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Article

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Abstract: Suboptimal knowledge of clinical pharmacology, therapeutics, and toxicology (CPT) and poor-quality prescribing are threats to patient safety. Our previous national survey of medical faculty identified limited confidence in medical student graduates' ability to prescribe safely and an interest in a national prescribing competence assessment. Given the in-person challenges posed by the restrictions related to the COVID-19 pandemic, we aimed to re-evaluate opinions and gauge interest in e-learning resources and assessments. Using public sources, a sampling frame of medical school leaders from all 17 Canadian medical schools, including deans, vice-deans, and program directors for clerkship, residency, and e-learning, were invited to participate in a cross-sectional survey. Survey questions were finalized after several rounds of testing and analyses were descriptive. Of 1448 invitations, 411 (28.4%) individuals reviewed the survey, and among them, 278 (67.6%) completed at least one survey question with representation from all schools. While more than 90% of respondents agreed that medical students should meet a minimum standard of prescribing competence, only 17 (7.9%) could vouch for their school meeting objectives in CPT and many had significant concerns about their own or other schools' recent graduate prescribing abilities. Given the lack of local CPT eCurricula resources, there was strong interest in a national online course and assessment in CPT. Our national survey results suggest an ongoing inadequacy of medical trainees' prescribing competence and provide a strong endorsement for both a national online CPT course and assessment during medical school.

Keywords: prescribing competency; medical education; survey; Canada; medication safety

Introduction

The discipline of Clinical Pharmacology, Therapeutics, and Toxicology (CPT) covers basic human pharmacology, therapeutics, toxicology, drug regulation knowledge, as well as prescribing and therapeutic monitoring skills.[1] Physicians must be competent in CPT, no matter their specialty, as prescribing is the most common act of treatment in medicine. A lack of competence correlates with medication errors, patient harm, and medicolegal risk.[2–4] There is well-documented evidence that knowledge and appropriate prescribing of medication reduces patient mortality and disability and improves the cost-effectiveness and sustainability of the healthcare system.[5] Our group has previously shown that fewer than half of final-year medical students in Ontario, Canada passed early

versions of the Canadian Prescribing Safety Assessment, and medical schools across the country and internationally struggle to ensure prescribing competence.[6–9] Ideally, CPT knowledge and prescribing skills objectives are longitudinally integrated into medical education beginning in early medical school and continuing through post-graduate training and ongoing professional development. By the time of graduation, medical students should be able to safely prescribe and monitor commonly used medications on the relevant Essential Medications list, and know how to collaborate to increase their scope of expertise.[10] However, medical school curricula are increasingly crowded as medical knowledge and public expectations of health care expand. Our previous survey of medical school leaders across Canada found a lack of confidence in many graduating medical students' prescribing competence and identified great interest among faculty for the creation of a standardized CPT curriculum and assessment prior to licensing exams.[11]

Currently, CPT related e-curricula resources and online assessment hold appeal since there are very few CPT faculty, there is a lack of reliable open-access CPT e-resources available, and because the pandemic has demonstrated the value of quality online medical education resources.[6,12,13] The most well-established English-language e-curricula products for CPT at present are the Australian National Prescribing Curriculum and the British Pharmacology Society's e-Curriculum (the latter restricted to Britain at present).[14–16] While these resources may be useful in teaching general principles of CPT, such as safe prescribing, establishing a drug history, or calculating appropriate dosing, these resources may be limited in their usefulness when describing specific therapeutics or toxicology for learners not based in those countries because of regional differences. For example, medications used to treat or self-treat conditions may vary depending on differences in the disease burden, medication supply both regulated and unregulated, approval from governmental health regulatory agencies, and availability of public funding.[17–19] In addition, the need for high quality online CPT resources that addressed country-specific   priorities, was amplified during the COVID-19 pandemic due to restrictions placed on in-person educational opportunities for students. During the pandemic, medical education was disrupted, with many institutions moving to online modes of delivering education and replacing clinical placements with simulations or role-playing.[20] Many medical schools reported being able to navigate these challenges and created online learning environments that trainees approved of with minimal impacts to their learning, providing evidence that a CPT e-curriculum may be feasible for the pandemic and beyond. (20–23)

In 2021, the Medical Council of Canada (MCC) added specific Prescribing Practices objectives, which highlighted the expectations that medical schools teach safe prescribing and monitoring skills.[24] The combination of explicit directives in CPT for medical schools, the deficiency of any national clinical pharmacology knowledge and prescribing skills textbook, and the added strain of the COVID-19 pandemic and its aftermath on medical education has created an urgent need to address medical students' prescribing competence especially considering the aging Canadian population, where patients are presenting with more comorbidities and with increasingly complex health concerns.

The objective of the present study was to survey all faculty who held medical education positions at Canadian medical schools regarding their views on the current prescribing competency of   undergraduate medical trainees, changes in education since COVID-19, their school's use of CPT e-curriculum, and their interest in a national CPT curriculum and assessment.

Methods

Settings, Participants, and Ethical Considerations

This study was a cross-sectional survey administered from August to November 2022 in English via LimeSurvey, an open source, online survey platform.[25] Survey distribution and data collection were conducted electronically. The LimeSurvey platform was chosen due to its data security, ease of use for researchers, and availability of technological support.[25]

Using publicly available sources, researchers gathered contact information for all educational leaders at Canada's 17 medical schools, specifically participants in the following roles: deans, vice-

deans, or assistant deans involved in medical education and program directors for clerkship, residency, or e-learning. Participant names, emails, and roles were gathered from websites, faculty lists, institutional directories, and administration personnel for Dalhousie University, McGill University, McMaster University, Memorial University of Newfoundland, the Northern Ontario School of Medicine, Queen's University, the University of Alberta, the University of British Columbia, the University of Calgary, the University of Manitoba, the University of Ottawa, the University of Saskatchewan, the University of Toronto, Western University, l'Université Laval, l'Université de Montréal, and l'Université de Sherbrooke. For representativeness, the final invitee number at each individual medical school was weighted by class size following consultation with a health sciences statistician. All survey participants were anonymized through the automated assignment of a unique token ID that was sent via an email invitation and allowed only a single complete response per participant. The survey was sent to participants on August 9, 2022 and stayed open for exactly 14 weeks until November 15, 2022. Reminders were sent out weekly to biweekly and were restricted to participants who were non-responders or had incomplete/unsubmitted surveys.

This project was reviewed and approved by the Hamilton Integrated Research Ethics Board (HiREB) prior to study commencement (HiREB #13806). To maintain confidentiality, survey responses were anonymized via token IDs and stored securely on the LimeSurvey platform.

Survey Overview

Survey questions were designed in consultation with the senior author, a clinician pharmacologist who has extensive experience and expertise in the field of CPT and medical education, to gather information related to the following themes:

1. Perceptions of prescribing competence of local medical students and incoming early junior residents and the ability of their school to meet MCC Prescribing Practices objectives.
2. The impact of the Covid-19 pandemic on clinical placements and rotations, and its educational impact on the prescribing competence of medical trainees.
3. e-Learning resources used for the Clinical Pharmacology and Prescribing Competence curriculum.
4. Current knowledge of non-Canadian CPT e-Curriculum resources.
5. Interest in CPT e-curriculum and online prescribing skills e-assessment.

Questions were reviewed and refined among investigators and volunteers for clarity, based on four rounds of survey pre-testing. The survey was designed to be short and succinct to maximize participation, with a planned maximum of ten minutes to complete. We asked nine content questions centered around the following content domains: 1) opinion on the importance of standardized CPT training in Canada, 2) perception of prescribing skills among their own medical students and incoming junior residents, 3) opinion on the importance of a CPT e-curriculum in Canada, and 4) opinion on the impact of COVID-19 on CPT education among medical students. Development of the content questions was guided, in part, by the questionnaire from a previous survey study conducted before the COVID-19 pandemic.(10) The present survey also includes five demographic questions that collected information on the participants' age, gender, role, institutional affiliation, and number of years on medical faculty. Seven out of nine content questions used a five-point Likert-rating scale to ensure a nuanced perspective could be gathered.[26] The first nine survey questions could not be bypassed without a response but included a "prefer not to answer" option, while the demographic questions were not mandatory for participants to complete. Analysis of the survey results was descriptive, and the *Equator Network's Consensus-Based Checklist for Reporting of Survey Studies (CROSS)* was used to guide survey development. [27]

Results

A total of 1448 survey invitations were sent by email with 411 (28.4%) faculty receiving and reviewing the email invitation. Out of the 411 who interacted with the email-based survey invitation, at least one survey response was submitted by 278 (67.6%) participants, with 206 (50.1%) completing

the entire survey including all demographic questions. The survey was closed 4 months after release. The mean total time spent completing the survey was 5.6 (SD 12.4) minutes.

Faculty representation from all 17 Canadian medical schools was present. Most respondents were between 40-49 years of age and 97 (46.4%) identified as female. A detailed breakdown of participant characteristics is found in Table 1. There were 109 (52.7%) residency program directors, 25 (12.1%) clerkship directors, and 18 (8.7%) in a deanery role (dean/vice dean/assistant dean of medicine or undergraduate medical education). The remaining 55 (26.6%) respondents were a mix of e-Learning directors, did not disclose their specific role, or listed their role as "other." The most commonly described "other" roles were reported as previous program directors, current clinical preceptors, associate program directors, or clinical professors. A detailed summary of respondent characteristics is shown in Table 1.

Table 1. Participant characteristics.

Age, *n* (%)	
20-29	0 (0.0)
30-39	38 (18.2)
40-49	88 (42.1)
50-59	54 (25.8)
>60	16 (7.7)
Prefer not to answer	13 (6.2)
Gender, *n* (%)	
Female	97 (46.4)
Male	96 (45.9)
Prefer not to disclose	14 (6.7)
Other	2 (1)
Role, *n* (%)	
Residency program director	109 (52.7)
Clerkship director	25 (12.1)
Assistant/vice/dean of medicine or undergraduate medicine	18 (8.7)
e-Learning directors or leads	2 (1.0)
Prefer not to answer	15 (7.2)
Other	38 (18.6)
University affiliation, *n* (%)	
Dalhousie University	17 (8.2)
McGill University	12 (5.8)
McMaster University	21 (10.1)
Memorial University of Newfoundland	8 (3.9)
Northern Ontario School of Medicine	5 (2.4)
Queen's University	9 (4.3)

University of Alberta	16 (7.7)
University of British Columbia	10 (4.8)
University of Calgary	11 (5.3)
University of Manitoba	4 (1.9)
University of Ottawa	15 (7.2)
University of Saskatchewan	15 (7.2)
University of Toronto	17 (8.2)
University of Western Ontario	13 (6.3)
Université Laval	9 (4.3)
Université de Montréal	15 (8.2)
Université de Sherbrooke	6 (2.9)
Prefer not to answer	4 (1.9)

Detailed responses to each survey question are shown in Table 2.

A total of 232 (92.1%) respondents agreed or strongly agreed that it is important for graduating medical students in Canada to meet a common threshold of prescribing competence by the end of their undergraduate training. When asked to think about medical students who graduated from their own school in the past 3 years, 46 respondents (19.3%) rated their students' CPT knowledge and prescribing skills as less than satisfactory. Additionally, 117 respondents (52.0%) specified that close supervision of prescribing was needed for more than one-third of their first-year residents, trainees who could have graduated from any medical school.

On whether their medical school curriculum meets the MCC objectives on Prescribing Practices, approximately half of respondents (49.3%) were unsure, with an additional 39 (17.3%) respondents reporting that fewer than half of the MCC objectives were currently met at their institution. Only 17 (7.9%) faculty were fully confident that all MCC objectives were met in their school's curriculum. Most respondents (61.2%) thought that the COVID-19 pandemic had a neutral effect on the prescribing competence of final year students, but 78 (36.4%) reported that COVID-19 had a negative effect on student prescribing skills.

Few participants (17, 7.5%) were aware of the specific e-learning resources used to teach CPT at their school. Only 10 (4.8%) respondents, were familiar with either the Australian National Prescribing Curriculum or the British Pharmacological Society e-Curriculum resources. Those familiar with these resources viewed them as trusted sources as they displayed a resemblance to Canadian medical standards or they knew involvement from Canadian CPT leaders supported the resource. For those not recommending either resource, reasons included lack of time in current curriculum and concern related to the use of externally developed curricula.

Lastly, 169 (80.9%) respondents agreed or strongly agreed that a national online prescribing skills competence assessment would improve the clinical performance of graduating medical students in Canada, and 159 respondents (76.1%) believed that an online course that included the main learning priorities for clinical pharmacology, therapeutics, and prescribing skills for medical students would significantly improve students' medical education.

Table 2. Participant Responses.

Study Consent and Preamble						
Q1. Study preamble and consent to participate (*n* = 278).	Proceed to survey 258 (92.8%)			No 20 (7.2%)		
Main survey content questions						
Q1. It is important for graduating medical students in Canada to meet a common threshold of prescribing competence by the end of their undergraduate training. (*n* = 252)	Strongly Agree 185 (73.4%)	Somewhat Agree 47 (18.7%)	Neutral 7 (2.8%)	Somewhat Disagree 0 (0.0%)	Strongly Disagree 13 (5.2%)	
Q2. Thinking of all of the medical students who graduated from your school over the past 3 years, please rate their average knowledge of clinical pharmacology, therapeutics and toxicology, and their prescribing skills at the time of graduation. (*n* = 238)	Excellent 3 (1.3%)	Good 60 (25.2%)	Satisfactory 129 (54.2%)	Poor 44 (18.5%)	Very Poor 2 (0.8%)	
Q3. Thinking of the early postgraduate Year 1 residents you have encountered in the past 3 years (who could be graduates of other medical schools), what proportion required close supervision for safe prescribing? (*n* = 225)	<10% 37 (16.4%)	10-33% 61 (27.1%)	34-50% 49 (21.8%)	>50% 68 (30.2%)	None 10 (4.4%)	
Q4. How well does your medical school's current curriculum meet the Medical Council of Canada's new Objectives on Prescribing Practice? Specifically how many of these MCC objectives are met at an acceptable standard? (*n* = 217)	None 0 (0.0%)	A few 9 (4.1%)	Approximately half 30 (13.8%)	Most objectives 54 (24.9%)	All objectives 17 (7.9%)	Don't know 107 (49.3%)

Q5. COVID-19 removed many clinical placements and rotations for medical students, with attempts to substitute online learning equivalents. How did this change influence the prescribing competence of your final year medical students? (*n* = 214)	Strongly Positive 0 (0.0%)	Positive Change 5 (2.3%)	Neutral 131 (61.2%)	Negative change 68 (31.8%)	Strongly Negative 10 (4.7%)	
Q6. Does your medical school use specific e-learning resources to teach Clinical Pharmacology and Toxicology? (*n* = 214)	Yes 16 (7.5%)		No 26 (12.2%)		Don't Know 172 (80.4%)	
Q7. There is currently no national Canadian Clinical Pharmacology knowledge or Prescribing Skills curricula or eLearning resource. Our systematic review found the most relevant to be Australia's National Prescribing Curriculum and the British Pharmacology Society's e-Curriculum (the latter is restricted to UK at present). Multiple options can be selected.	Familiar with the Australian NPC and would recommend it *n* = 4	Familiar with the Australian NPC but would not recommend it *n* = 1	Familiar with the BPS eCurriculum and would recommend it *n* = 7	Familiar with the BPS eCurriculum but would not recommend it *n* = 3	Not familiar with either resource *n* = 199	
Q8. A Canadian online prescribing skills competence assessment (e.g., mix of Multiple-Choice Questions, prescription writing scenarios, and virtual OSCE stations) would improve the clinical performance of graduating medical students in Canada. (*n* = 209)	Strongly Agree 63 (30.1%)	Somewhat Agree 106 (50.7%)	Neutral 29 (13.9%)	Somewhat Disagree 7 (3.3%)	Strongly Disagree 4 (1.9%)	
Q9. A Canadian online course which included the main learning priorities for clinical	Strongly Agree	Somewhat Agree	Neutral 34 (16.3%)	Somewhat Disagree	Strongly Disagree	

| pharmacology, therapeutics, toxicology, and prescribing skills for medical students, would offer a significant improvement in education for your school's medical students. (*n* = 209) | 62 (29.7%) | 97 (46.4%) | | 11 (5.3%) | 5 (2.4%) | |

Discussion

The present survey points to a common perception among medical school leadership that medical students in Canada are not learning sufficient CPT knowledge and do not have adequate prescribing skills at graduation. We found that approximately one-third of respondents believe that the alterations in medical teaching and learning related to the pandemic have adversely affected students' prescribing competence. Despite a relatively new emphasis on CPT knowledge and skills brought about by specific learning objectives mandated by the national medical school curriculum regulator (MCC), only a very small number of faculty could positively vouch that their school met all of the MCC objectives. Our findings are similar to investigations of CPT knowledge among medical students internationally. For example, a systematic review conducted by Brinkman et al. in 2018 evaluating studies of prescribing competence among final year medical students internationally found a general lack of knowledge and skills, and lack of confidence in their ability to prescribe safely.[9] In the 2019 Preparedness for Internship survey conducted by the Australian Medical Council and Medical Board of Australia, they noted that prescribing, "remains a relatively low rated clinical skill in terms of perceived preparedness."[28] Our survey also re-confirms and expands on perceptions from our 2015 survey that Canadian medical education leaders believe that a common national threshold of competence in CPT knowledge and prescribing skills is important.[11] However, results also confirm that schools need support in CPT curriculum development as there is no national resource.[11] This impression was present pre-COVID-19 but has increased post-pandemic. For example, the proportion of faculty who specified close supervision of prescribing was needed for more than 33% of their first-year residents increased from 44.8% in the 2015 survey to 52.0% presently.[11] However, it is unclear *why* faculty felt a greater proportion of trainees currently required supervision although it is likely because students had fewer in-person opportunities for clinical experiences and prescribing during the pandemic.

The perceived lack of medical trainee prescribing competence is likely related to a lack of teaching and assessment in CPT as well as a lack of experience in prescribing and monitoring medications during undergraduate medical education.[8,29,30] The knowledge requirements for CPT are arguably the most daunting of all medical specialties, given the thousands of prescription medications, over-the-counter drugs, unregulated substances and drugs of abuse that physicians must know about to serve the population.[31] At the same time, as CPT clinical content and expertise requirements expand, medical school curriculum attention to CPT is declining due to a very small number of CPT specialists available to advocate for this fundamental training in the face of competing, arguably less crucial, content.[32,33] It is likely that CPT education can be delivered effectively by non-CPT experts as long as explicit objectives, relevant resources and high quality educational activities and assessments are provided.

The COVID-19 pandemic impacted many aspects of medical training that had traditionally been carried out in person; however, this adjustment may have had somewhat of a 'silver lining' in that it accelerated interest in and comfort using e-curricula and online assessment methods.[34,35] This transition has proved particularly useful as widespread shortages of physicians to provide direct patient care make provision of extensive faculty presence for educational events difficult to manage.

Strengths and Limitations

Strengths of the study include the wide representation of respondents, particularly residency program directors who are well-placed to comment on graduating students' knowledge and skills. All medical schools in the country are represented in this survey, improving the generalizability of the results. Moreover, the survey topic and results remain completely novel in North America in terms of their exploration of CPT education and prescribing skills amongst medical students in the modern era where they are so critical to provider competence and patient safety.[11,36,37] However, this study also has limitations. Our survey may have had imperfect role representation, as there is no curated list of medical school leaders. We are also unable to ascertain whether the difference between surveys sent versus opened was due to emails never reaching their intended respondent, since the

LimeSurvey platform did not identify the number of emails that may have bounced. Additionally, our survey results, by definition, are self-reported opinions, resulting in a description-based analysis without external validation. Lastly, we also recognized that in our attempt to send out the invitation as broadly as we did, that some recipients would assume that other members of their faculty would be in a more suitable position to respond knowledgeably. We attempted to mitigate these limitations by ensuring our large list of participants was representative of educational leaders and decision-makers, was proportional to the size of the program, and prioritizing survey security and privacy with the use of the LimeSurvey platform.

Conclusion

Our study brings to attention the concerns involved in the prescribing competency of graduating medical students and junior residents in Canada, with resultant interest in a national CPT e-curriculum and assessment process.

Author Contributions: Conception and Design: AH, SL, Data Collection and Analysis: AH, SL, OC, JD, VT; Original Draft Preparation, AH and S.; Manuscript Review & Editing, AH, SL, OC, JD, DP, GD, ML, JR, HM, KR, AL, VT;   Funding Acquisition, AH.

Data Availability Statement: Data will be available upon reasonable request.

Conflicts of interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Dr Anne Holbrook MD. What is Clinical Pharmacology and Toxicology (CPT)? Accessed May 16, 2023. https://ecampusontario.pressbooks.pub/clinicalpharmacologyandprescribingskillsformedicine/chapter/chapter-1/

2. An In Depth Investigation into Causes of Prescribing Errors by Foundation Trainees in Relation to Their Medical Education—EQUIP Study. Published online April 26, 2023. Accessed May 16, 2023. https://psnet.ahrq.gov/issue/depth-investigation-causes-prescribing-errors-foundation-trainees-relation-their-medical

3. Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, Incidence and Nature of Prescribing Errors in Hospital Inpatients: A Systematic Review. *Drug Saf*. 2009;32(5):379-389. doi:10.2165/00002018-200932050-00002

4. Ross S, Bond C, Rothnie H, Thomas S, Macleod MJ. What is the scale of prescribing errors committed by junior doctors? A systematic review. *Br J Clin Pharmacol*. 2009;67(6):629-640. doi:10.1111/j.1365-2125.2008.03330.x

5. Canada H. A Prescription for Canada: Achieving Pharmacare for All - Final Report of the Advisory Council on the Implementation of National Pharmacare. Published July 20, 2020. Accessed February 11, 2023. https://www.canada.ca/en/health-canada/corporate/about-health-canada/public-engagement/external-advisory-bodies/implementation-national-pharmacare/final-report.html

6. 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-e110.

7. Brinkman D, 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

8. Heaton A, Webb DJ, Maxwell SRJ. Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. *Br J Clin Pharmacol*. 2008;66(1):128-134. doi:10.1111/j.1365-2125.2008.03197.x

9. Brinkman DJ, Tichelaar J, Graaf S, Otten RHJ, 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

10. Holbrook A. McMaster Essential/Core Drugs List for Medical Students. Published online 2018. Accessed November 16, 2023. https://macsphere.mcmaster.ca/handle/11375/27291

11. Liu J, Wong S, Foster G, Holbrook A. PRESCRIBING COMPETENCY OF MEDICAL STUDENTS: NATIONAL SURVEY OF MEDICAL EDUCATION LEADERS. *J Popul Ther Clin Pharmacol*. 2018;25(1):e18-e24. doi:10.22374/1710-6222.25.1.2

12. Coleman JJ, Samer C, Zeitlinger M, et al. The European Association for Clinical Pharmacology and Therapeutics—25 years' young and going strong. *Eur J Clin Pharmacol*. 2019;75(6):743-750. doi:10.1007/s00228-019-02690-5

13. Dhillon J, Salimi A, ElHawary H. Impact of COVID-19 on Canadian Medical Education: Pre-clerkship and Clerkship Students Affected Differently. *J Med Educ Curric Dev*. 2020;7:2382120520965247. doi:10.1177/2382120520965247

14. National Prescribing Curriculum. NPS MedicineWise. Published January 22, 2019. Accessed February 11, 2023. https://www.nps.org.au/cpd/npc-modules

15. Clinical Pharmacology and Prescribing. elearning for healthcare. Accessed February 11, 2023. https://www.e-lfh.org.uk/programmes/clinical-pharmacology-and-prescribing/

16. Zhang XY, Holbrook AM, Nguyen L, et al. Evaluation of online clinical pharmacology curriculum resources for medical students. *Br J Clin Pharmacol*. 2019;85(11):2599-2604. doi:10.1111/bcp.14085

17. Wagner JL, McCarthy E. International Differences in Drug Prices. *Annu Rev Public Health*. 2004;25(1):475-495. doi:10.1146/annurev.publhealth.25.101802.123042

18. Acosta A, Vanegas EP, Rovira J, Godman B, Bochenek T. Medicine Shortages: Gaps Between Countries and Global Perspectives. *Front Pharmacol*. 2019;10. Accessed May 16, 2023. https://www.frontiersin.org/articles/10.3389/fphar.2019.00763

19. Zhang Y, Hueser HC, Hernandez I. Comparing the Approval and Coverage Decisions of New Oncology Drugs in the United States and Other Selected Countries. *J Manag Care Spec Pharm*. 2017;23(2):247-254. doi:10.18553/jmcp.2017.23.2.247

20. Gordon M, Patricio M, Horne L, et al. Developments in medical education in response to the COVID-19 pandemic: A rapid BEME systematic review: BEME Guide No. 63. *Med Teach*. 2020;42(11):1202-1215. doi:10.1080/0142159X.2020.1807484

21. Mastour H, Emadzadeh A, Hamidi Haji Abadi O, Niroumand S. Are students performing the same in E-learning and In-person education? An introspective look at learning environments from an Iranian medical school standpoint. *BMC Med Educ*. 2023;23(1):209. doi:10.1186/s12909-023-04159-7

22. Moses TEH, Moreno JL, Greenwald MK, Waineo E. Training medical students in opioid overdose prevention and response: Comparison of In-Person versus online formats. *Med Educ Online*. 2021;26(1):1994906. doi:10.1080/10872981.2021.1994906

23. Fan J, Metting A. COVID-19 online medical education and outcomes on Internal Medicine In-Training Examination scores. *Proc Bayl Univ Med Cent*. 36(3):360-362. doi:10.1080/08998280.2023.2188991

24. Medical expert | Medical Council of Canada. Accessed May 16, 2023. https://mcc.ca/objectives/expert/

25. LimeSurvey — Free Online Survey Tool. Accessed February 11, 2023. https://www.limesurvey.org/

26. Artino AR, La Rochelle JS, Dezee KJ, Gehlbach H. Developing questionnaires for educational research: AMEE Guide No. 87. *Med Teach*. 2014;36(6):463-474. doi:10.3109/0142159X.2014.889814

27. A Consensus-Based Checklist for Reporting of Survey Studies (CROSS) | EQUATOR Network. Accessed May 16, 2023. https://www.equator-network.org/reporting-guidelines/a-consensus-based-checklist-for-reporting-of-survey-studies-cross/

28. Medical Board of Australia - Search. Accessed November 21, 2023. https://www.medicalboard.gov.au/Search.aspx?q=Preparedness+for+internship+survey

29. 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

30. Wasserman S, Potgieter S, Shoul E, et al. South African medical students' perceptions and knowledge about antibiotic resistance and appropriate prescribing: are we providing adequate training to future prescribers? *S Afr Med J*. 2017;107(5):405-410. doi:10.7196/SAMJ.2017.v107i5.12370

31. Commissioner O of the. Fact Sheet: FDA at a Glance. *FDA*. Published online August 17, 2022. Accessed May 16, 2023. https://www.fda.gov/about-fda/fda-basics/fact-sheet-fda-glance

32. Maxwell SR, Webb DJ. Clinical pharmacology—too young to die? *The Lancet*. 2006;367(9513):799-800. doi:10.1016/S0140-6736(06)68316-5

33. Wiernik PH, Pharmacology for the PPC of the AC of C. A dangerous lack of pharmacology education in medical and nursing schools: A policy statement from the American College of Clinical Pharmacology. *J Clin Pharmacol*. 2015;55(9):953-954. doi:10.1002/jcph.539

34. Khatami A, Holbrook A, Levinson AJ, Keshavjee K. Software Architecture for Automated Assessment of Prescription Writing. *Stud Health Technol Inform*. 2022;294:780-784. doi:10.3233/SHTI220583

35. Dedeilia A, Papapanou M, Papadopoulos AN, et al. Health worker education during the COVID-19 pandemic: global disruption, responses and lessons for the future—a systematic review and meta-analysis. *Hum Resour Health*. 2023;21(1):13. doi:10.1186/s12960-023-00799-4

36.   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

37.   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