Review

Longitudinal Assessment to Evaluate Continued Certification and Lifelong Learning in Healthcare Professionals: A Scoping Review

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Abstract

The balance of lifelong learning with assessment for continued certification is a challenge faced by healthcare professions. The value of single-point-in-time assessments has been questioned, and a shift to longitudinal assessments (LA) has been undertaken to assess lifelong learning over-time. This scoping review was conducted to inform healthcare certifying organizations who are considering LA as an assessment tool of competence and lifelong learning in healthcare professionals. A search of 6 databases and grey literature yielded 957 articles. After screening and removal of duplicates, 14 articles were included. Most articles were background studies informing the underpinnings of LA in the form of progress testing, pilot studies, and process of implementation. Progress testing is used in educational settings. Pilot studies reported satisfaction with LA's ease of use, online format, and provision of lifelong learning. Implementation processes reveal that key aspects of success include stakeholder participation, phased rollout, and a publicly available content outline. Initial outcomes data affirm that LA addresses knowledge gaps, and results in improved performance on maintenance of certification exams. Future research is needed to substantiate validity evidence of LA and its correlation with high-stakes exam performance when assessing lifelong learning and continued competence of healthcare professionals over time.

Keywords

longitudinal assessment, lifelong learning, certification, competence, knowledge

Identification of assessment tools in the evaluation of continued competence in healthcare professionals amidst a broadening array of technological advances, an increasing breadth of knowledge advancements in healthcare, and growing industry standards has been an ongoing challenge for healthcare certifying organizations. The impetus to incorporate lifelong learning through maintenance of certification processes was initiated by the American Board of Medical Specialties (ABMS) in the year 2000 (Brennan et al., 2004; Institute of Medicine, 1999, 2001). Along with an individualized program for each of the ABMS' 24 specialty member boards was the inclusion of a high-stakes proctored recertification exam every 10 years.

Over time, it became evident that a *single-point-in-time* exam was not optimal to promote learning or to assess learning over time. While diplomates valued certification, the perceived value of a *single-point-in-time* cognitive assessment was considered burdensome and did not promote lifelong learning (Culley et al., 2013; Sun et al., 2016). By 2011, the Advisory Committee on Interdisciplinary, Community-Based Linkages (ACICBL) provided recommendations to the United States Department of Health and Human Services (DHHS) to improve continuing education processes, assimilate lifelong learning programs, and develop more consistent evaluation

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tools for lifelong learning (Advisory Committee on Interdisciplinary Community-Based Linkages, 2011).

In 2018, the Rand Corporation reported on the use of longitudinal assessment (LA) amongst healthcare professions, and the emergence of LA as pilot studies within the ABMS member boards and the National Commission on Certification of Physician Assistants (NCCPA) (Reid et al., 2018). Longitudinal assessment is an evaluation method that assesses learning acquired *over-time*, is more formative in nature, and has an intent of identifying knowledge gaps and opportunities for continuing education (ACICBL, 2011; Griffis et al., 2022; Price et al., 2018). Longitudinal assessments are shorter assessments administered repeatedly over a defined period of time on a broad range of topics determined by the needs of the profession, healthcare practitioners, or public (Giron et al., 2021). With immediate feedback and rationale for correct and incorrect answers, learning and retention are enhanced over spaced intervals of time (Giron et al., 2021).

Studies have shown that spaced learning (exposure to materials interspersed with other activities), repeated testing, and interleaving of content (simultaneously presenting several different learning topics) improves knowledge retention by improving the brain's ability to differentiate between concepts, thereby strengthening memory associations[1] (Anzia, 2021; Brennan et al., 2004; Brown et al., 2014; Griffis et al., 2022; Price et al., 2018; Reid et al., 2018). Compared to studying content in blocks of time, interleaving allows for better knowledge retention due to studying related but distinct content *over time,* a concept that is similar to LA in that learning and testing occur in spaced increments (Price et al., 2018).

Longitudinal assessment is consistent with the theoretical underpinnings of adult learning that incorporate Knowles' six core principles of andragogy: (1) the learner's need to know; (2) the self-concept of the learner; (3) the prior experience of the learner; (4) the readiness to learn; (5) the orientation to learning; and (6) the motivation to learn (Knowles et al., 2005; Price et al., 2018). These principles align with the use of LA in continued certification, incorporating lifelong learning in the health professions.

The Rand Corporation elucidated the challenges between certificants and certifying organizations in that the latter have an obligation to the public to instill confidence that healthcare professionals have met predetermined standards for practice and possess the knowledge, judgment, and skills to provide high-quality patient care; they also have a responsibility to their certificants to keep the burden of continued certification in balance (Reid et al., 2018). In balancing the assurance to the public and the burden to certificants, LA provides platforms of formative assessment at regular, spaced intervals, while also providing summative assessments that offer consumers of healthcare a level of confidence that healthcare professionals retain knowledge, judgment, and skills after initial certification in their chosen professions (Reid et al., 2018).

Many physician specialty certifying boards are currently offering LA as a requirement or as an option for recertification, but evidence about the impact of LA on patient care and outcomes is unknown. Other healthcare certifying boards such as nursing specialties have not incorporated LA into their continued certification processes (Reid et al., 2018; Spence et al., 2021). With the novelty of LA as a means to assess healthcare providers' knowledge/judgment/skills, as well as lifelong learning, quality evidence does not yet exist on the psychometrics of LA tools in the varying healthcare specialties.

To inform and guide healthcare certifying organizations who look to the future in consideration of LA as an assessment tool of competence and lifelong learning in healthcare professionals, a synthesis of current information on the use of LA would be useful. For this reason, a scoping review was conducted to identify background studies that inform the underpinnings for use of LA in healthcare (Aim one), as well as to describe application and outcome data of LA in continued certification of healthcare providers (Aim two).

Methods

This scoping review followed reporting guidelines outlined in the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). The PRISMA-ScR can be accessed on the EQUATOR Network's Web site (https://www.equator-network.org/reporting-guidelines/prisma-scr/) and the Knowledge Translation Program Web site of St Michael's Hospital (https://knowledgetranslation.net/portfolios/the-prisma-scr-prisma-extension-for-scoping-reviews/). This scoping review was sponsored by the NBCRNA and was not registered.

Eligibility Criteria

To be included in the review, papers needed to focus on LA in the healthcare professions. Only articles in English were considered, along with articles meeting the search terms (*longitudinal assessment, competence, certification, and re-certification)* and aims of the scoping review. Studies from any country and at any level of evidence were included, as well as thought pieces and reports from national or international organizations. With LA being a novel concept in healthcare professions, there were no defined exclusion criteria in conducting the search such as date restrictions or geographic location.

Information Sources

To identify potentially relevant documents, the following bibliographic databases were searched (no date restriction was defined for the beginning date) up to March 2020, and a replicated search was completed from March 2020 to July 2022: Medline Complete, CINAHL Complete, Embase, PsycINFO, Scopus, and Nursing@Ovid. Unpublished reports,

also known as grey literature, were also searched on the following websites: Rand Corporation, ABMS, and SeaCrest Company. Rationale for including these grey literature sources was to ensure we captured all possible sources of evidence. The replicated search from March 2020 to July 2022 was to ensure we captured all relevant articles in that specified timeframe. The search strategies were drafted by an experienced university librarian and further refined through team discussion.

Search

Consistent with scoping review methods, critical appraisal and risk of bias assessment was not conducted. The final search strategies for EMBASE can be found in Appendix A.

Selection of Sources of Evidence

The articles and reports were screened initially in March 2020 by 12 different reviewers working in pairs. A replicated search was done between March 2020 through July 2022, and two reviewers working in a pair screened articles and reports in order to provide the most up-to-date screening. Titles and abstracts of each reference were screened against eligibility criteria by each pair of reviewers. From the remaining articles, the full text was then further reviewed against eligibility criteria. If an article met criteria, reviewers indicated which of the identified aims the article addressed (i.e. background study that informed underpinnings; or application/outcomes data of LA in continued certification). If the reviewers disagreed about the inclusion of an article, a third reviewer was consulted for a final decision.

Data Charting Process

Tricco et al., (2018) approach for data extraction and analysis guided this review. Data were entered into an Excel spreadsheet based on the matrix method for literature reviews (Goldman & Schmalz, 2004). Extraction of data was divided equally among the reviewers; each reviewer independently charted data from each eligible article and a second reviewer verified the data extraction for completeness and accuracy.

Data Items

Key data were extracted from each article to include author(s), year of publication, country, level of evidence/article type, study focus, purpose, and findings.

Synthesis of Results

Articles were grouped by the aims of the scoping review. Aim 1 identified background reports that informed underpinnings for use of LA in healthcare. Within that aim, articles were subgrouped into three different categories: progress testing; pilot testing; and the processes utilized for implementation of LA. Aim 2 described application and outcomes data of LA in the continued certification of healthcare providers. Articles are presented in Table 1 according to the aim that is depicted in the article.

Results

Selection of Sources of Evidence

The electronic database search identified 957 articles. Additionally, reference lists of all included articles were reviewed to identify literature not found in the initial search, resulting in 18 additional articles. After duplicates were removed, 700 articles remained. Abstracts were then reviewed to determine if these articles met eligibility criteria. Out of the 700 articles, 602 articles were excluded because the abstract was not pertinent to one of the two aims of the scoping review. Of the remaining 102 articles, full text review was undertaken to determine eligibility. After full review, 88 articles were further excluded, leaving 14 articles meeting eligibility criteria for inclusion in the scoping review (Figure 1). Twelve articles met the first aim [to identify background studies that inform the underpinnings for use of LA in healthcare]; and two articles met the second aim [to describe application and outcome data of LA in continued certification of healthcare providers]). Articles meeting the first aim included articles focused on progress testing ($n = 6$); pilot testing ($n = 3$); and articles describing the implementation process of LA ($n = 3$). All of the included articles meeting the inclusion criteria were published in 2012 or later (Table 1).

Characteristics of Sources of Evidence

The articles are described in Table 1, grouped by description of aim. The studies' authors, year of publication, country of origin, article type, focus, purpose, healthcare population, and main findings are presented.

The 14 articles included in the review were published in the years 2012–2022. Twelve articles were background studies that informed the underpinnings for use of LA in continued certification (aim one) (Albanese & Case, 2016; Ali et al., 2018; Dion et al., 2022; Favier et al., 2017; Harman et al., 2020; Hatala et al., 2019; Horber et al., 2020; Iyer et al., 2021; Newton et al., 2020; Schuwirth & van der Vleuten., 2012; Turner et al., 2019; Wallner et al., 2020). Longitudinal assessment is a novel form of assessment and certifying boards may utilize these reports to help inform development of LA respective to their specialty and profession. Two articles described the application of LA in their field and provided outcomes data relative to knowledge retention (aim two) (Robinson et al., 2020; Sun et al., 2016) (Table 1).

Eight of the 12 articles were based in the United States (U.S.) (Albanese & Case, 2016; Harman et al., 2020; Horber

Table 1. Summary of the Reviewed Sources.

Author/Year	Country	Article Type	Focus	Purpose/Population	Findings
Aim 1. Background Reports that Inform the Underpinnings for the Use of LA in Healthcare					
Albanese & Case (2016)	USA	Review	Progress testing	Describe important features and psychometric considerations in medical education	• Progress testing involves administration of comprehensive formative exams of medical knowledge repeatedly throughout a curriculum with goal to minimize rote memorization (steering effect), and promote knowledge retention through repeated testing • Characteristics of progress testing ○ Based on learning objectives ○ Comprehensive, repeated (3-4 times/year) formative assessments (e.g., 150 MCQs) designed to prevent steering effect ○ Individual exam scores are used for formative assessment ○ Summative decisions based on cumulative performance • Requires large item banks; expensive
Ali et al. (2018)	UK	Descriptive	Progress testing	Evaluate effect of progress testing in undergraduate students in a United Kingdom dental therapy and hygiene program	• Sample: 38 students from 2015 to 2017 • 7 comprehensive progress tests of applied knowledge mapped to learning outcomes administered over 3 years (100 MCQs each) • Immediate and comprehensive feedback provided after each test • Percent correct increased over time from 44% on test 1–73% on test 7 • Test-retest reliability = 0.76 • Study demonstrated progress testing promoted growth in applied knowledge over time in dental therapy and hygiene students
Dion et al. (2022)	Canada	Scoping review	Progress testing	To inform potential users of progress testing in order to describe characteristics, identify facilitators and barriers to implementation, and explore potential outcomes of its uses in higher education	• 104 studies revealed significant validity evidence • Formative assessment is the most desired approach • Key barrier is resource intensive; time intensive but collaboration amongst institutions allow for sharing of efforts • Frequency of testing encourages more frequent studying which contributes to increase in knowledge, and promotes learning • Progress test scores and longitudinal aspects of assessment promote curriculum evaluation: Evaluates gaps in the curriculum and supports faculty development
Favier et al. (2017)	Netherlands	Descriptive	Progress testing	Determine if progress testing can be used to monitor knowledge development over time in veterinary medicine students	• Sample: Veterinary medicine students taking two progress tests (150 item MCQs) 6 months apart (test 1 n = 331, test 2 n = 292, n = 247 took both tests) • Reliability ○ Test 1—Cronbach's alpha = .86 ○ Test 2—Cronbach's alpha = .88 • Scores significantly increased in all groups between test 1 and test 2 ($p < .001$) • test scores positively correlated, $r = .62$, $p < .001$) • survey responses indicated students agreed progress tests improved knowledge and provided useful feedback Progress testing promotes self-regulated learning and discourages binge learning because students must maintain knowledge across the program and show cumulative growth
Hatala et al. (2019)	Canada	Descriptive	Progress testing	Describes validity investigation of a learning curve-based assessment approach for ECG interpretation	• Sample: Medical students, residents, and fellows • Primary outcome measure diagnostic accuracy and secondary outcome measure was time on task • Findings support validity of learning curve assessment approach for repeated ECG interpretation Article provides citations to helpful sources explaining adult learning theory, including test-enhanced learning, feedback-enhanced learning, and learning curve theory
Schuwirth & van der Vleuten (2012)	Netherlands	Expert report	Progress testing	Review benefits of progress testing	• Progress testing is used in graduate medical educational settings and is a form of longitudinal assessment in which equivalent, yet different, formative assessments are given at fixed intervals with results combined to assess functional knowledge of each student enabling more reliable and valid decisions about promotion of student to next level • Benefits ○ Reduces exam stress ○ Promotes knowledge retention; discourages binge learning ○ Minimizes test-driven learning (i.e., cramming) • disadvantage ○ Ability to ensure equivalence of individual tests

(continued)

Table 1. (continued)

Author/Year	Country	Article Type	Focus	Purpose/Population	Findings
Horber (2020)	USA	Descriptive	Pilot testing	LA pilot study to determine diplomates' perceived value of the CATALYST platform and compare performance on CATALYST questions with performance on board/recertification examination	• Sample: *N* = 196 diplomates from AOBIM (*n* = 52), AOBP (*n* = 36), AOBOG (*n* = 108) • Participants received 2 questions/week x 16 weeks • 92–96% agreed process for answering questions was convenient • 91–100% agreed CATLYST format good opportunity to learn/reinforce material • 85–96% agreed rationales were effective learning tools • 75–87% agreed CATALYST question references were useful • 96–100% agreed they would prefer fixed number of CATALYST questions versus traditional high-stakes assessment • 87–95% agreed CATALYT help them provide better care to patients • 92–100% agreed CATALYST program will help them stay current • 96–100% would recommend CATALYST program • CATALYST versus board certification performance ○ AOBIM, $r = 0.51$, $p < .001$ ○ AOBP: $r = 0.197$, $p > .05$ • CATALYST versus recertification exam performance ○ AOBOG: $r = 0.37$, $p > .05$ • Limitations—small sample sizes for correlational analysis; CATALYST questions for each board may cover different content than board/recertification exams • Overall, participants preferred continuous formative assessment versus traditional exam
Newton (2020)	USA	Expert report	Pilot testing	FMCLA made permanent in 2021 based on pilot; describes what was learned and what next steps will be	• Permanent alternative to the 1-day exam for summative assessment • Popular with diplomates; 73% selected FMCLA in the years 2019–2021, >98% retention rate • Summative assessment necessary, given the evidence that physicians are ineffective at assessing their own knowledge • LA blueprint similar to 1-day exam but positive feedback based on: ease of use, IT platform, tracking progress, less anxiety, average time to complete each question 2 minutes, 21 seconds, more flexible delivery, more time per question, access to references • Pilot evidence (*n* = 11,000+) demonstrated strong support of self-reported learning ○ 2/3 of first cohort reported using references for 11 or more items ○ 84% sought information after the test ○ 82% indicated they had changed practice as result ○ 89% reported incorporating FMCLS into their approach for staying current with medical knowledge • Future steps as result of pilot ○ FMCLA will be incorporated into permanent certification portfolio ○ 25 questions per quarter, 5 minutes per question, use of references, and 300 items needed to score ○ Changes needed in item-writing process in that there will a second review by 2 family physicians before final deployment of questions ○ Item writers to reduce number of questions that are "easy lookups" ○ Will continue to offer 1-day exam ○ FMCLS will meet ABMS standards for continuing certification
Turner (2019)	USA	Descriptive	Pilot testing	Describes part 2 results of pilot study of MOCA-PEDS LA platform	• Survey design with thematic analysis of open-ended responses • sample *N* = 5081 pediatricians enrolled in MOCA-PEDS pilot; response rate = 81% • 97% agreed that lifelong learning a professional responsibility • 79% make time for self-directed learning • 77% agreed MOCA-PEDS helped identify knowledge gaps • 60% agreed MOCA-PEDS helped them provide better care • 87% agreed MOCA-PEDS questions useful learning tools • 98% indicated MOCA-PEDS helped them learn, enhance, or refresh their medical knowledge • 62% indicated MOCA-PEDS led to practice change • themes—positive practice improvements (*n* = 1469) ○ 26% improved knowledge ○ 57% indicated a practice change MOCA-PEDS improved self-reported learning and led participants to implement practice changes

(continued)

Table 1. (continued)

Author/Year	Country	Article Type	Focus	Purpose/Population	Findings
Harman (2020)	USA	Commentary	Implementation process	Describes rationale, history, and early results of ABA's MOCA platform and its evolution to MOCA 2.0 and MOCA minute	• Goal of maintenance of certification (MOC) is to mitigate decline in knowledge and application as a physician matures after residency • 2011: Original MOCA was reimagined to foster lifelong learning • By 2016, MOCA minute (an LA platform) was launched ○ 30 questions per quarter accessed from computer, tablet, or smartphone (formative feedback) ○ 60 seconds per question ○ After answering, the diplomate rates their level of confidence on its correctness; then correct answer, key points, and references for learning are shown ○ The confidence rating provides data to adapt future questions based on identified areas of weakness ○ Spaced repetition of subsequent questions are given on areas of weakness ○ Well received as assessment of medical knowledge • Opportunities for further improvements ○ 2019 innovation summit with expert educators and stakeholders to inform and guide development of MOCA 3.0 ○ Users group: MOCA participants give feedback for development of next version of MOCA ○ 2019 learning theory workshop to clarify purpose of MOCA and establish guiding principles of implementation
Iyer (2021)	USA	Commentary	Implementation process	Provides background information on MOCA-Peds and an introduction to MOCA-Peds: PEM as another option to participate in continuing certification	• Purpose of MOC is to enable physicians to provide excellent and high-quality medical care by addressing knowledge and practice gaps that occur secondary to rapid growth of scientific knowledge, personal knowledge decay, and delays in knowledge translation to practice changes • MOCA-peds development ○ Decision in 2015 to develop MOCA-peds as a web-based platform to combine learning and assessment ○ Modeled after ABA's MOCA-minute with adult learning principles focused on higher-order learning ○ Participation is voluntary ○ 20 timed, multiple-choice questions per quarter ○ Development • Content outline developed by professional practice analysis • Online validation survey sent to pediatric emergency physicians • Content outline shared publicly ○ Characteristics • 5 minutes per question • Questions based on learning objectives made available in advance (these change annually) • Resources permitted • Immediate feedback given with written rationale • Supporting references provided • Final score computed after 4-year evaluation period • Proctored exam must be taken if MOCA-peds is not passed • MOCA-peds: PEM development ○ Beginning in 2022, pediatric emergency medicine (PEM) physicians will have option to participate in the MOCA-peds: PEM ○ This is a LA providing at-home alternative to point-in-time exam to engage PEM physicians more flexible and continuous lifelong, self-directed learning similar to the POCA-peds

(continued)

Table 1. (continued)

Author/Year	Country	Article Type	Focus	Purpose/Population	Findings
Wallner (2020)	USA	Editorial	Implementation process	To provide rationale and summary of 6-month experience of the American board of radiology longitudinal assessment part 3	• In 2017, the American board of radiology (ABR) moved to provide alternative to part 3 exam, and transition to web-based instrument accessible by desktop and mobile hardware platforms • The ABR online longitudinal assessment (ABR OLA) developed over 2 years (summative, formative, and informative assessment aspects) • Summative ○ Represents what an individual has learned through the continuum of a career ○ ABR OLA reports results upon completion of 200 scorable questions—after 4 years ○ Performance evaluation based on respondents' actual weighting of item difficulty instead of predetermined standard passing score • Formative ○ 52 questions per year ○ Immediate feedback including rationale and reference regardless of correctness of response ○ If answered incorrectly, a variant of the topic is sent 3–6 weeks later with regular weekly offering including different clinical scenario ○ If learning has occurred, the variant question should be answered correctly, and formative experience is recorded • Informative ○ Diplomates able to ascertain areas of weakness as they progress through selected questions ○ After 200 questions are scored, diplomates receive a report of overall performance • >3000 participants reported efficient operation and widespread acceptance
Aim 2. Describe the application/outcomes data of LA in the continued certification of healthcare providers					
Robinson (2020)	USA and Canada	Descriptive	Application and outcomes	To evaluate LA-PM&R program as a replacement for ABPMR part 3 MOC exam	• Sample: Randomly selected from diplomates with certification expiration between 2019–2022 ○ Self-selected into either LA-PM&R + MOC exam group $n = 318$ or MOC exam only group $n = 266$ • ABPMR MOC exam taken in years 7–10 of certification cycle (160-item exam in testing center) • LA-PM&R—customize content domains; 20 MCQs per quarter with 2 minutes per question × 1 year • LA-PM&R group scored 9 points higher on MOC exam ($p < .05$) • positive correlation between LA-PM&R score and MOC exam score ($r = 0.50$, $p < .001$) • LA-PM&R group increased percent correct on clone items on MOC exam (74%–86%, $p < .01$) LA-PM&R program improves learning and knowledge retention when compared to the 10-year part 3 MOC exam
Sun (2016)	USA	Descriptive	Application and outcomes	Determine if voluntary participation in the ABA MOCA-minute program is associated with improved performance on MOCA cognitive exam	• Sample ○ Phase 1 (2014): $n = 336$ MOC exam + MOCA-minute and $n = 280$ MOC exam only ○ Phase 2 (2015): $n = 343$ MOC exam + MOCA-minute and $n = 341$ MOC exam only • Received weekly MOCA-minute MCQs with 1 minute to answer on topics covered on MOC cognitive exam • MOCA-minute questions included immediate feedback, key points, references, educational objective, and rationale • Active participants in MOCA-minute performance on MOC cognitive exam ○ 2014: 9.9 points higher (95% CI, 0.8–18.9) ○ 2015: 9.3 points higher (95% CI, 2.3–16.3) • MOCA-minute survey responses (% agreed) ○ 97% useful learning tools ○ 90% relevant to practice ○ 97% key points useful ○ 76% references useful ○ 92% prefer MOCA-minute ○ 81% helps me care for patients ○ 91% helps me stay current Active participation in MOCA-minute program improves performance on high-stakes MOC cognitive exam

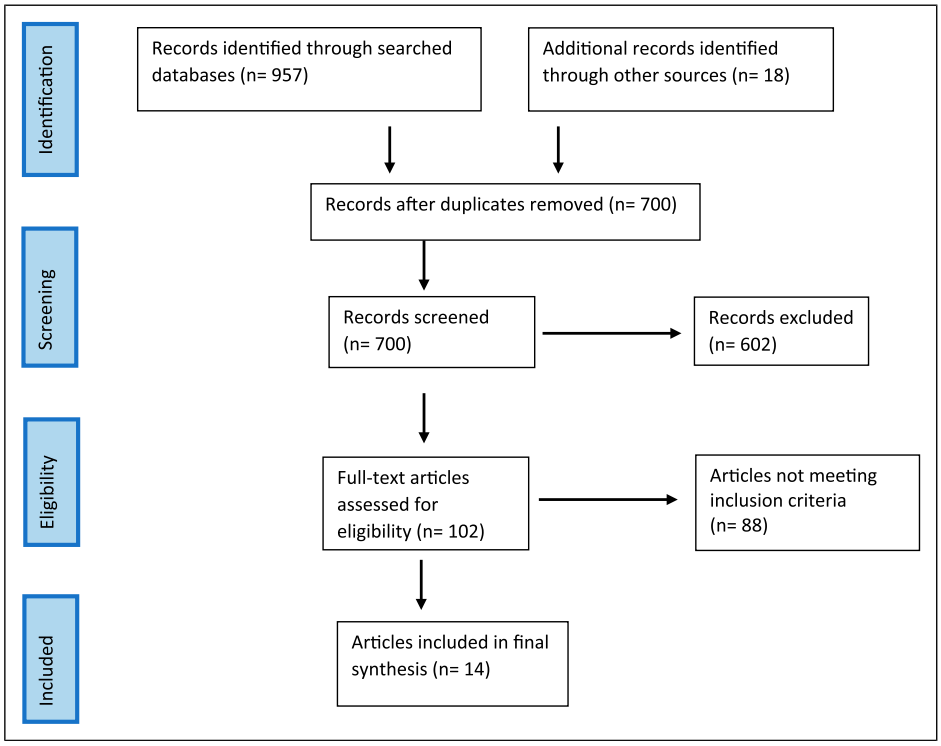

Figure 1. PRISMA.

et al., 2020; Iyer et al., 2021; Newton et al., 2020; Sun et al., 2016; Wallner et al., 2020); one article was based in the U.S and Canada (Robinson et al., 2020); two articles were based in Canada (Dion et al., 2022; Hatala et al., 2019); one article was based in the United Kingdom (Ali et al., 2018); and two articles were based in the Netherlands (Favier et al., 2017) (Table 1).

Based on Stillwell et al.'s (2010) hierarchy of evidence, eight of the 14 articles were Level VI descriptive studies, (Ali et al., 2018; Favier et al., 2017; Hatala et al., 2019; Horber et al., 2020; Newton et al., 2020; Robinson et al., 2020; Sun et al., 2016; Turner et al., 2019). Five studies were Level VII, based on expert report (Albanese & Case, 2016; Harman et al., 2020; Iyer et al., 2021; Schuwirth & van der Vleuten, 2012; Wallner et al., 2020). One study was a Level V scoping review of 104 articles of written-based progress testing, which revealed significant validity evidence for its use and positive impact on learning (Table 1).

The articles spanned a wide variety of educational settings and healthcare professions. Progress testing has roots in problem-based learning and was introduced in the 1970s at the University of Maastricht in the Netherlands and the University of Missouri Kansas City School of Medicine (Albanese & Case, 2016). Of six total studies reporting on progress testing, three studies are rooted in medical education (Albanese & Case, 2016; Hatala et al., 2019; Schuwirth & van der Vleuten, 2012); one study was in a dental therapy and hygiene educational program in the United Kingdom (Ali et al., 2018); one study described the use of progress testing in veterinary medical education (Favier et al., 2017); and a scoping review provided information in higher education on the use of progress testing and its positive impact on learning and knowledge retention (Dion et al., 2022).

Of the remaining eight studies, six studies described the use of LA amongst the American Board of Medical Specialties (ABMS) to include the following specialties: 1) the American Board of Anesthesiology (Harman et al., 2020; Sun et al., 2016); 2) the American Board of Pediatrics (Iyer et al., 2021; Turner et al., 2019); 3) the American Board of Radiology (Wallner et al., 2020); and 4) the American Board of Family Medicine (Newton et al., 2020). Finally, the remaining two studies described the use of LA in osteopathic specialty boards (Horber et al., 2020) and the American Board of Physical Medicine and Rehabilitation (Robinson et al., 2020) (Table 1).

Synthesis of Results

Aim One: Underpinnings for Use of Longitudinal Assessment in Healthcare

Progress Testing. Progress testing is a LA approach based on equivalent tests administered at fixed intervals with the intention to assess formative knowledge and competence (Schuwirth & van der Vleuten, 2012). Most progress testing work has been conducted in medical education (Albanese & Case, 2016), though dental hygiene/therapy and veterinary medicine have also reported positive outcomes using progress

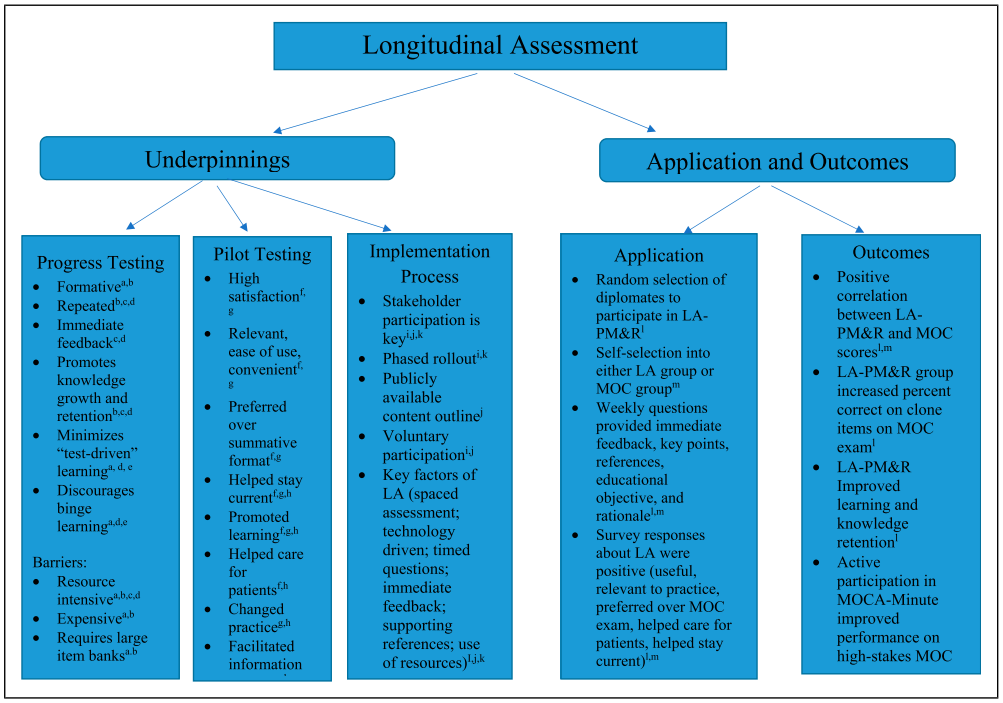

Figure 2. Conceptual diagram of longitudinal assessment scoping review findings and sources. [a]Schuwirth & van der Vleuten, L. W. T., C. P. M. (2012). The use of progress testing. Perspectives on Medical Education, 1(1), 24–30. https://doi.org/10.1007/s40037-012-0007-2. [b]Albanese, M., & Case, S. M. (2016). Progress testing: critical analysis and suggested practices. Advances in Health Sciences Education, 21(1), 221–234. https://doi.org/10.1007/s10459-015-9587-z. [c]Ali, K., Zahra, D., Tredwin, C., McIlwaine, C., & Jones, G. (2018). Use of progress testing in a UK dental therapy and hygiene educational program. Journal of Dental Education, 82(2), 130–136. https://doi.org/10.21815/JDE.018.015. [d]Dion, V./, St-Onge, C., Bartman, I., Touchie, C., & Pugh. D. (2022). Written-based progress testing: A scoping review. Academic Medicine journal of the Association of American Medical Colleges, 97(5), 747-757. doi: https://doi.org/10.1097/ACM.0000000000004507. [e]Favier, R. P., van der Vleuten, C. P. M., & Ramaekers, S. P. J. (2017). Applicability of progress testing in veterinary medical education. Journal of Veterinary Medical Education, 44(2), 351–357. https://doi.org/10.3138/jvme.0116-008R. [f]Horber, D. T., Flamini, J., Gimpel, J. R., Tsai, T.-H. E., Shrum, K., & Hudson, K. (2020). CATALYST: Piloting a longitudinal assessment and learning program for board recertification and continuous professional development. The Journal of the American Osteopathic Association, 120(3), 190–200. https://doi.org/10.7556/jaoa.2019.131 [g]Newton, W. P., Rode, K., O'Neill, T., Fain, R., Baxley, E., & Peterson, L. (2020). Family medicine certification longitudinal assessment after one year. The Journal of the American Board of Family Medicine, 33(2), 344–346. https://doi.org/10.3122/jabfm.2020.02.190055 [h]Turner, A. L., Olmsted, M., Smith, A. C., Dounoucos, V., Bradford, A., Althouse, L., & Leslie, L. K. (2019). Pediatrician perspectives on learning and practice change in the MOCA-Peds 2017 Pilot. Pediatrics, 144(6), e20192305. https://doi.org/10.1542/peds.2019-2305 [i] Harman, A. E., Warner, D. O., & Cole, D. J., (2020). Connecting purpose and performance: Rethinking the purpose of maintenance of certification. *Journal of the American Board of Family Medicine, 33,* S15-S20. doi: 10.3122/jabfm.2020.S1.190400 [k] Wallner, P.E., Segal, S., Michalski, J. M., & Ng, A. K. (2020). The American board of radiology online longitudinal assessment part 3 maintenance of certification instrument: Rationale and summary of 6-month experience (editorial). *Practical Radiation Oncology®, 10,* 386-388. https://doi.org/10.1016/j.prro.2020.07.009 [l]Robinson, L. R., Raddatz, M. M., & Kinney, C. L. (2020). Evaluation of longitudinal assessment for use in maintenance of certification: American Journal of Physical Medicine & Rehabilitation, 99(5), 420–423. https://doi.org/10.1097/PHM.0000000000001359 [m]Sun, H., Zhou, Y., Culley, D. J., Lien, C. A., Harman, A. E., & Warner, D. O. (2016). Association between participation in an intensive longitudinal assessment program and performance on a cognitive examination in the Maintenance of Certification in Anesthesiology Program®. Anesthesiology, 125(5), 1046–1055. https://doi.org/10.1097/ALN.0000000000001301 [n]Macario, A., Harman, A. E., Hosansky, T., Post, M. E., Sun, H., & McMahon, G. T. (2019). Evolving board certification—glimpses of success. New England Journal of Medicine, 380(2), 115–118. https://doi.org/10.1056/NEJMp1809322.

testing in their academic curriculums (Ali et al., 2018; Favier et al., 2017). Use of progress testing as a form of LA in academic settings allows assessment of growth in knowledge over time (summative) but also facilitates deep learning and long-term retention of knowledge (formative) (Albanese & Case, 2016; Ali et al., 2018; Dion et al., 2022). This approach is focused on applied learning instead of simple recall and prevents "test-directed" (i.e. binge) learning (Dion et al., 2022: Favier et al., 2017; Schuwirth & van der Vleuten, 2012). Questions are normed to expectations for a new graduate and contextualization of questions is critical (Dion et al., 2022).

Key aspects of progress testing include validation as a more reliable approach to support decisions about student learning as it provides good predictive validity for future competence and retention of knowledge (Schuwirth & van der Vleuten, 2012). Providing immediate and comprehensive feedback on

performance as well as repeated measurement of knowledge at multiple time points across the curriculum (Ali et al., 2018; Dion et al., 2022) are key hallmarks of progress testing. Immediate feedback facilitates self-directed learning and allows the student opportunities to identify gaps in knowledge for focused remediation (Dion et al., 2022; Hatala et al., 2019). The expectation is that scores increase across time as the student retrieves knowledge for application, analysis, and synthesis (Ali et al., 2018; Favier et al., 2017; Hatala et al., 2019; Schuwirth & van der Vleuten, 2012).

Documented challenges for progress testing include the labor and resource-intensive approach (time, item development and maintenance) as well as the need to ensure the equivalence of individual tests (Albanese & Case, 2016; Ali et al., 2018; Dion et al., 2022; Schuwirth & van der Vleuten, 2012). Ongoing psychometric analyses and requisite item adjustments are critical.

Pilot Testing. Pilot results from three medical specialties (family medicine (Newton et al., 2020), osteopathy (Horber et al., 2020), and pediatrics [Turner et al., 2019]) demonstrated participants were satisfied with the relevance, ease of use, and convenience of LA administered online (Horber et al., 2020; Newton et al., 2020). They believed LA helped them stay current and/or promoted learning (Horber et al., 2020; Newton et al., 2020; Turner et al., 2019), take better care of their patients (Horber et al., 2020; Turner et al., 2019) and facilitated seeking information after the test to enhance learning (Newton et al., 2020; Turner et al., 2019). LA was preferred over the summative exam format (Horber et al., 2020; Newton et al., 2020) and respondents reported changing their practice as a result of participating in the LA pilot for their specialty (Newton et al., 2020; Turner et al., 2019). Having adequate time to respond to questions was identified as important (Horber et al., 2020; Newton et al., 2020).

Implementation Process. Use of LA for maintenance of certification (MOC) has been recently reported in anesthesia (Harman et al., 2020), pediatric emergency medicine (Iyer et al., 2021), and radiology (Wallner et al., 2020). The intent of LA programs for MOC are not only to assess knowledge (summative), but also clinical judgement and critical medical skills. Additional goals of LA for MOC are to facilitate ongoing professional development and improved patient care alongside assessing a clinician's competence (formative). LA allows for assessing and addressing knowledge and practice gaps individualized to the learner; while allowing for voluntary participation, promotion of "deep" learning, reducing burden on certificants with easy access (i.e. online), and focusing on real-time national health priorities that require prioritization (Harman et al., 2020; Iyer et al., 2021).

Key aspects of the implementation process include stakeholder participation in determining the process (certificants, certifying board, pilot participants) (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020), phased rollout of the process (Harman et al., 2020; Wallner et al., 2020), and a publicly available content outline or learning objectives (Iyer et al., 2021). In addition, factors associated with LA include: 1) spaced assessment (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020); 2) technology driven (computer, tablet, smartphone) in a location and time of choice (i.e. asynchronous) (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020); 3) timed questions (60 seconds-5 minutes [Harman et al., 2020; Iyer et al., 2021]); 4) immediate feedback to enhance learning and retention (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020): 5) the inclusion of supporting references (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020), and 6) use of resources to complete the questions (Iyer et al., 2021). Some programs use participant data (questions answered incorrectly, relevance of question to practice, and self-identified confidence that the question was answered correctly) to determine future questions for spaced repetition to reinforce learning focused on individualized knowledge gaps (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020).

Aim Two: Application and Outcomes Data of Longitudinal Assessment. Most studies focused on stakeholder perceptions and satisfaction. Only two (Robinson et al., (2020); Sun et al., (2016)) provide empirical data related to LA outcomes. Similarities were noted in that both studies reported their LA programs used multiple-choice questions, delivered spaced assessment administration (though timing differed on frequency [i.e., once weekly vs. each quarter]), immediate feedback was provided, and response time was limited for each question (1-2 minutes per item).

Outcomes from these two studies showed correlation in scores between the LA and high-stakes cognitive exam, and improved learning and knowledge retention as evidenced by an increase in exam scores on the high-stakes exams (Robinson et al., 2020; Sun et al., 2016). Long term outcomes for LA programs are not yet available. Nursing organizations are not currently involved in piloting LA for certification. Barriers to LA are identified as cost, resource-intensive requirements, and concerns about sustainability (extensive volunteer commitment to develop each assessment and provide feedback).

Discussion

In this scoping review, we identified 14 articles published between 2012 and 2022 that serve to inform and guide certifying organizations who are considering the use of LA as a tool in continued certification and assessment of lifelong learning. Our findings indicate a paucity of outcomes data related to the utilization of LA in healthcare certifying organizations. Most studies since 2012 inform on the background and foundational elements for the use of LA in continued certification amongst three areas: progress testing, pilot studies, and the processes of implementation.

Progress testing, which has been utilized in educational settings, is a form of LA with similar underpinnings. While it has been shown to be resource-intensive, progress testing has been shown to be a valid and reliable form of formative assessment that promotes learning and knowledge retention

suggesting aspects of progress testing can be considered in the development of LA by certifying boards (Albanese & Case, 2016; Ali et al., 2018; Dion et al., 2022; Favier et al., 2017; Hatala et al., 2019; Schuwirth & van der Vleuten, 2012). Articles reporting solely on pilot testing of LA include those by the National Board of Osteopathic Medical Examiners for three osteopathic specialty boards (the American Osteopathic Board of Internal Medicine, the American Osteopathic Board of Pediatrics, and the American Osteopathic Board of Obstetricians and Gynecologists), the American Board of Family Medicine, and the American Board of Pediatrics (Horber et al., 2020; Newton et al., 2020; Turner et al., 2019).

Survey results of LA pilot testing are promising, and reveal that LA is well-received by diplomates (Figure 2). Commentary and editorial reviews of LA reveal that key factors in its implementation should consider a phased rollout with stakeholder participation, public access to an exam content outline, and voluntary participation. Elements in the process of implementation of LA include the use of timed, multiple-choice questions administered in spaced intervals, with immediate feedback to the exam taker (Harman et al., 2020; Iyer et al., 2021; Wallner et al., 2020). These pilot studies offer the historical context of LA and the goal of assessing the feasibility of such an approach (utilizing LA) in a larger scale study. The pilot studies of LA therefore inform future work of LA for certifying organizations.

While LA is somewhat of a novelty, and outcome data is scarce to this point, the reported outcomes data thus far is promising. This scoping review identified two successful ABMS certifying board pilot studies, who went on to adopt LA as a replacement to their maintenance of certification (MOC) exams. Outcome data revealed that learning and retention with LA was superior to the traditional summative exam and was less burdensome to diplomates (Robinson et al., 2020). The American Board of Physical Medicine and Rehabilitation (ABPMR) adopted LA in 2020 to replace the traditional MOC exam (Robinson et al., 2020). In addition, Sun et al. (2016) revealed that voluntary participation in LA was associated with improved performance on the high-stakes MOC examination and satisfaction was high (Sun et al., 2016).

The American Board of Anesthesiology (ABA) formally launched MOCA Minute in 2016, and surveys since that time are overwhelmingly positive (Macario et al., 2019). Macario et al. (2019) assert that the ABA's experiences with LA in the form of MOCA Minute offer valuable lessons that may be generalizable to certifying boards and accreditors. In addition, Zhou et al. (2019) reported that participation in the MOCA Minute program, in addition to meeting the performance standard of the MOCA Minute, were associated with lower risk of disciplinary license actions.

A majority of member boards (American Board of Medical Specialties [ABMS], National Board for Respiratory Care, and National Commission on Certification of Physician Assistants) are piloting or implementing LA into their maintenance of certification (MOC) programs (Giron et al., 2021), however there is limited published literature on the piloting of these programs. With the rapid evolution of technology and evolving landscape of healthcare, opportunities for certifying boards to incorporate meaningful and lasting activities, such as LA, that support lifelong learning and knowledge retention are vast. Interprofessional collaboration on lessons learned with LA amongst certifying boards of various healthcare disciplines will benefit healthcare for years to come.

Limitations

This scoping review has some limitations. To make our review more comprehensive, we included all levels of evidence. Most evidence sources were descriptive studies or expert reports/commentary. Consistent with scoping review methodology, we also did not complete a critical appraisal and risk of bias assessment of included sources. None of the ABMS member boards that conducted pilot studies on LA used randomized designs; rather, most compared LA performance and perception data with historical controls. To reduce the risk of bias, certifying boards that plan to conduct LA pilot studies should use random stratified selection to ensure subjects are representative of the certificant population, and participants should be randomized to assessment conditions (i.e., LA vs. point-in-time assessment).

Conclusions

Findings of this review reveal that the use of LA for certification purposes in the healthcare professions is in its early stages; however, included studies clearly support the benefits of LA and provide foundational elements on the application and processes of implementation to inform underpinnings for its utility. Despite the novelty of LA, initial survey research and associational descriptive studies are promising and indicate the process is well-received by healthcare providers. In addition, participants report the process improves and aids in maintenance of their knowledge in order to support lifelong learning. Future longitudinal outcomes research is needed in the areas of validity evidence of LA and its correlation with high-stakes exam performance when assessing lifelong learning and competence of healthcare professionals over time.

Based on findings from this scoping review, recommendations for future certifying bodies considering the use of LA in their continued certification processes include:

- Clear communication to certificants and stakeholders on the goals for LA in future continued certification processes;
- Solicitation and incorporation of user feedback with openness to change;
- Public availability of exam content outline;
- Phased rollout of LA with consideration of voluntary participation;
- Incorporation of key factors of LA into its implementation (assessment at spaced intervals, timed

questions, technology driven, immediate feedback, inclusion of supporting references, and consideration of use of resources during testing);
- Deliberate consideration and planning for needed resources (item writers, costs, oversite) to implement and maintain a LA program;
- Interprofessional collaboration amongst certifying boards on: 1) lessons learned in the incorporation of LA into MOC programs; and 2) dissemination and collection of data related to the impact of LA on patient outcomes in order to benefit the healthcare landscape and all stakeholders.

Appendix

Search Strategy Up To March 2020

EMBASE

1 'longitudinal assessment*'
2 'learning'/exp OR learn*
3 teach*
4 'test enhanced'
5 'education'/exp OR education
6 2 OR 3 OR 4 OR 5
7 6 AND 1
8 7 AND English Only

Search Strategy March 2020 through July 2022

EMBASE

1 'longitudinal assessment*'
2 'learning'/exp OR learn*
3 teach*
4 'test enhanced'
5 'education'/exp OR education
6 2 OR 3 OR 4 OR 5
7 competenc OR certification OR recertification
8 1 AND 6 AND 7
9 8 AND English Only
10 9 AND March 2020 thru July 2022

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Notes

1. Interleaving improves learning through a process of mixing up materials and concepts in a study session rather than focusing on one topic at a time, allowing for long-term retention and application of concepts to situations (Birnbaum et al., 2013; Brown et al., 2014; Foster et al., 2019; University of Arizona, 2021).

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