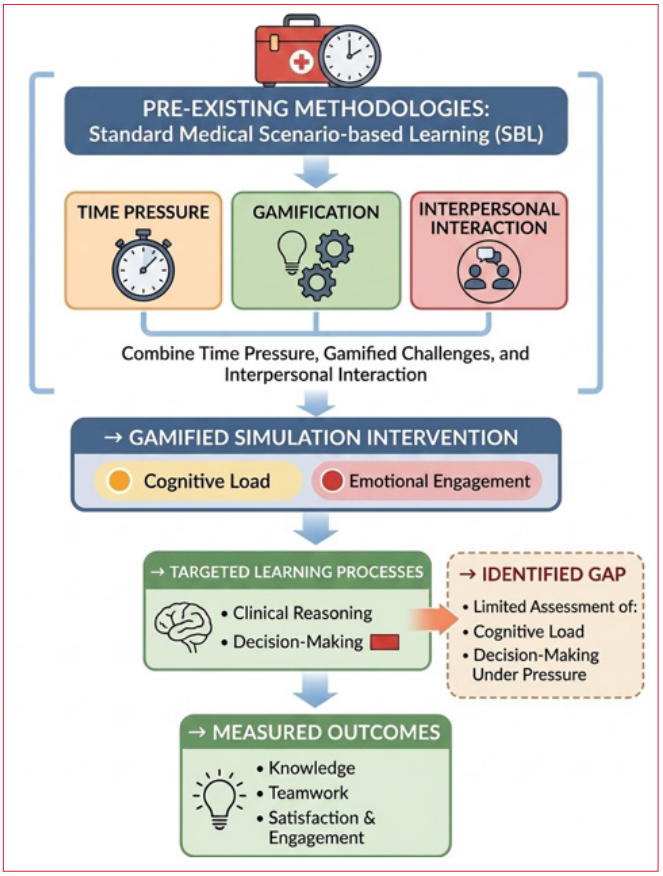

Figure 1: Conceptual Framework of Escape Room–Based Simulation in Medical Education

Conclusion

Escape room–based simulation is emerging as a compelling modality in medical education, combining experiential learning, time-constrained challenges, and collaborative problem-solving within an engaging framework. The evidence synthesized in this review demonstrates consistent benefits in learner engagement, motivation, and team-based competencies, supporting its value as an innovative educational strategy.

However, beyond these observable gains, a critical gap persists. Despite recreating elements of urgency and complexity that characterize real clinical environments, current evidence provides limited insight into how these interventions influence core cognitive processes, particularly clinical decision-making under pressure and the management of cognitive load. This disconnect highlights the need to move beyond descriptive evaluations toward a deeper understanding of learning mechanisms.

Future research should focus on integrating validated assessment tools, objective performance measures, and theory-driven frameworks to better capture the cognitive dimensions of learning in gamified simulation environments. Strengthening the methodological rigor of this field will be essential not only to substantiate its educational impact, but also to position escape room–based simulation as a robust and evidence-informed component of modern medical training.

Ethics Statement

This study is a systematic review conducted using previously published data. As it does not involve human participants, patient data, or identifiable personal information, ethical approval and informed consent were not required.

Escape room–based simulation integrates time pressure, gamification, and team interaction to generate cognitive and emotional activation, including cognitive load and emotional engagement. These processes influence key learning mechanisms such as clinical reasoning and decision-making, ultimately contributing to educational outcomes including knowledge acquisition, teamwork, and learner engagement. The framework also highlights a gap in the current literature regarding the limited assessment of cognitive load and decision-making under conditions of time pressure. This conceptual model was developed by the authors based on the synthesis of the included studies.

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