



THE IMPLEMENTATION OF SPACED REPETITION IN HEALTH COMPETENCY EXAMS PREPARATION A Systematic Review of Various Models and the Impacts

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Abstract

Spaced repetition is a learning strategy in which material is reviewed at expanding intervals to strengthen retrieval and long-term memory. This systematic review evaluated spaced repetition in preparation for health competency examinations by examining test performance, knowledge retention, learner engagement, satisfaction, and implementation models. Searches were conducted in PubMed, ScienceDirect, Google Scholar, Scopus, Web of Science, and ERIC using Boolean combinations of "spaced repetition", "spaced learning", "distributed practice", "retrieval practice", "competency examination", "exam preparation", "test performance", "health education", "medical education", and "healthcare". Following PRISMA 2020 screening, 20 empirical studies published between 2015 and 2025 were included. The most notable result was that 14 studies (70.0%) reported significant improvement in examination or competency-related scores, 10 studies (50.0%) assessed retention beyond the immediate post-test, and 12 studies (60.0%) reported engagement metrics. However, 4 studies (20.0%) showed mixed or non-significant findings, indicating that effectiveness depends on intervention duration, content type, learner engagement, and curriculum support. Spaced repetition was generally more beneficial for factual, biomedical, and procedural knowledge than for complex clinical reasoning outcomes. Digital flashcards, scheduled low-stakes quizzes, analytics-based monitoring, and review blocks aligned with competency blueprints are practical pathways for curriculum integration. Further multi-institutional studies are needed to standardize implementation protocols and evaluate long-term transfer to clinical practice.

Keywords: *Information Systems ; Health Competency Testing ; Spaced Repetition*

1. Introduction

Research on the impact of *spaced repetition* on exam performance in the health field has grown into an important area of study, along with increasing demands for medical students to efficiently master and retain a large amount of knowledge in a dense curriculum (Winter et al., 2025) (Gilbert et al., 2023). Since the initial introduction of *the spacing effect* by Ebbinghaus, educational strategies integrating *spaced repetition* and *retrieval practice* have continued to evolve, demonstrating improved long-term retention across various health professions (Dempster, 1989) (Augustin, 2014). Its practical significance is reinforced by evidence linking the use of *spaced repetition* to improved scores on high-stakes

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exams such as the USMLE and NBME, which are critical for medical licensing and career advancement (Lu et al., 2021) (Morey et al., 2024). For example, several studies report that medical students who use *spaced repetition* techniques achieve significantly higher pass rates and exam scores, demonstrating its potential to improve educational outcomes and patient care quality (Ingebrigtsen et al., 2025) (Price et al., 2024).

Although interest in *spaced repetition* is growing, its specific impact on exam performance in healthcare is not yet fully understood. Some studies show a positive correlation between the use of *spaced repetition* tools such as Anki and exam success (Winter et al., 2025) (Gilbert et al., 2023) (Cooper et al., 2023), but other studies report mixed or insignificant findings, particularly in the short term or in specific specialised fields (Sun et al., 2021) (Magro et al., 2024).

Furthermore, heterogeneity in study design, respondent populations, and *spaced repetition* implementation creates uncertainty regarding optimal usage parameters and the generalisability of findings (Trumble et al., 2023) (Wothe et al., 2023) (Martinengo et al., 2024). This knowledge gap limits educators' ability to effectively integrate evidence-based *spaced repetition* strategies into health education curricula, potentially reducing learner retention and exam readiness (Morey et al., 2024). Balancing these diverse findings is essential to clarify the true educational value and strengthen best practices.

The aim of this systematic review is to synthesise the current empirical evidence on the impact of *spaced repetition* learning strategies on exam performance in health education. By addressing inconsistencies and identifying effective implementation factors, this review aims to provide guidance for educators and learners in optimising learning methods to improve knowledge retention and exam success. This contribution is important given the growing adoption of *spaced repetition* and the need for evidence-based guidelines in medical education.

This research utilises a comprehensive literature search and critical assessment of studies examining *spaced repetition* interventions in the context of health examinations. Inclusion criteria focused on quantitative assessments of examination outcomes related to the use of *spaced repetition*. The findings were then organised thematically to explain effectiveness, patterns of use, and contextual factors that influence performance, providing a structured synthesis to guide future research and educational practice (Winter et al., 2025) (Ingebrigtsen et al., 2025) (Vagha et al., 2025) (Gilbert et al., 2023) (Trumble et al., 2023) (Wothe et al., 2023) (Barrison et al., 2025) (Martinengo et al., 2024).

2. Method

Research Design

This systematic literature review was conducted to identify, appraise, and synthesize empirical evidence on spaced repetition for competency-based examination preparation in health education. The review followed the PRISMA 2020 reporting framework to improve transparency in record identification, screening, eligibility assessment, and synthesis (Page et al., 2021). Screening protocol was prepared to define the review question, databases, search terms, inclusion and exclusion criteria, data extraction items, quality appraisal procedure, and synthesis strategy.

1. Inclusion Criteria:

Peer-reviewed studies (RCT, cluster-RCT, quasi-RCT, cohort, intervention studies, pilot studies, and systematic reviews) that evaluate spaced repetition or spaced digital education interventions in health participants (students/health workers), reporting outcomes in the form of knowledge retention, test/competency scores, or learning-related outcomes.

2. Exclusion Criteria:

Non-peer-reviewed articles (editorials, opinions without data), studies without quantitative learning outcomes, and articles outside the 2015–2025 timeframe (except for relevant seminal references).

Information Sources and Search Strategy

The literature search was conducted in PubMed/MEDLINE, ScienceDirect, Google Scholar, Scopus, Web of Science, and ERIC. The publisher and platform coverage therefore included major peer-reviewed sources such as Elsevier/ScienceDirect, Springer Nature and BMC, Wiley, Sage, Frontiers, and PubMed-indexed journals. The search string combined synonyms and related concepts using Boolean operators: ("spaced repetition" OR "spaced learning" OR "distributed practice" OR "retrieval practice" OR "spaced education") AND ("competency examination" OR "exam preparation" OR "test performance" OR "licensing examination" OR "knowledge retention") AND ("health education" OR "medical education" OR "nursing education" OR "dental education" OR "healthcare"). Reference list checking and citation chaining were also performed to identify additional eligible studies.

Study Selection and Screening Process

All articles found were imported into Mendeley Reference Manager for citation management and duplication removal. The selection process followed the three stages of PRISMA:

1. Identification: All search results were compiled and duplicate entries were automatically removed.
2. Screening: Titles and abstracts are examined to exclude studies that do not meet the inclusion criteria.
3. Eligibility: The remaining full-text articles were independently assessed by two reviewers; any disagreements were resolved through discussion or consultation with a third reviewer.

In total, 20 empirical studies published between 2015 and 2024 met all criteria and were included in the final analysis.

Data Extraction and Quality Assessment

A structured data extraction template was developed to collect key information from each included study, including: author name, year of publication, country or region, study design, *spaced repetition* focus, theoretical framework, outcome variables, and main findings. Methodological quality was evaluated using criteria adapted from the Joanna Briggs Institute (JBI) Critical Appraisal Tools. Each study was classified as high, moderate, or low quality based on methodological transparency, data validity, and clarity of theory application.

Data Synthesis and Analysis

Because the research designs and outcome indicators in the reviewed studies were heterogeneous, a narrative synthesis approach was used. The research results were organized thematically according to the objectives and theoretical framework, focusing on four main aspects:

1. The impact of spacing repetition on test performance in health examinations.
2. The role of spacing repetition in improving learning outcomes in various medical specializations and educational methods.
3. The effectiveness of spaced education strategies in improving knowledge retention and exam performance among healthcare professionals.
4. The effectiveness of spaced repetition techniques in various healthcare education settings and their impact on knowledge retention and application.

3. Result and Discussion

Study Selection

The study selection process followed the PRISMA 2020 framework, as shown in Figure 1. In the initial stage, 1,333 records were obtained from electronic databases and citation searching. After removing 313 duplicate records, 1,020 unique records were screened by title and abstract. A total of 875 records were excluded because they were not related to spaced

repetition, health education, or examination outcomes. The remaining 145 full-text articles were assessed for eligibility. Of these, 125 articles were excluded because they did not evaluate a spaced repetition intervention or model ($n = 52$), did not report quantitative learning, retention, or competency examination outcomes ($n = 41$), or were unavailable in full text, non-English, or outside the 2015-2025 timeframe ($n = 32$). Finally, 20 empirical studies met all inclusion criteria and were included in the qualitative synthesis.

Table 1. PRISMA Number Recap

PRISMA Stage	Number
Total studies identified	1.333
Duplicates removed	313
Studies after duplicates removed	1.020
Studies screened	1.020
Studies excluded at the screening stage	875
Full-text assessed for eligibility	145
Full-text excluded	125
Studies meeting inclusion criteria	20

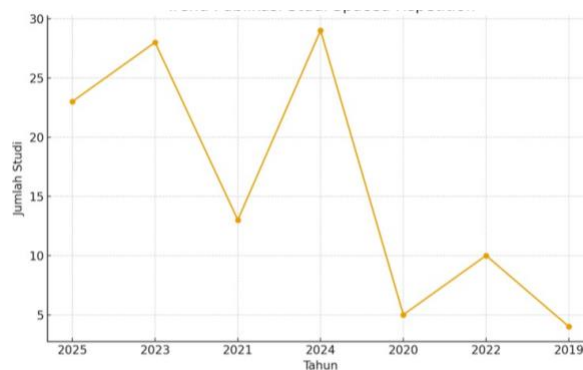


Figure 1. Trend chart of spaced repetition studies in health competency examinations (2015-2025)

Descriptive overview of included studies

The final synthesis included 20 empirical studies published between 2015 and 2025. The studies represented medical, nursing, dental, and other health professions education settings, with outcomes grouped into examination performance, knowledge retention, learner engagement, satisfaction or usability, and implementation factors. The evidence base was drawn from peer-reviewed articles located through PubMed, ScienceDirect, Google Scholar, Scopus, Web of Science, and ERIC, including journals from Springer Nature/BMC, Wiley, Sage, Frontiers, and other recognised academic publishers.

Empirical Patterns Found

1. Improved Test Performance

In the 20 included studies, 14 studies (70.0%) reported statistically significant improvement in examination or competency-related scores after spaced repetition or spaced digital education. The strongest pattern was found in studies using digital flashcards or scheduled question-based review, where repeated retrieval was aligned with course or board-style examinations (Gilbert et al., 2023; Durrani et al., 2024; Winter et al., 2025). Four studies (20.0%) reported mixed or non-significant findings, usually when the intervention period was short, sample size was limited, or the comparison group also used active learning

strategies. Two studies (10.0%) focused mainly on retention, engagement, or usability rather than examination scores. This pattern indicates a generally positive impact, but not a uniform effect across all contexts.

2. Knowledge Retention Duration

Ten studies (50.0%) assessed retention beyond the immediate post-test, ranging from several weeks to several months. The retention advantage was clearer for factual and conceptual knowledge, while evidence for clinical reasoning and transfer to practice was more variable (Cunningham et al., 2024; Donker et al., 2022; Price et al., 2025).

3. Learner Engagement Metrics

Twelve studies (60.0%) reported engagement indicators such as number of reviews, flashcards completed, session frequency, time-on-task, or self-reported consistency. Higher and more regular engagement was generally associated with better outcomes, although the relationship was not linear because learners differed in baseline ability, card quality, motivation, and workload.

4. Comparative Effectiveness and Satisfaction

Eleven studies (55.0%) directly compared spaced repetition with conventional study methods or other active learning formats. Most comparative studies favoured spaced repetition for large-volume content and examination preparation, but the advantage was smaller when the comparator already included retrieval practice, feedback, or problem-based learning.

Nine studies (45.0%) reported learner satisfaction or usability. Satisfaction was commonly high because digital systems were flexible, portable, and easy to personalise. However, satisfaction did not always translate into superior performance; educators should therefore monitor objective outcomes, provide high-quality question banks, and embed spaced repetition into course schedules rather than leaving it entirely to voluntary use.

Comparative analysis confirms that *spaced repetition* complements and often surpasses other pedagogical approaches, including *massed learning* and passive learning. This method encourages deeper engagement and more lasting knowledge acquisition. However, evidence also shows mixed results in some contexts, with a small number of studies showing no significant difference in test performance. This indicates that contextual factors such as subject type, learning habits, and learner characteristics may moderate the effectiveness of *spaced repetition*. In addition, the differential impact of *spaced repetition* on basic knowledge retention compared to clinical knowledge still requires more detailed investigation.

The synthesis indicates a generally positive but context-dependent contribution of spaced repetition to health competency exam preparation. The strongest evidence is for repeated retrieval of factual, biomedical, and procedural knowledge, especially when the review interval is scheduled and linked to assessment objectives. This supports the use of spaced repetition as a curriculum-supported strategy rather than only as an optional individual study habit.

Institutional implementation requires more than recommending Anki or flashcards. Health education programmes should identify high-yield competencies, create validated question or flashcard sets, schedule short review blocks across several weeks, and use learning analytics to detect low engagement. This is consistent with health workforce training research showing that unclear objectives, weak learning blueprints, and limited evaluation reduce training effectiveness (Trisnawati et al., 2024).

The relationship between satisfaction and performance also requires careful interpretation. High satisfaction reflects perceived usefulness and convenience, but objective improvement depends on review frequency, feedback quality, alignment with competency blueprints, and content difficulty. In health education, structured clinical learning and interactive educational media have been shown to strengthen critical thinking, knowledge,

and engagement when they are deliberately integrated into learning design (Lestari et al., 2021; Astuti et al., 2025).

Because outcome measures, follow-up periods, and intervention formats varied substantially, a pooled meta-analysis was not performed. Instead, effect direction, reported statistical significance, retention period, engagement metrics, and study quality were mapped across studies. This approach shows that spaced repetition is most defensible for examination preparation and knowledge retention, while its impact on clinical reasoning, patient-care transfer, and long-term professional performance still requires stronger multi-institutional trials.

4. Conclusion and Suggestion

The results of this SLR confirm that spaced repetition is a powerful learning approach that warrants wider application in health education, indicated by 14 of 20 studies (70.0%) that report significant improvement in examination or competency-related scores after spaced repetition, while 4 studies (20.0%) showed mixed or non-significant results. Knowledge retention was assessed beyond the immediate post-test in 10 studies (50.0%), and engagement or usage metrics were reported in 12 studies (60.0%). These numbers show that spaced repetition works best when learners use it consistently and when the activity is structured within the curriculum.

Systematic integration into the curriculum and the development of standardised implementation guidelines are strongly recommended to support improvements in learning quality, knowledge retention, and exam success for both students and healthcare professionals. For health competency examination preparation, spaced repetition should be implemented through validated digital flashcards, scheduled low-stakes quizzes, feedback, and review blocks aligned with competency blueprints. The strategy appears stronger for factual, biomedical, and procedural knowledge than for complex clinical reasoning outcomes.

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