DEVELOPMENT AND VALIDATION OF THE MCMASTER PRESCRIBING COMPETENCY ASSESSMENT FOR MEDICAL TRAINEES (MacPCA)

Vincent Wu[1], Oscar Chan[1], Simon R. Maxwell[2], Mitchell A. Levine[3,4], Dan Perri[3], Rolf J. Sebaldt[3,4], Bandar Baw[3], Anne Holbrook[3,4]

[1]Bachelor of Health Sciences Program, Faculty of Health Sciences, McMaster University, Canada;
[2]Clinical Pharmacology Unit, University of Edinburgh, Western General Hospital, United Kingdom;
[3]Division of Clinical Pharmacology & Toxicology, Department of Medicine, McMaster University, Canada;
[4]Centre for Evaluation of Medicines, St Joseph's Healthcare Hamilton

_____

ABSTRACT

Background

Prescribing is an essential skill for all physicians, built on knowledge of clinical pharmacology, therapeutics and toxicology across the life cycle. The decline in organized clinical pharmacology training in medical schools, combined with an expanding pharmacopeia and increasing complexity of patient care, makes prescribing competency difficult for medical students to master.

Objectives

To develop and validate the McMaster Prescribing Competency Assessment (MacPCA), an online tool suitable for evaluating clinical pharmacology knowledge and prescribing skills of medical trainees in Canada.

Methods

The MacPCA was developed using an online examination platform scalable to multiple sites across Canada. Questions represented 8 domains of safe and effective prescribing with level of difficulty aimed at a final year medical student. Validation assessment concentrated on face and construct validity.

Results

58 participants (7, 12 and 21 medical students in Years 1, 2, and 3, respectively and 8 undergraduate controls) were recruited. Mean scores were 31% (SD 13.6), 46% (SD 14.9), 75% (SD 8.3) and 81% (SD 10.5) for the controls, Year 1, Year 2, and Year 3 (final year) students, respectively. Combined Year 2/Year 3 scores were significantly better than control/Year 1 scores (p<0.0001). Final year student feedback indicated the test was fair, clear and unambiguous, aimed at the right level, with sufficient time for completion.

Conclusions

The MacPCA demonstrated good face validity and successfully discriminated between upper year medical students and their junior colleagues. Further expansion of testing and validation is warranted.

Key Words: _Prescribing, medical students, clinical pharmacology, competency, validation_

_____

With expanding types and numbers of medications to prescribe, increasingly complex medication regimens, and demand for personalized medicine, competence in the discipline of clinical pharmacology and toxicology becomes more difficult to master.[1] Yet every physician must learn to prescribe. Experts in this medical specialty have noted a decline in formal training in pharmacology, therapeutics, toxicology, and prescribing skills across medical schools in Canada and internationally.[2,3] The lack of formal training in clinical pharmacology for

medical students is associated with a future practice of more prescribing errors and poor communication with patients regarding their medications. This may lead to increased complaints and legal action, and reduce the cost-effectiveness of medications prescribed.[4,5] A survey of graduating medical students at McMaster University suggested that students are aware of and concerned about this important gap in their training, mirroring results in other countries.[6-8] The belief that a standardized assessment of knowledge and skills would be a requisite step towards ensuring trainee competence, which led the British Pharmacological Society (BPS) to develop the Prescribing Safety Assessment (PSA). The PSA is an online national assessment that aims to assess the clinical pharmacology knowledge and prescribing skills of pre-graduating medical students.[9] Preliminary results from the first PSA, offered in 2014, indicate that among more than 8000 students completing the test, 90% of the students exceeded a threshold mark of 72%. Passing the PSA is required before moving forward to the British Medical Licensing Exams.

A literature search regarding the Canadian setting did not reveal any systematic evaluation of clinical pharmacology knowledge and prescribing skills amongst medical schools. Our objective in this study was to develop and validate an online assessment tool suitable for evaluating clinical pharmacology knowledge and prescribing skills of medical trainees in Canada. The long-term goal is to ensure that medical students could pass such an assessment before proceeding to their final licensure exam.

METHODS

Development of the MacPCA
The MacPCA was adapted from the PSA developed by the BPS. Patient scenarios and questions corresponded to eight of the domains of safe and effective prescribing as outlined in the BPS curriculum: Prescription Writing, Prescription Review, Therapy Management, Communicating Skills, Calculation Skills, Adverse Reactions, Drug Monitoring and Data Interpretation. Faculty members of the Division of

Clinical Pharmacology & Toxicology developed and edited the questions, with the level of difficulty aimed for a final year medical student who is prepared for the pre-licensure exam. In addition, feedback was sought from the students on whether the test was at an appropriate level of training, with clear and unambiguous questions, and on the usability of the online examination platform.

Online Examination Platform
Computerized assessment of clinical scenarios alleviates some of the shortcomings of traditional in-person examinations, which require significant time, resources, and personnel in the form of assessors and invigilators. Prior to the start of the MacPCA, students created an anonymous guest account and then proceeded to the MacPCA pilot test. The online test was built on the open source TCExam: Computer-based Assessment Software, designed for creating, administering, scoring and providing feedback in electronic examinations. Twenty minutes were allowed to complete all 8 sections of the MacPCA with 9 questions. Eight of the questions on Prescription Review, Therapy Management, Communicating Skills, Calculation Skills, Adverse Reactions, Drug Monitoring and Data Interpretation, presented realistic patient scenarios with one best multiple-choice response. The ninth question, on Prescription Writing, presented a patient scenario and asked students to 'write a prescription'. Scoring of the MacPCA was equal for each question, except for the prescription-writing question, which was assigned double points, one for appropriate drug and one for appropriate dose. The computer-based assessment software marked multiple-choice questions automatically, while a single faculty member marked the Prescription Writing question according to pre-set criteria (Appendix 1) while blinded to participant identification.

Participants
McMaster University medical students from all levels were recruited on a voluntary basis through class email for the validation exercise, along with volunteer undergraduate students who served as controls. Year 3 medical students are in their final year at McMaster University. Each student

provided informed consent. No exclusion criteria such as sex, age, ethnicity, or prior clinical pharmacology knowledge, were applied.

Analysis Plan

Due to the lack of a gold standard assessment tool in prescribing competency, we evaluated face and construct validity of the MacPCA. Face validity of final year medical students was based on the hypothesis that the test would be at the correct level of difficulty for final year medical students while also being clear and unambiguous. This was measured by specific feedback questions at the end of the test asking about level of training, general readiness, perceived fairness and difficulty of the questions. Construct validation used mean scores across participant years of training, with the hypothesis that upper year (2nd and 3rd) students, who were involved in clinical rotations, would score significantly better than 1st year students and controls.

Statistical Analysis

Statistical analysis was conducted on the GraphPad Prism 5 software. One-way analysis of variance (ANOVA) was performed to determine any significant differences in the results between medical students in Years 1, 2, 3 and undergraduate controls. A Bonferroni post-hoc test was conducted to correct for multiple comparison errors. Statistical significance was set to $p<0.05$.

RESULTS

Fifty McMaster medical students (17, 12 and 21 in Years 1, 2 and 3, respectively) and 8 undergraduate science student controls participated in the study.

Undergraduate (mean score 31% SD 13.6) and first year medical students (mean score 46% SD 14.9) scored significantly lower than their 2nd year (mean score 75% SD 8.3) and 3rd year (mean score 81% SD 10.5) colleagues ($p<0.0001$ for 1st year vs. 2nd year, 1st year vs. 3rd year, control vs. 2nd year, control vs. 3rd year, Figure 1). Although there were clear trends, the differences between controls and 1st year ($p=0.13$), or between 2nd and 3rd year medical students, were not statistically significant ($p=0.09$).

Regarding face validity (Figure 2), final year students indicated on a scale of 1-5, where 1 represented 'do not agree' and 5 represented 'fully agree', that the MacPCA was an appropriate test of prescribing skills for their level of study (mean score 4.05, SD 1.02); their education had prepared them (mean score 3.86, SD 0.85); the questions were at the appropriate level of difficulty (mean score 4.24, SD 0.77); sufficient time was provided to answer the questions (mean score 4.76, SD 0.54); and the questions were clear and unambiguous (mean score 4.43, SD 0.75) and easy to follow (mean score 4.48, SD 0.68).
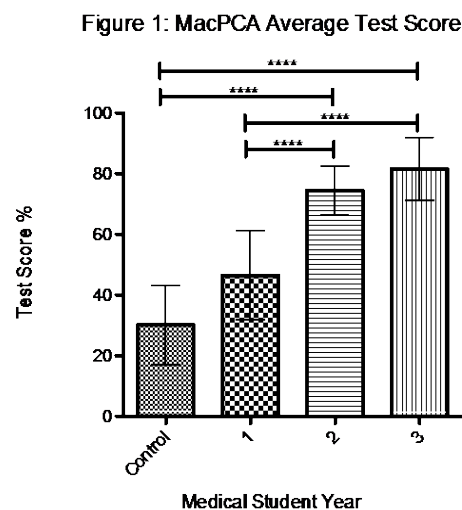
Figure 1: MacPCA Average Test Score

Figure 1: Average MacPCA test scores by year of medical school; error bars demonstrate SD. **** $p < 0.0001$.
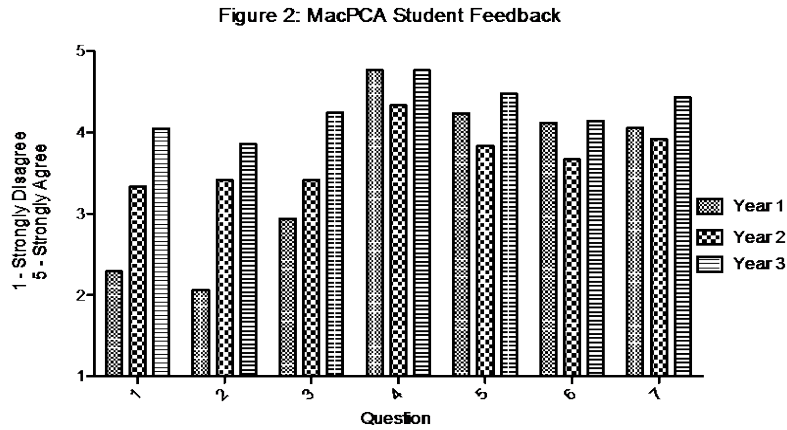
Figure 2: MacPCA Student Feedback

Figure 2: Average feedback scored from 1 through 5 (1 – Strongly Disagree, 5 – Strongly Agree) is shown from students in year 1, 2, and 3. Feedback questions 1 through 7 are shown in Table 1.

TABLE 1 – Feedback Questions

Question	Description
1	This assessment was an appropriate test of the prescribing skills expected from a medical student with my level of training.
2	My medical school experience prepared me for the content of the questions in this assessment.
3	The questions were of a reasonable level of difficulty.
4	The time provided for answering the questions was sufficient.
5	The layout and presentation of the questions was easy to follow.
6	The online interface was easy to use.
7	The questions in the assessment were clear and ambiguous.

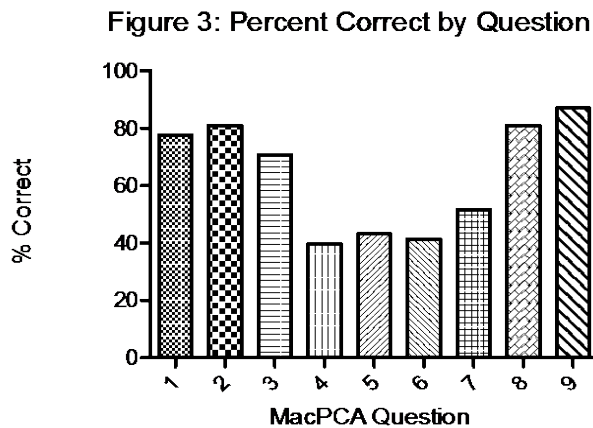Figure 3: Percent Correct by Question

Figure 3: Questions 1 through 9 reflects MacPCA domains: 1-Adverse Drug Reaction, 2-Calculation Skills, 3-Communication Skills, 4-Data Interpretation, 5-Drug Monitoring, 6-Therapy Management, 7-Prescribing, 8,9-Prescription Review.

Figure 3 shows that students from all years generally performed worse on questions in the domains of Data Interpretation (40% correct), Drug Monitoring (43% correct), Therapy Management (41% correct), and Prescription Writing (52% correct), as opposed to questions on Adverse Drug Reaction (78% correct), Calculation Skills (81% correct), Communication Skills (71% correct), and Prescription Review (84% correct). Third year medical students performed better than both 1st and 2nd year students on all domains except for Therapy Management, where performances were comparable between 2nd and 3rd year students at 67% and 57%, respectively.

DISCUSSION

We have developed and validated a short online assessment of therapeutics knowledge and prescribing skills suitable for final year medical students. The need for such an assessment tool across all Canadian medical schools is currently being assessed by a survey of leaders. We believe that this is the first such endeavour in Canada. Future versions of the MacPCA will expand on the number of questions and map them to the 7 CANMEDS roles of Medical Expert, Communicator, Collaborator, Manager, Health Advocate, Scholar, and Professional, incorporate a domain to evaluate cost-effectiveness of comparable medications, and provide more realistic prescription interfaces.[10] We are also investigating the role of simulation training in high risk prescribing situations (e.g., cardiac arrest, overdose with altered level of consciousness, SIRS, acute delirium, etc.) to augment the MacPCA.

Our study has several limitations. First, the sample size of 58, although demonstrating several features of validation, was small. The small sample size of the study contributed to a lack of power to detect statistically significant differences between the scores of 2nd versus 3rd year medical students. Further validation of the MacPCA as suitable for final year might be gained by administering it to early first year residents. Second, we have not yet been able to compare results with the much larger British test,

the PSA. Finally, it would be very useful to match individual scores on MacPCA with their licensure examination scores as a type of criterion validation.

CONCLUSION

We have completed the initial validation of a Prescribing Competency Assessment for final year pre-licensure medical students. Further expansion of testing and validation is warranted.

Corresponding Author: Holbrook@mcmaster.ca

REFERENCES
1. Association of American Medical Colleges. Contemporary Issues in Medicine: Education in Safe and Effective Prescribing Practices. Washington DC: Association of American Medical Colleges, 2008.
2. Reidenberg, MM. A new look at the profession of clinical pharmacology. Clin Pharmacol Ther 2008 Feb;83(2):213-7.
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 Final Report. http://www.gmc-uk.org/FINAL_Report_prevalence_and_causes_of_prescribing_errors.pdf_28935150.pdf (August 2015).
4. Cadieux G, Tamblyn R, Dauphinee D, Libman M. Predictors of inappropriate antibiotic prescribing among primary care physicians. CMAJ 2007 Oct 9;177(8):877–83.
5. Ben-David MF, Klass DJ, Boulet J, et al. The performance of foreign medical graduates on the National Board of Medical Examiners (NBME) standardized patient examination prototype: a collaborative study of the NBME and the Educational Commission for Foreign Medical Graduates (ECFMG). Medical Education 1999 Jun;33(6):439–46.
6. Qayyum F, Wright M, Lee M, Leung C, Sada A, Holbrook A. Medical Student Opinions On Their Training In Clinical Pharmacology And

Therapeutics. McMaster University Medical Journal 2012;9(1):4-8.

7. Heaton A, Webb DJ, Maxwell SR. Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. Br J Clin Pharmacol 2008 Jul;66(1):128-34.

8. Oshikoya K, Senbanjo IO, Amole OO. Interns' knowledge of clinical pharmacology and therapeutics after undergraduate and on-going internship training in Nigeria: a pilot study. BMC Medical Education 2009 Jan;9:50.

9. Ross S, Ryan C, Duncan EM, et al. Perceived causes of prescribing errors by junior doctors in hospital inpatients: a study from the PROTECT programme. BMJ Qual Saf 2013 Feb;22(2):97-102.

10. Frank JR, editor. The CanMEDS 2005 physician competency framework. Better standards. Better physicians. Better care. Ottawa: The Royal College of Physicians and Surgeons of Canada; 2005.

APPENDIX - EVALUATION CRITERIA

Section	Description	Total Mark	Mark Distribution
1	Prescribing	2	1 item worth 2 marks (1 mark for drug choice, 1 mark for dosage, route, frequency and signature)
2	Prescription Review	1	2 items worth 2 marks
3	Therapy Management	1	1 item worth 1 marks
4	Communicating Skills	1	1 item worth 1 marks
5	Calculation Skills	1	1 item worth 1 marks
6	Adverse Reactions	1	1 item worth 1 marks
7	Drug Monitoring	1	1 item worth 1 marks
8	Data Interpretation	1	1 item worth 1 marks
	Total Mark	**10**	