Received: 11 October 2023 | Revised: 4 January 2024 | Accepted: 10 January 2024

DOI: 10.1111/bcp.16033

THEMED ISSUE REVIEW

Assessment and evaluation of prescribing competences: A systematic review and recommendations

John C. McLachlan[1] | Asa Auta[2] | Aderonke Ajiboye[1]

[1]School of Medicine and Dentistry, University of Central Lancashire, Preston, PR1 2HE, UK

[2]Faculty of Health, Social Care and Medicine, Edge Hill University, Ormskirk, L39 4QP, UK

Correspondence
John C. McLachlan, School of Medicine and Dentistry, University of Central Lancashire, Preston PR1 2HE, UK.
Email: jcmclachlan1@uclan.ac.uk

Aims: Since assessment of prescribing competence is a key promoter of student learning and achievement, we aim to summarize existing national-level approaches, provide a systematic review of current literature, indicate the frequency of various methodologies, and make recommendations to promote and extend existing practice.

Methods: Regulatory body websites were accessed for details of national examinations. PubMed, Embase, the Allied and Complementary Medicine, and CINAHL databases were systematically searched in August 2023 for studies in English from Europe, North America, Australia and New Zealand reporting assessment of prescribing competencies among students/practitioners. Additional articles were identified through citation tracking.

Results: National approaches are described for several jurisdictions. A total of 20 514 articles were retrieved, of which 54 met the inclusion criteria. Most articles came from the UK, with medical students and qualified doctors most frequently featured. Multiple choice formats were most common, with short answer questions, calculations and scenario-based skills tests also featured. Direct observations of skills through Objective Structured Clinical Examinations and similar methods were less commonly described. Test reliability generally employed Classical Test Theory. Costs of developing and delivering assessments, differential attainment by demographics, and predictive validity were not indicated.

Conclusion: We recommend measurement of the predictive validity of prescribing competence assessments, the routine inclusion of performance by demographic characteristics, extension of competence assessments to professions other than medicine, and structured reporting of methods and findings, including costs and cost-effectiveness. Situational judgement tests would be a valuable addition to assessment practices.

KEYWORDS
assessment, competence predictive, prescribing, reliability, utility, validity

1 | INTRODUCTION

While it is simplistic to say that assessment *drives* learning,[1] it certainly plays an important part, not only in engaging students but also

John C. McLachlan is the Principal Investigator of this study.

in helping to determine if candidates have reached required standards. This is particularly important in healthcare education tasks, such as prescribing competence, where future patient safety is at stake. Yet a large study of junior doctors' preparedness for practice found that prescribing was the weakest area of practice across all the data sources.[2] Several studies have shown that prescribing errors are worryingly common among junior doctors.[3] This lack of confidence extends to other prescribing roles, such as those carried out by pharmacists.[4] A systematic literature review concluded that final-year medical students lacked adequate competence.[5]

Nor is there great confidence that current assessment methods meet the requirements of the public and the profession. Mucklow *et al.* indicated[6] that "No validated, reliable and widely accepted measure of prescribing performance currently exists".

The aims of this review are to describe existing national-level approaches to the problem, since these are rarely published in full in research papers, to provide a systematic review of current literature on assessment processes in use internationally, indicating the frequency with which various approaches are taken, and to make recommendations to promote existing best practice and to suggest additional steps for both institutional and national practice.

Cognitive knowledge[7] is generally assessed through written tests, frequently in the form of selected response formats such multiple choice questions (MCQs) or extended matching items (EMIs). Short answer questions (SAQs) may also be employed, and scenario-based calculations are an important part of prescribing skills. The psychomotor domain is frequently assessed through observation of skills and behaviours in either simulated or real settings, through such tests as Objective Structured Clinical Examinations (OSCEs), usually featuring simulated patients and assessment of a single attribute, or, in the workplace, by Mini-Clinical Examinations, with real patients and feedback to candidates. The affective domain may be tested using Situational Judgement Tests (SJTs): structured multiple-choice style tests in which candidates are presented with realistic scenarios, and must deduce the most appropriate course of action, not in terms of clinical knowledge, but by understanding the best course of action in that scenario.

The utility or usefulness of an assessment methodology is generally considered to depend on its validity, reliability, educational impact, acceptability and cost.[8] Validity is complex,[9] but in this article we will consider face validity (the appropriateness of individual items within a test), content validity (the coverage of the learning domain as a whole), predictive validity (the relationship between test performance and subsequent workplace performance) and construct validity (when a measurement tool accurately measures the intended concept).[10]

We will argue that the ultimate guarantor of validity of an assessment in healthcare is its predictive validity—how performance on a previous test corresponds to actual performance in the workplace. This may be assessed by potential and actual patient benefits and harms. Since we will argue that such tests of predictive validity are essential for genuine evaluation of tests of prescribing competence, the kinds of evidence that could be gathered for a predictive validity study comparing exam scores to actual clinical practice are considered further in Section 5.

1.1 | National level testing

Some jurisdictions rely on institutional testing as a sufficient guarantee of prescribers' competence. Others refer such decisions to a unified national process. There may be conflicts of interest with the former, since it is not in the institution's financial or reputational interest to have a high fail rate. The latter may be an independent assessment of competence, but are expensive, and cannot be as extensive as institutional tests. We reviewed these through internet searching of official websites.

In the UK, medical students currently undertake the Prescribing Safety Assessment (PSA), developed by a joint council of medical schools and the British Pharmacological Society.[11] The PSA is undertaken by medical students in their final year of study. Some medical schools make passing the PSA a requirement for graduation, while others do not, although all medical graduates must have passed the PSA by the end of the first year of practice after graduation (corresponding to Internship in the USA). The PSA is a 2-h 60-item written exam, based on the UK's General Medical Council's *Outcomes for Graduates*.[12] These are 8 test domains: Prescribing, Prescription Review, Planning Management, Communicating Information, Calculation Skills, Adverse Drug Reactions, Drug Monitoring, and Data Interpretation. Each may be set in various medical contexts. These are Surgery, Elderly Care, Paediatrics, Psychiatry, Obstetrics and Gynaecology and General Practice. The score available for each item type varies, and the total possible score is 200. The cut score is set by the modified Angoff Method[13] and is typically just above 60% (e.g. 63% in 1 recent year). Item formats include both constructed and selected response styles. Candidates have access to the online British National Formulary.[14]

Two reviews of the PSA have recently been carried out. The first focussed on the exam itself and concluded that it was generally fit for purpose.[15] The second explored the strategic place of the PSA, particularly in the light of the forthcoming national Medical Licencing Assessment for UK medical students.[16] This review concurred with the previous 1 that the PSA should continue but perhaps be joined with the Medical Licencing Assessment in a combined *Medical and Prescribing Assessment*. It also recommended that the PSA should be extended to those international medical graduates who wish to practise in the UK.[17]

For pharmacists in the UK, passing the General Pharmaceutical Council and Pharmaceutical Society of Northern Ireland (GPhC/PSNI) Registration Assessment is a pre-requisite for applying to register as a pharmacist.[18] Candidates undertake the GPhC/PSNI national Registration Assessment after they have graduated and have been in practice for at least 39 weeks, generally in either a community or a hospital environment, and have been signed off with a satisfactory Progress Report.[19] Passing is a pre-requisite for applying to register as a pharmacist in Great Britain or Northern Ireland.[20]

There are 2 papers, each of which must be passed separately. Part 1 involves 40 calculation items undertaken over 2 h. A calculator is provided. Part 2 is currently composed of 90 1-best-of-MCQs and 30 EMIs. Cut scores are generally around 70% in each part, and candidates are more likely to fail Part 1.

In applying to the UK National Health Service for a training post, there is also a 20-min 10-item numeracy test and a 52-item SJT undertaken over 104 min, with 2 response formats: ranking options from first to fifth and selecting 3 best options from 8.[21] Candidates are ranked on the basis of their SJT score, with the numeracy test used as a tiebreaker, although it is also possible to fail the numeracy test with a sufficiently low score.

In the USA, there is no separate prescribing test for medical graduates, but in the US Medical Licencing Assessment Step 3, there are items on health maintenance and disease prevention, pharmacotherapy, clinical interventions, and mixed management. Together, these represent 32–35% of the exam as a whole.[22]

For US pharmacists, the national exam is the North American Pharmacist Licensure Examination,[23] developed by the National Association of Boards of Pharmacy. The exam lasts 6 h and contains 225 items, in multiple choice (with both single and multiple options) and free text formats, with the latter being used for calculations. Candidates also sit a test of legal knowledge appropriate to their state, for instance, the multistate pharmacy jurisprudence examination.[24]

In Canada, the Pharmacy Examination Board of Canada examination consists of a computer-delivered 200-item test (of which 50 are pilot items) undertaken over 4.25 h, and an OSCE with 13 stations (one of which is an unscored pilot station).[25]

In the Netherlands, all 8 medical schools (and 3 Belgian medical schools) undertake the Dutch National Pharmacotherapy Assessment. This is a 1-h test paper with 40 items, focussed on common prescribing errors, which students must pass in order to graduate.[26] Consideration is being given to extending such a test elsewhere in Europe.[27] In 2019, 9 European universities, the European Agency for Clinical Pharmaceutics and Therapies, and the World Health Organization Europe commenced a 3-year project to develop, pilot and eventually implement an online examination on safe prescribing for joint use in European medical schools.[28] The aim of this potential *European Prescribing Exam* was to ensure that medical students in Europe graduate with prescribing competencies for safe and effective clinical practice. This has been challenging, however, due to the cost involved as well as different legal requirements and medications available in different countries. The European Prescribing Exam project was completed in 2022.[29] The 2-h digital exam consists of 47 items, over 9 subjects. Question types include scenario-based skills tests, which include dosage calculations. Importantly, the assessment is free, and is currently running in 50 EU medical schools.

Against this trend, Italian pharmacy graduates were previously required to pass a State Examination in order to join the professional register and to practise independently. However, this requirement was lifted in 2021.[30]

An internationalized version of the UK Prescribing Safety Assessment, the Prescribing Skills Assessment, is available and is extensively used in Australia and New Zealand for medical students,[31] but there is no formal national equivalent.

Pharmacists in Australia, on completion of their first degree, undertake a supervised practical internship, typically for 1 year. Subsequently, they undertake the Australian Pharmacy Council Examination.[32] This is 2 h long, with 75 questions in total. This exam is also delivered in New Zealand and Fiji. There is also a 35-min oral examination component, assessing the candidate's knowledge, skills, decision-making, communication and patient care skills in practical contexts, through scenarios and cases.

In this Introduction, we have summarized some general assessment principles, and considered national approaches to testing, following from our review of internet and public sources. We now present the methods and findings of our systematic review of the assessment and evaluation of prescribing competencies among medical and nonmedical students/practitioners.

2 | METHODS

National policies on prescribing assessment were accessed through the websites of national bodies, by hand-searching internet sources and Google Scholar, and by materials brought to light during a recent review of the PSA.[15]

2.1 | Search strategy

This review was conducted and reported in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses.[33] We systematically searched the PubMed, Embase (via Ovid), the Allied and Complementary Medicine, and CINAHL (via EBSCO) databases for original research articles published in the English language from the inception of these databases to August 2023. Our searches were aimed at retrieving articles that reported the assessment and evaluation of prescribing competencies among medical and nonmedical students/practitioners. Search terms including prescribing, assessments, competencies and skills were combined with others using Boolean operators. Additional articles were identified by checking reference lists of eligible studies and by Google Scholar citation tracking. Furthermore, geographical restrictions were applied to limit our searches to articles from Europe, USA, Canada, Australia and New Zealand, in which jurisdictions relatively similar types of healthcare systems are in place.

The screening and search criteria are described in Appendix A.

2.2 | Eligibility criteria

Studies were included in this systematic review if they reported on the assessment and/or evaluation of prescribing competence among medical and nonmedical healthcare students and/or professionals and described the methods used to measure prescribing competencies.

We considered prescribing competencies to include knowledge, skills and behaviours that are needed for safe and effective prescribing.[34] In addition, we included educational intervention studies if they assessed prescribing competence and reported on how they were assessed. There was no restriction on the study type.

2.3 | Exclusion criteria

We excluded reviews, editorials, opinion articles and conference abstracts. Also excluded were studies involving prescribing data analysis and those reporting on the opinion of healthcare professionals and/or students on their prescribing competence or confidence and on medicine reconciliation were excluded.

2.4 | Data extraction

Two reviewers (A.A. and A.A.) extracted data from the studies and entered them into Microsoft Excel for Microsoft 365 MSO version 2208. Any discrepancy in data extraction was resolved by consensus. The data extracted included author, year of publication, study country, study type, sample size, context of the assessment, target group, assessment delivery methods, assessment format, standard setting methods reported and types of validity and reliability measures.

2.5 | Study quality assessment

The quality of each study was assessed by 2 reviewers (A.A. and A.A.) using the Medical Education Research Quality Instrument (MERSQI).[35] This tool has been designed to measure the methodological quality of observational, quasiexperimental and experimental studies in medical education. The MERSQI included 10 items across 6 domains: study design, sampling, type of data (subjective or objective), validity, data analysis and outcomes. Each domain has a maximum score of 3, producing a maximum possible MERSQI score of 18 and potential range of 5–18.

2.6 | Data synthesis

Outcomes were categorized under the following headings:

Context: whether the papers relate to national or regional studies, or to single or multiple institutions.

Country/Region: the geographical location of the study, including those which were multinational.

Target population: the professions pursued by candidates and their status (e.g. students or practitioners).

Delivery method: how the assessments were delivered to candidates (online or in person).

Format: written tests such as MCQs or practical tests such as OSCEs.

Standard setting method(s) employed:

Reliability: evidence for the reliability of the assessments.

Validity: evidence for the validity of the assessments.

Educational impact: how the candidates responded to the testing process.

Differential attainment: how the candidates performed by protected characteristics such as age, sex, ethnicity or disability.

Hand searching of grey literature such as reports and minutes from professional bodies was also carried out and contributed particularly to the Introduction to this article.

3 | RESULTS

3.1 | Study selection

In total, 20 468 articles were identified through database searching and 46 records through citation tracking. Following the removal of duplicates and records that were clearly irrelevant, we assessed 188 full-text articles, of which 54 met the inclusion criteria (see Figure 1).

3.2 | Study quality

Total MERSQI scores for the 54 articles included in this review ranged from 9.00 to 14.40, with a mean (standard deviation) of 11.53 (1.27). Mean domain scores were highest for type of data (3.00), data analysis (2.81), and sampling (2.00). The scores were lowest for validity evidence (0.63) and study design (1.44; Appendix B).

Nearly 2/3 of studies were of single-group cross-sectional or single-group post-test-only designs (Appendix B). Two-fifths of the studies reviewed included participants from 3 or more institutions. In addition, about half (46.3%) of the included studies had response rates of 75% or more. Not many studies reported on the validity of the evaluation instrument in relation to content (29.6%), internal structure (25.9%) and relationship to other variables (7.4%). However, almost all studies (96.3%) applied statistical analysis that were appropriate for their study designs and type of data.

The analysis of the papers is shown in Table 1.

The original articles may not provide all the required details, and in some cases reasonable inferences had to be made. For instance, face and content validity might not be explicitly mentioned, but could reasonably be deduced from the process of constructing items. If the PSA or a test based on the PSA are used, this is cited as evidence of validity and reliability.

4 | SUMMARY

Since a number of the entries have very many references (e.g. >20), we have individually listed those with only 3 or fewer citations: for the others, they are more easily found by reference to Table 1.

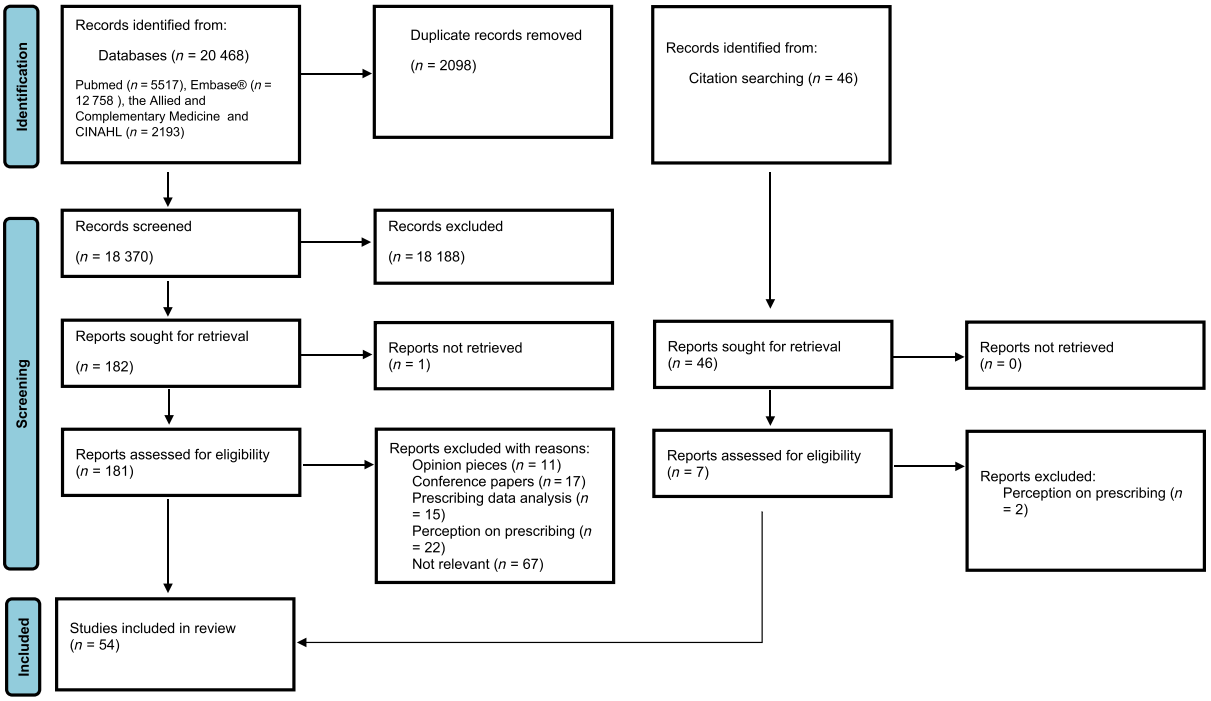

FIGURE 1 Flow diagram of article selection process.

4.1 | Context

Two studies referred to national assessments,[40,60] and 2 to regional assessments.[54,64] Of the remainder, 22 studies were multi-institutional, and 28 took place within a single institution, as indicated in Table 1.

4.2 | Country/region

The largest source of articles was the UK with 19 (about 1/3 of all results), followed by Australia with 12, the Netherlands with 7, the USA with 6 and Canada with 5. Three studies covered multiple countries in Europe. Poland, Germany, New Zealand and Switzerland were represented by 1 article each.

4.3 | Target population

Medical students represented the largest study population, with 26 article references (approximately half of all results), followed by qualified doctors with 21 (see Table 1). Pharmacy students were indicated by 3 articles,[53,69,86] and pharmacists and pharmacist prescribers by 4 articles. One article referred to nursing students,[85] and nurses were indicated by 2.[46,48] Two articles referred to dental students[38,66] and 2 to dentists.[38,46] One article referred to physician associates[46] and 1 to nonmedical prescribers.[42] An article might refer to >1 of these groups, so the total exceeds 54.

4.4 | Delivery method

Thirty-five studies were characterized as in-person (including both written and practical tests), and 15 as delivered remotely online. Computer adaptive testing was not employed in any of the studies, and the impact of possible cheating and/or the use of AI was not considered.

4.5 | Format

For written assessments, 20 articles described the use of MCQ formats, mostly single best answer though 1 article[64] mentioned true/false format. One article specified extended matching items.[52] Two articles indicated the use of very short answers,[50,73] and 15 SAQs. Eight articles were classed as employing calculations on the basis of specific information, but others may have included these as SAQs. We classified 17 articles as involving *scenario-based skills tests* on the information provided, but again, there will have been overlap between these, SAQs and calculations. Patient management problems were mentioned in 1 article,[51] therapeutic consultations in 1,[36] clinical vignettes in 1,[56] and in 1 the assessment methodology was not specified within the article.[46]

TABLE 1 Characteristics of included studies.

	Article	Context	No. of candidates	Country/region	Candidate group	Delivery method	Format
1	Brinkman *et al*. 2014[36]	Single Institution	483	Netherlands	Medical students	In person	Therapeutic consultation
2	Brinkman *et al*. 2017[37]	Multi-institution	895	Europe	Medical students	Remote online	MCQ SBST
3	Brinkman *et al*. 2019[38]	Multi-institution	63 30	Netherlands	Dentists Dental students	Remote online	MCQ SBST
4	Celebi *et al*. 2009[39]	Single Institution	74	Germany	Medical students		SBST
5	Chin *et al*. 2022[40]	National	6440	Australia New Zealand	Medical students	Remote online	MCQ SAQ Calc (PSA)
6	Coombes *et al*. 2007[41]	Single Institution	233	Australia	Medical students	In Person	SAQ
7	Cubbin *et al*. 2009[42]	Single Institution	36	UK	Practicing NMPs Doctors	In person	OSCE
8	Cullinan *et al*. 2017[43]	Multi-institution	80	Republic of Ireland	Doctors	Remote online	MCQ Case study
9	Davis *et al*. 2013[44]	Single Institution	113	UK	Doctors	In person	SAQ
10	Deskur-Smielecka *et al*. 2020[45]	Single Institution	183 138	Poland	Medical students Doctors	In person	MCQ
11	Dewey *et al*. 2016[46]	Multi-institution	174	USA	Doctors Nurses Physician associates Dentists	In person	Not specified
12	Donker *et al*. 2022[47]	Multi-institution	326 325	Europe	Doctors	Remote online	MCQ SBST
13	Ganeshan *et al*. 2006[48]	Single Institution	53 30	UK	Nurses Doctors	In person	VSA SBST
14	Garbutt *et al*. 2006[49]	Single Institution	28	USA	Medical students	In person	VOTT
15	Gordon *et al*. 2011[50]	Multi-institution	76 86	UK	Doctors	By post	VSA SAQ Calc
16	Grossman & Sheidler 1985[51]	Multi-institution	20 68	USA	Medical students Doctors	In person	PMP
17	Harding *et al*. 2010[52]	Multi-institution	128	UK	Doctors	In person	EMI WUSCE
18	Hardisty *et al*. 2019[53]	Multi-institution	397 236	UK	Pharmacy students, pre-reg trainees	Remote online	MCQ SAQ Calc (PSA)
19	Hilmer *et al*. 2009[54]	Regional	191	Australia	Doctors	In person	SBST

TABLE 1 (Continued)

	Article	Context	No. of candidates	Country/region	Candidate group	Delivery method	Format
20	Holbrook *et al.* 2019[55]	Multi-institution	714	Canada	Medical students	Remote online	MCQ SAQ Calc (PSA)
21	Ibia *et al.* 2005[56]	Multi-institution	989	USA	Medical students	In person	Clinical Vignettes
22	Jansen *et al.* 2019[27]	Single Institution	576	Netherlands	Medical students	Remote online	MCQ
23	Kalfsvel *et al.* 2022[57]	Single Institution	381	Netherlands	Medical students	In person	SBST
24	Kalfsvel *et al.* 2022b[58]	Single Institution	270	Netherlands	Medical students	In person	MCQ SBST
25	Kidd *et al.* 2010[59]	Single Institution	62	UK	Doctors	In person	SBST
26	Maxwell *et al.* 2017[60]	National	7343	UK	Medical students	Remote online	MCQ SAQ Calc (PSA)
27	Menon *et al.* 2006[61]	Single Institution	32	UK	Doctors	In person	SBST
28	McGhan *et al.* 1982[62]	Single Institution	30	USA	Pharmacists	In person	MCQ
29	Mokrzecki *et al.* 2021[63]	Single Institution	24	Australia	Medical students	In person	SBST
30	Summative Neubauer *et al.* 2004[64]	Regional	285	Canada	Pharmacists	In person	MCQ T/F SAQ
31	Newby *et al.* 2019[65]	Multi-institution	16	Australia	Medical students	In person	SBST
32	Park *et al.* 2019[66]	Multi-institution	185	Australia	Dental students	RemoteOnline	MCQ
33	Petit *et al.* 2020[67]	Multi-institution	65	Switzerland Canada	Doctors	Remote online	
34	Phillips *et al.* 2017[68]	Single Institution	85	Australia	Doctors	Remote online	MCQ
35	Power *et al.* 2022[69]	Multi-institution	238 167	UK	Pharmacy students, pre-reg trainees	In person	MCQ SAQ Calc PSA
36	Powell *et al.* 2013[70]	Multi-institution	177	UK	Doctors	In person	MCQ
37	Reid *et al.* 2018[71]	Multi-institution	59	UK	Pharmacist prescribers	Online	MCQ SAQ Calc (PSA)
38	Compares with summative Rogers *et al.* 2014[72]	Single Institution	84	Australia	Medical students	In person	MCQ SAQ SBST SCT

TABLE 1 (Continued)

	Article	Context	No. of candidates	Country/region	Candidate group	Delivery method	Format
39	Summative Rothwell *et al*. 2012[2]	Multi-institution	284	UK	Doctors	In person	SBST
40	Sam *et al*. 2019[73]	Multi-institution	364	UK	Medical students	In person	SBA VSA
41	Sandilands *et al*. 2010[74]	Single Institution	78	UK	Medical students	In person	SBST
42	Scobie *et al*. 2003[75]	Multi-institution	40	UK	Medical students	In person	OSCE
43	Summative Sikkens *et al*. 2018[76]	Single Institution	356	Netherlands	Medical students	In person	OSCE
44	Starmer *et al*. 2013[77]	Single Institution	40	Australia	Doctors	In person	SAQ
45	Stewart *et al*. 2010[78]	Multi-institution	10	UK	Pharmacist prescribers		Video assessment
46	Thomas *et al*. 2013[79]	Single Institution	153	Australia	Doctors	In person	SBST
47	Tonkin *et al*. 2006[80]	Single Institution	144	Australia	Medical students	In person	OSCE
48	van der Steen *et al*. 2020[81]	Single Institution	129	Netherlands	Doctors	In person Remote online	MCQ
49	van der Voort *et al*. 2019[82]	Multi-institution	856	Europe	Medical students	Remote online	SBST
50	Walson *et al*. 1981[83]	Single Institution	29	USA	Doctors	In person	SAQ
51	Ward & Wasson 2016[84]	Single Institution	106	UK	Medical students	In person	Direct observation of procedural skills
52	Whitehair *et al*. 2014[85]	Single Institution	192	Australia	Nursing students	In person	SAQ
53	Woit *et al*. 2020[86]	Single Institution	16 31	Canada	Medical students, Pharmacy students	Remote online	SBST
54	Wu *et al*. 2015[87]	Single Institution	58	Canada	Medical students	Remote online	MCQ SAQ Calc (PSA)

The following notes are provided for each of the analysis groups.
Number of candidates: Where 2 or more different groups are identifiable, the number in each group is recorded in the same order as the candidate group (e.g. dentists, dental students, 63, 30).
Candidate group: NMP: Nonmedical prescribers.
Delivery method: Where this is not stated, and cannot reasonably be inferred, the entry is left blank.
Format: CBD: case-based discussion; MCQ: multiple choice questions. The exact format may not have been specified in the article; T/F: true/false questions; EMI: extended matching items; SAQ: short answer questions; SBA: single best answer; VSA: very short answer (e.g. single word answers); PMP: patient management problems; SBST: scenario-based skills test. This may overlap with SAQs, since many of these will have introductory scenarios; Calc: calculations questions. Again, this may overlap with SAQs and SBSTs, depending on how much detail is provided; PSA: Prescribing Safety Assessment, indicating the assessment was based in whole or in large part on the UK version; OSCE: objective structured clinical examination; WUSCE: written unobserved structured clinical examination; VOTT: verbal order transcription test; SCT: script concordance test; PBL, problem-based learning; UG, undergraduate.

TABLE 1 (Continued)

	Standard setting method	Reliability	Validity	Acceptability	PSA based	Differential performance
1						
2		Guttman λ2 Item-rest correlation Kappa				By education style e.g. PBL *vs*. traditional
3		Guttman λ2 Item rest correlation Kappa	Face Content			By profession
4		Inter rater reliability	Face			
5	Angoff	PSA	PSA	Yes	PSA	By institution
6						
7						By specialty
8		Kappa	Face			
9			Face			
10			Face			
11			Face Content Construct			
12		Cronbach's α Discriminant analysis	Face Content			By specialty and level
13						
14						
15						
16						By level of training
17		Cronbach's α Inter class correlation coefficients Kappa				
18		PSA	PSA	Yes	PSA	UG *vs*. preregistration trainees
19						By institution
20	Angoff	PSA	PSA	Yes	PSA	By institution
21			Face			
22		Cronbach's α Item rest correlation discriminant analysis	Face Content Concurrent Construct			
23			Face			
24						

TABLE 1 (Continued)

	Standard setting method	Reliability	Validity	Acceptability	PSA based	Differential performance
25						
26	Angoff	PSA	PSA		PSA	By institution
27						Paediatric experience
28	Fixed cut score from experts	Cronbach's α Inter rater reliability KR20	Face Content Concurrent			By institution
29			Face			
30						By years of experience
31						
32			Face			
33		Item analysis				
34			Content			
35		PSA	PSA	Yes	PSA	By level of training
36			Face			NHS regions
37	Angoff	PSA	PSA	Yes	PSA	
38						
39						
40		Cronbach's α				
41						
42						
43			Face			
44						
45		Inter-rater reliability	Construct	Yes		
46						
47						
48	Wijnen	Cronbach's α Guttman λ2 Item–rest correlation	Face Content			
49			Face			By education style
50						
51			Face Content			
52						Routinely administering medication *vs*. not

TABLE 1 (Continued)

	Standard setting method	Reliability	Validity	Acceptability	PSA based	Differential performance
53			Face Content			By profession
54		PSA	PSA		PSA	Science students

The following notes are provided for each of the analysis groups.
Number of candidates: Where 2 or more different groups are identifiable, the number in each group is recorded in the same order as the candidate group (e.g. dentists, dental students, 63, 30).
Candidate group: NMP: Nonmedical prescribers.
Delivery method: Where this is not stated, and cannot reasonably be inferred, the entry is left blank.
Format: CBD: case-based discussion; MCQ: multiple choice questions. The exact format may not have been specified in the article; T/F: true/false questions; EMI: extended matching items; SAQ: short answer questions; SBA: single best answer; VSA: very short answer (e.g. single word answers); PMP: patient management problems; SBST: scenario-based skills test. This may overlap with SAQs, since many of these will have introductory scenarios; Calc: calculations questions. Again, this may overlap with SAQs and SBSTs, depending on how much detail is provided; PSA: Prescribing Safety Assessment, indicating the assessment was based in whole or in large part on the UK version; OSCE: objective structured clinical examination; WUSCE: written unobserved structured clinical examination; VOTT: verbal order transcription test; SCT: script concordance test; PBL, problem-based learning; UG, undergraduate.

Skills assessments in educational environments were more varied in format and were, therefore, more difficult to categorize. OSCEs were specifically named in 4, and *written unobserved structured clinical examinations* in 1.[52] *Direct observation of procedural skills* was mentioned in 1 article[84] and video assessments in 1.[78]

We noted that 7 articles employed the UK PSA in whole or part, and this is indicated in Table 1.

4.6 | Standard setting methods

Four articles described the use of Modified Angoff methods, and unique methods were described in a further 2: a fixed cut score set by experts,[62] and the Wijnen method.[81]

4.7 | Reliability

Cronbach's α was employed in 6 studies, KR20 in 1 article,[62] and standard error of measurement in 1 article.[60] Kappa was employed in 4 articles and other inter-rater reliability measures in 3.[39,62,78] Gutmann λ2 was employed in 3 articles.[37,38,81]

4.8 | Validity

Face validity (either stated explicitly, or inferred when item relevance was confirmed by appropriate experts) was indicated in 18 articles, and content validity (items covered an appropriate range of topics) in 16 articles. Concurrent validity (where several different tests gave similar results) appeared twice. The term construct validity was mentioned in 5 publications.

4.9 | Cost

Although cost of delivery of an assessment method would be important to describing cost effectiveness, it was not clearly indicated in any articles.

4.10 | Acceptability

Seven articles explored the acceptability of the assessments to candidates, generally concluding that the assessment methods were positively viewed by the stakeholders.

4.11 | Differential attainment

Surprisingly, none of the articles from the literature review considered differential attainment by protected characteristics such as age, sex,

ethnicity and disability. Differential performance by institution, speciality and professional category, and by years of experience, was, however, described as shown in Table 1.

4.12 | Formative or summative usage

The great majority of the articles referred to research purposes and formative uses, generally combined. Three articles[2,64,76] referred to summative uses of the tests. The PSA in use in the UK is *semi-summative* in that students may be required to pass it before graduation, or may fail it with a requirement to then pass before the end of Foundation Year 1.

One article was found that explored a possible crossover between the assessments for pharmacy students and medical students. The pharmacy students generally did well on the PSA, with mean scores above the likely pass mark for both undergraduate students and those in preregistration training.[53]

5 | DISCUSSION AND RECOMMENDATIONS

This review provides a current snapshot of the ways in which prescribing competence is measured and, in addition, reviews national requirements in several jurisdictions, where the information is available. After summarizing the findings from the systematic part of the assessment, we consider the information that may be missing from some or all the published articles, and we propose recommendations both for the institutional and national levels, based on our findings.

The majority of studies were carried out on medical students and junior doctors, rather than on other prescribers, despite the increasing role of nonmedical prescribers in the delivery of health care. Methods of choice in the cognitive knowledge domain remain selected response items such as MCQs and extended matching items, with SAQs, other *scenario-based skills tests* and calculations in various formats also featuring strongly. In terms of skills associated with prescribing (other than knowledge about prescribing) OSCEs and other observational methods were employed, but less frequently. Any debate about the relative value and cost effectiveness of written tests *vs*. OSCE style observations can only be resolved with the aid of: (i) predictive validity data on the relationship between test performance and later clinical performance; and (ii) at least some recording of relative costs of development and delivery of each approach. We return to these points below.

While we believe that this review of what is currently being done is a useful snapshot of previous practice, it additionally sheds light on what is not being done, and perhaps ought to be. Reported information did not include cost, or approaches to reliability other than Classical Test Theory. In the research papers, performance by demographic data such as age, sex, ethnicity and disability was not indicated.

By contrast, several national sources of data on candidate performance by demographic are available and show that there are significant differences by demographic data. These sources are the UK Prescribing Skills Assessment, the NHS National Pharmacist Recruitment Programme[88] (NPRP) and the GPhC National Registration Assessment, for which an assessment report is published in annual minutes.[89]

For the NPRP in 2022–2023, younger applicants scored slightly higher than older applicants both on the SJT and the numeracy tests. Female candidates scored slightly higher than male candidates on the SJT, and male candidates scored slightly higher than female candidates on the numeracy tests. These effect sizes were small. For ethnicity, self-identifying White and Chinese candidates scored higher than Asian, Black, Mixed and Other candidates both on the numeracy test and the SJT, with a medium effect size. These effects were consistent with previous iterations of the NPRP. Analysis of Differential Item Functioning indicates that these discrepancies in scores are not the result of bias in individual items, and, as in the case of widespread patterns of differential attainment, the causes remain obscure.

For the GPhC Registration Assessment 2022, younger candidates scored higher than older candidates, and candidates self-identifying as White or Chinese scored higher than other demographic groups. Males slightly outperformed females. Again, these results are generally comparable with earlier iterations of the assessments.

As far as we know, the UK PSA does not publish demographic analyses, and a review of the performance of the PSA in Australia and New Zealand also did not report on demographic data of the participants.[40]

We consider this missing evidence below and make recommendations to address these issues.

5.1 | National programmes for collecting evidence of predictive validity

The ultimate guarantor of assessment methodology, outcomes and standard setting, and arbiter for cost-effectiveness, we propose, is predictive validity: how the assessment predict how candidates subsequently perform in the workplace, with particular regard to patient safety.

How might such clinical performance best be measured? A number of outcome measures have been used in clinical practice and compared to previous assessment scores.

While some of these involve clinical skills other than prescribing, many could be adapted for use in prescribing settings. These include peer ratings of skills,[90] indices obtained from claims-for-fees data, including appropriate prescribing, incidence of contraindicated drug prescribing,[91] use of structured review charts of performance,[92] and supervisor ratings with the need for subsequent remedial support.[93] All of these studies showed a positive relationship between earlier assessment scores and subsequent workplace performance.

In several studies, later successful disciplinary proceedings were used as the outcome variable. This is no doubt because the data are more readily available than data arduously obtained through physician and patient case reviews, or by colleague or supervisor reviews. A

disadvantage is that successful disciplinary action only affects a small proportion of healthcare providers. Inverse relationships have been demonstrated between earlier assessment scores and the likelihood of subsequent disciplinary action,[94–97] the number of nontrivial complaints,[98] and having significantly lower clinical competence and professional behaviour ratings.[99]

The unequivocal conclusion that can be drawn is that written tests of declarative knowledge, practical tests such as OSCEs, and Situational Judgement Tests all have predictive validity for later clinical practice.

There is, therefore, plainly a major need for tests of the predictive validity of tests of prescribing competence, particularly for national examinations. Such tests could, as described above, employ outcome measures such as normal progression in later professional assessments, *Fitness to Practise* issues and measures of patient benefits and harms. In the UK, it would be most valuable to be able to include referrals to the former National Clinical Assessment Service (now Practitioner Performance Advice, with National Clinical Assessment Service falling under the aegis of NHS Resolution). For the UK Prescribing Safety Assessment, data on the future performance of medical students, including any subsequent sanctions, is obtainable through the UK Medical Education Database. However, retrospective review of charts by trained pharmacists is potentially the most direct and quickest method of obtaining relevant data, as described in[93] above. It is appreciated that this is expensive and time-consuming, but no methods with the same validity but lower cost have been published. In view of the importance of national assessments as the *gatekeepers* for clinical practice and patient safety, such research must be viewed as value for money.

5.1.1 | Recommendation 1: predictive validity

National authorities and regulators, such as the GPhC, should commission the appropriate research, replicating studies more commonly carried out with medical students and doctors, to explore the predictive validity of their current tests, and from these, deduce the relative and incremental value of written tests, practical and observational tests such as OSCEs and SJTs. Similarly, regional and local institutions should consider if it is possible to measure the predictive validity of their educational assessments in later clinical practice.

The creation of national data sets analogous to the UK Medical Education Database (UKMED),[100] containing all available performance data in training and subsequent clinical practice, would empower such analyses, and we recommend that this be considered by national and regional regulators.

5.2 | Differential performance

There is a systemic issue of significant and unexplained group differences across ethnic subgroups and other protected characteristics for many assessment outcomes,[101] including, as data here indicate, tests of prescribing competence. The causes of differential performance are likely to be complex and to include societal issues and are outside the scope of this review. However, it would be valuable to establish the presence and scale of the issue in tests of prescribing competence, particularly in fields where ethnic minority candidates may be present in relatively large numbers.

5.2.1 | Recommendation 2: demographic data

In tests of prescribing competence, candidates should be routinely invited to include demographic data, including protected characteristics such as age, sex, disability and ethnicity on a voluntary basis to allow subgroup analysis to be performed.

5.3 | Range of professions covered

Medical students and doctors were featured in the great majority of articles, possibly because of greater funding opportunities, or greater research expertise in the medical community. However, there are significant and expanding role in prescribing by pharmacists, nurses and physician associates. Extending studies of assessment in these professions would be a welcome addition to the literature.

5.3.1 | Recommendation 3: professions other than medicine

Research on tests of prescribing competence in allied health professions would extend and benefit the knowledge pool on prescribing competence in general, with particular reference to future patient safety.

5.4 | Good practice in reporting the assessment of prescribing

The results of this study indicate that there is considerable variability in reporting of information relating to assessment of prescribing skills, with key information frequently lacking. The following recommendation suggests some *good practice* steps that would ease the task of identifying best practice in this area in future.

5.4.1 | Recommendation 4: reporting practice

When research on assessment of prescribing is published, clear descriptions of how tests were developed, their format, size and delivery time are essential. We recommend that data on reliability, sample size, cut score and standard-setting methods be published consistently.

With increasing delivery of tests online, information about delivery format and security measures is essential.

Where Classical Test Theory is used to describe reliability, we recommend citing the standard error of measurement as well as Cronbach's α, but we also recommend considering the use of Generalisability Theory (particularly where OSCEs are employed) and Item Response Theory, increasingly widely used in medical education, where appropriate (e.g. in large regional and national tests).

Approaches to validity are extremely valuable, but not always described. A description of the chosen approaches to validity would be an invaluable addition to articles on assessments of prescribing competence, with particular reference to the face validity of items, and the content validity of tests.

Cost (e.g. in terms of staff time to develop, deliver, quality assure and score the assessments) is very rarely described. However, since cost effectiveness is a highly desirable property of assessments, such information would be invaluable, and we recommend at least an indication of the time costs involved in the assessment, even if this is not reduced to an exact financial sum.

5.4.2 | Recommendation 5: situational judgement tests

Since SJTs have demonstrated predictive validity in the affective domain, they would provide a valuable complement to tests in the cognitive and psychomotor domains.

6 | STRENGTHS AND LIMITATIONS

This study represents a snapshot, current at the time of analysis, of practice in assessment of prescribing competence. It identifies not only what is present in current practice, but also what is absent, but desirable. It makes recommendations for future research projects and their reporting, to address such lacunae.

This study has limitations. First, the findings of our review may not apply to countries in Africa, Asia and South America as studies from these regions were excluded in this systematic review. Also, it is possible that the standards of reporting prescribing assessment studies from these countries may be different to what we found. Second, our search strategy excluded articles that were not reported in English and could have missed other important assessment strategies that may exist in these studies. Third, medical students and qualified doctors represented the majority of the population groups studied in the papers we reviewed. Hence, our findings may be more reflective of the situation within medicine, as prescribing assessments in other disciplines are currently under researched/reported. Fourth, many of the included studies were conducted in a single institution (51.9%) or had small cohorts with <100 participants (40.7%).

AUTHOR CONTRIBUTIONS

All 3 authors designed the study. Drs Ajiboye and Auta carried out the systematic review, and resolved any discrepancies in scoring and analysis. Professor McLachlan provided the general educational background and wrote the first draft. All 3 authors extensively reviewed and commented on the article before submission and during the refereeing process.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the input of the referees in improving the original draft.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest with regard to this work.

DATA AVAILABILITY STATEMENT

Data are available from the Principal Investigator on request.

ORCID

John C. McLachlan https://orcid.org/0000-0001-5493-2645

REFERENCES

1. McLachlan JC. The relationship between assessment and learning. *Med Educ*. 2006;40(8):716-717. doi:10.1111/j.1365-2929.2006.02518.x
2. Rothwell C, Burford B, Morrison J, et al. Junior doctors prescribing: enhancing their learning in practice. *Br J Clin Pharmacol*. 2012;73(2):194-202. doi:10.1111/j.1365-2125.2011.04061.x
3. Dornan T, Ashcroft D, Heathfield H, et al. An in-depth investigation into causes of prescribing errors by foundation trainees in relation to their medical education: EQUIP study. London: General Medical Council, pp. 1–215; 2009.
4. Woit C, Yuksel N, Charrois TL. Competence and confidence with prescribing in pharmacy and medicine: a scoping review. *Int J Pharm Pract*. 2020;28(4):312-325. doi:10.1111/ijpp.12595
5. Brinkman DJ, Tichelaar J, Graaf S, Otten RH, Richir MC, van Agtmael MA. Do final-year medical students have sufficient prescribing competencies? A systematic literature review. *Br J Clin Pharmacol*. 2018;84(4):615-635. doi:10.1111/bcp.13491
6. Mucklow J, Bollington L, Maxwell S. Assessing prescribing competence. *Br J Clin Pharmacol*. 2012;74(4):632-639. doi:10.1111/j.1365-2125.2011.04151.x
7. Anderson LW, Krathwohl DR (Eds). *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition*. Longman; 2001.
8. Van Der Vleuten CP. The assessment of professional competence: developments, research and practical implications. *Adv Health Sci Educ*. 1996;1(1):41-67. doi:10.1007/BF00596229
9. Downing SM. Validity: on the meaningful interpretation of assessment data. *Med Educ*. 2003;37(9):830-837. doi:10.1046/j.1365-2923.2003.01594.x
10. Messick S. Validity. In: Linn RL, ed. *Educational Measurement*. 3rd ed. American Council on Education/Macmillan; 1989:13-103.
11. https://prescribingsafetyassessment.ac.uk/
12. https://www.gmc-uk.org/education/standards-guidance-and-curricula/standards-and-outcomes/outcomes-for-graduates
13. Angoff WH. Scales, norms and equivalent scores. In: *Educational Measurements*. American Council on Education; 1971.
14. https://www.bnf.org/
15. https://www.bps.ac.uk/getmedia/8028ab78-0e36-4e11-a2d8-9da39f4833e8/PSA-Independent-Review-Report-(public).pdf.aspx
16. https://www.gmc-uk.org/education/medical-licensing-assessment
17. https://prescribingsafetyassessment.ac.uk/resources/Independent_Review_Into_The_PSA.pdf

18. https://www.pharmacyregulation.org/education/pharmacist-foundation-training-scheme/registration-assessment
19. https://www.pharmacyregulation.org/sites/default/files/document/registration-assessment-regulations-for-sittings-in-2023a.pdf
20. https://www.pharmacyregulation.org/the-registration-assessment
21. nhs_england_foundation_pharmact_recruitment_applicant_handbook_2023_final.pdf (hee.nhs.uk)
22. https://www.usmle.org/prepare-your-exam/step-3-materials/step-3-content-outline-and-specifications
23. https://nabp.pharmacy/programs/examinations/naplex/
24. https://nabp.pharmacy/programs/examinations/mpje/
25. https://pebc.ca/about-pebc/
26. Kramers C, Janssen BJ, Knol W, et al. A licence to prescribe. *Br J Clin Pharmacol*. 2017;83(8):1860-1861. doi:10.1111/bcp.13257
27. Jansen DR, Keijsers CJ, Kornelissen MO, Olde Rikkert MG, Kramers C, Education working group of the Dutch Society for Clinical Pharmacology and Biopharmacy. Towards a "prescribing license" for medical students: development and quality evaluation of an assessment for safe prescribing. *Eur J Clin Pharmacol*. 2019;75(9):1261-1268. doi:10.1007/s00228-019-02686-1
28. https://www.prescribingeducation.eu/
29. Donker EM, Brinkman DJ, Richir MC, et al. The European prescribing exam: assessing whether European medical students can prescribe rationally and safely. *Eur J Clin Pharmacol*. 2022;78(6):1049-1051. doi:10.1007/s00228-022-03301-6
30. https://apps.unimi.it/files/manifesti/eng_manifesto_E26of1_2024.pdf
31. https://www.bpsassessment.com/products-services/prescribing-skills-assessment/
32. https://www.pharmacycouncil.org.au/pharmacist/skills-assessment/intern-written-exam/
33. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Int J Surg*. 2021;88:105906. doi:10.1016/j.ijsu.2021.105906
34. https://www.rpharms.com/resources/frameworks/prescribers-competency-framework#:~:text=It%20describes%20the%20demonstrable%20knowledge,both%20the%20prescriber%20and%20patient
35. Reed DA, Cook DA, Beckman TJ, Levine RB, Kern DE, Wright SM. Association between funding and quality of published medical education research. *JAMA*. 2007;298(9):1002-1009. doi:10.1001/jama.298.9.1002
36. Brinkman DJ, Tichelaar J, van Agtmael MA, Schotsman R, de Vries TP, Richir MC. The prescribing performance and confidence of final-year medical students. *Clin Pharmacol Ther*. 2014;96(5):531-533. doi:10.1038/clpt.2014.162
37. Brinkman DJ, Tichelaar J, Schutte T, et al. Essential competencies in prescribing: a first European cross-sectional study among 895 final-year medical students. *Clin Pharmacol Ther*. 2017;101(2):281-289. doi:10.1002/cpt.521
38. Brinkman DJ, Nijland N, van Diermen DE, et al. Are Dutch dental students and dental-care providers competent prescribers of drugs? *Eur J Oral Sci*. 2019;127(6):531-538. doi:10.1111/eos.12658
39. Celebi N, Weyrich P, Riessen R, Kirchhoff K, Lammerding-Köppel M. Problem-based training for medical students reduces common prescription errors: a randomised controlled trial. *Med Educ*. 2009;43(10):1010-1018. doi:10.1111/j.1365-2923.2009.03452.x
40. Chin PK, Charles K, Murnion B, et al. Evaluation of the prescribing skills assessment implementation, performance and medical student experience in Australia and New Zealand. *Br J Clin Pharmacol*. 2023;89(10):3105-3115. doi:10.1111/bcp.15814
41. Coombes I, Mitchell C, Stowasser D. Safe medication practice tutorials: a practical approach to preparing prescribers. *Clin Teach*. 2007;4(3):128-134. doi:10.1111/j.1743-498X.2007.00164.x
42. Cubbin S, Pearce J, Bullock R, McShane RU. Training and assessing independent nurse prescribers: a model for old age psychiatry. *Psychiatr Bull*. 2009;33(9):350-353. doi:10.1192/pb.bp.108.020156
43. Cullinan S, O'Mahony D, Byrne S. Use of an e-learning educational module to better equip doctors to prescribe for older patients: a randomised controlled trial. *Drugs Aging*. 2017;34(5):367-374. doi:10.1007/s40266-017-0451
44. Davis T, Thoong H, Kelsey A, Makin G. Categorising paediatric prescribing errors by junior doctors through prescribing competency assessment: does assessment reflect actual practice? *Eur J Clin Pharmacol*. 2013;69(5):1163-1166. doi:10.1007/s00228-012-1440-1
45. Deskur-Smielecka E, Kotlinska-Lemieszek A, Kropinska S, Wieczorowska-Tobis K. Medical students' and internal medicine trainees' knowledge of drug prescribing recommendations in older patients with impaired kidney function. *Clin Interv Aging*. 2020;15:53-60. doi:10.2147/cia.s231330
46. Dewey CM, Ghulyan MV, Swiggart WH. Misprescribing controlled substances: an evaluation of a professional development program. *Subst Abus*. 2016;37(3):412-418. doi:10.1080/08897077.2015.1096318
47. Donker EM, Brinkman DJ, van Rosse F, et al. Do we become better prescribers after graduation: a 1-year international follow-up study among junior doctors. *Br J Clin Pharmacol*. 2022;88(12):5218-5226. doi:10.1111/bcp.15443
48. Ganeshan A, Hon LQ, Soonawalla ZF. Oxygen: can we prescribe it correctly? *Eur J Intern Med*. 2006;17(5):355-359. doi:10.1016/j.ejim.2006.02.007
49. Garbutt JM, DeFer TM, Highstein G, McNaughton C, Milligan P, Fraser VF. Safe prescribing: an educational intervention for medical students. *Teach Learn Med*. 2006;18(3):244-250. doi:10.1207/s15328015tlm1803_10
50. Gordon M, Chandratilake M, Baker P. Improved junior paediatric prescribing skills after a short e-learning intervention: a randomised controlled trial. *Arch Dis Child*. 2011;96(12):1191-1194. doi:10.1136/archdischild-2011-300577
51. Grossman SA, Sheidler VR. Skills of medical students and house officers in prescribing narcotic medications. *Acad Med*. 1985;60(7):552-557. doi:10.1097/00001888-198507000-00007
52. Harding S, Britten N, Bristow D. The performance of junior doctors in applying clinical pharmacology knowledge and prescribing skills to standardized clinical cases. *Br J Clin Pharmacol*. 2010;69(6):598-606. doi:10.1111/j.1365-2125.2010.03645.x
53. Hardisty J, Davison K, Statham L, Fleming G, Bollington L, Maxwell S. Exploring the utility of the prescribing safety assessment in pharmacy education in England: experiences of pre-registration trainees and undergraduate (MPharm) pharmacy students. *Int J Pharm Pract*. 2019;27(2):207-213. doi:10.1111/ijpp.12479
54. Hilmer SN, Seale JP, Le Couteur DG, Crampton R, Liddle C. Do medical courses adequately prepare interns for safe and effective prescribing in New South Wales public hospitals? *Intern Med J*. 2009;39(7):428-434. doi:10.1111/j.1445-5994.2009.01942.x
55. Holbrook A, Liu JT, Rieder M, et al. Prescribing competency assessment for Canadian medical students: a pilot evaluation. *Can Med Educ J*. 2019;10(1):e103. https://pubmed.ncbi.nlm.nih.gov/30949264
56. Ibia E, Sheridan M, Schwartz R. Knowledge of the principles of judicious antibiotic use for upper respiratory infections: a survey of senior medical students. *South Med J*. 2005;98(9):889-896. doi:10.1097/01.smj.0000177439.89762.ee
57. Kalfsvel L, Hoek K, Bethlehem C, et al. How would final-year medical students perform if their skill-based prescription assessment was real life? *Br J Clin Pharmacol*. 2022;88(12):5202-5217. doi:10.1111/bcp.15427

58. Kalfsvel L, Versmissen J, van Doorn A, van den Broek W, van der Kuy H, van Rosse F. Better performance of medical students on pharmacotherapy knowledge and skills tests is associated with practising with e-learning program P-scribe. *Br J Clin Pharmacol*. 2022; 88(3):1334-1346. doi:10.1111/bcp.15077
59. Kidd L, Shand E, Beavis R, Taylor Z, Dunstan F, Tuthill D. Prescribing competence of junior doctors: does it add up? *Arch Dis Child*. 2010; 95(3):219-221. doi:10.1136/adc.2008.156042
60. Maxwell S. Prescribing safety assessment: ensuring that new graduates are competent to prescribe and supervise the use of medicines in modern healthcare. *Clin Ther*. 2017;39(8):e105. doi:10.1016/j.clinthera.2017.05.327
61. Menon L, Taylor Z, Tuthill DP. Can paediatric junior hospital doctors prescribe competently. *Paediatr Perinat Drug Ther*. 2006;7(3):118-120. doi:10.1185/146300906X105168
62. McGhan WF, Stimmel GL, Gilman TM, Segal JL. Pharmacists as drug prescribers: validation of certification exams and evaluation instruments. *Eval Health Prof*. 1982;5(2):115-129. doi:10.1177/016327878200500201
63. Mokrzecki S, Pain T, Mallett A, Perks S. Pharmacist-led education for final year medical students: a pilot study. *Front Med*. 2021;8: 732054. doi:10.3389/fmed.2021.732054
64. Neubauer SL, Suveges LG, Phillips KA, Kolodziejak LR. Competency assessment of pharmacists providing emergency contraception. *Can Pharm J*. 2004;137(2):28-33. doi:10.1177/171516350413700204
65. Newby DA, Stokes B, Smith AJ. A pilot study of a pharmacist-led prescribing program for final-year medical students. *BMC Med Educ*. 2019;19(1):54. doi:10.1186/s12909-019-1486-1
66. Park JS, Li J, Turner E, Page A, Kruger E, Tennant M. Medication knowledge among dental students in Australia—a cross-sectional study. *J Dent Educ*. 2020;84(7):799-804. doi:10.1002/jdd.12167
67. Petit LM, Le Pape P, Delestras S, et al. E-learning training to improve pediatric parenteral nutrition practice: a pilot study in two university hospitals. *J Parenter Enter Nutr*. 2020;44(6):1089-1095. doi:10.1002/jpen.1730
68. Phillips CJ, McKinnon RA, Woodman RJ, Gordon DL. Junior doctors' preparedness to prescribe, monitor, and treat patients with the antibiotic vancomycin in an Australian teaching hospital. *J Educ Eval Health Prof*. 2017;14(13):13. doi:10.3352/jeehp.2017.14.13
69. Power A, Stewart D, Craig G, et al. Student and pre-registration pharmacist performance in a UK prescribing assessment. *Int J Clin Pharm*. 2022;44(1):100-109. doi:10.1007/s11096-021-01317-z
70. Powell AG, Walker VC, Paterson-Brown L, Clark G, Drummond GB, Paterson-Brown S. Intravenous fluid prescribing knowledge and confidence in F1 doctors. *Ann R Coll Surg Engl*. 2013;95(6):1-6. doi:10.1308/147363513X13588739440979
71. Reid F, Power A, Stewart D, et al. Piloting the United Kingdom 'prescribing safety assessment' with pharmacist prescribers in Scotland. *Res Soc Adm Pharm*. 2018;14(1):62-68. doi:10.1016/j.sapharm.2016.12.009
72. Rogers GD, McConnell HW, Jones de Rooy N, Ellem F, Lombard M. A randomised controlled trial of extended immersion in multi-method continuing simulation to prepare senior medical students for practice as junior doctors. *BMC Med Educ*. 2014;14:90. doi:10.1186/1472-6920-14-90
73. Sam AH, Fung CY, Wilson RK, et al. Using prescribing very short answer questions to identify sources of medication errors: a prospective study in two UK medical schools. *BMJ Open*. 2019;9(7): e028863. doi:10.1136/bmjopen-2018-028863
74. Sandilands EA, Reid K, Shaw L, et al. Impact of a focussed teaching programme on practical prescribing skills among final year medical students. *Br J Clin Pharmacol*. 2010;71(1):29-33. doi:10.1111/j.1365-2125.2010.03808.x
75. Scobie SD, Lawson M, Cavell G, Taylor K, Jackson SH, Roberts TE. Meeting the challenge of prescribing and administering medicines safely: structured teaching and assessment for final year medical students. *Med Educ*. 2003;37(5):434-437. doi:10.1046/j.1365-2923.2003.01492.x
76. Sikkens JJ, Caris MG, Schutte T, Kramer MH, Tichelaar J, van Agtmael MA. Improving antibiotic prescribing skills in medical students: the effect of e-learning after 6 months. *J Antimicrob Chemother*. 2018;73(8):2243-2246. doi:10.1093/jac/dky163
77. Starmer K, Sinnott M, Shaban R, Donegan E, Kapitzke D. Blind prescribing: a study of junior doctors' prescribing preparedness in an Australian emergency department. *Emerg Med Australas*. 2013;25(2): 147-153. doi:10.1111/1742-6723.12061
78. Stewart D, George J, Bond C, et al. Developing and validating a tool for assessment of pharmacist prescribers' consultations. *Fam Pract*. 2010;27(5):520-526. doi:10.1093/fampra/cmq034
79. Thomas JS, Koo M, Shakib S, Wu J, Khanal S. Impact of a compulsory final year medical student curriculum on junior doctor prescribing. *Intern Med J*. 2014;44(2):156-160. doi:10.1111/imj.12316
80. Tonkin AL, Taverner D, Latte J, Doecke C. The effect of an interactive tutorial on the prescribing performance of senior medical students. *Med Educ*. 2006;11(1):4588. doi:10.3402/meo.v11i.4588
81. van der Steen CN, Brokx S, van den Hanenberg F, van der Stelt R, van Onzenoort-Bokken L, Keijsers CJ. A pharmacotherapy self-assessment improves prescribing by prompting junior doctors to study further. *Br J Clin Pharmacol*. 2021;87(8):3268-3278. doi:10.1111/bcp.14747
82. van der Voort T, Brinkman DJ, Benemei S, et al. Appropriate antibiotic prescribing among final-year medical students in Europe. *Int J Antimicrob Agents*. 2019;54(3):375-379. doi:10.1016/j.ijantimicag.2019.05.008
83. Walson PD, Hammel M, Martin R. Prescription-writing by pediatric house officers. *Acad Med*. 1981;56(5):423-428. doi:10.1097/00001888-198105000-00007
84. Ward S, Wasson G. Bridging the gap: improving safe prescribing from university to workplace. *Int J Clin Pharm*. 2016;38(5):1023-1026. doi:10.1007/s11096-016-0346-x
85. Whitehair L, Provost S, Hurley J. Identification of prescribing errors by pre-registration student nurses: a cross-sectional observational study utilising a prescription medication quiz. *Nurse Educ Today*. 2014;34(2):225-232. doi:10.1016/j.nedt.2012.12.010
86. Woit C, Yuksel N, Charrois TL. Pharmacy and medical students' competence and confidence with prescribing: a cross-sectional study. *Curr Pharm Teach Learn*. 2020;12(11):1311-1319. doi:10.1016/j.cptl.2020.06.005
87. Wu V, Chan O, Maxwell SR, et al. Development and validation of the McMaster prescribing competency assessment for medical trainees (MacPCA). *J Popul Ther Clin Pharmacol*. 2015;22(2):e173. https://www.jptcp.com/index.php/jptcp/article/view/253
88. national_recruitment_scheme_2022_outcome_report.pdf (hee.nhs.uk)
89. https://www.pharmacyregulation.org/sites/default/files/document/gphc-council-papers-8-september-2022_0.pdf
90. Ramsey PG, Carline JD, Inui TS, Larson EB, LoGerfo JP, Wenrich MD. Predictive validity of certification by the American Board of Internal Medicine. *Ann Intern Med*. 1989;110(9):719-726. doi:10.7326/0003-4819-110-9-719
91. Tamblyn R, Abrahamowicz M, Dauphinee WD, et al. Association between licensure examination scores and practice in primary care. *JAMA*. 2002;288(23):3019-3026. doi:10.1001/jama.288.23.3019
92. Wenghofer E, Klass D, Abrahamowicz M, et al. Doctor scores on national qualifying examinations predict quality of care in future practice. *Med Educ*. 2009;43(12):1166-1173. doi:10.1111/j.1365-2923.2009.03534.x
93. Cousans F, Patterson F, Edwards H, Walker K, McLachlan JC, Good D. Evaluating the complementary roles of an SJT and

academic assessment for entry into clinical practice. *Adv Health Sci Educ*. 2017;22(2):401-413. doi:10.1007/s10459-017-9755-4

94. Papadakis MA, Arnold GK, Blank LL, Holmboe ES, Lipner RS. Performance during internal medicine residency training and subsequent disciplinary action by state licensing boards. *Ann Intern Med*. 2008;148(11):869-876. doi:10.7326/0003-4819-148-11-200806030-00009
95. Tiffin PA, Sanger E, Smith DT, Troughton A, Paton LW. Situational judgement test performance and subsequent misconduct in medical students. *Med Educ*. 2022;56(7):754-763. doi:10.1111/medu.14801
96. Tiffin PA, Paton LW, Mwandigha LM, McLachlan JC, Illing J. Predicting fitness to practise events in international medical graduates who registered as UK doctors via the professional and linguistic assessments board (PLAB) system: a national cohort study. *BMC Med*. 2017;15(1):66. doi:10.1186/s12916-017-0829-1
97. Sam AH, Bala L, Westacott RJ, Brown C. Is academic attainment or situational judgment test performance in medical school associated with the likelihood of disciplinary action? A national retrospective cohort study. *Acad Med*. 2021;96(10):1467-1475. doi:10.1097/ACM.0000000000004212
98. Tamblyn R, Abrahamowicz M, Dauphinee D, et al. Physician scores on a national clinical skills examination as predictors of complaints to medical regulatory authorities. *JAMA*. 2007;298(9):993-1001. doi:10.1001/jama.298.9.993
99. Hess BJ, Weng W, Lynn LA, Holmboe ES, Lipner RS. Setting a fair performance standard for physicians' quality of patient care. *J Gen Intern Med*. 2011;26(5):467-473. doi:10.1007/s11606-010-1572-x
100. https://www.ukmed.ac.uk/
101. Woolf K. Differential attainment in medical education and training. *BMJ*. 2020;2020(368):m339. doi:10.1136/bmj.m339

How to cite this article: McLachlan JC, Auta A, Ajiboye A. Assessment and evaluation of prescribing competences: A systematic review and recommendations. *Br J Clin Pharmacol*. 2024;1-19. doi:10.1111/bcp.16033

APPENDIX A

SCREENING AND SEARCH STRATEGY

The titles and abstracts of articles retrieved from our searches were initially screened by 2 reviewers (A.A. and A.A.) to identify potentially eligible studies. The full texts of all potentially relevant studies were obtained and independently assessed against the eligibility criteria by these 2 reviewers. Any discrepancy in screening of articles was resolved by consensus.

The search strategy is shown in the Table below.

	Keywords/mesh terms
1.	("Prescriptions"[Mesh] OR "Prescription Drugs"[Mesh])
2.	(Medical students OR doctors OR nurses OR pharmacists OR physiotherapists OR nonmedical prescribers OR nurse prescribers OR allied health students OR healthcare students OR nursing students OR pharmacy students OR dental students OR nonmedical prescribing students OR nurse prescribing students OR physiotherapy students OR pharmacist prescribing students OR nonmedical prescribing course OR pharmacists prescribing course OR independent prescribing course OR supplementary prescribing course)
3.	(Assessment OR evaluation OR examination OR exam OR competenc* OR knowledge OR skill*)
4.	(United Kingdom OR Europe OR United States OR United States of America OR USA OR Canada OR Australia OR New Zealand)
5	1 AND 2 AND 3 AND 4

APPENDIX B

MERSQI domain and items cores for included studies

Domain	MERSQI item	Study No. (%)[a]	Maximum score		MERSQI score Mean (SD)	
			Item	Domain	Item	Domain
Study design	1. Study design			3	1.44 (0.68)	1.44 (0.68)
	Single-group cross-sectional or single-group post-test only	34 (62.9)	1			
	Single-group pretest and post-test	4 (7.4)	1.5			
	Nonrandomized, 2 group	10 (18.5)	2			
	Randomized controlled trial	6 (11.1)	3			
Sampling	2. No of institutions studied			3	0.94 (0.48)	2.00 (0.60)
	1 institution	28 (51.9)	0.5			
	2 institutions	4 (7.4)	1			
	3 or more institutions	22 (40.7)	1.5			
	3. Response rate				1.13 (0.44)	
	Not applicable	7 (13.0)				
	<50% or not reported	13 (24.1)	0.5			
	50–74%	9 (16.7)	1			
	≥75%	25 (46.3)	1.5			
Type of data	4. Type of data			3	3.00 (0.00)	3.00 (0.00)
	Subjective	0	1			
	Objective measurement	54 (100)	3			
Validity	5. Content			3	0.30 (0.46)	0.63 (0.83)
	Reported	16 (29.6)	1			

Domain	MERSQI item	Study No. (%)[a]	Maximum score		MERSQI score Mean (SD)	
			Item	Domain	Item	Domain
	Not reported	38 (70.4)	0			
	6. Internal structure				0.26 (0.44)	
	Reported	14 (25.9)	1			
	Not reported	40 (74.1)	0			
	7. Relationship to other variables				0.07 (0.26)	
	Reported	4 (7.4)	1			
	Not reported	50 (92.6)	0			
Data analysis	8. Appropriateness of data analysis			3	0.96 (0.19)	2.81 (0.39)
	Data analysis inappropriate for study design and type of data	2 (3.7)	0			
	Data analysis appropriate for study design and type of data	52 (96.3)	1			
	9. Complexity of analysis				1.85 (0.36)	
	Descriptive analysis only	8 (15.4)	1			
	Beyond descriptive analysis	46 (85.2)	2			
Outcomes	10. Outcomes			3	1.50 (0.00)	1.50 (0.00)
	Satisfaction, attitudes, perceptions, opinions, general facts	0	1			
	Knowledge, skills	54 (100)	1.5			
	Behaviours	0	2			
	Patient/health care outcomes	0	3			

[a]Percentages may not total 100 due to rounding.